Foreign Firms and Indigenous Technology Development in the People's Republic of China

FREDRIK SJÖHOLM AND NANNAN LUNDIN*

The People's Republic of China (PRC) is currently promoting indigenous technology development through support of Chinese firms and, arguably, by restricting operations of foreign multinational firms. This policy seems to overlook the impact of foreign firms on technology development in local firms. For instance, technology might leak out to local firms though spillovers. Moreover, competition from foreign firms might force local firms to engage in technology development. We examine the impact of foreign direct investment (FDI) on technology development in the PRC. We start by surveying a large and growing literature on FDI and spillovers in the country. Most previous studies find evidence of positive spillovers. We then continue to examine the effect of FDI on competition in the Chinese manufacturing sector and the effect of competition on firms' research and development (R&D). Our analysis is conducted on a large dataset including all large- and medium-sized Chinese firms over the period 1998–2004. Our results show that FDI increases competition but there are no strong indications of competition affecting investments in R&D.

Keywords: People's Republic of China, FDI, spillovers, technology, R&D
JEL codes: F23, L11, O31

I. Introduction

Rapid development of the People's Republic of China (PRC) during the last few decades is closely related to its success in attracting foreign direct investment (FDI). The PRC is one of the world's largest recipients of FDI which has substantially contributed to production and export. Moreover, FDI to the PRC, according to some reports, has undergone a structural change away from simple manufacturing towards more technology-intensive activities. For instance, the PRC has become the third most important offshore research and development (R&D) location for multinational enterprises (MNEs) according to a survey by UNCTAD (2005).

Despite the increase in FDI and R&D, there is a concern in the PRC that inflows of FDI do not contribute to technology development to the same extent that they contribute to production and export. It is noted by policymakers and academics alike that while foreign firms account for a large share of exports and production, their share of R&D is small. The recent emphasis on "indigenous innovation" and "indigenous capacity building" in Chinese science and technology policy partly reflects an uncertain and even skeptical attitude towards FDI.

However, the discussion on FDI and R&D in the PRC neglects how indigenous technology development is affected by FDI. Such an effect could arise if, for instance, domestic firms learn from foreign-owned firms. FDI might also affect the competitive pressure in the market which, in turn, could affect the amount of technology development in domestically-owned firms.

The expected impact of FDI on the R&D of domestically-owned (indigenous) firms, however, is not clear. First and as previously mentioned, there could be a demonstration effect or technology externalities from FDI that might affect productivity in domestic firms. This effect is typically attributed to a spillover effect from foreign to domestic firms. A large number of studies have identified such spillovers in various countries. The positive effect on productivity could be caused by technological externalities but could also capture other aspects such as more efficient use of existing technologies through a competition effect.

There could also be an effect of FDI on R&D in domestic firms. An impact on R&D is perhaps more closely related to technology development than the above mentioned spillover effect on productivity. The most obvious channel would be through the impact of FDI on the market structure. The direction of this effect is more uncertain since it depends both on how FDI affects market structure and how market structure affects R&D. Starting with FDI and market structure, foreign firms might increase the degree of competition in the local market but it could also happen that successful foreign firms force local firms to exit the market with a resulting increased industry concentration. Moreover, increased competition could both increase R&D, by firms struggling to compete, or decrease R&D because of diminishing monopoly rents.

This paper examines how FDI might affect technology development in local Chinese firms. We will examine both general productivity effects through spillovers from FDI and the effect of FDI on market structure and how market structure, in turn, affects investments in R&D. Our section on spillovers surveys the large and growing existing literature on the PRC and concludes that there is ample evidence of positive spillovers. The exact nature of these spillovers and how they are affected by various factors are less clear. We then continue with our second issue where we use firm-level data containing detailed information on operational and R&D activities of large- and medium-sized Chinese manufacturing firms for the period 1998–2004. Our results suggest that FDI tends to increase competition, as measured by price cost margins, but there is no visible effect of competition on R&D intensity in Chinese firms.

The paper is organized as follows. Section II discusses FDI and indigenous technology development in the Chinese context. In Section III, we set up a conceptual framework for our empirical analysis and briefly review previous studies in the field of interest. We show the econometric models in Section IV, give a detailed description of the dataset and show some descriptive statistics in Section V, and present the results in Section VI. We then conclude the paper in Section VII.

II. The Chinese Context

The policy focus in the PRC has changed in some important respects over the last years. One key change following the people's party congress in 2006 has been the increased focus on technology development (Chinese Ministry of Science and Technology 2006, Sjöholm and Lundin 2010a). The ambition was to make the PRC an innovation-driven economy, the background being increased uneasiness with the dependence on manufacturing of labor-intensive goods. The perception has been that an upgrading of production towards higher-value-added goods would be desirable. It is argued that continued assembly of imported inputs would not enable the country to continue its rapid development.

In light of this, Chinese officials worry that some technology indicators other than aggregate R&D, which is increasing, seem to suggest a low level of technology sophistication. For example, it has been shown that most new Chinese firms are heavily concentrated in relatively simple manufacturing activities (Sjöholm and Lundin 2010a). But it is not clear that the Chinese concern is necessary. For instance, Brandt, Van Biesebroeck, and Zhang (2012) show that total factor productivity (TFP) growth has been very high in the PRC between 1998 and 2007, which suggests that there have been considerable technology improvements taking place.

This focus on technology development has been repeated by various policymakers at frequent occasions. For instance, in August 2009, Science and Technology Minister Wan Gang argued that "The most effective way to withstand the impact of the global economic meltdown is to accelerate technological innovation, the new economic growth engine."[1] More recently, President Hu Jintao argued for the importance of technology in a more broad sense, "We must focus on promoting innovation in science and technology if we want to push forward reform and opening up policy, the modernization of socialism, and achieve the overall target for building a moderately prosperous society in an all-round way, improve the people's living standard, as well as achieve the great rejuvenation of the Chinese nation."[2]

---

[1]"Government Pledges Strong Support for Innovation-based SMEs," *China Daily*, 1 September 2009.
[2]"Top Leaders Urge Innovation in Science, Technology," China.org.com, accessed 8 July 2012. Available at www.china.org.cn/china/2012-07/08/content_25847720.htm

The Chinese innovation strategy is also related to discussions on the middle-income trap. This refers to the seemingly difficult task for countries that wish to move from a middle-income position to become a high-income economy. Few countries have managed such a transition in recent decades as rising wage costs tend to erode competitiveness with slowing growth as a result (Griffith 2011). Excluding the small city states, only three Asian economies have managed the transition from middle-income to high-income positions: Japan in the 1960s and Taipei,China and the Republic of Korea in the 1990s.

The middle-income trap is frequently discussed also in a Chinese context. The World Bank (2012, xvi) discusses in a report how continued high economic growth in the PRC can be secured and highlights the need to "accelerate the pace of innovation and create an open innovation system." It is argued that a higher degree of technological sophistication could balance rising labor costs and enable the PRC to move to higher-value-added production.

An important aspect of the PRC's technology policy is the emphasis on indigenous technology development. In other words, with general technology development deemed insufficient, indigenous Chinese firms in particular should develop the new products and production processes that would secure continued economic development. This is arguably an important change of strategy in a country as dependent on foreign multinationals as the PRC. The aspect of indigenous technology development was already stressed in the 2006 5-year plan and then again in the 12th 5-year plan in 2011.

> [The People's Republic of] China should upgrade its capabilities in indigenous research and innovation in science, technology and administration, train more innovative talents and improve education for workers. In a word, we will strive to speed up the construction of an innovation country (National People's Congress 2011, p. 3).

Current policy promotes indigenous technology development through access to finance and subsidies and by preferential treatment to indigenous firms in public procurement. Another aspect of the policy has to do with increased restrictions on foreign multinationals in the PRC. Koyama and Golub (2006) find that in a sample of 42 countries, the PRC and India tend to have the most restrictions on FDI. The Chinese investment regime has since become even more restrictive. For instance, a new investment regime in 2006 has made it more difficult to acquire Chinese companies (Sauvant 2009, p. 12). The Chinese government has also closed some industries to entry of foreign multinational firms. These sectors are typically the ones considered important from a national security perspective. In recent years, the "economic security" criteria has additionally been used to keep foreign firms out of the PRC.

Further restrictions were introduced in 2008. Foreign acquisitions can now be stopped by the authorities if considered a threat to local state-owned companies—an option that was used to stop Coca Colas' $2.3 billion purchase of Huiyuan Juice in 2009. Other frequently used restrictions include requiring foreign firms to have local joint-venture partners, tap local suppliers, and locate R&D in the country.

The new Chinese policies are not unproblematic. Public strategies for technology development are common in developing countries and it seems fair to say that the results are often disappointing. Subsidies and protection of indigenous high-tech firms have a tendency to result in a lack of international competitiveness. Moreover, labor-intensive production in foreign multinational firms are presumably a suitable development strategy for a country where a large share of the population still lives in poverty, income inequality is large and growing, and modern sector employment greatly needed (Karlsson et al. 2009, Sjöholm and Lundin 2010b).

III. FDI and R&D: Conceptual Framework and Previous Studies

As discussed above, Chinese authorities seem to be concerned by the level of indigenous technology development. This has resulted in a more hesitant approach towards FDI. However, there are reasons to believe that indigenous technology development might be affected by FDI. A suitable conceptual framework to discuss this angle can be based on two strands of literature—the effect of FDI on the host country's market structure and the effect of market structure on firms' investment in R&D.

The presence of foreign MNEs may exert a significant influence on the host country's market structure. However, different theoretical models and previous empirical evidence show the relationship between FDI and market structure to be highly complex.[3] FDI can both increase and decrease the degree of competition depending on the specific context.

On the one hand, FDI may increase the number of firms in an industry and thereby decrease the concentration and increase the competition in the market, particularly in industries with high start-up costs and high barriers to entry (e.g., Barba Navaretti and Venables 2004, p. 174). This is true for greenfield investments but not for mergers and acquisitions, and the former type therefore has a more competitive effect on the local economy (Haller 2005). Moreover, the entrance of foreign MNEs might have a positive effect on production in existing domestic firms through spillovers and even increase the number of firms if employees in MNEs leave to set up their own businesses (Caves 1996). This would also tend to increase competition.

---

[3]See, for example, UNCTAD (1997) and OECD (2002) for more detailed reviews.

On the other hand, FDI may raise the level of concentration in the host-country market (Aitken and Harrison 1999). Foreign MNEs possess competitive firm-specific assets and might therefore be able to capture a leading market position. The number of firms in an industry might then fall after the entry of foreign MNEs, if only the most efficient firms can survive and less efficient (domestic) firms are forced to exit. As a consequence, the industry will become more concentrated. It is important to note that in this case, high concentration is associated with initial high intensity of competition. Once firms are forced out of the market, competition will tend to decline.

With regard to the impact of market structure on innovation, this issue has been addressed in a large body of theoretical work, which often yields conflicting results (e.g., Aghion and Howitt 1992, Aghion et al. 2005).

Innovations are, in the classic Schumpeterian view of creative destruction, made by firms that earn no rents if they fail to innovate and that obtain monopolistic power if they succeed. The market would be characterized by Arrow's "replacement effect," i.e., new firms replacing monopolists that fail to innovate (Arrow 1962). However, when competition intensifies and in turn trims down monopoly rents, the incentive to innovate decreases. This theory therefore predicts a negative relationship between market competition and innovation.

In contrast to the "replacement effect," the "selection effect" of market competition predicts a positive relation between competition and innovation. Competition may stimulate innovation when firms with innovation advantages further strengthen their innovation capabilities in order to escape competition with "neck-to-neck" rivals (e.g., Vickers 1997, Boone 2000, Aghion and Schankerman 1999).

In more recent theoretical work, the relationship between competition and innovation is described as non-monotone, which can happen when there are different types of innovators in terms of leaders and followers. Both the level of the technology gap and the degree of rivalry are important aspects that are taken into account in so-called step-by-step innovation models (e.g., Aghion et al. 2001, Boone 2001). The step-by-step innovation models are of particular relevance for analyzing unlevelled industries, i.e., industries where different firms have different levels of innovation capacity. In such industries, there are technically laggard firms which have to catch up with the leading-edge technology before they can compete with their more technologically advanced rivals. The ability to catch up partly depends on the level of competition. When competition is low, the leading firms will invest relatively little in R&D, which means that laggard firms have a higher potential for catching up and thereby a higher incentive to innovate. In the case of high market competition, the leading firms have a higher incentive to innovate to remain in their strong position. This makes it more difficult for followers to catch up and will, in turn, tend to decrease their incentives to innovate, and they will instead try to find industrial niches with less competition from the leading firms.

As to the question of the impact competition, economic theory gives us little guidance in making predictions on how this would affect R&D. There are reasons to expect the effect to be positive as well as negative, and we have to address the issue by empirical analysis to obtain information on how the relationship works in a Chinese context.

A.   Previous Studies on FDI and Competition

There are relatively few empirical studies on the competitive effects of FDI. One exception is Co (2001) who found both positive and negative effects of FDI on competition in the United States depending on market conditions and the extent of spillovers. Chung (2001) also finds mixed effects and suggests that the degree of competitive pressure imposed by FDI depends on both the entry mode and the various investment traits. The most interesting paper for our purposes is by Fu and Wu (2012) who study the effect of FDI on profits in Chinese firms. They find an inverted U-shape effect of FDI on profits, where profits tend to increase with smaller inflows of FDI but then decrease with larger flows.

B.   Previous Studies on FDI and Domestic Innovation

Studies on the impact of FDI on domestic innovation and R&D are also rare. Veugelers and Vanden Houte (1990) study the Belgian manufacturing sector and find that domestic firms tend to have lower innovation intensities the higher the share of FDI in the industry. It is not examined if this result is caused by an effect of FDI on the market structure.

Two studies on the PRC by Jefferson et al. (2006) and Girma, Gong, and Görg (2006) are related to our work. Jefferson et al. (2006) use a similar measure of investment in R&D, the firm-level R&D-to-sales ratio, and find a negative relationship between firm size and R&D intensity and a positive but fragile effect of high industry concentration. Girma, Gong, and Görg (2006) find state-owned enterprises (SOEs) with foreign capital participation to have relatively high degree of innovation activity. Innovations in SOEs without foreign capital participation can be both positively and negatively affected by FDI depending on the absorptive capacity of these firms.

C.   A Survey of Literature on FDI and Spillovers in the PRC

As discussed above, there are few studies on FDI, competition, and R&D in indigenous firms. This stands in large contrast to the extensive literature on spillovers from FDI. This literature examines how productivity in domestic firms can be affected by FDI and captures a broader set of productivity-increasing mechanisms than just the firms' own R&D.

Table 1. **Papers on Spillovers from FDI in the PRC**

Author(s)	Years	Dependent Variable	Measure of Foreign Presence	Result
Wei and Liu (2006)	1998–2001	Output	Shares of output, employment, capital	Negative at a national level, positive at a province level
Liu (2008)	1995–1999	TFP	Share of output	Short-term negative effects, long-term positive effects
Abraham et al. (2010)	2002–2004	TFP	Share of sales	Positive
Du, Harrison, and Jefferson (2011)	1998–2007	Output	Share of output	Positive
Du, Harrison, and Jefferson (2012)	1998–2007	Output	Share of output	Positive
Girma and Gong (2008)	1999–2002	TFP	Share of output	No effect
Xu and Sheng (2012)	2000–2003	TFP	Share of output	Mixed

FDI = foreign direct investment, PRC = People's Republic of China, TFP = total factor productivity.

The presence of foreign multinational firms is believed to benefit the host country through access to advanced technologies, some of which might be absorbed by domestic firms. Local firms might, for instance, imitate foreign firms' techniques, either by reverse engineering or by hiring away some of their employees. These types of externalities or spillovers are present within industries. There might also be backward spillovers to suppliers and forward spillovers to customers. The former occurs if, for instance, foreign firms help suppliers to improve upon their products, the latter if domestic firms benefit from better inputs.

The issue of spillovers from FDI has been extensively debated and examined since the influential article by Caves (1974). The increased availability of firm-level databases in recent years has led to new waves of studies. A few generalizations from the large literature can be made. First, some of the previously large spillover effects found in earlier papers using industry-level data were probably exaggerated. More recent papers on firm- and plant-level data tend to find smaller effects (Görg and Strobl 2001). Second, the results on within-industry spillovers are mixed, and there are more uniform findings of positive spillovers to local suppliers and customers. Finally, the extent of spillovers differs between countries and industries and depends on the absorptive capacity, type of FDI, and degree of competition in the local economy (Lipsey and Sjöholm 2005).

These generalizations seem to hold also for the PRC. Table 1 lists reviewed and published studies on spillovers from FDI in the PRC using firm-level data.[4] Most studies find some sort of spillover in the PRC, more often to local firms in linkage

---

[4]There are also a large number of spillover studies on the PRC using industry-level data (e.g., Buckley, Clegg, and Wang 2002) and regional data (e.g., Madariaga and Poncet 2007). Most of these studies tend to find positive spillovers from FDI.

industries rather than within industries. For instance, Du, Harrison, and Jefferson (2012) examine spillovers in a long panel of Chinese firms and find little evidence of spillovers within the industries of investment but strong evidence for spillovers to both supplying industries and customer industries. Similar results are found in Liu (2008) who finds evidence of both intra-industry and interindustry spillovers but concludes that backward linkages seems to be the strongest ones.

The paper by Xu and Sheng (2012) differs from the studies above and finds positive spillovers from regional presence of multinational firms within the industry but negative effects of regional presence in backward and forward industries. It seems plausible that geographic proximity could enhance intra-industry spillovers but it is more difficult to understand why the presence of foreign multinational firms should hurt local firms in the same region in neighboring industries. Accordingly, Wei and Liu (2006) find evidence of positive intra-industry and interindustry spillovers at the regional level but negative ones at a national level. Hence, their results suggest that local firms benefit from foreign firms in the same region but are hurt by foreign firms in other regions, irrespective of which industries the foreign firms are located in. The contrasting effects might be caused by a different balance between competition effects and spillover effects from FDI within and between regions.

As found in studies on other countries, it seems that spillovers to local Chinese firms are not automatic but affected by various factors. For instance, absorptive capacity seems important. Girma and Gong (2008) examine spillovers to state-owned Chinese enterprises. The authors find little evidence of spillovers and attribute this to a low level of absorptive capacity.

Other studies focus on the role of geographic proximity in spillovers, an issue already touched upon above, and on how spillovers from different types of multinational firms differ. The latter issue is often analyzed in the context of spillovers from FDI from Hong Kong, China; Taipei,China; and Macau, China (often referred to as South–South FDI) versus FDI from other countries (often referred to as North–North FDI). Most studies find spillovers to be higher from North FDI than from South FDI.

For instance, Du, Harrison, and Jefferson (2012) argue that the lack of spillovers from FDI from Hong Kong, China; Taipei,China; and Macau, China in their study suggests that much of the flows may really be round-tripping capital rather than FDI. An additional finding is that FDI in firms benefiting from tax incentives to investing firms "generates greater productivity spillovers than unsubsidized firms" (Du, Harrison, and Jefferson 2012, p. 28).

Another paper on the PRC based on 4 years of census data and which uses the distinction between FDI from Hong Kong, China and Taipei,China and FDI from all other locations finds evidence of smaller spillovers from the South–South FDI (Xu and Sheng 2012).

Abraham, Konings, and Slootmaekers (2010) also compare spillovers in the PRC from North–South FDI with those from South–South FDI. They define South–South FDI as FDI from Hong Kong, China; Macau, China; and Taipei,China (or HMT) plus FDI from tax havens, which they include following the suggestion of Naughton (2007, p. 164) who states that FDI from tax havens are generally "diverted investment from HMT or [the People's Republic of] China itself for tax evasion." Spillovers from HMT and non-HMT FDI are both positive and statistically significant, but those from HMT are larger though not significantly so. However, FDI from HMT is negatively related to the productivity of domestic exporters and firms located in special economic zones (SEZs).

Girma and Gong (2008) find distance to be a factor in spillovers, in this case, spillovers from FDI to SOEs. One result they describe as "robust" across all specifications is that there is "no evidence of productivity spillovers. . .outside the region FDI takes place" (Girma and Gong 2008, p. 735–736). SOEs also appear to lose from the presence of "ethnic Chinese" FDI (South–South FDI) in downstream sectors in their regions.

Wei and Liu (2006, p. 553), using similar industry data and definitions of sources of FDI in the PRC, conclude that FDI from Organisation for Economic Co-operation and Development (OECD) countries has "played a much greater positive role in inter-industry productivity spillovers to indigenous Chinese firms" than FDI from Hong Kong, China; Macau, China; and Taipei,China, adding that "FDI from these two different sources has played a similar role in terms of magnitude in intra-industry productivity spillovers within regions." They suggest that the contributions of FDI from the two sources to Chinese firms' productivity may be of a different nature (Wei and Liu 2006, p. 553). Specifically, technologies transferred or diffused by HMT firms (South–South FDI) may be more compatible with (the mainland's) current resource endowments. Authors also state that "Foreign-invested firms from OECD countries have higher technological capabilities, and their productivity spillovers may concentrate on the enhancement of technological knowledge and competence in indigenous Chinese firms, and this is very important for (the PRC's) move to a higher development stage."

A few conclusions can be made from the literature surveyed above. First, most studies find evidence of some type of spillover from FDI in relation to the PRC. Second, the studies differ quite substantially on exactly what type of spillovers they find and on firm and industry characteristics that affect the degree of spillover. There are results pointing to both interindustry and intra-industry spillovers in the PRC, but with more evidence of the former. Moreover, there seems to be a clear geographic component with FDI benefiting local firms primarily within the same region. Absorptive capacity seems to be important and may explain why SOEs do not appear to benefit from spillovers. Finally, the results from previous studies seem to indicate less spillovers from FDI coming from Hong Kong, China; Taipei,China; and Macau, China than from FDI coming from other countries.

IV. Econometric Models

A.   The Effect of FDI on Market Structure

We use a two-step econometric approach. First, we investigate the impact of FDI on the market structure. We follow a standard approach and use the price cost margin (PCM) as a measure of competition. This is defined as:[5]

$$PCM = \frac{Value\ added - payroll}{Value\ added} \tag{1}$$

A high value on PCM means a large markup and presumably a low level of competition. Our measure of FDI penetration is calculated as the share of sales by foreign firms in total sales in the domestic market at the 4-digit industry level. Exports by foreign firms are excluded from the sales figures, since these do not impose competitive pressure on the Chinese market.

The baseline econometric model is specified as:

$$PCM_{jt} = \alpha + FDI_{i,t-n} + \delta Firm_{jt} + \rho H_{i,t-n} + \omega DOWNER_w + \lambda_1 DT_t$$
$$+ \lambda_2 DIND_i + \lambda_3 DRe\ gion_r + \varepsilon_{jt} \tag{2}$$

where

PCM_{jt} is the price cost margin of firm j at time t;

$FDI_{i,t-n}$ indicates the presence of FDI in industry i at time t at the 4-digit industry level, where n is the number of lags;

$Firm_{jt}$ represents a vector of firm-level control variables such as capital intensity, market share, export intensity, and relative TFP;

$H_{i,t-n}$ is the Herfindahl index in industry i as a proxy for industrial concentration at the 4-digit industry level; and

$DOWNER_w$ represents a vector of ownership dummy variables.

DT, $DIND$, and $DRegion$ denote year dummy variables, industry dummy variables at the 4-digit level, and region dummy variables at the 2-digit level (31 geographic units).

In the above specification, FDI and the Herfindahl index are two industry-level variables that measure the effect of market structure on the PCM. The key hypothesis is that high concentration raises market power and, hence, increases PCM. Moreover, FDI may have a negative or positive effect on competition in the

---

[5]The approach makes the restrictive assumption of constant returns to scale. Konings, Van Cayseele, and Warzynski (2005) apply an alternative methodology developed by Roeger (1995). The need to impose the constraint that markup (alternative expression of PCM) is the same for all firms within the same industry makes this methodology less suitable when firms are as heterogeneous as in the PRC.

same industry. We do not examine if FDI affect downstream and upstream local firms.

In examining the effect of competition on the PCM, it is also important to control for efficiency effects. A high PCM does not necessarily only reflect low competition in the market, but may also be associated with higher efficiency in the firm. To control for such efficiency effects, we include a firm's TFP relative to average TFP in the industry.

Furthermore, a firm's domestic market share and export intensity might also pick up the efficiency aspect. Market share may also capture firm-specific market power. Following previous empirical studies by Scherer and Ross (1990) and Roberts and Tybout (1997), we specify a nonlinear relationship between domestic market share and PCM and add a quadratic term of market share. The effect of export share on PCM depends on the relative price elasticity of demand for the firm's product in the home market and abroad.

B.   The Effect of Competition and FDI on R&D Intensity

In the second step, we examine the effect of competition on R&D intensity at the firm level and estimate the following model:

$$RDINT_{jt} = \alpha + RDINT_{j,t-n} + PCM_{j,t-n} + FDI_{i,t-n} + \delta Firm_{jt} + \omega DOWNER_w$$

$$+ \lambda_1 DT_t + \lambda_2 DIND_i + \lambda_3 DRe\,gion_r + \varepsilon_{jt} \qquad (3)$$

where

$RDINT_{jt}$ is the ratio of R&D expenditures to sales of firm j at time t; and

$Firm_{jt}$ denotes a vector of firm-level control variables such as the share of science and technology personnel in total employment, export share, and firm size.

An important methodological issue when estimating this type of model is the treatment of persistence in firms' R&D investment behavior. We include lagged R&D intensity to deal with this aspect, which means that we estimate a dynamic model. However, one econometric problem in estimating a dynamic model is that OLS estimates are likely to suffer from a "dynamic panel bias." Therefore, we follow standard approaches and use system generalized method of moments (GMM) estimates developed by Arellano and Bover (1995) and Blundell and Bond (1998) which imply that *RDINT* and any other potentially endogenous variables are instrumented. The system first uses differenced and level versions of the estimating equation, where lagged values in the former and lagged differences in the latter can serve as valid instruments. The differentiated transformed instruments are assumed to be uncorrelated with unobserved fixed effects, implying that first differentiated variables can act as instruments for variables in levels, i.e., instrumenting levels with differences.

We use the Sargan/Hansen test to evaluate the instruments and the Arellano and Bond (1991) test for autocorrelation in the idiosyncratic disturbance term e_{it}.

V. Data and Descriptive Statistics

A.   Data

Our data on large- and medium-sized manufacturing enterprises (LMEs) are compiled annually by the National Bureau of Statistics of China (NBS) and cover the period 1998–2004. All firms classified as LMEs are included making it a census rather than a survey.[6] The classification of LMEs follows the NBS's classification from 2000. In this classification, employment, turnover, and fixed capital are applied as a combined indicator of firm size (see Table A2 in the appendix).[7] The sample of firms is unbalanced—there are almost 16,000 firms included in 1998 and more than 24,000 in 2004. These firms constitute roughly a third of total industrial sales and about a fourth of total industrial employment. One source of potential bias is that firms that shrink in size may exit our sample. In other words, R&D in weak firms (shrinking in size) might be differently affected by foreign entry. This calls for some caution in interpreting the results.

The NBS collects information on a large number of firm characteristics such as sales, employment, labor cost, materials, fixed assets, export, and ownership. The information on LMEs' R&D activities includes R&D expenditures and the number of employees involved in science and technology. R&D figures are sometimes claimed to be exaggerated in the PRC, partly as a consequence of tax breaks for R&D, but also because of policies mandating annual R&D targets for firms. Unfortunately, we are not in a position to evaluate how serious this possible exaggeration could be and if it biases our results. What we can say from other studies is that R&D seems to be highly correlated with other R&D indicators such as sales of new products and patents (e.g., Sjöholm and Lundin 2010a), suggesting that it is a reasonable indicator of innovative activities at the firm level.

The industry classification is similar to the classification ISIC, Rev. 3. The included sectors at the 2-digit industry level can be found in Table 3. In our econometric analysis, we construct industry-level variables such as industry concentration and FDI penetration at the 4-digit industry level in order to have industrial control variables that are as disaggregated as possible.

Finally, the effect of FDI on competition and R&D might differ for firms with different kinds of ownership. Therefore, we divide our dataset into domestic

---

[6]See Jefferson et al. (2003) for a detailed description of the same data.

[7]To compare market structure over time, we have reclassified the firms in 1998–1999 according to the new classification. This explains why the number of firms can differ from the officially published sources where the classification of firm size is not the same for the period prior to and after 2000.

Table 2. **Number of Foreign Firms and Foreign Share of Chinese Manufacturing, 1998–2004 (share of total manufacturing)**

Year	Number of Foreign Firms	Firms	Value-added	R&D Expenditure	Export	Employment
1998	3,489	0.22	0.26	0.21	0.58	0.14
1999	3,764	0.23	0.28	0.23	0.61	0.16
2000	4,221	0.25	0.30	0.20	0.63	0.18
2001	4,585	0.27	0.31	0.23	0.66	0.20
2002	5,327	0.29	0.33	0.23	0.68	0.23
2003	6,512	0.31	0.36	0.25	0.71	0.27
2004	8,745	0.36	0.40	0.29	0.76	0.34

R&D = research and development.
Source: Authors' calculations on Chinese firm data.

and foreign subsamples according to the classification given by Table A3 in the appendix.

B.   Descriptive Statistics

The share of foreign firms in our data on Chinese manufacturing between 1998 and 2004 is seen in Table 2.[8] Foreign firms include wholly foreign-owned firms and joint ventures between foreign and domestic firms.[9] Foreign ownership has increased substantially in relative as well as absolute terms. For instance, the number of foreign-owned firms increased by 150% over the period—from 3,489 in 1998 to 8,745 in 2004. This increase was higher than in domestically owned firms, with the foreign share of LMEs rising from about 22% to 36%. The other variables show a similar pattern of rapid increases. Foreign-owned firms account for about one-third of employment, 40% of value-added, and a staggering 76% of total exports.

Turning our attention to the focus of this paper, R&D, it is interesting to note that foreign share is relatively small. Foreign share of R&D expenditures was 21% in 1998, which was larger than the foreign share of employment and about the same as the foreign share of LMEs. However, this increased to only about 29% in 2004, or lower than the foreign share of any other economic indicator in Table 2. One conclusion that can be drawn from the figures is that even if the PRC has become increasingly attractive as a location of foreign firms' R&D, as suggested for instance by UNCTAD (2005), this trend has grown more slowly than the increase in foreign firms' production, employment, and export.

---

[8]The share of foreign firms in total Chinese manufacturing is likely to be lower since domestic firms dominate among the non-included small firms.

[9]Hence, firms with any foreign ownership share are classified as foreign. Changing the threshold of foreign ownership that is required for a firm to be classified as foreign does not have any major impact on the econometric results.

Table 3. **Foreign Firms, Price Cost Margins, and R&D Intensities across 2-digit Level Industries, 2004**

		Number of Firms		Share of Foreign Firms (%)		PCM (%)		R&D Intensity (%)	
		FDI	Domestic	VA	R&D	FDI	Domestic	FDI	Domestic
13	Processing food from agriculture	252	654	38	8	11.3	15.4	0.09	0.22
14	Production, processing of food	214	361	43	29	15.6	13.2	0.15	0.40
15	Beverage	191	351	39	43	19.9	17.0	0.25	0.37
17	Textiles	776	1673	28	32	10.6	8.1	0.32	0.36
18	Wearing apparels	483	353	45	15	9.6	11.0	0.09	0.17
19	Leather, footwear	376	158	67	50	9.4	11.4	0.11	0.23
20	Wood, timber, bamboo products	79	123	33	11	9.0	14.5	0.21	0.37
21	Manufacture of furniture	184	80	82	82	11.1	10.5	0.15	0.28
22	Pulp and paper	180	432	43	38	12.3	11.5	0.23	0.26
23	Publishing, print	110	185	46	37	17.7	16.2	0.21	0.21
24	Musical instruments, sport goods	257	80	69	54	9.0	8.0	0.19	0.66
25	Refined petroleum products	27	340	9	7	16.4	15.9	0.08	0.16
26	Basic chemicals	221	1443	21	15	12.0	12.3	0.67	0.77
27	Pharmaceuticals, medicinal chemistry	158	593	23	22	14.8	10.9	1.44	1.34
28	Manufacture of chemical fiber	58	165	31	18	8.1	8.5	0.21	0.63
29	Rubber products	173	187	46	23	10.0	11.9	0.20	0.69
30	Plastics products	454	268	55	28	11.6	14.5	0.27	0.59
31	Non-metallic mineral products	322	1482	23	26	14.3	13.1	0.50	0.35
32	Ferrous metals	114	813	11	4	15.7	12.4	0.41	0.24
33	Non-ferrous metals	98	460	16	25	11.4	11.3	0.82	0.56
34	Metal product	331	475	50	21	15.4	12.1	0.15	0.54
35	Machinery, general	383	1265	34	24	14.1	8.2	0.67	1.29
36	Machinery, special purpose	215	742	24	13	15.6	7.3	0.60	1.43
37	Transport equipment	437	1231	46	32	13.1	8.0	0.70	1.30
39	Electrical machinery and apparatus	795	965	43	23	11.0	10.8	0.47	1.17
40	Computer, communication	1445	488	86	49	11.9	13.5	0.60	2.93
41	Office machinery, measuring instrument	221	169	82	42	12.1	10.3	0.84	2.85
42	Manufacture n. e. c.	186	154	45	07	11.6	4.6	0.09	1.47

Source: Authors' calculations.

We continue by looking at the foreign share of different sectors. Table 3 shows that the number of foreign firms is highest in electronic products (sectors 39–41) and textiles, clothes, and shoes (17–19). In relative terms, FDI is of great importance in many industries and of particularly high importance in footwear,

furniture, sporting goods, computers, and office machines, where more than two-thirds of the value added come from foreign-owned firms. Once more, the foreign share of R&D expenditures tends to be lower than the shares of other economic indicators. For instance, the foreign share of R&D expenditures is 50% or above in only three sectors (leather and footwear, furniture, musical instruments and sporting goods) and the foreign share of R&D is lower than the foreign share of value added in all but four industries (beverage, textiles, non-metallic mineral products, and non-ferrous metals).

The PCM is higher in foreign firms than in domestic firms in about two-thirds of the industries. There seem to be important sector-specific effects in PCMs as foreign and domestic firms show a similar pattern across sectors. For instance, PCMs are particularly high in food, beverage, petroleum, metals, and machinery and low in clothing, footwear, wood products, and some chemical industries. For domestic firms, the PCM is also relatively high in publishing and plastics and low in various machinery sectors. More importantly, there is no obvious relation between the share of foreign firms in a sector and the PCMs in domestic firms—PCMs are relatively high in some sectors with low foreign presence such as ferrous metals and petroleum products, but also high in some sectors with high foreign presence such as plastics and computers.

Finally, R&D intensities are relatively high in pharmaceuticals, machinery, transport equipment, electronics, computers, and office machinery, but there is a large difference between foreign and domestic firms. R&D intensity is higher in foreign firms than in domestic ones in only three sectors: non-metallic mineral products, ferrous metals, and non-ferrous metals. It is difficult to detect a direct relationship between PCM and R&D intensity. Domestic firms conduct relatively large shares of R&D in some sectors with high PCMs such as computers and in some sectors with low PCMs such as machinery. Accordingly, there is no obvious relation seen in Table 2 between FDI share and R&D intensity in domestic firms.

VI. Results

A.   The Effect of FDI on Price Cost Margins

We start by estimating the effect of FDI on the PCM using the complete sample of firms with results shown in Table 4. A number of different estimators are used: OLS with and without industry and regional dummies and a fixed-effect estimator. It should be noted that the relatively short time period together with lagged dependent variables makes the fixed-effect estimations relatively weak but including them gives us a sense of the robustness of the results.[10] Moreover, there are obvious

---

[10]We also tried to estimate random effect models but they did not pass the Hausman specification test and were therefore not included.

Table 4.   **Determinants of Price Cost Margins at the Firm Level, 1998–2004 (full sample, domestic, and foreign firms)**

Variables	OLS (1)	OLS (2)	FE (3)	OLS (4)	OLS (5)	FE (6)
FDI penetration	−0.002	−0.001	0.002	−0.000	−0.002	0.001
(with 1 lag)	(0.016)	(0.009)	(0.008)	(0.022)	(0.011)	(0.010)
FDI penetration	−0.027*	−0.031***	−0.023**	−0.037**	−0.038***	−0.032***
(with 2 lags)	(0.015)	(0.009)	(0.009)	(0.018)	(0.010)	(0.010)
Herfindahl index	4.365***	2.585*	2.239*	3.068	1.727	1.622
(with 1 lag)	(1.562)	(1.486)	(1.352)	(3.099)	(2.035)	(1.782)
FDI penetration ×	–	–	–	0.003	0.009	0.009
Herfindahl index				(0.070)	(0.037)	(0.032)
(with 1 lag)						
FDI penetration ×	–	–	–	0.055	0.035	0.048*
Herfindahl index				(0.041)	(0.022)	(0.027)
(with 2 lags)						
Market share	−0.192**	−0.275***	−0.111***	−0.192**	−0.276***	−0.110**
	(0.067)	(0.047)	(0.038)	(0.064)	(0.050)	(0.038)
Market share ×	0.002**	0.003***	0.001**	0.002**	0.003***	0.001***
market share	(0.0008)	(0.0008)	(0.0005)	(0.0008)	(0.0008)	(0.0005)
Capital–labor ratio	2.946***	3.244***	3.187***	2.947***	3.243***	3.189***
	(0.544)	(0.234)	(0.195)	(0.539)	(0.234)	(0.195)
Relative TFP	0.196***	0.208***	0.220***	0.197***	0.208***	0.220***
	(0.013)	(0.015)	(0.004)	(0.013)	(0.011)	(0.004)
Export intensity	−0.022***	−0.017***	−0.002	−0.022***	−0.017***	−0.002
	(0.005)	(0.005)	(0.007)	(0.005)	(0.005)	(0.007)
Ownership dummy	–	−1.050**	–	–	−1.051**	–
(Private)		(0.359)			(0.359)	
Ownership dummy	–	−0.880**	–	–	−0.880**	
(JV–HTM)		(0.331)			(0.330)	–
Ownership dummy	–	−1.691***	–	–	−1.689***	–
(JV foreign and		(0.418)			(0.418)	
Foreign)						
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	No	Yes	–	No	Yes	–
Regional dummies	No	Yes	–	No	Yes	–
R^2	0.20	0.33	Within: 0.23 Between: 0.19 Overall 0.20	0.20	0.33	Within: 0.23 Between: 0.19 Overall 0.20
Observations	23,123	23,123	23,123	23,123	23,123	23,123

***= significant at 1% level, **= significant at 5% level, *= significant at 10% level, HTM = Hong Kong, China; Taipei,China; Macau, China, JV = joint venture.

Note: Standard errors in parentheses are adjusted both for heteroskedasticity and potential dependency among firms in the same industry at the 4-digit level.

Source: Authors' computations.

instances of omitted variables and simultaneity biases. We try to control for these aspects but the results should be interpreted with caution and be seen as correlations rather than causations.

Our first estimation shows that FDI has a negative impact on the PCM, but there is a time lag before the competition from FDI exhibits an effect (Table 4). Lag 1

of FDI is statistically insignificant but lag 2 is significant. Excluding lag 1 of FDI did not change the results for lag 2, while including lag 2 of the Herfindahl index rather than lag 1 did not change its significance (not shown). Moreover, the PCM is high in concentrated markets. The results seem stable across different estimations (columns 2 and 3).

Turning to the other variables, results show that capital-intensive firms with high levels of TFP have high PCMs and that, surprisingly, firms with large market shares and export intensities have low PCMs.[11] Significant and negative coefficients of ownership dummy variables in columns (2) and (4) comprise another interesting outcome. This suggests that, compared to the reference group of SOEs and collective firms, both domestic private firms and foreign-owned firms have low PCMs. This can be due to both market-related and institutional effects. As an example, SOEs often obtain subsidies in terms of, for instance, access to capital at below market interest rates, which might explain the relatively high PCMs.

The above estimations on the effect of FDI on PCMs are rather conservative considering that we control for market shares and industry concentration. These variables are likely to be endogenous to FDI and we therefore run the risk of underestimating the impact of FDI on competition. Excluding the market share and Herfindahl index increased the coefficient on FDI marginally (not shown). Accordingly, experimenting with different subsets of control variables had no major impact on the results.

To further examine the robustness of the results, and whether the effect of FDI on the PCM depends on the degree of market concentration, we insert an interaction term of FDI and the Herfindahl index. As shown in columns 4–6, the negative effect of FDI on PCMs remains robust and a significant interaction effect can only be observed in the fixed-effect estimation where the competitive effect imposed by FDI seems to be weaker in industries with high concentration.

Our main interest is to examine how FDI affects the competition for domestically owned firms. Therefore, we repeat the estimations above but exclude foreign-owned firms and joint ventures. The results are shown in Table 5.[12] The estimations yield fairly similar results, but with two differences if compared to the full sample estimations in Table 4. First, the negative effect of export intensities on the PCM disappears. Second, domestic firms in concentrated industries do not have comparably high PCMs. The results are again robust to the inclusion of interaction variables as seen in columns 4–6 and to changes in the lag structure (not shown).

---

[11]We also used labor productivity as an alternative productivity measure. Firms with high labor productivity were found to have high PCM, while the results for the other included variables remained unchanged (not shown).

[12]The estimations include SOEs, collective firms, and private firms. Shareholding firms and "other firms" are not clearly defined (i.e., can include foreign ownership) and have therefore been excluded. As an additional robustness check, they were included in the domestic subsample but this had little impact on the results (not shown).

Table 5.   **Determinants of Price Cost Margins at the Firm Level, 1998–2004**
(domestic firms)

Variables	OLS (1)	OLS (2)	FE (3)	OLS (4)	OLS (5)	FE (6)
FDI penetration (with 1 lag)	−0.010 (0.030)	−0.017 (0.010)	−0.019 (0.015)	−0.004 (0.042)	−0.019 (0.020)	−0.024 (0.020)
FDI penetration (with 2 lags)	−0.037 (0.024)	−0.033** (0.014)	−0.013 (0.016)	−0.073** (0.036)	−0.042** (0.022)	−0.038* (0.021)
Herfindahl index (with 1 lag)	6.386** (2.760)	1.138 (2.846)	3.288 (2.487)	2.752 (4.431)	0.248 (3.431)	2.481 (2.693)
FDI penetration × Herfindahl index (with 1 lag)	–	–	–	0.023 (0.167)	0.021 (0.086)	0.020 (0.080)
FDI penetration × Herfindahl index (with 2 lags)	–	–	–	0.309 (0.200)	0.078 (0.139)	0.176* (0.094)
Market share	−0.202** (0.091)	−0.248*** (0.058)	−0.157** (0.055)	−0.220** (0.099)	−0.250*** (0.059)	−0.158** (0.055)
Market share × Market share	0.002** (0.0010)	0.003*** (0.0008)	0.002** (0.0007)	0.003** (0.001)	0.003** (0.0008)	0.002** (0.0007)
Capital–labor ratio	3.805*** (1.186)	3.189*** (0.439)	3.281*** (0.287)	3.803*** (1.170)	3.190*** (0.439)	3.274*** (0.288)
Relative TFP	0.179*** (0.021)	0.182*** (0.014)	0.196*** (0.005)	0.179*** (0.021)	0.182*** (0.014)	0.196*** (0.005)
Export intensity	−0.014* (0.010)	0.000 (0.011)	0.015 (0.015)	−0.014 (0.010)	0.000 (0.010)	0.015 (0.015)
Ownership dummy (Private)	–	−0.421 (0.372)	–		−0.425 (0.373)	–
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	No	Yes	–	No	Yes	–
Regional dummies	No	Yes	–	No	Yes	–
R^2	0.16	0.35	Within: 0.17 Between: 0.14 Overall 0.15	0.16	0.35	Within: 0.17 Between: 0.14 Overall 0.16
Observations	12,891	12,891	12,891	12,891	12,891	12,891

*** = significant at 1% level, ** = significant at 5% level, * = significant at 10% level.
Note: Standard errors in parentheses are adjusted both for heteroskedasticity and potential dependency among firms in the same industry at the 4-digit level.
Source: Authors' computations.

The proper definition of a market in a large country like the PRC can be discussed. Our definition assumes the competitive effect of FDI to be the same throughout the country. This might be questionable hence we also constructed FDI penetration variables as the foreign share of a region–industry (region being defined as east, west, or central). The overall results remained unchanged, but the FDI coefficient was slightly larger suggesting the competitive effect of FDI to be strongest within the same region.

We also experimented with alternative estimation methods. For instance, we tried to specify a dynamic model with lagged PCMs as the independent variable.

Table 6. **Determinants of R&D Intensity at the Firm Level, 1998–2004**
(GMM estimations)

Variables	All Firms	Domestic Firms	FDI Firms	High-tech Firms	Non high-tech Firms
R&D intensity	0.273***	0.289***	0.204***	0.387***	0.225***
(with 1 lag)	(0.034)	(0.039)	(0.038)	(0.064)	(0.033)
PCM	0.003	0.003	0.003	0.027**	−0.004
(with 1 lag)	(0.004)	(0.005)	(0.004)	(0.012)	(0.003)
PCM × PCM	0.0000	0.000	0.000	−0.0004**	0.000
(with 1 lag)	(0.0001)	(0.000)	(0.000)	(0.0002)	(0.000)
FDI penetration	0.001	−0.003	0.001	−0.001	0.002
(with 1 lag)	(0.001)	(0.003)	(0.001)	(0.004)	(0.001)
Skill share	0.069***	0.069***	0.070***	0.090***	0.062***
	(0.011)	(0.013)	(0.008)	(0.019)	(0.012)
Export intensity	0.0000	0.002	−0.001	−0.002	0.001
	(0.001)	(0.002)	(0.001)	(0.003)	(0.001)
Firm size	−0.156***	−0.177***	−0.118**	−0.174	−0.114**
	(0.054)	(0.067)	(0.061)	(0.135)	(0.054)
Ownership dummy	−0.149***	−0.124**	–	−0.358*	−0.124***
(Private)	(0.038)	(0.051)		(0.215)	(0.033)
Ownership dummy	−0.103*	–	–	−0.121	−0.152***
(JV-HTM)	(0.061)			(0.263)	(0.058)
Ownership dummy	−0.053	–	0.057**	0.023	−0.125***
(JV foreign & Foreign)	(0.062)		(0.029)	(0.277)	(0.057)
Year dummies	Yes	Yes	Yes	Yes	Yes
Industry dummies	No	No	No	No	No
Regional dummies	No	No	No	No	No
R^2	–	–	–	–	–
AR (2)	0.212	0.971	0.144	0.261	0.282
Hansen test	0.475	0.428	0.835	0.719	0.668
Observations	39,687	22,942	16,745	4,986	34,701

Note: ***= significant at 1% level, **= significant at 5% level, *= significant at 10% level, HTM = Hong Kong, China; Taipei,China; Macau, China, JV = joint venture.
Source: Authors' computations.

However, although the estimations confirmed previous results on PCMs and R&D, the models failed to pass the Sargan/Hansen specification tests and are therefore not shown.

To sum up the results so far, it has been shown that FDI imposes significant competitive pressure on Chinese firms. The result is robust to different estimators and various industry- and firm-level controls as well as to different subsamples. We now continue to examine if this increased competition has an effect on investments in R&D.

B.   The Effect of Price Cost Margins on R&D Intensities

Results from the GMM estimations are shown in Table 6. Most results are stable across different models and samples.

The results show no strong signs of an effect of competition on R&D. The PCM coefficient is statistically insignificant in the different samples: all firms, only domestic firms, only foreign firms, and non-high-tech firms. The one possible exception to a non-significant effect of competition can be seen in high-tech industries where high competition (low PCM) has a negative effect on R&D.[13] We also included an FDI variable, which is expected to capture the effect of FDI on R&D after controlling for the indirect effect on competition. Such an effect could be through demonstration effects or technology spillovers. The results consistently show that no such effect seems to exist in Chinese manufacturing.

The coefficients of lagged R&D intensity are positive and highly significant, indicating persistence in R&D and justifying inclusion of the lag.[14] We also observe a significant and positive effect of skills share but a significant and negative effect of firm size on R&D intensity.[15] These results are robust across the different specifications. Finally, private domestic and foreign firms seem to have lower R&D intensities than SOEs after controlling for various firm characteristics.

We tried to estimate specifications with the same control variables as in the PCM estimations. Excluding skills share and replacing firm size with market share had no impact on the results (not shown). Moreover, estimations including TFP unfortunately did not pass the specifications tests. As an alternative robustness check, we estimated a fixed-effect model but the results did not change (not shown). Moreover, a relatively large proportion of the firms do not engage in R&D at all. It might be that such firms are located in small segments of industries where they are not significantly affected by foreign firms or the industry level of competition. We examined this issue by including only those firms that have positive R&D spending in at least one year of their existence. Once more, the results remained unchanged (not shown). Hence, we conclude by noting that the effect of firms' PCMs on R&D intensities seems to be insignificant with the result appearing robust across samples and estimation methods.

VII. Concluding Remarks

FDI can be an important channel for developing countries to gain access to new technology. The impact of FDI on the technology development of domestically owned firms is less examined, but it is frequently argued that technology externalities or a demonstration effect could have a positive impact. Another little examined effect

---

[13] We follow OECD (2006) and define high-tech as including pharmaceuticals; aircraft and spacecraft; radio, television, and communication equipment; office, accounting, and computing machinery; and medical, precision, and optical instruments.

[14] We also estimated the model by including a 2-year lag of R&D intensity. The coefficients on the second lag turned out to be insignificant, and those on the first lag remained significant (not shown).

[15] Jefferson et al. (2006) find a similar effect of firm size on R&D intensity.

of FDI on technology development in domestically owned firms works through the impact on competition. FDI might affect the degree of competition in the market which in turn may affect efforts to upgrade technology in domestic firms.

We have surveyed the literature on FDI and spillovers in the PRC. It seems that the spillovers are relatively large for suppliers and customers, for firms within the same region as the foreign firms, and from FDI coming from OECD countries. The studies on spillovers focus on the effect on productivity (labor or TFP) in local firms. It can be argued that this is only an indirect measure on technology and not the primary concern of the Chinese government. We therefore center our analysis on the impact of FDI on R&D in Chinese firms.

Our hypothesis was that FDI could positively or negatively affect R&D through an impact on the degree of competition. We find a strong and robust negative effect of FDI on PCMs of firms which suggests that FDI does increase the level of competition in Chinese manufacturing. This result stands in some contrast to studies on countries other than the PRC, which typically find mixed effects of FDI on competition (e.g., Co 2001, Chung 2001, Fu and Wu 2012).

We continue the analysis by examining determinants of R&D with a special focus on the role of competition. The general conclusion is that we find a high degree of persistence in R&D and little evidence of any effect of competition, negative or positive, on the level of R&D. The result is slightly different from Jefferson et al. (2006) who find a positive (albeit fragile) effect of industry concentration on R&D. Moreover, there is no indication of a direct effect of FDI on R&D in domestic firms, which contrasts with the finding on FDI in Belgium by Veugelers and Vanden Houte (1990) who estimate a negative effect. Finally, firms with high R&D intensities tend to have a relatively skilled labor force and to be relatively small in size. Moreover, SOEs tend to be more R&D intensive than domestic and foreign private firms.

It is clear from our analysis that many issues need more research. For instance, the available data does not permit us to examine how small Chinese firms are affected by FDI, or how firms in upstream and downstream industries are affected. Accordingly, the effect of FDI on alternative measures of technology development such as patents or changes in the product mix awaits further research. It is also possible that FDI might have an effect on the impact of R&D in local firms even if the amount of R&D is not affected.[16]

Bearing these caveats in mind, we believe our results contribute to the ongoing policy debate in the PRC. Most importantly, there is substantial evidence of a positive effect of FDI on productivity in local firms. Some of these productivity gains might be caused by technology spillovers but there could also be other explanations. We do not find any positive impact of FDI on R&D in domestically owned firms. Hence, it seems that although FDI has contributed to productivity, it has not been an important force for promoting R&D investment in domestic firms.

---

[16]We are grateful to an anonymous referee who highlighted these areas as suitable for future research.

References

Abraham, Filip, Jozef Konings, and Veerle Slootmaekers. 2010. FDI Spillovers in the Chinese Manufacturing Sector: Evidence of Firm Heterogeneity. *Economics of Transition* 18(1):143–182.

Aghion, Philippe, Nicholas Bloom, Richard Blundell, Rachel Griffith, and Peter Howitt. 2002. Competition and Innovation: An Inverted-U Relationship. *NBER Working Paper* No. 9269. Cambridge, Mass.: National Bureau of Economic Research.

——. 2005. Competition and Innovation: An Inverted-U Relationship. *Quarterly Journal of Economics* 120(2):701–728.

Aghion, Philippe, Christopher Harris, Peter Howitt, and John Vickers. 2001. Competition, Imitation and Growth with Step-by-step Innovation. *Review of Economic Studies* 68(3):467–492.

Aghion, Philippe, and Peter Howitt. 1992. A Model of Growth through Creative Destruction. *Econometrica* 60(2):323–351.

Aghion, Philippe, and Mark Schankerman. 1999. Competition, Entry and the Social Returns to Infrastructure in Transition Economies. *Economics of Transition* 7(1):79–104.

Aitken, Brian, and Ann Harrison. 1999. Do Domestic Firms Benefit from Foreign Investment? Evidence from Venezuela. *American Economic Review* 89(3):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(2): 277–97.

Arellano, Manuel, and Olympia Bover. 1995. Another Look at the Instrumental Variable Estimation of Error-components Models. *Journal of Econometrics* 68(1):29–51.

Arrow, Kenneth. 1962. Economic Welfare and the Allocation of Resources for Inventions. In Richard Nelson, ed. *The Rate and Direction of Technological Change*. Princeton: Princeton University Press.

Barba Navaretti, Giorgio, and Anthony Venables. 2004. *Multinational Firms in the World Economy*. Princeton and Oxford: Princeton University Press.

Blundell, Richard, and Stephen Bond. 1998. Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. *Journal of Econometrics* 87(1):115–43.

Boone, Jan. 2000. Competitive Pressure: The Effects on Investments in Product and Process Innovation. *RAND Journal of Economics* 31(3):549–569.

Boone, Jan. 2001. Intensity of Competition and the Incentive to Innovate. *International Journal of Industrial Organization* 19(5):705–726.

Brandt, Loren, Johannes Van Biesebroeck, and Yifan Zhang. 2012. Creative Accounting or Creative Destruction? Firm-Level Productivity Growth in Chinese Manufacturing. *Journal of Development Economics* 97(2):339–351.

Buckley, Peter, Jeremy Clegg, and Chengqi Wang. 2002. The Impact of Inward FDI on the Performance of Chinese Manufacturing Firms. *Journal of International Business Studies* 33(4):637–55.

Caves, Richard. 1974. Multinational Firms, Competition, and Productivity in Host Country Markets. *Economica* 41(162):171–193.

——. 1996. *Multinational Enterprise and Economic Analysis*. Cambridge: Cambridge University Press.

Chinese Ministry of Science and Technology (MOST). 2006. *National Guidelines for Medium- and Long-term Plans for Science and Technology Development (2006–2020) of China*. Available at www.most.org.cn/eng/newsletters/2006/t20060213_28707.htm

Chung, Wilbur. 2001. Mode, Size, and Location of Foreign Direct Investments and Industry Mark-ups. *Journal of Economic Behavior & Organization* 45(2):185–211.

Co, Catherine. 2001. Trade, Foreign Direct Investment and Industry Performance. *International Journal of Industry Organization* 19(1–2): 163–183.

Du, Luosha, Ann Harrison, and Gary Jefferson. 2011. Do Institutions Matter for Spillovers? The Implications of China's "Special Characteristics." *NBER Working Paper* 16767. Cambridge, MA: National Bureau of Economic Research.

——. 2012. Testing for Horizontal and Vertical Foreign Investment Spillovers in China, 1998–2007. *Journal of Asian Economics* 23(3):234–243.

Foster, Lucia, John C. Haltiwanger, and C. J. Krizan. 2001. Aggregate Productivity Growth: Lessons from Microeconomic Evidence. In Charles R. Hulten, Edwin R. Dean, and Michael J. Harper, eds. *New Developments in Productivity Analysis*. Cambridge: National Bureau of Economic Research.

Fu, Dahai, and Yanrui Wu. 2012. Foreign Entry and Profitability of Domestic Firms: Evidence from China. *Paper presented at Asian Economic Panel*, 5–6 October, Keio University.

Girma, Sourafel, and Yundan Gong. 2008. FDI, Linkages and the Efficiency of State Owned Enterprises in China. *Journal of Development Studies* 44(5):728–749.

Girma, Sourafel, Yundan Gong, and Holger Görg. 2006. Can You Teach Old Dragons New Tricks? FDI and Innovation Activity in Chinese State-owned Enterprises. *CEPR Discussion Paper* No. 5838. London: Centre for Economic Policy Research.

Görg, Holger, and David Greenaway. 2004. Much Ado about Nothing? Do Domestic Firms Really Benefit from Foreign Direct Investment? *World Bank Research Observer* 19(2):171–197.

Görg, Holger, and Eric Strobl. 2001. Multinational Companies and Productivity Spillovers: A Meta-analysis. *Economic Journal* 111(475):723–739.

Griffith, Breda. 2011. Middle Income Trap. In Raj Nallari, Shahid Yusuf, Breda Griffith, and Rwitwika Bhattacharya, eds. *Frontiers on Development Policy: A Primer on Emerging Policy Issues*. Washington, DC: World Bank Publications.

Haller, Stefanie. 2005. The Impact of Multinational Entry on Domestic Market Structure and R&D. *EUI Working Paper* No. 16. Florence: European University Institute.

——. 2009. More Intra-region Direct Investment through Economic Integration? Modelling the Experience of the EU's Single Market. *Journal of Economic Integration* 25(3):427–456.

Jefferson, Gary, Albert Hu, Xiaojing Guan, and Xiaoyun Yu. 2003. Ownership, Performance, and Innovation in China's Large and Medium-size Enterprise Sector. *China Economic Review* 14(1):89–113.

Jefferson, Gary, Bai Huamao, Guan Xiaojing, Yu Xiaoyun. 2006. R and D Performance in Chinese Industry. *Economics of Innovation and New Technology* 15:345–366.

Karlsson, Sune, Nannan Lundin, Fredrik Sjöholm, and He Ping. 2009. Foreign Firms and Chinese Employment. *The World Economy* 32(1):178–201.

Konings, Jozef, Patrick Van Cayseele, and Frederic Warzynski. 2005. The Effects of Privatization and Competitive Pressure on Firms' Price–Cost Margins: Micro Evidence from Emerging Economies. *Review of Economics and Statistics* 87(1):124–134.

Koyama, Takeshi, and Stephen Golub. 2006. OECD's FDI Regulatory Restrictiveness Index: Revision and Extension to More Economies. Working Papers on International Investment no. 4. Paris: Organisation for Economic Co-operation and Development.

Lipsey, Robert. 2004. Home- and Host-country Effects of Foreign Direct Investment. In Robert Baldwin, and Alan Winters, eds. *Challenges to Globalization*. Chicago: University of Chicago Press.

Lipsey, Robert, and Fredrik Sjöholm. 2005. Host Country Impacts of Inward FDI: Why Such Different Answers? In Theodore Moran, Edward Graham, and Magnus Blomström, eds., *The Impact of Foreign Direct Investment on Development: New Measurements, New Outcomes, New Policy Approaches*. Washington, DC: Institute for International Economics.

Liu, Zhiqiang. 2008. Foreign Direct Investment and Technology Spillovers: Theory and Evidence. *Journal of Development Economics* 85(1–2):176–193.

Madariaga, Nicole, and Sandra Poncet. 2007. FDI in Chinese Cities: Spillovers and Impact on Growth. *The World Economy* 30(5):837–862.

National People's Congress. 2011. *China's Twelfth Five-year Plan (2011–2015)*. Beijing: NPC. Available: http://cbi.typepad.com/china_direct/2011/05/chinas-twelfth-five-new-plan-the-full-english-version.html

Naughton, Barry. 2007. *The Chinese Economy, Transitions and Growth*. Cambridge, Mass.: MIT Press.

Organisation for Economic Co-operation and Development (OECD). 2002. *Foreign Direct Investment for Development: Maximising Benefits, Minimising Costs*. Paris: OECD.

——. 2006. *OECD Science, Technology and Industry Outlook*. Paris: OECD.

Roberts, Mark, and James Tybout. 1997. The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs. *American Economic Review* 87(4):545–564.

Roeger, Werner. 1995. Can Imperfect Competition Explain the Difference between Primal and Dual Productivity Measures? Estimate for US Manufacturing. *Journal of Political Economy* 103(2):316–330.

Sauvant, Karl. 2009. FDI Protectionism is on the Rise. *World Bank Policy Research Working Paper* No. 5052. Washington, DC: World Bank.

Scherer, Frederic, and David Ross. 1990. *Industrial Market Structure and Economic Performance*. Boston: Houghton Mifflin Company.

Sjöholm, Fredrik, and Nannan Lundin. 2010a. The Role of Small Firms in the Technology Development of China. *The World Economy* 33(9):1117–1139.

——. 2010b. Will Science and Technology Solve China's Unemployment Problem? *Asian Economic Papers* 9(2):1–28.

United Nations Conference on Trade and Development (UNCTAD). 1997. *World Investment Report 1997: Transnational Corporations, Market Structure and Competition Policy*. Geneva: UNCTAD.

——. 2005. *World Investment Report 2005: Transnational Corporations and the Internationalisation of R&D*. Geneva: UNCTAD.

Veugelers, Reinhilde, and Peter Vanden Houte. 1990. Domestic R&D in the Presence of Multinational Enterprises. *International Journal of Industrial Organization* 8(1):1–15.

Vickers, John. 1997. Regulation, Competition, and the Structure of Prices. *Oxford Review of Economic Policy* 13(1):15–26.

Wei, Yingqi, and Xiaming Liu. 2006. Productivity Spillovers from R&D, Exports, and FDI in China's Manufacturing Sector. *Journal of International Business Studies* 37(4):544–557.

World Bank. 2012. *China 2030: Building a Modern, Harmonious, and Creative High-income Society*. Washington, DC: World Bank.

Xu, Xinpeng, and Yu Sheng. 2012. Are FDI Spillovers Regional? Firm-level Evidence from China. *Journal of Asian Economics* 23(3):244–258.

Appendix

I. Total Factor Productivity Calculation:

$$\ln TFP_{ji} = \ln Y_{ji} - \alpha_{Ki} \ln K_{ji} - \alpha_l \ln L_{jt} - \alpha_{Mi} \ln M_{ji}$$

where Y is real gross output, K is real capital, L represents number of employees, and M real material use. α_l is the share of wages in output and α_{Mi} is the share of material inputs in output. α_{Ki} is calculated as one minus the shares for labor and material inputs. We deflate output, capital, and materials by the appropriate 4-digit industry price deflator. Following Foster, Haltiwanger, and Krizan (2001), we calculate the factor shares at the 4-digit industry level to minimize the effects of measurement errors. We use annual weights in our calculations.

Table A1. **Variable List and Definitions**

Variable	Definition
Firm-level Variables	
PCM	(Value added − payroll)/Value added
Market share	Sales by firm i/Total domestic sales of industry j at the 4-digit industry level
Capital intensity	Log(Capital stock/Total number of employees)
Relative TFP	TFP for firm i /Average TFP in industry j at the 4-digit industry level
Export intensity	Export/Total sales
R&D intensity	R&D expenditure/Total sales
Skill share	Number of S&T personnel/Total number of employees
Firm size	Log (Real total sales)
Industry-level Variables	
FDI penetration	Sales by foreign firms/Total domestic sales at the 4-digit industry level
Herfindahl index (H)	Sum of squared firm-level (domestic) market shares at the 4-digit industry level

Table A2. **Classification of Large, Medium, and Small Enterprises**

	Large (1)	Medium (2)	Small (3)
Employment (person)	2000+	300–2000	300−
Turnover (yuan, million)	300+	30–300	30−
Fixed assets (yuan, million)	400+	40–400	40−

Source: National Bureau of Statistics of China.

Table A3. **Ownership Classifications**

Code	Ownership
Domestic Ownership: SOE	
110	State-owned enterprises
141	Stated-owned, jointly operated enterprises
151	Wholly stated-owned enterprises
Domestic Ownership: Collective	
120	Collective-owned enterprises
130	Shareholding cooperatives
142	Collective-owned, jointly operated enterprises
Domestic Ownership: Private	
171	Private wholly owned enterprises
172	Private-cooperative enterprises
173	Private limited liability enterprises
174	Private shareholding enterprises
Foreign Ownership: Hong Kong, China; Taipei,China; and Macau, China Invested	
210	Overseas joint ventures
220	Overseas cooperatives
230	Overseas wholly owned enterprises
240	Overseas shareholding limited companies
Foreign Ownership: Foreign-invested Joint Ventures	
310	Foreign joint ventures
320	Foreign cooperatives
340	Foreign shareholding limited companies
Foreign Ownership: Foreign Invested	
330	Foreign wholly owned enterprises

Source: National Bureau of Statistics of China.