Foreign Firms, Competition, and R&D in China*

Fredrik Sjöholm

Research Institute of Industrial Economics and Örebro University

P.O. Box 55665

SE-102 15 Stockholm, Sweden

Email: Fredrik.sjoholm@ifn.se

Nannan Lundin

E3G and Stockholm Environment Institute

SE-106 91 Stockholm, Sweden

Email: nanan.lundin@sei.se

Abstract

FDI can be an important channel for developing countries' ability to get access to new technology. The impact of FDI on domestically-owned firms' technology development is less examined but it is frequently argued that technology externalities or demonstration effects could have a positive impact. Another and so far little examined effect of FDI on technology development in domestically-owned firms is through the impact on competition. We examine the effect of FDI on competition in the Chinese manufacturing sector and the effect of competition on firms' R&D. Our analysis is conducted on a large dataset including all Chinese large and medium sized 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: China, FDI, competition, R&D
JEL codes: F23, L11, O31

* Xiaojing Guan, He Ping and Jinchang Qian from the National Bureau of Statistics of China have been most helpful in providing us with the data. Fredrik Sjöholm gratefully acknowledges financial support from the Torsten and Ragnar Söderberg's foundation.

1. INTRODUCTION

Research and Development (R&D) expenditures in China have increased rapidly in recent years. R&D as a share of GDP has more than doubled from 0.6% in 1995 to around 1.3% in 2005 and is expected to reach 2.5% or more in 2020. Most R&D is conducted in the industry sector (MOST, 2006), which is also a major recipient of Foreign Direct Investment (FDI). China is one of the world's largest recipients of FDI which has substantially contributed to production and export. Moreover, FDI to China is according to some reports undergoing a structural change away from simple manufacturing towards more technology intensive activities. For instance, China has become the third most important offshore 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 China that inflows of FDI do not contribute to technology development to the same extent as they contribute to production and exports. For instance, it is noted by policy makers and academics alike that while foreign firms account for a large share of export and production, their share of R&D is small. The recent emphasis on "indigenous innovation" and "indigenous capacity building" in the Chinese science and technology policy partly reflects an uncertain and even sceptical attitude towards FDI (MOST, 2006).

However, the discussion on FDI and R&D in China 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. Once more, there has been a large focus on the (direct)

effect of FDI on technology development in the ongoing debate, whereas the indirect effect of FDI on technology development in domestically-owned firms has not been discussed or examined to the same extent.

It is important to note that the expected impact of FDI on the R&D of domestically-owned firms is not clear. First, and as previously mentioned, there could be a demonstration effect or technology externalities from FDI that might increase R&D in domestic firms. This effect is typically attributed to a spillover effect from foreign to domestic firms. However, there could also be an effect of FDI on R&D in domestic firms 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.

The relationships between FDI, market structure and R&D investment have not been examined in a Chinese context, if at all. There are, however, studies related to the issue at hand. For instance, Girma et al. (2006) examine R&D in Chinese state-owned enterprises (SOEs) and find relatively high R&D in firms with foreign capital participation. The effect of FDI on innovations in purely domestically-owed SOEs is ambiguous. Moreover, Jefferson et al. (2006) find a positive correlation between high industry concentration and R&D intensities in Chinese manufacturing.

We contribute to the literature by examining the effect of FDI on market structure and how market structure, in turn, affects investments in R&D. Our analysis is based on firm-level data containing detailed information on operational and R&D activities of all 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 intensities in Chinese firms.

The paper is organised as follows. In Section 2, we set up a conceptual framework for our empirical analysis and briefly review previous studies in the field of interest. We give a detailed description of the dataset, classifications and some descriptive statistics in section 3, and continue with our econometric models in section 4. Finally, the results are presented in section 5 and we conclude the paper in section 6.

2. CONCEPTUAL FRAMEWORK AND PREVIOUS STUDIES

The conceptual framework is 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. Starting with the former aspect, 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.[1] In other words, 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, in particular in industries with high start-up costs and high barriers to entry (e.g. Barba

[1] See e.g. UNCTAD (1997) and OECD (2002) for more detailed reviews.

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, 2004). 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.

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 the 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.

Continuing with 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, and Aghion et al. 2002).

Innovations are in the classic Schumpeterian view of creative destruction made by firms which earn no rents if they fail to innovate and which obtain monopolistic power if they succeed. The market will be characterised 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

will decrease. 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 (see e.g. Vickers, 1997; Boone, 2000; and 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 (see e.g. Aghion et al. (2001) and Boone (2001)). The step-by-step innovation models are of particular relevance for analysing “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 technology 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 of 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 for the question of FDI and competition, economic theory gives us little guidance in making predictions on how competition affects R&D. There are reasons to expect that the effect can 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.

Previous studies

Host country effects of FDI are subject to extensive empirical research, in particular in the field of technological development and spillovers.[2] Substantially less work has been done on the competitive effects of FDI. One exception is Co (2001) who found both positive and negative effects of FDI on competition in the U.S., depending on market conditions and the extent of spillovers. Chung (2001) also finds mixed effects of FDI on competition and suggests the degree of competitive pressure imposed by FDI to depend on both the entry mode and various investment traits.

Studies on the impact of FDI on domestic innovations and R&D are also rare. Veugelers and Vanden Houte (1990) study the Belgian manufacturing sector and find domestic firms 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 China by Jefferson et al. (2006) and Girma et al. (2006) are related to our work. Jefferson et al. (2006) use a similar measure on investments 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 et

[2] See e.g. Görg and Greenaway (2004) and Lipsey (2004) for more detailed surveys.

al. (2006) find SOEs with foreign capital participation to have relatively high degrees of innovation activities. Innovations in SOEs without foreign capital participation can be both positively and negatively affected by FDI, depending on the absorptive capacity in these firms.

3. DATA AND DESCRIPTIVE STATISTICS

Data

Our data on large- and medium-sized manufacturing enterprises (LMEs) are compiled by the National Bureau of Statistics of China (NBS) and cover the period 1998-2004. The classification of LMEs follows the NBS' 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).[3] NBS conducts a yearly census of LMEs and collects information on a large number of firm characteristics such as sales, employment, labour cost, material, 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.

The industry classification is similar to the classification ISIC, REV. 3 and the included sectors at the 2-digit industry-level can be found in Table 2. 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.

[3] To compare market structure over time, we have re-classified 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.

Finally, the effect of FDI on competition and R&D might differ for firms with different kinds of ownership and therefore, we divide our dataset into domestic and foreign sub-samples according to the classification given in Table A3 in the appendix.

Descriptive Statistics

The share of foreign firms in Chinese manufacturing between 1998 and 2004 is seen in Table 1. Foreign firms include wholly foreign-owned firms and joint ventures between foreign and domestic firms. Foreign ownership has increased substantially in relative as well as absolute terms. For instance, the number of foreign-owned firms increased by 150 percent over the period: from 3,489 in 1998 to 8,745 in 2004. This increase was higher than the increase in domestically-owned firms, as seen from the foreign share of LMEs that increased from about 22 percent to 36 percent. The other variables show a similar pattern of rapid increases, and foreign-owned firms account for about one third of employment, 40 percent of value added, and a staggering 76 percent of total exports.

Table 1 about here

Turning our attention to the focus of this paper, R&D, it is interesting to note that the foreign share is relatively small. More precisely, the foreign share of R&D expenditures was 21 percent in 1998 which, for instance, was larger than the foreign share of employment and about the same as the foreign share of LMEs. However, the foreign share of R&D has only increased to about 29 percent in 2004, which is lower than the foreign share of any other economic indicator in Table 1. One conclusion that can be drawn from the figures is that even if China is becoming increasingly attractive as a location of foreign firms' R&D, as suggested by for instance UNCTAD (2005), this trend

is growing more slowly than the increase in foreign firms' production, employment and exports.

We continue by looking at the foreign share of different sectors in Table 2. 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 large importance in many industries but of particularly high importance in footwear, furniture, sport 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 percent or above in only three sectors (leather and footwear; furniture; musical instruments and sport 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; non-ferrous metals).

Table 2 about here

The price cost margin 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 price cost margins, since foreign and domestic firms show a similar pattern across sectors. For instance, price cost margins are particularly high in food, beverage, petroleum, metals and machinery and low in cloths, footwear, wood products and some chemical industries. For domestic firms, the price cost margin 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 price cost margins in domestic firms: price cost margins 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 generally 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 than in domestic firms in three sectors alone: non-metallic mineral products, ferrous metals, and non-ferrous metals. It is difficult to detect a direct relationship between price cost margin and R&D intensity. Domestic firms conduct relatively large shares of R&D in some sectors with high price cost margins, such as computers, and in some sectors with low price cost margins, such as machinery. Accordingly, there is no obvious relation in Table 2 between the share of FDI and the R&D intensity in domestic firms.

4. ECONOMETRIC MODELS

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 for competition, which is defined as:[4]

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

[4] Van Cayseele et al. (2005) apply an alternative methodology developed by Roeger (1995). The need to impose the constraint that mark-up (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 China.

A high value on PCM means a large mark-up and presumably a low level of competition. Our measure on FDI penetration is calculated as the share of sales by foreign firms in total sales in the domestic market at the four-digit industry level. Exports by foreign firms are excluded from the sales figures, since such exports do not impose a competitive pressure in the Chinese market. The baseline econometric model is specified as:

$$PCM_{jt} = \alpha + FDI_{i,t-n} + \delta Firm_{jt} + \rho H_{i,t-n} + \omega OWNER_{w} + \lambda_1 DT_{t} + \lambda_2 DIND_{i} + \lambda_3 D\,\mathrm{Re}\,gion_{r} + \varepsilon_{jt} \quad (1)$$

where

PCM_{jt}: The price cost margin of firm *j*, at time *t.*

$FDI_{i,t-n}$: The presence of FDI in industry *i* at time *t* at the 4-digit industry level, and where *n* is the number of lags.

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

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

$DOWNER_{w}$: a vector of ownership dummy variables.

DT, *DIND* and *DRegion* are 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.

When 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. The market share may also capture the firm-specific market power. Following previous empirical studies by Scherer and Ross (1990) and Tybout and Roberts (1997), we specify a non-linear 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.

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:

$$RDINT_{jt} = \alpha + RDINT_{j,t-n} + PCM_{j,t-n} + FDI_{i,t-n} + \delta Firm_{jt} + \omega DOWNER_{w} + \lambda_1 DT_t + \lambda_2 DIND_i + \lambda_3 D\,\mathrm{Re}\,gion_r + \varepsilon_{jt} \qquad (2)$$

where

$RDINT_{jt}$: The R&D intensity, measured by the ratio of R&D expenditures to sales of firm *j*, at time *t*.

$Firm_{jt}$: a vector of firm-level control variables such as the share of S&T 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 behaviour. 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 the OLS estimates are likely to suffer from a "dynamic panel bias". Therefore, we follow standard approaches and, in addition to OLS, use system 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 will 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}.

5. RESULTS

The effect of FDI on price cost margins

We start by estimating the effect of FDI on the price cost margin in the whole sample of firms and the results are shown in Table 3. 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 will give us a sense of the robustness of the results.

Table 3 about here

Our first estimation shows that FDI has a negative impact on the price cost margin, but there is a time lag before the competition from FDI has an effect; 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 and including lag 2 of the Herfindahl index rather than lag 1 did not change its significance (not shown). Moreover, the price cost margin is high in concentrated markets. The results seem stable across different estimations as seen in columns 2 and 3.

Turning to our other included variables, it is seen that capital intensive firms with high levels of TFP have high price cost margins and that, surprisingly, firms with large market shares and export intensities have low price cost margins. Another interesting result is the significant and negative coefficients of ownership dummy variables in columns (2) and (4). It suggests that, as compared to the reference group of SOEs and collective firms, both domestic private firms and foreign-owned firms have low PCM. 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 below market interest rates, which might explain the relatively high price cost margins.

To examine the robustness of the results, and whether the effect of FDI on 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 PCM 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 4.[5] The estimations yield fairly similar results, but with two differences as compared to the full-sample estimations in Table 3. First, the negative effect of export intensities on the price cost margin disappears. This suggests that the negative effect found in Table 3 is caused by the foreign firms that are excluded in Table 4, and that those foreign firms therefore have a higher PCM when they sell to the Chinese market as compared to when they export. Second, domestic firms in concentrated industries do not have comparably high price cost margins. The results are, once more, robust to the inclusion of interaction variables as seen in columns 4-6 and to changes in the lag structure (not shown).

Table 4 about here

The proper definition of a market in a large country like China can be discussed. Our definition assumes the competitive effect of FDI to be the same throughout the country. This might be questionable and we did also construct FDI penetration variables as the foreign share of a region-industry; region being defined as east, west or central.

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

The overall results remained unchanged but the FDI coefficient was slightly larger which suggests the competitive effect of FDI to be strongest within the same region.

We did also experiment with alternative estimation methods. For instance, we tried to specify a dynamic model with lagged PCM as the independent variable. However, although the estimations confirmed previous results on PCM and R&D, the models did typically not 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 a significant competitive pressure on Chinese firms. The result is robust to different estimators and various industry- and firm-level controls as well as in different subsamples. We now continue to examine if this increased competition has an effect on investments in R&D.

The effect of price cost margins on R&D intensities

The results from our OLS and GMM estimations are shown in Table 5. Most results are stable across different models and samples.

Table 5 about here

The results show no strong signs of an effect of competition (PCM) on R&D. For instance, PCM has a negative effect on R&D intensities in the OLS estimation on the whole sample, but the preferred GMM estimation shows a statistically insignificant effect. The same result with a negative effect in the OLS and an insignificant effect in the GMM is seen in the sample of non-high technology firms. The results in the sample with only domestically owed firms or only foreign firms show insignificant effects for both types of estimations.

The one possible exception to a non-significant effect of competition is in high-tech industries where high competition (low PCM) might have a negative effect on R&D.[6] Note that this result is only significant in the GMM estimation and not in the OLS.

We have 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 the lagged R&D intensity are positive and highly significant, which shows persistence in R&D and justifies the inclusion of the lagged R&D intensity.[7] We also observe a significant and positive effect of the skill-share but a significant and negative effect of firm size on R&D intensity.[8] 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.

As an alternative robust 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 affected by foreign firms or the industry level of competition to any considerable extent. We examined this issue by only including firms that have positive R&D expenditures in at least one year of their existence. Once more,

[6] We follow OECD (2006) and define high-tech as including Pharmaceuticals; Air- and spacecraft; Radio, TV and communication equipment; Office, accounting and computing machinery; and Medical, precision and optical instruments.
[7] We have also estimated the model by including a two-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).
[8] Jefferson et al. (2006) find a similar effect of firm size on R&D intensity.

the results remained unchanged (not shown). Hence, we conclude by noting that the effect of firms' price cost margins on R&D intensities seems to be insignificant and robust across samples and estimation methods.

6. CONCLUDING REMARKS

FDI can be an important channel for developing countries' ability to get access to new technology. The impact of FDI on domestically-owned firms' technology development is less examined, but it is frequently argued that technology externalities or a demonstration effect could have a positive impact. Another and so far little examined effect of FDI and technology development in domestically-owned firms is through the impact on competition. FDI might affect the degree of competition which, in turn, might affect efforts to upgrade technology in domestic firms. However, economic theory does not provide us with certain predictions on how FDI is expected to affect competition or how competition is expected to affect technology development. Some theories suggest positive effects while others claim negative effects. Hence, there are obvious needs for empirical studies but the existing literature is very limited.

It is also worth noting that the issue is of particular importance in a Chinese context. China is a major receiver of FDI but there are recent complaints that foreign MNEs do not contribute to Chinese technology development to any larger extent. Such complaints tend to focus on R&D conducted in MNEs and do not consider the impact of FDI on R&D in domestically-owned firms.

Our study starts by examining the impact of FDI on price cost margins in Chinese firms. We find a strong and robust negative effect of FDI on firms' price cost margins

which suggests that FDI does increase the level of competition in Chinese manufacturing. We also find robust positive effects on price cost margins from high efficiency (TFP) and state ownership.

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, negative or positive, effect of competition on R&D. Moreover, there is no indication of a spillover effect of FDI on R&D in domestic firms. Finally, firms with high R&D intensities tend to have a relatively skilled labour force, are relatively small in size, and SOEs are more R&D intensive than domestic and foreign private firms.

Relating our results to the ongoing policy debate in China, we do not find any positive impact of FDI on R&D in domestically-owned firms. Hence, it seems that although FDI has contributed substantially to Chinese production and exports and, as seen in the paper, to a competitive economic environment, it has not been an important force for promoting R&D investment in domestic firms, which is an important issue in China's strive towards technological upgrading.

REFERENCE

Aghion, Philippe, Bloom, Nichlas, Blundell, Richard, Griffith, Rachel, Peter, Howitt, 2002. Competion and innovation: an inversed U relationship". NBER working paper No. 9269.NBER, Cambridge, MA.

Aghion, Philippe, Harris, Christopher, Howitt, Peter, Vickers, John, 2001. Competition, imitation and growth with step-by-step innovation. Review of Economic Studies, Vol. 68 (3), pp. 467–492.

Aghion, Philippe, Howitt, Peter, 1992. A model of growth through creative destruction. Econometrica, Vol. 60 (2), pp 323-351.

Aghion, Philippe, Schankerman, Mark, 1999. Competition, entry and the social returns to infrastructure in transition economies. Economics of Transition, Vol. 7(1), pp. 79-104.

Aitken, Brian J., Harrison, Ann E., 1999. Do Domestic Firms Benefit from Foreign Investment? Evidence from Venezuela. American Economic Review, Vol. 89, pp.605-618.

Arellano, Manuel, Bond, Stephen, 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. The Review of Economic Studies, Vol. 58, pp. 277-97.

Arellano, Manuel, Bover, Olympia 1995. Another look at the instrumental variable estimation of error-components models. Journal of Econometrics, Vol. 68, pp. 29-51.

Arrow, Kenneth, J., 1962. Economic welfare and the allocation of resources for inventions" in Nelsson Richard R. (Eds.), The Rate and Direction of Technological Change. Princeton University Press, Princeton.

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

Blundell, Richard, Bond, Stephen, 1998. Initial conditions and moment restrictions in dynamic panel data models. Journal of Econometrics, Vol. 87, pp. 115-43.

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

Boone, Jan, 2001. Intensity of competition and the incentive to innovate. International Journal of Industrial Organization, Vol. 19(5), pp. 705-726.

Caves, Richard E., 1996. Multinational Enterprise and Economic Analysis. Cambridge University Press, Cambridge.

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. http://www.most.org.cn/eng/newsletters/2006/t20060213_28707.htm. MOST, Beijing.

Chung, Wilbur, 2001. Mode, size, and location of foreign direct investments and industry mark-ups. Journal of Economic behaviour & organization, Vol. 45, pp. 185-211.

Co, Catherine Y., 2001. Trade, foreign direct investment and industry performance. International Journal of Industry Organization, Vol. 19, pp.163-183.

Girma, Sourafel, Gong, Yundan, Görg, Holger, 2006. Can you teach old dragons new tricks? FDI and innovation activity in Chinese State-owned enterprises. GEP Research Paper 2005/34, Nottingham.

Görg, Holger, Greenaway, David, 2004. Much ado about nothing? Do domestic firms really benefit from foreign direct investment?. World Bank Research Observer, Vol. 19(2), pp. 171-197.

Haller, Stefanie, 2004. The Impact of Multinational Entry on Domestic Market Structure and R&D. mimeo, Department of Economics, European University Institute.

Jefferson, Gary, H., Bai, Huamao, Guan, Xiaojing, Yu, Xiaoyun, 2006. R and D performance in Chinese industry. Economics of Innovation and New Technology, Vol. 15, pp.345-366.

Lipsey, Robert E., 2004. Home- and Host-Country Effects of Foreign Direct Investment. In: Baldwin, Robert E., Winters, L. Alan (Eds.), Challenges to globalization. University of Chicago Press, Chicago.

Organisation for Economic Co-operation and Development (OECD), 2002. Foreign Direct Investment for Development: maximising benefits, minimising costs. OECD, Paris.

Organisation for Economic Co-operation and Development (OECD), 2006. OECD Science, Technology and Industry Outlook. OECD, Paris.

Roeger, W. (1995), "Can Imperfect Competition Explain the Difference between Primal and Dual Productivity Measures? Estimate for U.S. Manufacturing", *Journal of Political Economy*, Vol. 103 (2), pp. 316-330.

Scherer, Frederic M., Ross, David R., 1990. Industrial market structure and economic performance. Third edition, Houghton Mifflin Company, Boston.

Tybout, James R., Roberts, Mark J., 1997. The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs. The American Economic Review, Vol. 87, pp. 545-564.

United Nations Conference on Trade and Development (UNCTAD), 1997. World Investment Report, 1997: Transnational Corporations, market structure and competition policy. UNCTAD, Geneva.

United Nations Conference on Trade and Development (UNCTAD), (2005), "World Investment Report, 2005: Transnational corporations and the internationalisation of R&D", UNCTAD, Geneva.

Van Cayseele, Patrick, Konings, Jozef, Warzynski, Frederic, 2005. The effects of privatisation and competitive pressure on firm's price-cost margins: Micro evidence from emerging economies. Review of Economics and Statistics. Vol. 87(1), pp. 124 - 134.

Veugelers, Reinhilde, Vanden, Houte P., 1990. Domestic R&D in the presence of multinational enterprises. International Journal of Industrial Organization, Vol. 8(1), pp. 1-15.

Vickers, John, 1997. Regulation, Competition, and the Structure of Prices. Oxford Review of Economic Policy. Vol. 13 (1), pp. 15-26.

Table 1. The number of foreign firms and the 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	3489	0.22	0.26	0.21	0.58	0.14
1999	3764	0.23	0.28	0.23	0.61	0.16
2000	4221	0.25	0.30	0.20	0.63	0.18
2001	4585	0.27	0.31	0.23	0.66	0.20
2002	5327	0.29	0.33	0.23	0.68	0.23
2003	6512	0.31	0.36	0.25	0.71	0.27
2004	8745	0.36	0.40	0.29	0.76	0.34

Table 2. Foreign firms, price cost margins, and R&D intensities, across 2-digit level industries in 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 & 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

Table 3. 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 (with 1 lag)	-0.002 [0.016]	-0.001 [0.009]	0.002 [0.008]	-0.000 [0.022]	-0.002 [0.011]	0.001 [0.010]
FDI penetration (with 2 lags)	-0.027* [0.015]	-0.031*** [0.009]	-0.023** [0.009]	-0.037** [0.018]	-0.038*** [0.010]	-0.032*** [0.010]
Herfindahl index (with 1 lag)	4.365*** [1.562]	2.585* [1.486]	2.239* [1.352]	3.068 [3.099]	1.727 [2.035]	1.622 [1.782]
FDI penetration X Herfindahl index (with 1 lag)	-	-	-	0.003 [0.070]	0.009 [0.037]	0.009 [0.032]
FDI penetration X Herfindahl index (with 2 lags)	-	-	-	0.055 [0.041]	0.035 [0.022]	0.048* [0.027]
Market Share	-0.192** [0.067]	-0.275*** [0.047]	-0.111*** [0.038]	-0.192** [0.064]	-0.276*** [0.050]	-0.110** [0.038]
Market share×market share	0.002** [0.0008]	0.003*** [0.0008]	0.001** [0.0005]	0.002** [0.0008]	0.003*** [0.0008]	0.001*** [0.0005]
Capital-labour ratio	2.946*** [0.544]	3.244*** [0.234]	3.187*** [0.195]	2.947*** [0.539]	3.243*** [0.234]	3.189*** [0.195]
Relative TFP	0.196*** [0.013]	0.208*** [0.015]	0.220*** [0.004]	0.197*** [0.013]	0.208*** [0.011]	0.220*** [0.004]
Export intensity	-0.022*** [0.005]	-0.017*** [0.005]	-0.002 [0.007]	-0.022*** [0.005]	-0.017*** [0.005]	-0.002 [0.007]
Ownership dummy (Private)	-	-1.050** [0.359]	-	-	-1.051** [0.359]	-
Ownership dummy (JV-HTM)	-	-0.880** [0.331]	-	-	-0.880** [0.330]	-
Ownership dummy (JV foreign & Foreign)	-	-1.691*** [0.418]	-	-	-1.689*** [0.418]	-
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	23123	23123	23123	23123	23123	23123

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

Table 4. 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 X Herfindahl index (with 1 lag)	-	-	-	0.023 [0.167]	0.021 [0.086]	0.020 [0.080]
FDI penetration X 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-labour 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	12891	12891	12891	12891	12891	12891

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

Table 5. Determinants of R&D intensity at the firm level 1998-2004

Variables	All firms		Domestic firms		FDI firms		High-tech firms		Non-high-tech firms	
	OLS	GMM	OLS	GMM	OLS	GMM	OLS	GMM	OLS	GMM
R&D intensity (with 1 lag)	0.198*** [0.074]	0.273*** [0.034]	0.316*** [0.046]	0.289*** [0.039]	0.098 [0.064]	0.204*** [0.038]	0.346*** [0.048]	0.387*** [0.064]	0.161** [0.074]	0.225*** [0.033]
PCM (with 1 lag)	-0.006* [0.003]	0.003 [0.004]	-0.006 [0.005]	0.003 [0.005]	-0.007 [0.005]	0.003 [0.004]	0.006 [0.006]	0.027** [0.012]	-0.009** [0.004]	-0.004 [0.003]
PCM X PCM (with 1 lag)	0.0001* [0.00007]	0.0000 [0.0001]	0.0001 [0.0001]	0.000 [0.000]	0.0001 [0.0001]	0.000 [0.000]	0.000 [0.000]	-0.0004** [0.0002]	0.0002* [0.0001]	0.000 [0.000]
FDI penetration (with 1 lag)	-0.0002 [0.0008]	0.001 [0.001]	-0.001 [0.002]	-0.003 [0.003]	0.0004 [0.0008]	0.001 [0.001]	0.003 [0.002]	-0.001 [0.004]	-0.001 [0.001]	0.002 [0.001]
Skill share	0.091*** [0.012]	0.069*** [0.011]	0.090*** [0.017]	0.069*** [0.013]	0.085*** [0.009]	0.070*** [0.008]	0.075*** [0.007]	0.090*** [0.019]	0.095*** [0.016]	0.062*** [0.012]
Export intensity	-0.0008* [0.0004]	0.0000 [0.001]	0.000 [0.001]	0.002 [0.002]	-0.002*** [0.0006]	-0.001 [0.001]	-0.001 [0.001]	-0.002 [0.003]	-0.0005 [0.0004]	0.001 [0.001]
Firm size	-0.059*** [0.019]	-0.156*** [0.054]	-0.063*** [0.024]	-0.177*** [0.067]	-0.069** [0.022]	-0.118** [0.061]	-0.131** [0.038]	-0.174 [0.135]	-0.041* [0.023]	-0.114** [0.054]
Ownership dummy (Private)	-0.091*** [0.032]	-0.149*** [0.038]	-0.041 [0.031]	-0.124** [0.051]	-	-	-0.126 [0.162]	-0.358* [0.215]	-0.083** [0.031]	-0.124*** [0.033]
Ownership dummy (JV-HTM)	-0.088** [0.044]	-0.103* [0.061]		-	-	-	-0.098 [0.141]	-0.121 [0.263]	-0.090** [0.045]	-0.152*** [0.058]
Ownership dummy (JV foreign & Foreign)	-0.077** [0.039]	-0.053 [0.062]		-	0.017 [0.028]	0.057** [0.029]	-0.033 [0.141]	0.023 [0.277]	-0.084** [0.041]	-0.125*** [0.057]
Year dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies		No	Yes	No	Yes	No	Yes	No	Yes	No
Regional dummies	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
R^2	0.28	--	0.33	--	0.22	--	0.40	--	0.23	--
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	39687	39687	22942	22942	16745	16745	4986	4986	34701	34701

APPENDIX

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 variable	
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

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 are number employees, and M is real material use. The α:s are shares of each factor in gross output, j denotes firms and i industries. We deflate output, capital and materials by the appropriate four-digit industry price deflator. Following Foster et. al. (1998) and Disney et. al. (2000), we calculate the factor shares at the four-digit industry level to minimize the effects of measurement errors.

Table A2. Classification of Large, Medium and Small Enterprises

	Large (1)	Medium (2)	Small (3)
Employment (Person)	2000+	300-2000	300-
Turnover (Million Yuan)	300+	30-300	30-
Fixed assets (Million Yuan)	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, Taiwan and Macau 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.