FDI, Market Structure and R&D Investments in China

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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 data set including all Chinese large and medium sized firms over the period 1998-2004. Our results show that FDI increase competition but there are no strong indications that competition affects investments in R&D.

Keywords: China, FDI, competition, R&D
JEL codes: J21, O14; O33

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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 above in 2020. Most R&D takes place 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 contributed substantially to production and export. Moreover, FDI to China is according to some reports going through a structural change away from simple manufacturing towards more technology intensive activities. For instance, China has become the 3rd most important offshore R&D location for multinational enterprises (MNEs) according to a survey by UNCTAD (2005).

This development notwithstanding, there is a concern in China that inflows of FDI are not benefiting technology development as positively as it benefits production and exports. It is for instance 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. To some extent, the recent emphasis on "indigenous innovation" and "indigenous capacity building" in the Chinese science and technology policy reflects an uncertain and even sceptical attitude towards FDI (MOST, 2006).

However, this argument suffers a neglect of how indigenous technology development is affected by FDI. Such an effect could arise if, for instance, domestic firms learn from foreign owned firms, a spillover effect. FDI might also affect the competitive pressure in the economy, which in turn could affect the amount of technology development in domestically-owned firms. Again, in the ongoing debate, much attention has been focused on the (direct) effect of FDI on technology development 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 domestically owned firms' R&D is not clear. Firstly 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, there are reasons to believe that inflows of foreign firms will increase the degree of competition in the local economy but it could also happen that successful foreign firms force local firms to exit the market with an increased industry concentration as a result. 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) examines 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 SOEs is ambiguous. Moreover, Jefferson et al. (2006) find a positive correlation between high industry concentration and R&D intensities.

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 large- and medium-sized Chinese manufacturing firms for the period 1998-2004. Our results suggest that FDI tend 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 and classifications in section 3. Using detailed aggregate industry-level descriptive statistics, we present some stylized facts in the Chinese manufacturing in section 4 and continue with our econometric models in section 5. Finally, the results are presented in section 6 and we conclude the paper in section 7.

2. CONCEPTUAL FRAMEWORK AND PREVIOUS STUDIES

The conceptual framework of FDI, market structure, and R&D investment is based on two strands of literature: the effect of FDI on the host country's market structure; and the effect of market structure and competition on firms' investment in R&D. In this section, we provide a brief overview of the theories and integrate these two strands of literature to set up a theoretical framework for our empirical analysis in a Chinese context.

2.1 FDI and market structure

The presence of foreign MNEs may exert a significant influence on the host country 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.

FDI may increase the number of firms in an industry, and thereby decrease concentration and increase competition in the market, in particular in industries with high start-up costs and high barriers to entry. Moreover, the entrance of foreign MNEs might positively affect 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.

On the other hand, FDI may also raise the level of concentration in the host country market. Foreign MNEs possess advantageous firm-specific assets and might therefore be able to capture the 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 is getting more concentrated. It is important to note that, in this case high concentration is associated with high intensity of competition.

Hence, FDI can both increase and decrease the level of concentration. Hence, the issue needs empirical analysis.

2.2 Market structure and R&D: replacement, selection & step-by-step innovation

The impact of market structure on innovation 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).

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

Derived from the classic Schumpeterian view of creative destruction, innovations are made by outsider firms who earn no rents if they fail to innovate and who obtain monopolistic power if they succeed in innovating. As a result, the market will be characterised by Arrow's replacement effect, i.e. outsider firms replacing incumbent monopolists who do not have the potential 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 monotonically decreasing and negative relationship between market competition and innovation.

In contract to the "replacement effect", the "selection effect "of market competition predicts a positive relation between competition and innovation, i.e. market competition may stimulate innovation, when firms with innovation advantages further strengthen their innovation 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 relation 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. Technology gap and substitutability of innovation are two important additional 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 firms have different levels of innovation capacity. In such industries, there are technically laggard firms who have to catch up with the leading-edge technology, before they can compete with their more technology advanced rivals. If there are weak competition in the market, followers may leapfrog and catch up with the technologically most advanced firms. If there is, on the other hand, a high degree of market competition, this will benefit leading firms at the technological frontier and increase their dominance.

As for the question of FDI and competition, theory gives us little guidance in making prediction on how competition is expected to affect 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.

2.3 An integrated framework in the Chinese context

Bringing the above two strands of framework together, it becomes clear that the impact of FDI on R&D activities is uncertain both because of the complexity of the effect of FDI on the market structure, and because of the effect of market structure on R&D. Again, FDI can be important in shaping the market structure, and consequently to influence (both foreign and domestic) firms' R&D investments. Firstly, based on the assumption that foreign MNEs possess more advanced technology, foreign entry can trigger a process of strategic restructuring when domestic firms update their obsolete machinery and outdated production methods through investments in R&D. Secondly, if a "catch-up" process is taking place in domestic firms, the technology gap between domestic and FDI firms can be narrowed. This will in turn impose a strong competitive pressure on foreign firms to innovate.

There are also instances where we expect a negative effect of FDI on R&D. The most apparent example is the classical Schumpeterian case. The incentives to innovate may be reduced in (both FDI and domestic) firms when market competition is intense and lead to low returns on innovations. Furthermore, foreign firms with large market power and with superior technology may replace domestic firms which were previously protected by regulations or entry barriers on foreign firms. If the technology gap between domestic and foreign firms is sufficiently large, the foreign firms do not have incentives to innovate, while domestic firms will not survive. There is then no room left for innovations. In these two cases, innovations will not increase at the aggregate level.

The bottom line is that the relation between FDI and innovation is complex, and depends on both changes in market structure and on the technology- and innovation gap between foreign and domestic firms. In the Chinese context, the step-by-step innovation model seems relevant. There is often a technological gap between foreign and domestic firms in China, which imply that the influence of competition on firms' innovation behaviour may be taking several steps, instead of being monotonically positive or negative.

Secondly, the degree of product market competition in the Chinese market needs to take in to account the degree of substitutability between products and not only look at the number of firms in an industry. It is common that domestic firms are not competing directly with foreign firms as they are located in the low-end market, while the foreign firms dominate the high-end market. In such cases, an increased number of firms may not necessarily induce higher competitive pressure, and in turn an impact on innovation activities.

2.4 Previous studies

The effects of FDI on the host country 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 in the host countries. One exception is Co (2001) who found both positive and negative effects of FDI on the market structure in the U.S., measured by price-cost margins, depending on market conditions and on the extent of spillovers. Chung (2001) comes to a similar conclusion and suggests that the degree of competitive pressure imposed by FDI depends on both the entry mode and on various investment traits. Moreover, Van Cayseele et al. (2005) find foreign MNEs to have high price-cost margins (high market power) compared to firms with domestic ownerships in Bulgaria and Romania.

Studies on the impact of FDI on domestic innovations and R&D are rare. One exception is the study by Veugelers and Vanden Houte (1990) on the Belgium manufacturing sector. They find domestic firms to have lower innovation intensities, the higher the share of FDI in the industry. It is not examined if this result depends on 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 study in various aspects. 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 effect of high industry concentration. However, the results are not robust when industry dummies are included in the estimations. Girma et al. (2006) find SOEs with foreign capital participation to have relatively high degrees of innovation activities. Innovations in SOEs without foreign

[2] See e.g. Görg and Greenaway (2004) and Lipsey (2002) for more detailed surveys.

capital participation can be both positively and negatively affected by FDI, depending on the absorptive capacity in these firms.

3. DATA AND CLASSIFICATIONS

Our data on large- and medium-sized manufacturing enterprises (LMEs) are compiled by the National Bureau of Statistics of China (NBS) and covers the period 1998-2004. The classification of LMEs follows the NBS' classification from 2000. In this new classification, employment, turnover and fixed capital are applied as a combined indictor for firm size and the detailed classification is given in 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 in our dataset is similar to the classification ISIC, REV. 3 and the detailed list of included sectors at the 2-digt industry-level can be found in Table 2. However, in our empirical analysis we construct industry-level variables such as industry concentration and FDI penetration at the 4-digit industry level in order to have industrial controls as disaggregated as possible.

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

[3] In order to make the comparison of market structure over time, we have re-classified the firms in 1998-1999 in our dataset according to the new classification and it is also why the number of firms at the industry level in our paper can differ from the officially published sources where the classifications of firm size are not the same for the periods prior to and after 2000.

4. DESCRIPTIVE STATISTICS

The FDI share in Chinese manufacturing between 1998 and 2004 is seen in Table 1. FDI is measured as wholly foreign owned firms or joint ventures between foreign and domestic firms. FDI has increased substantially in relative as well as in 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 of 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 story of a rapidly increasing importance of FDI, which account for about one third of employment, 40 percent of value added, and a staggering 76 percent of total export.

Turning our attention to the focus of our paper, R&D, it is interesting to note that the foreign share of R&D is relatively small. More precisely, the foreign share of R&D expenditures was 21 percent in 1998, which was for instance 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 increased modestly since, to about 29 percent in 2004, which is a lower figure than the foreign shares of all the other economic indicators in Table 1. One conclusion that can be drawn from the figures is that even if China is becoming increasingly attractive for foreign firms as a location of R&D, as suggested by for instance UNCTAD (2005), this trend is growing slower than the increase in foreign MNEs' production, employment and export.[4]

[4] It should be noted however, that our figures on foreign R&D might be underestimated since there are foreign firms who have set up R&D laboratories outside the manufacturing sector, for instance as independent research institutes.

We continue by looking at the foreign share of different sectors in Table 2. The absolute presence of FDI, in terms of number of 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 particular high importance in electronics and in furniture, where more than 50 percent of value added and 90 percent of export comes from FDI. Again, the FDI 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).

Considering the relative low foreign share of R&D, it comes as no surprise that R&D intensities are relatively low in FDI firms. Table 3 shows R&D intensities in Chinese firms of different ownerships in 1998 and 2004. R&D intensities are measured as the ratio of R&D expenditures to sales, and ownership is divided in different types of domestic and foreign ownership. SOEs have the highest R&D intensities in 1998 as well as in 2004. Private domestically owned firms have also a higher R&D intensity than foreign owned firms in both years. Finally, the R&D intensity differs between different types of FDI firms where joint ventures (with firms from Hong-Kong, Taiwan, and Macau or with firms from other countries) have higher R&D intensities than wholly foreign owned firms. This last result is rather surprising considering that firms typically want high levels of control (no joint-ventures) in activities such as technology development. Most likely, the result is affected by the Chinese policy of often requiring foreign firms to form joint-ventures and to perform R&D in order to be granted permission to locate in China.

5. ECONOMETRIC MODELS

5.1 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:[5]

$$PCM = \frac{\text{Re}venues - Variable\ \cos t}{\text{Re}venunes}$$

A high value on PCM means a large mark-up and presumably a low level of competition. Our measure on FDI is calculated as the share of sales by foreign firms in total domestic sales at the 4-digit industry level. Exports by foreign firms are excluded, since such exports do not impose a competitive pressure in the Chinese market. The baseline econometric model is specified as:

$$PCM_{jt} = \alpha + FDI_{i,t-n} + \delta Firm_{jt} + \rho H_{i,t-n} + \omega OWNER_{w} + \lambda_1 DT_t + \lambda_2 DIND_i + \lambda_3 D\,\text{Re}\,gion_r + \varepsilon_{jt} \quad (1)$$

where

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

[5] Van Cayseele et al. (2005) apply an alternative methodology developed by Roeger (1995). The need to impose a constraint that the 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.

$FDI_{i,t-n}$: 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 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) . More detailed definitions of the variables are presented in Table A1 in the appendix.

In the above specification, FDI and the Herfindahl index are two industry-level variables to measure the effect of market structure on the PCM. The key hypothesis is that high concentration tends to raise market power. Moreover, FDI may have a negative or a 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 reflect only low competition in the market but may also be associated with higher efficiency in the firm. In order to control for such efficiency effect, we include a firm's TFP relative to the 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 Robert and Tybout (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.

5.2 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:

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

Where

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

$Firm_{jt}$: a vector of firm-level control variables such as share of S&T personnel in total employment, export share, and firm size.

An important methodological issue when estimating such model is the treatment of the time persistency in firms' R&D investment behaviour. We therefore include lagged R&D 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". We therefore follow standard approaches and, in addition to OLS, use system GMM estimates developed by Arellano and Bover (1995) and Blundell and Bond (1998) which implies that *RDINT* and any other similarly endogenous variables are instrumented. The system uses first differenced and level versions of the estimating equation, where in the former lagged values, and in the latter lagged differences can serve as valid instruments. The differentiated transformed instruments are assumed to be uncorrelated with the unobserved fixed-effects, implying that first differentiated variables can act as instruments for variables in levels, i.e. instrumenting levels with differences.

The joint validity of the instruments will be tested with the Sargan/Hansen test. In addition, the validity of the instruments depends on the assumption that there is no second order correlation of the residuals in the first-differenced equation. Arellano and Bond (1991) develop a test for the autocorrelation in the idiosyncratic disturbance term e_{it} that would render some lags as invalid instruments.

6. RESULTS

6.1 The effect of FDI on price cost margins

We start by estimating the effect of FDI on PCM in the whole sample of firms and the results are shown in Table 4. A number of different estimators are used: OLS with and without industry and regional dummies, and 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.

Our first estimation shows that FDI has a negative impact on the price cost margin but that there is a time lag before the competition from FDI firms are having 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 column 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, compared to the reference group of SOEs and collective firms, both domestic private firms and foreign-owned firms have lower PCM. It can be due to both market-related and to 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 control for the robustness of the results, and to examine if 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 Column (4)-(6), the negative effect of FDI on PCM remains robust and an 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 higher concentration.

Our main interest is to examine how FDI affects competition for domestically-owned firms. We therefore repeat the estimations above but excluding foreign-owned firms and joint-ventures. The results are shown in Table 5.[6] The estimations yield fairly similar results, but with two differences in comparison to the full-sample estimations in

[6] 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 it had little impact on the results (not shown).

Table 4. Firstly, the negative effect of export intensities on the price cost margin disappears. Secondly, domestic firms in concentrated industries do not have comparably high price cost margins. The results are, again, robust to inclusion of interaction variables as seen in column 4-6 and to changes in the lag structure (not shown).

We did also experiment with alternative estimation methods. For instance, we tried to specify a dynamic model with lagged PCM as independent variable. The results remained robust but the models did typically not pass the Sargan/Hansen specification tests because of the large number of included industry- and regional dummies and are therefore not shown.

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

6.2 The effect of price cost margins on R&D intensities

The results from our OLS and GMM estimations are shown in Table 6. Most results are stable across estimation approaches and samples. Most importantly, there are little 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 FDI firms show insignificant effects in 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.[7] Note, that this result is only significant in the GMM estimation and not in the OLS.

We also include 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 show consistently that no such effect 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.[8] Regarding other firm-level control variables, we observe a significant and positive effect of the skill-share but a significant and negative effect of firm size on the R&D intensity.[9] 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 much affected by foreign firms or by the industry level of competition. We examined this issue by only including firms that have positive R&D

[7] 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.

[8] We have 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 the first lag remained significant (not shown).

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

expenditures in at least one year of their existence. Again, the results remained unchanged (not shown). Hence, we conclude by noting that the effect of firms' price cost margins on R&D intensities seem to be insignificant and robust across samples and estimation methods.

7. 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 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 much to Chinese technology development. 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 suggest that FDI do increase the level of competition in Chinese manufacturing. We do also find robust positive effects on price cost margins from high efficiency (TFP) and from 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 labor force, are relatively small in size, and SOEs are more R&D intensive than are domestic and foreign private firms.

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

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Table 1. The importance of FDI in the Chinese manufacturing sector 1998-2004
(Share of total manufacturing)

Year	Number of FDI firms	Share of number of LMEs	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. The importance of FDI across 2-digit level industries in 2004
(Share of total manufacturing)

		Number of FDI firms	Share of number of LMEs	Value-added	R&D expenditure	Export	Employment
13	Processing food from agriculture	252	0.28	0.38	0.08	0.50	0.30
14	Production, processing of food	214	0.37	0.43	0.29	0.39	0.32
15	Beverage	191	0.35	0.39	0.43	0.38	0.27
17	Textiles	776	0.32	0.28	0.32	0.47	0.24
18	Wearing apparels	483	0.58	0.45	0.15	0.60	0.56
19	Leather, footwear	376	0.70	0.67	0.50	0.85	0.78
20	Wood, timber, bamboo products	79	0.39	0.33	0.11	0.51	0.29
21	Manufacture of furniture	184	0.70	0.82	0.82	0.90	0.77
22	Pulp and paper	180	0.30	0.43	0.38	0.86	0.29
23	Publishing, print	110	0.37	0.46	0.37	0.90	0.40
24	Musical instruments, sport goods	257	0.76	0.69	0.54	0.78	0.80
25	Refined petroleum products	27	0.07	0.09	0.07	0.46	0.08
26	Basic chemicals	220	0.13	0.21	0.15	0.33	0.10
27	Pharmaceuticals, medicinal chemistry	158	0.21	0.23	0.22	0.21	0.16
28	Manufacture of chemical fiber	58	0.26	0.31	0.18	0.37	0.19
29	Rubber products	173	0.48	0.46	0.23	0.63	0.48
30	Plastics products	454	0.63	0.55	0.28	0.86	0.65
31	Non-metallic mineral products	322	0.18	0.23	0.26	0.52	0.15
32	Ferrous metals	114	0.12	0.11	0.04	0.10	0.07
33	Non-ferrous metals	98	0.18	0.16	0.25	0.26	0.09
34	Metal product	331	0.41	0.50	0.21	0.80	0.40
35	Machinery, general	383	0.23	0.34	0.24	0.60	0.20
36	Machinery, special purpose	215	0.22	0.24	0.13	0.65	0.19
37	Transport equipment	437	0.26	0.46	0.32	0.47	0.22
39	Electrical machinery & apparatus	795	0.45	0.43	0.23	0.71	0.48
40	Computer, communication	1445	0.75	0.86	0.49	0.96	0.77
41	Office machinery, measuring instrument	221	0.57	0.82	0.42	0.96	0.61
42	Manufacture n. e. c	186	0.55	0.45	0.07	0.64	0.50

Table 3. The comparison of S&T- and R&D intensities across ownerships, 1998 and 2004

	Domestic firms			**FDI firms**		
	SOE	**Collective**	**Private**	**JV-KTM**	**JV-foreign**	**Foreign**
Average R&D intensity in 1998	0.006	0.002	0.004	0.001	0.004	0.000
Average R&D intensity in 2004	0.013	0.004	0.009	0.004	0.006	0.003

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 (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 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 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

Table 6. Determinants of R&D intensity at the firm level 1998-2004

	All firms		Domestic firms		FDI firms		High-tech firms		Non-high-tech firms	
Variables	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	(Revenue –variable cost) /Revenue
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 and L are number employees, and *M* is real material use. The α:s are shares of each factor in gross output and *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 4-digit industry level to minimize the effects of measurements 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.