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ABSTRACT

Using a unique firm-level dataset from China's "Silicon Valley," we investigate how multinational enterprises (MNEs) affect local entrepreneurship and R&D activities upon entry. We find that R&D activities of MNEs in an industry stimulate entry of domestic firms into the same industry and enhance R&D activities of newly entering domestic firms. By contrast, MNEs' production activities or domestic firms' R&D activities do not have such effect. Since MNEs are technologically more advanced than domestic firms, our findings suggest that diffusion of MNEs' advanced knowledge to potential indigenous entrepreneurs through MNEs' R&D stimulates entry of domestic firms.

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1 Introduction

The clustering of high-tech firms has played an important role in the prosperity of some regions in the United States, such as Silicon Valley in California and Route 128 in Boston. Similar examples can also be found in less developed countries, such as Bangalore in India and Hsinchu Science Park in Taiwan. These successful high-tech clusters become a birthplace of new technology and contribute to innovation in their home economies as well as in the world economy.

To investigate how such clustering takes place, this study focuses on the role of technology leaders in stimulating entrepreneurship in the cluster. Specifically, we hypothesize that development of a high-tech cluster can be promoted by knowledge diffusion from technologically leading firms to potential entrepreneurs.

To test the knowledge-diffusion hypothesis, we use a unique dataset for a new high-tech cluster in China, the Zhongguancun Science Park (hereafter, the Z-Park) during the period 1998-2003. The Z-Park, established in Beijing in 1988, is the first and largest national science park in China and has recently experienced rapid agglomeration of high-tech firms. Therefore, the Z-Park, now widely known as China's "Silicon Valley," provides us a unique case for studying what promotes clustering of high-tech firms. The Z-Park is also home to many high-tech multinational enterprises (MNEs) such as Google, IBM, Microsoft, Motorola, Nokia, and Panasonic, which account for 12 percent of all establishments in the Z-Park in terms of the number of firms in 2003. These MNEs are technologically more advanced to a large extent than domestic firms. Therefore, in the case of the Z-Park, technological leaders in our knowledge-diffusion hypothesis are MNEs, whereas followers are domestic firms.

Thus, this paper specifically examines how MNEs (technological leaders) affect the entry decision of potential indigenous entrepreneurs (technological followers) through knowledge diffusion. In particular, we distinguish between MNEs' production and R&D activities and examine whether each type of MNEs' activity induces entry of indigenous firms and stimulates R&D of the entrants, highlighting important roles of MNEs' R&D in promoting knowledge diffusion and fostering domestic entrepreneurship.

In estimating those impacts, we employ Blundell and Bond's (1998) system GMM to control for possible biases due to endogeneity and fixed effects. Then, we find that the size of MNEs' R&D activities in a particular industry has a positive and statistically significant impact on the number of entries of domestic firms into the same industry and on the size of R&D of entering domestic firms. The benchmark results indicate that 31 percent of entries of domestic firms attribute to MNEs' R&D activities. By contrast, either MNEs' production activities or domestic firms' R&D activities do not have such effect on domestic entry.

We also find that MNEs' R&D activities contribute to not only gross entry of newly born domestic firms but also gross entry of domestic firms existing elsewhere in China to the Z-Park and net entry of domestic firms. These results indicate that MNEs' R&D activities enhance clustering of domestic firms in the Z-Park by stimulating local entrepreneurship and promoting the relocation of existing firms.

These findings are consistent with the knowledge-diffusion hypothesis, leading to a conclusion that diffusion of MNEs' advanced knowledge to potential indigenous entrepreneurs particularly through MNEs' R&D activities stimulates entry of domestic firms. Our interviews with managers of several multinational and domestic firms in the Z-Park point out several potential mechanisms of such knowledge diffusion, most notably learning by doing in MNEs' R&D centers, inter-firm R&D cooperation between MNEs and domestic institutions, and technical assistance associated with outsourcing from MNEs to domestic firms.

This paper relies on the literature on the effect of MNEs on the growth of domestic firms in general and on indigenous entrepreneurship in particular. Many empirical studies have explored the effects of MNEs on the productivity of domestic firms in less developed countries, such as Kokko (1994), Aitken and Harrison (1999), and Javorcik (2004). In particular, Todo and Miyamoto (2006), using firm-level data from Indonesia, find that MNEs' R&D activities improve domestic firms' productivity, while MNEs' production activities do not. Todo, Zhang, and Zhou (2006) identify a similar effect, using the same dataset from the Z-Park as in this paper. In a related study, Swenson (2007) using firm-level data for China finds that growth in the size of MNEs is positively associated with the formation of new export connections by local Chinese firms, and there is evidence suggesting that information spillovers from MNEs to local firms may drive this result.

Closest to our analysis includes Görg and Strobl (2002) who use industry-level data of the Irish manufacturing sector and find a positive effect of the size of MNEs on entry of indigenous firms. Backer and Sleuwaegen (2003) also analyze the effect of foreign direct investment (FDI) on domestic entrepreneurship, using Belgian data. They find that FDI discourages entry and stimulates exit of domestic entrepreneurs in the short run, while in the long run the knowledge-diffusion effect of FDI through learning and networking will mitigate or even reverse the short-run crowding-out effect.

Our innovation, compared with these existing studies on MNEs and indigenous entrepreneurship, is that we are the first to explore impacts of *R&D activities* of MNEs on entry of domestic firms, distinguishing them from impacts of MNEs' production activities. Another contribution of this study is that we compare predictions of several hypotheses, such as those based on the standard agglomeration theory of Marshall (1890) and on crowding-out effects of MNEs, concluding that the knowledge-diffusion hypothesis best fits the data.

Our analysis is also related to the studies on the recent growth of the computer software industry in less developed countries such as Arora and Gambardella (2004) and Arora, Arunachalam, Asundi, and Fernandes (2001), since this industry is one of the major industries in our data for China's "Silicon Valley." In particular, Arora and Gambardella (2004), who analyze five non-G7 economies including China, point to a positive role of MNEs in the growth of the software industry in these economies. However, they do not focus on MNEs' R&D activities as a particular stimulus to indigenous entrepreneurship or use firm-level data for the analysis, as we do in this paper.

Our study may be able to contribute to debate on FDI policies in China and other less developed countries. MNEs' potential threat to domestic firms through market competition frequently raises serious concerns among policy makers in less developed countries about whether policies subsidizing FDI ultimately benefit the domestic economy. In China, one of the largest recipients of FDI in the world, there has been hot debate on the effect of MNEs on the catch-up of Chinese firms in innovative capacity with foreign rivals.[1] The conclusion of this study suggests that such policies favoring FDI in R&D may be beneficial to local firms through knowledge diffusion.

The remainder of the paper is organized as follows. Section 2 briefly describes the institutional background of the Zhongguancun Science Park and discusses the linkages between MNEs and domestic entrepreneurship in the Z-Park, based on our field interviews. Section 3 develops several theoretical hypotheses to be tested in this paper. Section 4 explains the estimation procedure, whereas Section 5 describes the dataset and variables used in the estimation. Section 6 presents estimation results, and Section 7 concludes.

2 Entrepreneurship and MNEs in the Zhongguancun Science Park

2.1 Description of the Z-Park

The Zhongguancun Science Park was established in 1988 as the first national-level high technology district and has remained the largest science park in China since its establishment.[2] In 2003, the Z-Park was home to more than 12,000 knowledge-intensive firms with a total employment of over 480,000 and a gross industrial value of about 80 billion US dollars. According to a research report released by Beijing Bureau of Statistics (2002), the Z-Park contributed to one seventh of the total output of all science parks combined in China and two thirds of the industrial growth in Beijing. In the early years of its development, the Z-Park was only confined to a small geographical area of Zhongguancun, located in the northwestern part of the Haidian District in Beijing. However, the past two decades has witnessed its evolution into an agglomeration of five sub-parks spread all over Beijing.

A unique advantage of the Z-Park is that it has the highest density of top universities and research institutions in China. The whole park hosts 73 universities and 232 research

[1] For example, there has been a popular view that China's automobile industry is still heavily dependent on imported foreign technology and lacks self-innovation after over 20 years of joint ventures with foreign automobile producers.

[2] Nowadays China has 58 national-level science parks and more than six thousand industrial parks at local levels. We thank Mr. Hongjia Wang at the Research Department of Zhongguancun Administrative Commission for providing the background information of the Z-Park.

institutions, while the Zhongguancun area itself accommodates over 50 universities including the two leading universities in the nation, Peking University and Tsinghua University, and more than one hundred research institutions including the Chinese Academy of Sciences and the Chinese Academy of Engineering. By the end of 2005, the Zhongguancun area had one third of China's national laboratories and accounted for one fifth of China's total R&D expenditure.

Another feature of the Z-Park is the strong, continuing support from the government. In order to encourage entry of high-tech firms and develop the Z-Park as the innovation engine for China's high-tech industries, the government offers several preferential benefits to firms located in the Z-Park. The most notable is the tax incentive which has been issued since the establishment of the Z-Park. For all eligible firms, the corporate income tax rate is 15 percent, less than half of the normal corporate income tax rate of 33 percent. New entrants additionally enjoy tax wavier for the first three years. In 1999, additional preferential policies were granted by the government, such as enlarging the scope of the tax waiver and deductions (e.g., reduction of sales taxes on technological transfers, consulting, and services and R&D expenditures). In order to attract strong inflows of brainpower from other parts of China as well as from overseas, the government allows high-tech employees in the Z-Park to obtain Beijing residence.[3]

2.2 Domestic Entrepreneurship in the Z-Park

Entrepreneurial activities in the Z-Park resulted in the birth of numerous small- and medium-sized high-tech firms.[4] In particular, the Z-Park experienced a dramatic increase in entry of domestic firms into the Z-Park after 1998, an increase which attributes to the break-throughs in information technology (IT), the booming new economy in the United States, and supportive government policies.

Among the domestic entrants into the Z-Park, there are two groups of firms which stand out because of their distinctive origins. The first group of firms are those closely

[3]China has long instituted a strict *hu kou* (household registration) system to regulate the mobility of people across localities. A person is not entitled to social benefits (e.g., schooling and housing subsidies) in a locality if s/he does not have a *hu kou* in that locality.

[4]Section 5 will give a detailed description of firm entry in major industries in the Z-Park.

connected with universities and research institutions in the Zhongguancun area.[5] These research centers provide ample supply of new ideas and talents and hence nurture the birth of start-ups. In addition, many universities are keen in setting up new venture incubators within the campuses to encourage and help young graduates to try out their ideas and start up their own business. Peking University and Tsinghua University have established many university-affiliated high-tech firms, some of which are leading firms in the Z-Park, such as Founder from Peking University and Tsinghua Unisplendour from Tsinghua University. A significant portion of CEOs of the well-known companies in the Z-Park are alumnus of the universities located in Zhongguancun.[6]

The second group of entrepreneurs are returnees from overseas. They hold overseas master or Ph.D. degrees, mostly in engineering, and many of them have previously worked in MNEs in foreign countries. When good opportunities arise in China, they come back to China and start up their businesses. The exposure to the frontier of new technology, previous working experience in MNEs, and familiarity with Chinese business environments provide these returnees with unique advantages. The overseas background including fluent English and understanding of foreign business culture also helps those returnees take advantage of cooperative relationship with MNEs in China.

2.3 MNEs and their Linkages with Domestic Entrepreneurship

MNEs have been a critical part of the high growth of the Z-Park. Our data show that up to 2003, the shares of MNEs in sales, employment and R&D employment are 40%, 20%, and 19%, respectively, as we will explain in more detail in Table 3. Many multinational giants, such as Microsoft, IBM, Motorola, Nokia, and LG, are the residents of the Z-Park. More importantly, the Z-Park has become a cluster of MNEs' R&D centers. By the end of

[5] Our data show that the share of firms affiliated to universities or research institutions in the Z-Park peaked (18 percent) in 2000 in terms of the number of firms and declined to less than 5 percent in 2003 due to the large-scale privatization of these publicly-owned firms.

[6] Research institutions also support their researchers to commercialize research outputs by providing start-up financing. An early legendary example in this regard is the establishment of Legend (the former incarnation of Lenovo) in 1984. The Chinese Academy of Sciences invested 300 thousand yuan (or about 40 thousand US dollars) as the seed money and became the owner of the company. The founding CEO, Chuanzhi Liu, was then a researcher at the CAS, and many of his colleagues at that time came from the CAS.

2005, 43 corporations out of the top 500 in the world have located their R&D centers in the Z-Park. The first MNE which sets up an R&D center in the Z-Park was IBM in 1995, followed by Microsoft, Bell Labs, Fujitsu, Intel, Motorola, and Oracle, among many others. In general, those MNEs are technologically more advanced than domestic firms: Using the same dataset as in this paper, Todo, Zhang, and Zhou (2006) find that the total factor productivity (TFP) of MNEs is about 40 percent higher than the TFP of domestic firms on average.

The presence of MNEs in the Z-Park and especially their R&D centers has profoundly changed the landscape of the Chinese IT industry as well as business opportunities in the Z-Park. The spike in the entry of domestic firms since late 1990s coincided with the significant presence of MNEs in the Z-Park and their decision to build R&D centers. But was it just a coincidence? Our field interviews with managers of several domestic firms and MNEs collected a number of interesting cases pointing to the potential mechanisms through which MNEs improve the knowledge level of domestic engineers and thus promote domestic entrepreneurship. Such mechanisms include learning by doing in MNEs' R&D units, R&D cooperation between MNEs and domestic firms and universities, and outsourcing from MNEs to domestic firms.

A notable example of local engineers' learning by doing in MNEs and their subsequent spin-offs from the MNEs is the start-up of TechFaith, a cell-phone software company. The CEO of TechFaith, Defu Dong, had formally been a sales manager of Motorola in China. Several years of close contact with suppliers and clients made him familiar with the whole process of cell phone production and marketing, and especially China's dynamic market. In the late 1990s, many MNEs started to enter China's cell phone industry and set up their R&D centers in the Z-Park, which triggered fierce competition in China's market. While the whole industry suffered from profit erosion during 1999-2001, Dong realized that a good business opportunity emerged in the software design of cell phones which was typically outsourced by MNEs. Dong jumped at this golden opportunity and quit from Motorola in 2002, together with a dozen of designers and engineers who were his colleagues in Motorola and had experiences in its R&D unit. He set up his own company TechFaith in the Z-Park which specialized in software design and development for cell phones. The later success proved that Dong's judgment was right: the company's sales and profits grew by over 100-200% in the first 3 years. The promising prospect attracted several prominent venture capitalists to pour further investment in the company. Remarkably, TechFaith succeeded in going public in the NASDAQ in 2005. In May 2006, it signed an R&D alliance agreement with Microsoft which promised to cooperate in the R&D of mobile entertainment based on Windows Mobile and Windows Media technologies.

The growth of Ultrapower Software provides an example of knowledge improvement of local engineers through R&D cooperation with and outsourcing from MNEs. Ultrapower Software is one of numerous start-up companies established in the Z-Park in 2001 when China's IT industry grew in leaps and bounds and many MNEs rushed in to compete for the big Chinese IT market. It specializes in business service management (BSM), provision of management schemes using IT solutions and services, in industries ranging from telecommunication and finance to government services. Despite its short history, Ultrapower has become the largest in the BSM industry in China, with a market share of 15 percent. Ultrapower's unique advantage comes from its great R&D team in China, and especially its sustained strong partnership in R&D and outsourcing relationships with multinational industrial leaders, such as BMC Software, CA, Hewlett Packard, and IBM. Such relations in R&D with those industrial innovators lay an important platform for Ultrapower's continuing product innovation and improvements in service quality.

TechFaith and Ultrapower are not alone in making use of R&D linkages with MNEs to outperform competitors in the market. Smartdot, which was originated from the new venture incubator of Tsinghua University in 1998, is a leading provider of solutions and services in the areas of enterprise office automation, information management, and e-government projects in China. These solutions and services are mainly built on IBM advanced software platforms. As the Preferred Lotus Partner in China and the winner of the Beacon Award from IBM in 2005 and 2006, Smartdot has been engaged in a long-term strategic cooperation with IBM. Since 2004, the IBM Innovation Center has sent several technical consultants on-site to provide hands-on training, on-site enablement and troubleshooting support on different applications of IBM software. This constant and comprehensive support has substantially improved Smartdot's R&D strength and extended its core competitive capacity.

Those relations between MNEs and domestic engineers and firms above are confirmed by the interview with a manager of an MNE in the Z-Park. The manager told that local engineers of the MNE generally start with a relatively low level of knowledge, learn advanced knowledge of the MNE through learning by doing in its laboratory, and tend to leave the firm after three years of experiences either moving to another MNE or starting up a new firm. The manager also informed us that the MNE often engaged in R&D cooperation with domestic firms and universities, since domestic institutions are more familiar with local conditions such as consumers' needs and the government's regulations.

These cases from the domestic and multinational firms in the Z-Park suggest that the relation with MNEs, particularly their R&D activities, can benefit domestic firms and engineers through knowledge diffusion. Since local engineers who achieve a high level of knowledge are likely to start up their own firms, MNEs' R&D activities may promote domestic entrepreneurship. Below, we use industry-level panel data for quantitative analysis of this hypothesis.

3 Empirical Hypotheses

The previous section suggests a knowledge-diffusion hypothesis on the relation between MNEs and domestic entrepreneurship, whereas the existing literature has suggested some other hypotheses about how the presence of incumbent firms affects entry of new firms. In this section, we discuss these hypotheses and compare their predictions on the effect of MNEs on entry of domestic firms. We will also examine the prediction of each hypothesis on the effect of incumbent MNEs on R&D activities of domestic entrants and entry and R&D of new MNEs, since by so doing, we can find which hypothesis fits the actual data with greater precision.

3.1 Knowledge-Diffusion Effect

One possible reason why MNEs stimulate entry of domestic firms is knowledge diffusion from incumbent MNEs, technology leaders. Such diffusion of knowledge improves knowledge of potential indigenous entrepreneurs to a level sufficiently high to start up a firm. As our case studies in Section 2 have shown, knowledge of MNEs diffuses to domestic entrepreneurs through several channels, most notably through learning by doing in MNEs' units, inter-firm R&D cooperation, and technical assistance associated with R&D outsourcing. These observations suggest that MNEs' R&D activities in particular contribute to knowledge diffusion, while MNEs' production activities may not have such a diffusion effect after controlling for the size of MNEs' R&D activities.

Therefore, the number of entries of domestic firms should increase in the size of incumbent MNEs' R&D activities in the same industry, while it is not affected by the size of MNEs' production activities. In addition, since MNEs' R&D enhances the knowledge level of domestic entrants through knowledge diffusion, the size of R&D activities of new domestic firms upon entry should also increase in the size of R&D of incumbent MNEs.

By contrast, since potential entrants of MNEs are likely to be as technologically advanced as incumbent MNEs, their benefits from incumbent MNEs due to knowledge diffusion are not as large as domestic firms' benefits. Consequently, incumbent MNEs' R&D activities should not have a significant effect on entry of MNEs or their R&D activities upon entry.

In addition, the hypothesis that knowledge diffuses from leaders to followers implies that incumbent domestic firms' R&D should have no effect on entry of either domestic firms or MNEs, nor on their R&D activities upon entry.

These predictions from the knowledge-diffusion hypothesis are summarized in rows 1-3 in Table 1, as predictions from the alternative hypotheses presented below are shown in lower rows.

3.2 Agglomeration Effect

The standard theory of agglomeration of firms claims that firms want to cluster together to take advantage of potential positive externalities they generate for each other (Marshall, 1890; Krugman, 1991; Ellison and Glaeser, 1997). For example, an effective labor market for skilled labor or some critical inputs is more likely to form and function well when there are a large number of firms in the cluster.

Unlike the knowledge-diffusion effect that works unilaterally from technologically superior firms to inferior firms, this agglomeration effect emphasizes mutual forces driving firms to cluster together. Therefore, the agglomeration effect predicts that the size of production activities of incumbent firms, regardless of whether domestic or multinational, should be positively correlated with the degree of entry of both domestic and multinational firms. Furthermore, when there are positive externalities among firms in the same industry in the area of R&D through, for example, creating an effective labor market for scientists and engineers, then R&D activities of new firms should expand when R&D of incumbent domestic or multinational firms is large in size.

3.3 Crowding-out Effect

MNEs may not be benign to local entrepreneurship. With their technological and financial advantages, MNEs may put much competitive pressure on domestic firms producing similar products, thus crowding out domestic investment (Backer and Sleuwaegen, 2003). This crowding-out effect suggests that entry of domestic firms should be negatively affected by the size of incumbent MNEs, regardless of whether the size of their R&D or non-R&D activities. Incumbent domestic firms may also have the crowding-out effect on entry of domestic firms, but their effect is likely to be smaller than that of MNEs because domestic firms do not have technological advantages as MNEs do. The crowding-out effect does not apply equally to potential multinational entrants, as they are likely to be similarly competitive as incumbent MNEs. Thus, entry and R&D of new MNEs should be little affected by the incumbent MNEs or domestic firms.

3.4 Preemption Effect

Aghion, Blundell, Griffith, Howitt, and Prantl (2004) theoretically and empirically show that in technologically advanced industries incumbent firms engage in innovation to a large extent to preempt entry of new firms. In the case of our analysis, by the Z-Park's high-tech requirements, most industries can be considered technologically advanced.[7] Thus, the preemption effect implies that the size of incumbent MNEs' R&D activities should be negatively correlated with the extent of entry of domestic firms. Incumbent domestic firms should also have the preemption motive, but since they are not as technologically advanced as MNEs are, their effect on entry of domestic firms should be negative but weak. The preemption hypothesis does not predict any impact of R&D of incumbent firms on R&D of new firms and thus we expect the impact to be ambiguous.

The preemption effect should also apply to potential multinational entrants. Thus, according to this hypothesis, entry and R&D activities of new MNEs are affected by R&D of incumbent MNEs and domestic firms in the same way as those of new domestic firms are affected.

3.5 Demand-Creation Effect

Another important channel through which MNEs can stimulate local entrepreneurship is creation of demand for local intermediary products and services. Our case studies in fact indicate that domestic firms often undertake outsourcing from MNEs. Note, however, that our case studies also suggest that outsourcing is often associated with technical assistance and hence leads to knowledge diffusion. Since the effect through knowledge diffusion has already been considered, here we distinguish between the pure demand-creation effect of outsourcing and its knowledge-diffusion effect.

When MNEs create demand for domestic firms' products and services, entry of domestic firms should be expanded in the presence of incumbent MNEs, represented by the size of their production activities. If MNEs outsource their R&D activities in addition to production activities, we would expect the same impact of MNEs' production activities on R&D activities of new domestic firms upon entry. However, the size of incumbent MNEs' R&D activities should not have any effect on entry and R&D of new domestic firms, after controlling for the size of production activities of incumbent MNEs.

[7]Table 2 will later show that the information and communication industries are the leading industries in the Z-Park in terms of sales, employment and the number of firms.

In contrast to incumbent MNEs, incumbent domestic firms do not necessarily provide demand to domestic entrants but can be even competitors to them. Thus, the demand creation effect does not have definite predictions regarding the effect of incumbent domestic firms on entry of domestic firms. Similarly, the effect of incumbent MNEs on entry and R&D activities of new MNEs is theoretically ambiguous.

4 Empirical Methodology

4.1 Econometric Specification

To test our hypotheses, we employ the following estimation equation:

$$\begin{aligned} E_{it} &= \beta_1 MNE_{i,t-1} + \beta_2 R\&D\_dom_{i,t-1} + \beta_3 Y\_dom_{i,t-1} + \beta_4\, gY_{i,t-1} \\ &\quad + \beta_5 Y\_mean_{i,t-1} + \alpha_i + \nu_t + \varepsilon_{it}, \end{aligned} \tag{1}$$

where the definitions of the variables are as follows (all regressors except for gY are expressed in logs):

1. The dependent variable E_{it} represents the size of entry of domestic firms to industry i in year t. We aggregate firm-level data to 3-digit industry level data to construct the following three alternative measures of entry at the firm level. First, E_{it} is represented by the log of the number of gross entries of new domestic firms that did not exist anywhere in previous years, which we will simply call new domestic firms. By using this measure of domestic firms' entry, we can examine whether the presence of MNEs stimulates local entrepreneurship. Second, we employ the log of the number of gross entries of firms to the Z-Park that have existed elsewhere in China, which we will call existing firms. By using this measure, we can examine whether the presence of MNEs promotes relocation of domestic firms to the Z-Park. Third, we also use the number of net entries of domestic firms, i.e., the number of gross entries of both new and existing domestic firms less the number of exits of domestic firms. The use of this measure enables us to investigate the overall impact of MNEs on clustering of domestic firms in the Z-Park.

2. $MNE_{i,t-1}$ represents the presence of MNEs in the previous year. We use one or both of

the two measures in the regressions: non-R&D and R&D employment of MNEs, respectively denoted by L_MNE and $R\&D\_MNE$.[8] All the regressors are first-lagged, since we assume that the entry decision is determined based on information in the previous year.

3. $R\&D\_dom_{i,t-1}$ and $Y\_dom_{i,t-1}$ are R&D employment and sales of domestic firms of industry i in year $t-1$, respectively.

4. $gY_{i,t-1}$ and $Y\_mean_{i,t-1}$ are the growth rate of total sales and the mean of firm-level sales of industry i in year $t-1$, respectively. These variable are included in the regressions because following Görg and Strobl (2002), we need to control for industry characteristics that may be related to the level of expected post-entry profits and the level of barriers to entry.[9]

5. α_i, ν_t, and ε_{it} are industry-specific fixed effects, the year-specific effects, and the error term, respectively.

Besides entry of domestic firms, we also estimate equation (1) using either R&D employment of domestic firms upon entry, the number of gross entries of new MNEs, or R&D employment of new MNEs upon entry as the dependent variable. The results from these 4 types of regression will inform us which hypothesis is supported by our data.

4.2 Estimation Method

There are two major econometric issues when estimating equation (1): estimation biases due to the endogeneity of regressors and unobservable industry-specific fixed effects. For example, when growing industries attract more MNEs than stagnating industries, the reverse causality leads to endogeneity of the MNE variables. In addition, policies in the Z-Park may encourage entries of domestic firms to some particular industries and expand the presence

[8] R&D expenditure is commonly used in the literature as a measure for R&D activities. Our dataset does not contain information on R&D expenditure until 2001. The use of R&D employment as a measure of R&D can substantially increase the sample size. Moreover, our alternative estimation using R&D expenditure yields qualitatively similar results.

[9] Another variable that may represent the level of entry barriers and is used in Görg and Strobl (2002) is the mean of firm ages. Although we used this variable in our regression, we found that its effect was insignificant in all specifications, probably because firms in the Z-Park are mostly young so that the mean age of firms does not reflect entry barriers as it often does in national-wide datasets. Therefore, we do not use this variable in this study.

of MNEs in the same industries. The lack of information on such policies in our dataset may lead to endogeneity due to omitted variables. Furthermore, the extent of entry to each industry may be determined by time-invariant characteristics of the industry. Thus, ordinary least squares (OLS) estimations without controlling for such industry-specific fixed effects are, again, likely to be biased.

To correct for these potential biases due to endogeneity and fixed effects, we employ the system generalized method of moments (GMM) estimation developed by Blundell and Bond (1998). In the system GMM estimation, we apply GMM estimation to the system of equation (1) and its first-difference in which the industry-specific fixed effects are eliminated, using the lagged first-differenced regressors as instruments for equation (1) and the lagged regressors as instruments for the first-differenced equation. More specifically, instruments used for the regressors in the level equation for year t are $\Delta z_{i,t-1} \equiv z_{i,t-1} - z_{i,t-2}$ where z denotes endogenous regressors, whereas instruments in the first-differenced equation are $z_{i,t-2}$.[10] The lagged regressors can be used as instruments, since they are predetermined and thus should not be correlated with the contemporaneous error term. The major advantage of the system GMM estimation, compared with its predecessor, the difference GMM developed by Arellano and Bond (1991), is that in the latter, instruments are weak if regressors have near unit root properties, whereas this problem can be alleviated in the former. We apply the two-step procedure to the system GMM estimation to obtain larger efficiency. In addition, we use Windmeijer's (2005) methodology to obtain robust standard errors. The estimator thus obtained is consistent even in the presence of heteroskedasticity and autocorrelation and corrects for finite sample biases found in the two-step estimations.

[10]We restrict the number of lags so that the number of instruments is not too large compared with the number of observations. Roodman (2007) argues that Hansen J tests for overidentifying restrictions are weak when there are too many instruments in the system GMM estimations.

5 Data

5.1 Description of the Dataset and Variables

Firms in the Z-Park must file with the Administrative Commission of the Z-Park an annual report containing balance sheets as well as information on their management, human resources, and R&D activities. The firm-level annual data for the period 1998–2003 are aggregated at the industry level and used in this study. An advantage of our dataset is that since every firm in the Z-Park must file an annual report, entries and exits of firms can be identified with precision. Industries are categorized according to the Industrial Classification Codes for National Economic Activities of China at the 3-digit level. To avoid biases from including negligibly small industries, we restrict our sample to 54 3-digit industries in which the number of firms exceeds five in each year during the period 1998–2003. Thus, we have 324 year-industry observations in total over the 6-year period. Since we use twice lagged variables as instruments in our econometric estimations, the effective number of observations is reduced to 216 during the period 2000–2003.

An entry of a firm is identified when the firm's identification number first appears in the dataset. We can thus obtain the number of gross entries into each industry in each year. The number of net entries in an industry is defined as the number of gross entries less the number of exits in the industry. Domestic firms are defined as those with zero foreign share in capital. Among entries of domestic firms, we distinguish between entries of new and existing domestic firms by defining new firms as firms whose reported year of establishment is equal to the year of entry and existing firms as other firms. We define MNEs as firms with a foreign share in capital of 20 percent or more.[11]

MNEs' R&D employment in an industry, $R\&D\_MNE$, is the log of the sum of employment in R&D activities of all MNEs in the industry.[12] Similarly, MNEs' non-R&D employment, L_MNE, is the log of the sum of total employment of MNEs less their R&D

[11]This definition of MNEs, combined with the definition of domestic firms above, implies that firms with a foreign share between 0 and 20 percent are not classified as either domestic firms or MNEs. In an earlier version of the paper, we defined MNEs as firms with any positive share of foreign capital and obtained very similar results.

[12]When we define $R\&D\_MNE$ as the log of the weighted sum of employment in R&D activities of all MNEs in the industry, using the firm-level foreign share in capital as weights, we obtain similar results.

employment. The industry's sales of domestic firms, *S_dom*, are the log of the sum of sales of all domestic firms. R&D employment of domestic firms, *R&D_dom*, is defined in the same way. *gS* and *S_mean* are the growth rate of total sales and the log of the average sales of all firms in the industry, respectively. Note that we add one when we take logs of variables, if the minimum of these variables is zero.

5.2 Descriptive Statistics

The extent of firm entry to the Z-Park by year is presented in the upper panel of Table 2. Clearly, the number of firms in the Z-Park is rapidly increasing over time from 1,957 in 1998 to 8,487 in 2003. This increase largely comes from a large amount of entry of domestic firms, in particular entry of new domestic firms, which takes place in an accelerating pace over the years (except for a slower pace in 2003). For example, the number of gross entries of new domestic firms increases from 203 in 1998 to 1,540 in 2003. The lower panel of Table 2 reports the extent of firm entry by 2-digit industry. The computer software industry has the largest number of firms, followed by the communication and computing equipment industry and the computing services industry. Naturally, these industries also see the largest amounts of entry over the years.

Table 3 shows total sales, total employment, employment in R&D activities, and the share of MNEs in each of the three variables by year and by industry. The upper panel shows that the share of MNEs in each of the three variables has an overall increasing trend, with large jumps in 2000 and 2002. MNEs' share in sales is 40 percent averaged over the sample years, whereas their share in employment is 20 percent. This suggests that labor productivity of MNEs is higher on average than that of domestic firms. MNEs' share in R&D employment is 19 percent averaged over the sample years, a figure similar to MNEs' share in total employment. From the lower panel of Table 3, we can see that the IT industries, such as the communication and computing equipment, the computing services, and the computer software industries, are dominant in the Z-Park in terms of sales and employment. Note that these industries are also among those with the largest foreign shares. For example, MNEs account for 42 percent of sales in the communication and computing equipment industry.

The upper panel of Table 4 shows the mean of sales, overall employment, and employment in R&D for each of five types of firm: incumbent domestic firms, new domestic firms entering to the Z-Park, existing domestic firms newly entering to the Z-Park, incumbent MNEs, and newly entering MNEs. Clearly, new domestic firms are on average the smallest in sales, employment, and R&D activities, and the difference between incumbent domestic firms and existing domestic firms newly entering to the Z-Park is quite small. These observations suggest that the Z-Park hosts local entrepreneurs starting with a small venture firm, whereas established large firms in other areas of China are also attracted to the Z-Park. Incumbent MNEs are significantly larger than any other type of firm in all three dimensions. New MNEs are substantially smaller than incumbent MNEs, but are larger in sales and R&D than any type of domestic firm. In particular, both incumbent and new MNEs have much higher sales-employment ratios than domestic firms, consistent with our assumption that MNEs are technologically superior and more efficient.

The lower panel of Table 4 presents changes from 1998 to 2003. Notably, the number of firms and the average sales increased from 1998 to 2003 for any type of firm, while the average level of employment and R&D employment substantially decreases in the same period for any type of domestic firm. This decrease in the firm-level employment can be explained by the massive entry of smaller firms to the Z-Park.

Finally, Table 5 exhibits summary statistics of the dependent and independent variables used in the regressions below. This table indicates that the minimum of some variables, such as the log of the number of gross entries of new domestic firms and the log of MNEs' non-R&D and R&D employment, is zero. In addition, the standard deviation of these variables is often large, suggesting that there may be some outliers. If the data include many zeros and outliers, our estimation results may be biased. Therefore, we check if this is the case by creating scatter diagrams which present relation between the log of gross entries of new domestic firms, the major dependent variable, and the log of MNEs' non-R&D and R&D employment, the key independent variables (Figure 1). These diagrams indicate that the log of the number of gross entries of new domestic firms is zero for only six observations out of 216 observations during the period 2000–2003. Moreover, we do not find any clear outliers in Figure 1. Therefore, we conclude that it is not necessary to correct for possible biases due to many zeros and outliers.

6 Estimation Results

6.1 The Impact of MNEs on Entry of Domestic Firms

We start with the estimation of equation (1) using the log of the number of gross entries of new domestic firms as the dependent variable and report the results from both the OLS and the system GMM estimation in Table 6.

Columns (1) and (2) use MNEs' non-R&D employment as a proxy for the size of MNEs, whereas columns (3) and (4) use MNEs' R&D employment. Columns (5) and (6) use both measures of MNEs. The p value of the Hansen J and the Arellano-Bond statistics shown in the last two rows indicates that instruments are orthogonal to the error term and that there is no autocorrelation in the error term in all GMM estimations. Therefore, we mostly rely on the GMM results, while the OLS results are reported for reference.

Columns (1) and (2) of Table 6 show that non-R&D employment of MNEs has a positive and significant impact on entry of new domestic firms, even after controlling for the possible endogeneity problem through the system GMM estimation. Columns (3) and (4) indicate that R&D employment of MNEs also has a positive and significant impact, and the size of the estimated coefficient is larger for R&D employment than for non-R&D employment. Moreover, when we use both measures of MNEs, we find in columns (5) and (6) that the effect of non-R&D employment of MNEs turns to be insignificant, while the effect of R&D employment of MNEs remains positive and significant.

This evidence suggests that the positive effect of non-R&D employment of MNEs found in columns (1) and (2) may actually pick up the effect of R&D employment of MNEs and that non-R&D employment of MNEs may not have a significant impact on the entry of new domestic firms. These results are consistent with the knowledge-diffusion hypothesis that MNEs' R&D activities create benefits through knowledge linkage to local entrepreneurs and thereby promote birth of domestic firms. In contrast, these results do not support the predictions of the agglomeration, crowding-out, preemption, or demand-creation hypothesis summarized in Table 1.

The impact of MNEs' R&D on domestic entrepreneurship is quantitatively large. Using the result in column (6) of Table 6 and the mean of the log of the number of gross entries of new domestic firms and the log of MNEs' R&D employment, 1.80 and 2.23, respectively, presented in Table 5, we conclude that on average, MNEs' R&D activities contribute to 33 percent of entries of domestic firms.[13]

In contrast to MNEs' R&D employment, R&D employment of domestic firms has no significant effect on the entry of new domestic firms in all GMM estimations (columns [2], [4], and [6] of Table 6), although it has a positive and significant effect in all OLS estimations (columns [1], [3], and [5]). The comparison between the GMM and OLS results suggests that the positive correlation between R&D employment of domestic firms and the number of entries of domestic firms in OLS does not reflect causality but is generated by endogeneity of R&D employment of incumbent firms. This result implies that unlike R&D activities of MNEs, R&D activities of domestic incumbent firms do not facilitate entry of new domestic firms. Since domestic incumbents in the industry generally do not embody so high technological advantage over potential entrants as incumbent MNEs do, this evidence provides further support to our knowledge-diffusion hypothesis that emphasizes technological leadership as a primary source of knowledge diffusion.

The coefficient of other regressors, while not necessarily statistically significant, mostly shows the expected sign. Sales of domestic firms always have a positive and significant effect, whereas the effect of the growth rate of total sales is positive but often insignificant. The mean of firm-level sales of the industry has a negative and significant effect, suggesting that fixed costs of starting a firm (or economies of scale in a certain range) may present some entry barrier.

[13] $\exp(0.276 \times 2.52 - 1.80) = 0.331$.

Alternative Measures of Firm Entry

So far we have focused on the gross entry of new firms, i.e., birth of new firms. To check the robustness of the benchmark results, we employ two alternative measures of domestic entry. First, existing firms in other areas of China also enter to the Z-Park in order to benefit from the cluster of high-tech firms. Thus, we now investigate whether the presence of MNEs or their R&D activities facilitates the entry of existing firms to the Z-Park, using the log of the number of gross entries of existing firms as the dependent variable for equation (1).

Second, even when the presence of MNEs stimulates indigenous entrepreneurship, competition in product and labor markets between MNEs and domestic firms may drive some domestic firms out of the industry. Thus, to check the total effect of MNEs on the growth of indigenous industries, we employ the number of net entries of domestic firms. Since the number of net entries of domestic firms is defined as the number of gross entries of new and existing firms less the number of exits, it can be negative. So the dependent variable is not expressed in logs, unlike the case of gross entries.

Columns (1)–(3) of Table 7 report the results from the system GMM regressions on gross entries of existing firms, whereas columns (4)–(6) report those on net entries of domestic firms. Results from the two alternative measures of entry are even more supportive to the knowledge-diffusion hypothesis than are the results on gross entries of new firms presented in Table 6: Non-R&D employment of MNEs has no significant impact in all the GMM results, while the effect of R&D employment of MNEs is positive and significant. In addition, R&D employment of domestic firms has no significant impact. From these results, we can conclude that the R&D activities of MNEs promote local entrepreneurship and contribute to the growth of the Z-Park as a high-tech cluster.

6.2 The Impact of MNEs on R&D of Domestic Entrants

If knowledge diffusion drives the observed relationship between MNEs' R&D activities and local entrepreneurship, then the size of R&D activities of newly entering domestic firms should be positively linked with the size of R&D activities of incumbent MNEs. To check if this is the case, we further examine the effect of MNEs' R&D activities on R&D of both new domestic firms and existing firms newly entering to the Z-Park.

The GMM results on new domestic firms reported in columns (1)-(3) of Table 8 indicate that MNEs' non-R&D activities do not have a robust impact on R&D activities of new domestic firms, while MNEs' R&D activities have a positive and robust impact. On the other hand, incumbent domestic firms' R&D activities do not have a statistically significant effect on domestic entrants' R&D activities. Columns (4)-(6) of Table 8 show similar results for existing domestic firms entering to the Z-Park. In both cases, the impact of incumbent MNEs' R&D activities on domestic entrants' R&D is quantitatively large: a 1-percent increase in MNEs' R&D employment leads to a 0.6-0.8 percent increase in R&D employment of domestic firms upon entry into the Z-Park.

Overall, these results provide further evidence supporting the knowledge-diffusion hypothesis: knowledge of incumbent MNEs diffuses to indigenous entrepreneurs through MNEs' R&D activities, and such improvement in knowledge enlarges the size of R&D activities of new entrants. In addition, the results are not consistent with the predictions of the alternative hypotheses shown in Table 1.

6.3 The Impact of Incumbent MNEs on New MNEs

If the positive effect of MNEs' R&D on domestic entrepreneurship and clustering is induced by knowledge diffusion from technologically leading MNEs to local followers, then a natural implication is that R&D activities of incumbent MNEs will not have the same effect on entry of new MNEs which are also technologically advanced. To test this prediction, we estimate equation (1), using the number of gross entries of MNEs or R&D employment of new MNEs as the dependent variable. The GMM results for these estimations are reported in Table 9.

Columns (1) and (2) of Table 9 show that either MNEs' non-R&D employment or MNEs' R&D employment has an insignificant effect on the entry of MNEs in any specification. It is worth pointing out that compared to the effect of MNEs' R&D employment on entry of domestic firms identified in column (6) of Table 6, its effect on gross entries of MNEs shown in column (3) is not only statistically insignificant, but also very small in magnitude (0.067

versus 0.276). Columns (4)–(6) of Table 9 investigate the effect of MNEs' R&D employment on R&D activities of entering MNEs and show a similar pattern: either non-R&D or R&D employment of incumbent MNEs has no significant impact on the size of R&D activities of new MNEs.

These results clearly show that incumbent MNEs' impacts on entry and R&D of new MNEs are much weaker than their impacts on entry and R&D of new domestic firms. This stark contrast suggests that the strength of knowledge diffusion from MNEs through their R&D activities depends on the technological gap between leaders and followers, providing further support for our knowledge-diffusion hypothesis and rejecting the alternative hypotheses.

6.4 Summary and Discussion

The results above have established strong evidence for the positive role of MNEs' R&D activities in promoting local entrepreneurship, clustering, and R&D upon entry. We interpret this evidence as consistent with the knowledge-diffusion hypothesis which emphasizes positive impacts of knowledge diffusion from technologically leading MNEs to local followers on local entrepreneurship. Our results confirm the conclusion of the existing studies of Görg and Strobl (2002) and Backer and Sleuwaegen (2003) and in addition, reveal the importance of MNEs' R&D activities in particular in knowledge diffusion.

We also find that every alternative hypothesis explained in Section 3 and summarized in Table 1 is inconsistent with our empirical findings. First, the agglomeration effect predicts that the size of MNEs' non-R&D activities has a positive impact on entry of domestic and multinational firms. However, we do not find such evidence. Second, the crowding-out effect provides an obviously wrong prediction, since the presence of MNEs does not have any negative impact on entry of domestic firms. Third, the prediction of the preemption hypothesis that R&D activities of incumbent firms have a negative impact on R&D of new entrants is also inconsistent with our results. Finally, the demand-creation effect suggests that MNEs' production activities enhance demand for products and services of domestic firms, for example, through outsourcing, and thus stimulate indigenous entrepreneurship.

This effect is positive and significant in some specifications (columns [1] and [2] of Table 6) but insignificant in others (columns [5] and [6] of Table 6 and columns [1], [3], [4], and [6] of Table 7). Thus, we conclude that the evidence supporting the demand-creation effect is weak. In summary, competing with each of the alternative hypotheses, the knowledge-diffusion hypothesis is the clear winner.

Two cautious notes are in order here. First, our analysis is based on data from the Z-Park. As the existing literature has shown, those alternative hypotheses that are not supported in this paper may be supported by evidence in other cases, since whether a particular effect is relevant and important may be case-dependent. Second, we cannot rule out the possibility that some combination of the alternative effects are simultaneously operating in the Z-Park.

7 Conclusion

Using a unique firm-level dataset from the Zhongguancun Science Park in Beijing, we investigate how the presence of MNEs affects entry of new firms and their R&D activities upon entry. We find that MNEs' R&D activities in an industry stimulate entry of domestic firms into the same industry and enhance R&D activities of newly entering domestic firms, while MNEs' production activities do not have such effect. In addition, the effect of incumbent MNEs' R&D activities on entry of MNEs is insignificant, whereas the R&D activities of incumbent domestic firms have little effect on entry of either domestic firms or MNEs.

Since MNEs are substantially more efficient and technologically more advanced than domestic firms, our findings provide strong evidence supporting the knowledge-diffusion hypothesis that diffusion of MNEs' advanced knowledge to potential indigenous entrepreneurs through MNEs' R&D activities stimulates entry of domestic firms. Our interviews with managers of domestic firms and MNEs in the Z-Park indicate specific channels of diffusion, such as learning by doing in MNEs' R&D units, inter-firm R&D cooperation, and technical assistance associated with outsourcing from MNEs. By contrast, alternative hypotheses studied in the existing literature, such as the agglomeration effect, the crowding-out effect, the preemption effect, and the demand-creation effect, are not supported by our empirical findings.

Finally, although our regression analysis identifies an important link between MNEs' R&D activities and local entrepreneurship, and our field interviews point out specific mechanisms through which the knowledge-diffusion effect takes place, as our current dataset does not allow us to examine which mechanisms are relatively more important and effective than others. Examination of this issue will deepen our understanding of how technology and managerial knowledge diffuses from industry leaders to followers, and will help design more specific policies to facilitate such diffusion. This awaits better data and further research.

References

Aghion, Philippe, Richard Blundell, Rachel Griffith, Peter Howitt, and Susanne Prantl, 2004, Entry and productivity growth: Evidence from microlevel panel data, *Journal of European Economic Association* 2, 265–376.

Aitken, Brian J., and Ann E. Harrison, 1999, Do domestic firms benefit from direct foreign investment? Evidence from Venezuela, *American Economic Review* 89, 605–618.

Arellano, Manuel, and Stephen Bond, 1991, Some tests of specification for panel data: Monte carlo evidence and an application to employment equations, *Review of Economic Studies* 58, 277–297.

Arora, Ashish, V.S. Arunachalam, Jai Asundi, and Ronald Fernandes, 2001, The Indian software services industry, *Research Policy* 30, 1267–1287.

Arora, Ashish, and Alfonso Gambardella, 2004, The globalization of the software industry: Perspectives and opportunities for developed and developing countries, NBER Working Paper, No. 10538.

Backer, Koen De, and Leo Sleuwaegen, 2003, Does foreign direct investment crowd out domestic entrepreneurship?, *Review of Industrial Organization* 22, 67–84.

Beijing Bureau of Statistics, 2002, Firm innovations in the zhongguancun science park: An international comparison, http://www.stats.gov.cn.

Blundell, Richard, and Stephen Bond, 1998, Initial conditions and moment restrictions in dynamic panel data models, *Journal of Econometrics* 87, 115–143.

Ellison, Glenn, and Edward L. Glaeser, 1997, Geographic concentration in U.S. manufacturing industries: A dartboard approach, *Journal of Political Economy* 105, 889–927.

Görg, Holger, and Eric Strobl, 2002, Multinational companies and indigenous development: An empirical analysis, *European Economic Review* 46, 1305–1322.

Javorcik, Beata Smarzynska, 2004, Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages, *American Economic Review* 94, 605–627.

Kokko, Ari, 1994, Technology, market characteristics, and spillovers, *Journal of Development Economics* 43, 279–293.

Krugman, Paul, 1991, Increasing returns and economic geography, *Journal of Political Economy* 99, 483–499.

Marshall, Alfred, 1890, *The Principles of Economics* (Macmillan: London).

Roodman, David, 2007, How to do xtabond2: An introduction to "difference" and "system" GMM in Stata, Working Paper, No. 103, Center for Global Development.

Swenson, Deborah, 2007, Multinationals and the creation of chinese trade linkages, NBER Working Paper, No. 13271.

Todo, Yasuyuki, and Koji Miyamoto, 2006, Knowledge spillovers from foreign direct investment and the role of R&D activities: Evidence from Indonesia, *Economic Development and Cultural Change* 55, 173–200.

Todo, Yasuyuki, Weiying Zhang, and Li-An Zhou, 2006, Intra-industry knowledge spillovers from foreign direct investment in R&D: Evidence from a Chinese science park, SSRN Working Paper, No. 938079.

Windmeijer, Frank, 2005, A finite sample correction for the variance of linear two-step GMM estimators, *Journal of Econometrics* 126, 25–51.

Figure 1: Relation between Entries of Domestic Firms and the Presence of MNEs

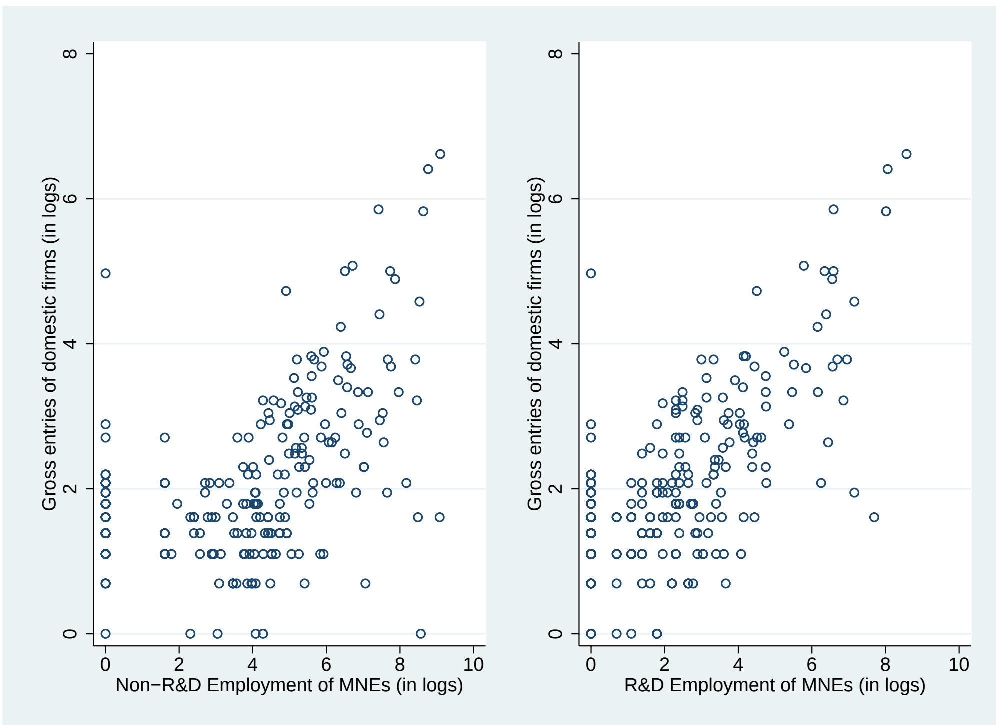

Table 1: Comparison between Hypotheses

Hypothesis	Cause of the effect	Effect on entry of		Effect on R&D of	
		Domestic firms	MNEs	Domestic firms	MNEs
Knowledge diffusion	MNEs' production	0	0	0	0
	MNEs' R&D	+	0	+	0
	Domestic firms' R&D	0	0	0	0
Agglomeration	MNEs' production	+	+	0	0
	MNEs' R&D	0	0	+	+
Crowding out	MNEs' production	-	0	-	0
	MNEs' R&D	-	0	-	0
Preemption	MNEs' R&D	-	-	0	0
	Domestic firms' R&D	- (weak)	- (weak)	0	0
Demand creation	MNEs' production	+	0	+	0
	MNEs' R&D	0	0	0	0

Table 2: The Extent of Firm Entry by Year and by Industry

		Number of firms	Number of domestic firms	Number of gross entries of domestic firms		Number of net entries
				New firms	Existing firms	
Year						
1998		1957	1584	203	159	-8
1999		2030	1652	302	38	68
2000		2903	2463	811	124	811
2001		3799	3280	935	177	817
2002		6828	5911	1803	1476	2631
2003		8487	7445	1540	545	1534
Average		4334	3723	932	420	976
2-digit industry	Code					
Food processing	13	27	25	4	1	3
Food products	14	21	19	4	3	4
Petroleum refinery	25	14	14	3	1	3
Chemicals	26	154	140	28	16	31
Pharmaceutical	27	202	169	39	19	39
Plastic products	30	7	5	1	1	2
Non-metallic mineral products	31	66	54	11	6	9
Metal products	34	49	44	10	4	9
Machinery	35	155	134	28	8	12
General equipment	36	315	276	62	33	67
Transport equipment	37	51	46	10	6	12
Electrical machinery	39	109	97	20	12	24
Communication and computing equipment	40	696	548	117	56	94
Precision and optical instruments	41	332	295	55	32	66
Computing services	61	653	576	124	86	194
Computer Software	62	1246	1054	365	93	306
Scientific services	77	239	228	54	44	102

Note: Yearly averages are reported for figures for each 2-digit industry.

Table 3: The Extent of FDI Penetration by Year and by Industry

		Sales		Employment		R&D employment	
		Amount (billion yuan)	Share of MNEs (percent)	Amount (thousand)	Share of MNEs (percent)	Amount (thousand)	Share of MNEs (percent)
Year							
1998		18.7	10.8	102.5	10.8	24.6	8.8
1999		52.2	6.2	114.9	8.6	19.5	9.9
2000		95.4	32.2	166.2	17.0	28.8	21.7
2001		129.6	25.1	202.5	15.6	43.8	17.2
2002		183.6	55.1	283.7	26.0	59.6	24.1
2003		219.3	49.9	347.5	23.8	67.8	21.7
Average		116.5	39.9	202.9	19.5	40.7	19.3
2-digit industry	*Code*						
Food processing	13	0.6	12.3	1.6	5.5	0.1	4.4
Food products	14	0.2	1.5	0.8	3.3	0.1	2.6
Petroleum refinery	25	0.7	0.0	1.1	0.0	0.1	0.0
Chemicals	26	2.3	11.7	7.4	7.7	0.8	8.4
Pharmaceutical	27	3.7	12.8	12.3	14.2	1.3	13.0
Plastic products	30	0.0	26.2	0.2	27.4	0.0	30.5
Non-metallic mineral products	31	1.6	10.3	5.4	9.5	0.4	10.3
Metal products	34	0.4	9.6	2.5	9.1	0.2	7.0
Machinery	35	1.6	20.4	7.2	12.2	1.1	8.6
General equipment	36	4.1	28.2	12.9	9.3	2.3	7.4
Transport equipment	37	2.2	29.4	4.2	7.1	0.4	2.5
Electrical machinery	39	2.5	23.8	7.7	10.8	0.9	4.9
Communication and computing equipment	40	62.3	51.5	61.0	26.7	9.8	27.6
Precision and optical instruments	41	11.2	30.5	15.1	22.8	2.4	18.2
Computing services	61	10.8	33.8	18.0	18.7	4.2	16.8
Computer Software	62	10.3	32.9	40.5	23.3	15.4	20.4
Scientific services	77	2.0	12.8	5.0	11.3	1.3	17.4

Note: Yearly averages are reported for figures for each 2-digit industry.

Table 4: Characteristics of Firms in the Z-Park by Type

Firm-level mean over the period 1998-2003

	Number of firms (yearly mean)	Sales (million yuan)	Employment	R&D Employment
Domestic firms				
Incumbent firms	2370	20.7	47.8	10.1
New firms	932	5.6	23.7	6.1
Existing firms newly entering to the Park	420	27.9	56.7	8.8
MNEs				
Incumbent firms	451	100.1	88.0	16.1
New firms	160	36.1	42.8	10.4
Total	4334	27.1	47.5	9.8

Firm-level mean in 1998 and in 2003 (in italic)

	Number of firms		Sales (million yuan)		Employment		R&D Employment	
	1998	2003	1998	2003	1998	2003	1998	2003
Domestic firms								
Incumbent firms	1222	*5360*	10.2	*18.2*	45.2	*41.7*	12.1	*8.2*
New firms	203	*1540*	1.6	*4.0*	37.9	*17.1*	9.3	*4.4*
Existing firms newly entering to the Park	159	*545*	4.3	*11.2*	101.6	*30.3*	20.6	*4.8*
MNEs								
Incumbent firms	312	*842*	16.2	*116.9*	80.1	*90.6*	17.2	*15.8*
New firms	61	*200*	3.2	*55.7*	38.1	*37.4*	4.5	*8.4*
Total	1957	*8487*	9.6	*25.9*	54.2	*41.3*	13.0	*8.1*

Table 5: Summary Statistics of the Key Variables

		Mean	S.D.	Min.	Max.
Dependent variables					
Log of the number of gross entries of new domestic firms		1.80	1.23	0.00	6.62
Log of the number of gross entries of existing domestic firms		1.16	1.12	0.00	5.71
Number of net entries		18.06	72.39	-111.00	732.00
Log of the number of gross entries of new MNEs		0.66	0.88	0.00	4.74
Log of R&D employment of new domestic firms		6.32	3.42	0.00	16.84
Log of R&D employment of existing domestic firms newly entering to the Park		4.95	3.75	0.00	15.68
Log of R&D employment of new MNEs		3.47	3.82	0.00	14.93
Independent variables					
L_MNE	Log of MNEs' non-R&D employment	4.18	2.46	0.00	9.49
R&D_MNE	Log of MNEs' R&D employment	2.52	2.07	0.00	8.68
L_dom	Log of domestic firms' non-R&D employment	6.88	1.38	2.20	10.51
R&D_dom	Log of domestic firms' R&D employment	5.01	1.60	0.00	9.98
Y_dom	Log of domestic firms' sales	12.20	2.10	6.52	17.09
Y	Log of total sales of the industry	12.62	2.12	6.52	17.62
gS	Growth rate of total sales (in raw ratios)	0.65	1.20	-2.71	8.64
S_mean	Log of the mean of firm-level sales	9.27	1.40	4.72	14.13

Note: These figures above are the summary statistics for the 54 industries during the period 1998-2003. Thus, the number of observations is 324.

Table 6: Impact of MNEs on the Entry of New Domestic Firms

		(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable:	Log of the number of gross entries of new domestic firms					
Regressor	Description	OLS	GMM	OLS	GMM	OLS	GMM
L_MNE	MNEs' non-R&D employment	0.101	0.133			0.011	0.003
		(0.027)**	(0.035)**			(0.038)	(0.061)
R&D_MNE	MNEs' R&D employment			0.182	0.275	0.170	0.276
				(0.036)**	(0.063)**	(0.052)**	(0.089)**
R&D_dom	Domestic firms' R&D employment	0.279	0.061	0.261	-0.002	0.257	0.038
		(0.070)**	(0.082)	(0.067)**	(0.126)	(0.068)**	(0.080)
Y_dom	Domestic firms' sales	0.347	0.316	0.259	0.256	0.265	0.250
		(0.074)**	(0.090)**	(0.073)**	(0.097)**	(0.076)**	(0.108)*
gY	Growth rate of total sales	0.131	0.037	0.138	0.075	0.139	0.067
		(0.051)*	(0.042)	(0.049)**	(0.043)+	(0.050)**	(0.041)
Y_mean	Mean of firm-level sales	-0.473	-0.301	-0.387	-0.271	-0.394	-0.257
		(0.067)**	(0.099)**	(0.065)**	(0.093)**	(0.069)**	(0.088)**
No. of observations		216	216	216	216	216	216
R^2		0.672		0.688		0.688	
Hansen *J* statistic			0.480		0.294		0.501
Arellano-Bond statistic			0.583		0.734		0.783

Notes: All regressors are first lagged. All regressors except for gY are in logs. Standard errors are in parentheses. **, *, and + signify statistical significance at the 1%, 5%, and 10% levels, respectively. Year dummies are included in all specifications. GMM estimation is based on the system GMM estimation developed by Blundell and Bond (1998). *P* values are reported for the Hansen *J* and Arellano-Bond statistics.

Table 7: Impact of MNEs on the Entry of Domestic Firms: Alternative Measures of Entry

		(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable:	Log of the number of gross entries of existing domestic firms			Number of net entries		
Regressor	Description	GMM	GMM	GMM	GMM	GMM	GMM
L_MNE	MNEs' non-R&D employment	0.060		0.021	3.205		-2.817
		(0.064)		(0.053)	(2.409)		(3.646)
R&D_MNE	MNEs' R&D employment		0.173	0.158		10.773	13.334
			(0.060)**	(0.077)*		(4.031)**	(5.301)*
R&D_dom	Domestic firms' R&D employment	0.025	0.022	-0.002	-2.519	-3.773	-2.671
		(0.074)	(0.082)	(0.083)	(3.054)	(5.866)	(3.845)
Y_dom	Domestic firms' sales	0.091	0.074	0.069	8.511	5.872	4.701
		(0.077)	(0.056)	(0.084)	(3.412)*	(3.765)	(3.685)
gY	Growth rate of total sales	0.065	0.078	0.081	4.525	6.113	6.100
		(0.038)+	(0.031)*	(0.033)*	(3.195)	(3.763)	(3.883)
Y_mean	Mean of firm-level sales	-0.134	-0.060	-0.098	-7.376	-4.918	-3.390
		(0.110)	(0.079)	(0.095)	(3.957)+	(4.852)	(4.839)
No. of observations		216	216	216	216	216	216
Hansen *J* statistic		0.308	0.325	0.363	0.643	0.249	0.489
Arellano-Bond statistic		0.700	0.837	0.655	0.256	0.278	0.278

Notes: All regressors are first lagged. All regressors except for gY are in logs. Standard errors are in parentheses.**, *, and + signify statistical significance at the 1%, 5%, and 10% levels, respectively. Year dummies are included in all specifications. GMM estimation is based on the system GMM estimation developed by Blundell and Bond (1998). P values are reported for the Hansen J and Arellano-Bond statistics.

Table 8: Impact of MNEs on R&D Employment of New Domestic Entrants

		(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable:	Log of R&D employment of					
		New domestic firms			Existing domestic firms newly entering to the Park		
Regressor	Description	GMM	GMM	GMM	GMM	GMM	GMM
L_MNE	MNEs' non-R&D employment	0.224		-0.167	0.124		-0.104
		(0.089)*		(0.155)	(0.178)		(0.188)
R&D_MNE	MNEs' R&D employment		0.626	0.798		0.530	0.604
			(0.153)**	(0.234)**		(0.143)**	(0.248)*
R&D_dom	Domestic firms' R&D employment	0.451	0.208	0.271	0.413	0.226	0.264
		(0.229)*	(0.284)	(0.218)	(0.284)	(0.319)	(0.350)
Y_dom	Domestic firms' sales	0.582	0.601	0.453	0.268	0.270	0.223
		(0.321)+	(0.262)*	(0.186)*	(0.282)	(0.244)	(0.266)
gY	Growth rate of total sales	0.013	0.066	0.051	0.120	0.213	0.219
		(0.113)	(0.124)	(0.125)	(0.134)	(0.097)*	(0.087)*
Y_mean	Mean of firm-level sales	-0.358	-0.324	-0.169	-0.379	-0.006	-0.140
		(0.290)	(0.241)	(0.210)	(0.416)	(0.390)	(0.371)
No. of observations		216	216	216	216	216	216
Hansen *J* statistic		0.325	0.271	0.440	0.408	0.392	0.317
Arellano-Bond statistic		0.824	0.439	0.574	0.290	0.251	0.261

Notes: All regressors are first lagged. All regressors except for gY are in logs. Standard errors are in parentheses.**, *, and + signify statistical significance at the 1%, 5%, and 10% levels, respectively. Year dummies are included in all specifications. GMM estimation is based on the system GMM estimation developed by Blundell and Bond (1998). P values are reported for the Hansen J and Arellano-Bond statistics.

Table 9: Impact of Incumbent MNEs on New MNEs

		(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable:	Log of the number of gross entries of MNEs			Log of R&D employment of new MNEs		
Regressor	Description	GMM	GMM	GMM	GMM	GMM	GMM
L_MNE	MNEs' non-R&D employment	0.016		-0.001	-0.015		0.021
		(0.038)		(0.041)	(0.202)		(0.240)
R&D_MNE	MNEs' R&D employment		0.048	0.067		0.033	-0.030
			(0.063)	(0.089)		(0.311)	(0.449)
R&D_dom	Domestic firms' R&D employment	-0.092	-0.086	-0.048	-0.273	-0.248	-0.200
		(0.083)	(0.082)	(0.113)	(0.466)	(0.480)	(0.520)
Y_dom	Domestic firms' sales	0.715	0.675	0.547	3.241	3.319	3.094
		(0.166)**	(0.208)**	(0.259)*	(0.808)**	(1.036)**	(1.169)**
gY	Growth rate of total sales	0.050	0.056	0.060	0.215	0.248	0.307
		(0.042)	(0.031)+	(0.040)	(0.224)	(0.183)	(0.199)
Y_mean	Mean of firm-level sales	-0.710	-0.669	-0.531	-3.296	-3.278	-3.174
		(0.159)**	(0.217)**	(0.264)*	(0.813)**	(1.024)**	(1.127)**
No. of observations		216	216	216	216	216	216
Hansen *J* statistic		0.379	0.344	0.299	0.348	0.319	0.432
Arellano-Bond statistic		0.805	0.846	0.784	0.898	0.845	0.926

Notes: All regressors are first lagged. All regressors except for gY are in logs. Standard errors are in parentheses.**, *, and + signify statistical significance at the 1%, 5%, and 10% levels, respectively. Year dummies are included in all specifications. GMM estimation is based on the system GMM estimation developed by Blundell and Bond (1998). *P* values are reported for the Hansen *J* and Arellano-Bond statistics.