What determines innovation activity in Chinese State-owned enterprises?

The role of foreign direct investment

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Abstract

We investigate whether inward FDI, either at the firm or industry level, has any impact on product innovation by Chinese State owned enterprises (SOEs). We use a comprehensive firm level panel data set of some 20,000 SOEs covering the period 1999 to 2005. Our results show that foreign capital participation is associated with higher innovative activity. Inward FDI in the sector has a negative effect on innovative activity in SOEs. However, there is a positive effect of FDI on SOEs that export, invest in human capital or R&D. We also find that SOEs with *internal* R&D activity and human capital development are successful innovators. Hence, our results suggest that rather than relying on sector level inward FDI to improve domestic innovative activity, it is important to get the firm-level fundamentals right.

JEL Classification: F23, O31

Keywords: Innovation, FDI, state owned enterprises, spillovers, competition, China

Acknowledgements: The authors are grateful to three anonymous referees and the guest editors for helpful comments on an earlier draft. Holger Görg gratefully acknowledges financial support from the Leverhulme Trust (Programme Grant F114/BF). Sourafel Girma is grateful to the ESRC for financial support under its "National and international aspects of financial development" programme.

I. Introduction

China has undergone dramatic economic changes since it started its economic reforms in 1979. Indeed, it has now emerged as a rapidly growing manufacturing base and exporting nation; an issue that has stirred much recent debate in the popular press as well as among academics. The process of opening up the Chinese economy has received a further boost since its accession to the World Trade Organisation (WTO) in 2001.

Economic reforms have had particular implications for Chinese State-owned enterprises (SOEs). From being the by far dominant form of enterprise in pre-reform China their importance has declined rapidly over the last two decades. For example, as Bajona and Chu (2004) show, the share of output produced by SOEs decreased from 78 percent in 1978 to 28 percent in 1999. Also, the SOE sector was shown to have been making net losses since the late 1990s. Still, the welfare of tens of millions of urban workers, the efficiency of the domestic banking sector and the generation of adequate state revenues all depend to a large extent on the success of SOEs. Given this development, a number of economists argue that without state subsidies, protection and easy access to bank credits, the majority of SOEs would be on the verge of collapse (e.g. Lin et al. 1998). Hence, reforming SOEs in order to make them efficient to compete successfully on domestic and international markets is of utmost importance for sustained growth of the Chinese economy in particular in the light of the necessary adjustment of domestic policy to WTO rules.

One way of improving efficiency and competitiveness in a firm is through innovative activity.[1] Innovation allows firms to develop new processes to produce existing goods more efficiently or indeed develop new products (or differentiate existing ones) that

[1] Of course, alternative responses at the firm level may be to reduce costs at given levels of output and technology ("downsizing"), or to shut down completely. We do not consider these issues here but focus on innovative activity in SOEs.

allows it to expand sales and improve market performance. These two innovation activities are generally referred to as process and product innovation. We concern ourselves with the latter of these, product innovation. Specifically, our research question is to examine the role of firm level characteristics as well as inward foreign direct investment (FDI) for SOEs innovative activity.[2]

FDI can affect SOEs' activities in two ways. Firstly, directly at the level of the firm through injections of foreign capital, e.g., through acquisitions or joint ventures. In this case, our working assumption is that foreign capital participation at the firm level may bring with it transfer of knowledge from the foreign parent company which should stimulate innovation activity. Alternatively, even without knowledge transfer a capital inflow may reduce financial constraints and hence improve innovation. Secondly, FDI at the level of the industry can impact on SOEs innovation activity through potential competitive effects or spillovers. Competition from foreign multinationals can either stimulate domestic innovative activity or the effect can turn out to be negative, similar to the ideas discussed recently by Aghion et al. (2005). Furthermore, knowledge spillovers can have positive effects on innovative activity of SOEs.[3]

To investigate these issues we use a rich panel data set of some 20000 state-owned enterprises (SOEs) in manufacturing industries for the period 1999 to 2005. We estimate an empirical model of SOEs product innovation activity where we take explicit account of endogeneity of regressors and allow for heterogeneous FDI effects. Our results show that inward FDI at the sector level impacts negatively on the innovative activity of SOEs. We also find that SOEs with foreign capital participation innovate more than other SOEs.

[2] Our paper is thus related to the study by Hu et al. (2005) who investigate the impact of domestic and foreign R&D, and foreign direct investment on productivity of Chinese large and medium sized enterprises.

[3] This latter argument is similar to that made in the literature on "productivity spillovers" (e.g., Görg and Greenaway, 2004) that argues that domestic firms can "learn" from multinationals, e.g., through input-output linkages, demonstration effects or movement of workers.

Taking account of firm level heterogeneity we find that there is a positive effect of sector level FDI on SOEs which are R&D active, engage in labour training or are exporters.

The remainder of the paper is structured as follows. Section II provides a brief overview of the development of inward FDI in China. Section III describes the empirical approach, while Section IV introduces the data set and provides some summary statistics. Econometric results are discussed in Section V and Section VI concludes.

II. An overview of FDI in China

To motivate the empirical analysis, this section provides a brief overview of the trends of FDI flows into China over the past two and half decades.[4] When the Chinese government initiated economic reforms in the late 1970s, FDI was only allowed in four designated Special Economic Zones (SEZs)[5] and foreign investors were required to have local partners. However by 1986 the government started to implement further policies to attract FDI. Wholly foreign-owned enterprises were allowed for the first time, and export-oriented joint ventures and those employing advanced technology were encouraged through the provision of tax benefits.

As Figure 1 shows the various policies that are designed to attract FDI appear to have paid off. From nearly zero in 1979, the annual flow of FDI into China reached US$ 53.51 billion in 2003, leaving China to be ranked top FDI destination worldwide. The surge of FDI after 1992 had been mainly attributed to a wave of new policies of further economic liberalisation. Foreign investors were offered better opportunities to sell their products in

[4] Some of the material in this section draws on Chen (1996, 1997), Lemoine (2000) and Wei (2003).
[5] The SEZs consisted of three in Guangdong province (Shenzhen, Zhuhai and Shantou) and Xiamen in Fujian Province .

the domestic market and allowed to invest into hitherto restricted sectors such as retail trade and finance.[6]

[Figure 1 here]

A noteworthy feature of FDI in China is that it is characterised by a very uneven regional distribution. During the period 1987-2000, about 87% of cumulative FDI was located in the coastal regions (Wei, 2003). This is a reflection of the initial policy that restricted FDI to coastal regions and the proximity of those regions to Hong Kong and Taiwan, the main sources of foreign investment, especially at the initial stages of the economic reforms. Although western and central regions (where SOEs have significant presence) have started to gradually attract more and foreign investors, the skewed distribution of FDI in favour of the eastern coastal regions has raised serious concerns that FDI might exacerbate existing regional disparities.

Given the huge potential of the Chinese market, it is perhaps surprising that only few countries are the major sources of inward investment. Between 1979 and 1991, Hong Kong accounted for nearly two-thirds of total FDI. Most of the investment from Hong Kong is export-oriented and concentrated in labour intensive sectors. During the same period, the share of Japanese and US FDI was 14% and 10% respectively. During the period 1992 to 1998, the average share of FDI from the US has declined to 8% and inward investment from the European Union countries accounted for less than 7% of total FDI. In general, FDI from OECD countries tends to be directed to more capital-intensive sectors and is predominantly motivated by the desire to access the huge domestic market.

III. Empirical approach

[6] However, it is worth noting that the devaluation of the Rembini also played an important part in the surge of FDI during this period.

Why would one expect the increased influx of FDI to have had any effect on product innovation carried out by State-owned enterprises? Firstly, the influx of foreign capital can alleviate financial constraints that may hinder innovation. In addition, foreign capital participation in an SOE may bring with it an inflow of technology. After all, in standard models of multinational enterprises (MNEs) they are assumed to have a "superior technology" compared to domestic firms (Markusen, 2002). Hence, a foreign capital inflow through an acquisition, joint venture or some other form of capital transfer may lead to the installation of the foreign technology in the SOE. Both of these processes could manifest themselves in increasing innovative activity. However, as multinationals generally undertake their innovative activity in the headquarters large inflows of foreign capital may actually be expected to reduce innovative activity, as these functions may be redirected to the parent company's home country.

At the level of the industry, the superior knowledge brought into the economy through FDI may leak to domestic firms through, e.g., worker movements, imitation etc, similar to the arguments made in the literature on productivity spillovers (e.g., Görg and Greenaway, 2004). If domestic firms learn the better technology from MNEs then this may also lead to more innovation activity in the SOEs affected.

In addition to being potential generators of spillovers, multinationals will also affect the competitive landscape in the domestic economy, leading to an increase in competition for domestic firms. It is well known that competition affects innovative activity (e.g., Geroski, 1995, Blundell et al., 1999, Aghion et al., 2005) and we may therefore expect that an increasing influx of FDI will, through changes in competition, also impact on domestic innovative activity. Aghion et al. (2005) argue theoretically and provide evidence that increasing competition is expected to discourage laggard firms from innovating, but may stimulate innovative activity in firms that are neck-on-neck in terms of technology with

their competitors. Hence, the effect of FDI may depend on the "quality" of domestic firms: if they were laggards relative to multinationals then we would expect a negative competition effect. If, however, they are close to their multinational competitors we would expect increasing levels of FDI to stimulate innovation in domestic firms.

In order to investigate the impact of FDI on SOEs' innovative activity, we specify a production function which relates the (logged) value of output involving new process or product innovation for firm i in year t, y_{it}, to a number of covariates in the following way:

$$y_{it} = \alpha + \beta_0 y_{i,t-1} + \beta_1 k_{it} + \beta_2 l_{it} + \beta_3 X_{i,t} + \beta_4 FDI_{i,t} + \tau_t + \eta_i + \varepsilon_{j,t} \qquad (1)$$

where l and k are measures of (logged) labour and capital inputs (as in a standard production function), X is a vector of control variables respectively and FDI is a vector of industry and firm level measures of foreign direct investment (see data section below for more detail). We also allow for persistence in innovation activity by specifying a dynamic production function including the lagged value of y as regressor. Moreover, τ_t, η_{it}, and ε_{it} are time specific effects, firm specific time invariant effects, and an i.i.d. error term.

The vector X consists of determinants of innovation which includes exporting intensity, R&D intensity, age, the level of training expenditure per employee and an index of three-digit industry concentration. The choice of these firm level covariates is guided by theoretical considerations as well as existing empirical evidence (e.g. Crepon et al., 1998, Blundell et al., 1999, Jefferson and Bai, 2004, Aghion et al., 2005).

One should note that simply using OLS to estimate (1) is likely to prove problematic. In order to take account of such potential endogeneity while also controlling for plant specific fixed effects, we thus resort to using the now popular GMM systems estimator developed by Blundell and Bond (1998). Accordingly, one simultaneously estimates first differenced and level versions of equation (1), where for the former appropriately lagged values and for the latter appropriately lagged differences of the endogenous variables can

serve as valid instruments. The validity of these instruments can be tested using Arellano and Bond's (1991) Sargan test. Since the consistency of the estimates also rests on the non-existence of second order serial correlation in the error term, we also test for this in all estimated models.

IV. Database description and variable construction

Our econometric analysis draws on the Annual Report of Industrial Enterprise Statistics compiled by the State Statistical Bureau of China (SSB). The report covers the population of state-owned enterprises and all non-state firms with annual turnover of over five million Renminbi (just above $600,000). It is estimated that the firms contained in the data set account for about 85-90% of total output in most industries. The Statistical Bureau performs several logic tests to ensure the accuracy of the information in the report and identify illogical data.[7]

The data set includes information on firm ownership structure, industry affiliation, geographic location, establishment year, employment, gross output, sales, R&D, value added, net fixed assets, exports, R&D and employee training expenditures[8]. The data set available to us spans the period 1999 to 2005, and comprises of more than 1.3 million observations from about 446,000 firms.

Interestingly, the data set provides information on the extent of foreign capital participation (distinguished between Chinese Diaspora and other foreign sources) at the level of the firm. This enables us to calculate the share of foreign ownership in the domestic enterprise and identify the direct effects of FDI on SOE performance.

[7] Different versions (in terms of coverage) of this data set are used by academics (e.g. Hu et al, 2005 and Jefferson et al. 2006).
[8] Nominal values are deflated using industry-specific ex-factory price indices obtained from China Statistical Yearbook 2006.

It is worth noting that we used the whole sample to construct various variables of interest (e.g. share of foreign firms in an industry-region or the Herfindhal index of market concentration). However, the econometric work is confined to state-owned enterprises, in view of the objective of this paper. The SSB assigns to each firm in the database a categorical variable indicating ownership status. Nevertheless, it is also possible to construct a continuous measure of ownership composition from the database by looking at the fraction of paid-in capital contributed by the state and private and foreign investors. Using this measure of ownership, we define a firm as being state-owned if the state is the majority investor in the firm.

Another feature of the database is that it maintains a unique enterprise, identifier irrespective of the dynamics of ownership change. This feature is useful when it comes to distinguishing between SOEs that are liquidated and those that are transferred to non-state hands. Accordingly, we identified more than 45000 SOEs at the start of the sample period (i.e.1999), and by the end of the sample period (2005), less than 8000 of these were still under majority state ownership. However only 20761 firms (67149 observations) have the necessary time series information for the dynamic panel data GMM estimations of the product innovation model.

The degree of horizontal (i.e. intra-industry) FDI, say $HRFDI_{jrt}$, in each of the 171 three-digit industries and 31 provinces is constructed as the proportion of output accounted for by multinational companies in the industry and region. To gauge the extent of backward linkages (spillovers received by domestic firms in upstream sectors), the backward measure of FDI for region r and industry j at time t is computed as in Smarzynska-Javorcik (2004). That is

$$BRFDI_{jrt} = \sum_{\forall k \neq j} \alpha_{kj} HRFDI_{krt} \qquad (2)$$

where α_{kj} is the proportion of sector *j*'s output supplied to industry *k*. The greater the proportion of output supplied to an industry with foreign multinational presence, the greater the degree of linkages between foreign and local firms. We refer to this FDI as *downstream FDI*.

Similarly, an index of FDI in upstream sectors is calculated as

$$FRFDI_{jrt} = \sum_{\forall k \neq j} \beta_{kj} HRFDI_{krt} \qquad (3)$$

where β_{kj} represents the proportion of sector *k*'s output supplied to industry *j*. This measure of *upstream FDI* captures the extent of local firms' forward linkages in downstream sectors with MNEs in upstream sectors. The information to construct the backward and forward linkage indices is obtained from the 1997 Input-Output Table of China published by the State Statistical Bureau. Each of the three FDI indices, viz. horizontal, downstream and upstream FDI, is further distinguished by its source, i.e. whether it is from foreign MNEs or the Chinese Diaspora.[9]

Table 1 gives the definition of the variables used in the analysis along with some summary statistics. In Table 2, we report the pattern of product innovation development between 1999 and 2005 for SOEs across the two-digit industries.

[Tables 1 and 2 here]

V. Discussion of the results

[9] Our FDI variables are defined using data on foreign owned multinationals only, which are those firms with at least 25 percent foreign ownership. However, there are domestically-owned enterprises which have foreign capital participation of less than 25 percent which are not considered in this definition. Our argument for doing so is that while these firms benefit from foreign capital participation in terms of innovation (as shown in our estimations) there may be less potential for spillovers from them as foreign owners are unlikely to transfer the best technology. This is in line with the evidence by Javorcik and Spatareanu (2003) who find that foreign MNEs tend to transfer more technology to their wholly-owned projects than to those owned partially.

Table 3 presents the estimations of the benchmark models. In all specifications, the Sargan test confirms the validity of the instrumental variables and the serial correlation test shows the absence of a second order serial correlation in the models.

The estimates suggest that R&D intensity exerts a positive and significant influence on the rate of product innovation. This is reassuring given that R&D intensity is a major input in the product innovation process. We also find that SOEs that invest in employee training have a higher propensity to innovate. This suggests that there may be complementarity between human capital investment and innovation as discussed by, for example, Redding (1996). In addition, firms that are operating in more concentrated industries are more likely to engage in product innovation activity.

We also find that older firms are more likely to engage in product innovation than their younger counterparts.[10] This is consistent with the idea that older SOEs might be realising that their survival depends on the constant upgrading of their productive capabilities and changing their existing way of doing things. We also find a positive relationship between product innovation and exporting intensity. This accords with Kraay (1999)'s view that amongst Chinese enterprises exporting is an indicator of superior performance.[11]

More closely related to the central issue of our paper, we find evidence that SOEs with some foreign capital participation are more likely to engage in product innovation. We, however, also find that the relationship between foreign capital participation and innovation is concave. This suggests that foreign capital participation increases innovation up to a critical value, after which the marginal effect of changes in foreign capital on

[10] This appears to be somewhat in contrast with Jefferson and Bai (2004) who find no statistically significant relationship between age and innovation in their analysis of a smaller sample of Chinese firms. . However since our study considers a more heterogeneous and older group of firms (i.e. SOEs) and excludes non-state enterprises, the results are not strictly speaking comparable, even ignoring differences in sample size, specification and methodology.

[11] However Eckaus (2004) argues that there exists a strong correlation between subsidies received by loss-making SOEs and their export performance. This would appear to indicate that exporting amongst Chinese SOEs is not necessarily an indicator of superior performance.

innovative activity starts to decline. This probably reflects the fact that generally multinationals undertake their innovative activity in their headquarters (Markusen, 2002). Hence, while some foreign capital participation may bring with it knowledge transfer which initially increases innovative activity, further increases in the foreign ownership share may lead to innovation activity being relocated to the parent of the foreign owner abroad. However, according to the point estimates presented in column (1) of Table 3, the implied optimal value for foreign capital participation is about 61% (for foreign) and 54% (for Diaspora) respectively, well above the sample maximum of 25%.[12]

Turning our attention to the spillover effects of FDI, it is evident from Table 3 that the nature and extent of these vary according to the type of FDI under consideration. Specifically, we do not find any statistically significant effects from backward or forward linkages between multinationals and domestic firms. We also do not find any significant statistical association between domestic innovation and FDI outside the SOE's region, suggesting limited linkages across regions.

In contrast, we find strong negative effects of horizontal Diaspora FDI on innovative activity. This suggests that the competition effect is important. However, we also find moderate positive spillovers from foreign MNEs, which are generally more technologically advanced than Diaspora MNE, suggesting that for the average SOE, the competition effect resulting from foreign MNEs is more than compensated by technological externalities from those firms.

However, an important lesson that can be drawn from the literature on FDI spillovers is that average effects are seldom representative, and the incidence of positive spillovers from MNEs to indigenous enterprises is a function of the characteristics of the latter. For example, Girma (2005) argues and provides evidence for the United Kingdom

[12] This indicates that innovative activity decreases once the firm is nearly majority-foreign owned, which is in line with our argument. Recall that once foreign participation exceeds 25% the firm is no longer classified as a domestically-owned SOE but as a foreign multinational.

that the extent of FDI spillovers is a function of domestic firms' ability to absorb technology.

[Table 3 here]

Accordingly, we explore the role of absorptive capacity in the present setting by interacting the FDI variables with alternative indicators of firm learning and competitive capabilities. Throughout, we work with a parsimonious model which excludes the vertical indices of FDI, as these were found to be jointly insignificant in our benchmark model.[13] The indicators of absorptive capacity include past experience in R&D activity, labour training and exporting. As shown in Table 3, SOEs with more R&D, labour training expenditure and exports are more likely to innovate. Hence, they may be better able to increase their innovative activity in the presence of increasing competition from FDI.

The results show that, controlling for absorptive capacity, we find strong unconditional negative effects of horizontal foreign presence (both Diaspora and foreign MNEs) on innovative activity of domestic SOEs. However, allowing for different coefficients of these variables conditional on the various indicators of absorptive capacity, we establish that there are statistically significant positive effects from horizontal foreign presence on the innovative activity by SOEs.

This can be interpreted in two ways: either, there are indeed positive knowledge spillovers from foreign multinationals to these types of firms, or the increase in competition stimulates innovative activity a la Aghion et al. (2005), indicating that these firms are "neck-on-neck" with foreign multinationals in their industry. Either way, policy makers involved in the reform of SOEs should ensure that managers have the right incentives to make long-term investments in absorptive capacity development, rather than rely on unconditional and uniformly distributed spillovers from multinationals.

[13] A test of the joint significance of the vertical FDI and outside region FDI variables in the benchmark model shows that these variables are jointly statistically insignificant. The p-value of the test statistics for vertical FDI = 0.719 and for outside region FDI = 0.801.

[Table 4 here]

Policy discussion:

To put our results into perspective, recent evidence from other countries suggests that inter-industry linkages can play important roles as vehicles of positive FDI spillovers in developing and developed economies (e.g. Smarzynska-Javorcik, 2004, Kugler, 2006, Girma et al., 2007). Furthermore, a case study undertaken by scholars from China and the US provides a fascinating and detailed account of successful inter-industry linkages arising from Coca Cola's investment in China.[14] The report estimates that every job created directly by Coca Cola has resulted in thirty additional jobs through upstream and downstream linkages. Our findings that FDI linkages are not key to SOEs' innovation performance must therefore be disappointing from policy makers' perspective.

However the fact that foreign capital participation at the level of the firm enhanced innovation, suggests that policy should encourage more MNEs and domestic entrepreneurs to acquire underperforming SOEs, or at least invest some capital in them. Naturally, the best SOEs would have no difficulty in attracting foreign takeover bids. The policy challenge is to get foreign investors interested in under-performing SOEs.

An important policy lesson that can be drawn from our analysis is that the incidence of positive spillovers from FDI to SOEs is neither automatic nor unconditional: it is contingent upon the action of those enterprises. An important policy challenge in this respect would be to ensure that the managers of SOEs have the right organisational and incentive structures to invest in long-term absorptive capacity development.

VI. Conclusions

[14] "Economic Impact of the Coca Cola System in China, August 2000". Accessed on 12/12/2004 at http://mooreschool.sc.edu/export/sites/default/moore/research/presentstudy/Coca-Cola/China/china.full.aug.pdf

This paper investigates whether inward FDI, at the level of the firm and industry, has any impact on the rate of product innovation by the Chinese State owned enterprises (SOEs). To do so we use a rich firm level panel data set of some 20,000 SOEs covering the period 1999 to 2005. Our results show that that foreign capital participation in an SOE is associated with higher innovative activity. Inward FDI in the sector has a negative effect on innovative activity in SOEs. However, there is a positive effect of FDI on SOEs that export, invest in human capital or have prior innovation R&D experience.

We can interpret our findings in terms of the ideas developed by Aghion et al. (2005) on the role of competition for innovation. Poorly performing SOEs may be "laggards" and hence their innovative activity is discouraged due to increasing competition through FDI. By contrast, Chinese SOEs with higher level of absorptive capacity may be "neck-on-neck" with foreign multinationals and, hence, their innovative activities are stimulated. This points to the conclusion that, rather than just relying on unconditional FDI spillovers to improve domestic innovative activity, policy makers should focus more on getting the firm-level fundamentals right.

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Table 1
Variables definition and summary statistics

Variable	Definition	Mean	Std. dev
Product innovation	Log of output involving new process or product innovation	1.258	3.242
Employment	Log of total number of employees	5.168	1.497
Capital	Log of fixed assts used in production	8.980	2.052
R&D	R&D expenditure divided by sales	0.003	0.130
Labour training	Employee training expenditure per employee	0.003	0.071
Export intensity	Share of exports in total sales	0.054	0.182
Industry concentration	Herfindhal index of three-digit industry concentration	0.147	0.174
Age	Log year since establishment	41.534	154.686
Foreign capital	Share of foreign multinationals' capital in firm's total capital	0.013	0.076
Diaspora capital	Share of capital in firm's total capital coming from the Chinese Diaspora in Hong Kong, Taiwan and Macau.	0.012	0.075
Foreign horizontal FDI	The share of foreign multinationals' sales in three digit industry-region total sales	0.101	0.177
Diaspora horizontal FDI	The share of Diaspora's foreign multinationals' sales in three digit industry-region total sales	0.113	0.169
Foreign backward FDI	An index foreign MNEs' FDI in downstream industries (see Equation 2).	0.001	0.002
Diaspora backward FDI	An index of Diaspora FDI in downstream industries (see Equation 2).	0.001	0.008
Foreign backward FDI	An index of foreign MNEs FDI in upstream industries (see Equation 3)	0.002	0.005
Diaspora backward FDI	An index of Diaspora FDI in upstream industries (see Equation 3).	0.001	0.005
Foreign FDI outside region	The average share of foreign multinationals' sales in three digit industry total sales, outside the SOE region	0.121	0.221
Diaspora FDI outside region	The average share of Diaspora's foreign multinationals' sales in three digit industry total sales, outside the SOE region.	0.134	0.188
Number of firms	20761		
Total observations	67149		

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Table 2:
Sectoral and temporal pattern of product innovation for SOEs

	Fraction of innovators		New product sales/total sales	
Two-digit industry classification	1999	2005	1999	2005
13-Food Processing	0.020	0.101	0.323	0.166
14-Food Production	0.043	0.116	0.292	0.239
15-Beverage Industry	0.060	0.120	0.272	0.251
16-Tobacco Processing	0.123	0.211	0.149	0.152
17-Textile Industry	0.173	0.172	0.307	0.296
18-Garments and Other Fibre Products	0.035	0.065	0.450	0.453
19-Leather, Furs, Down and Related Products	0.041	0.081	0.494	0.397
20-Timber Processing	0.028	0.068	0.462	0.230
21-Furniture Manufacturing	0.042	0.100	0.360	0.214
22-Papermaking and Paper Products	0.040	0.072	0.371	0.190
23-Printing and Record Medium Reproduction	0.018	0.059	0.375	0.350
24-Cultural, Educational and Sports Goods	0.094	0.092	0.335	0.389
25-Petroleum Refining and Coking	0.050	0.064	0.289	0.209
26-Raw Chemical Materials and Chemical Products	0.092	0.107	0.313	0.332
27-Medical and Pharmaceutical Products	0.204	0.252	0.358	0.372
28-Chemical Fibre	0.140	0.104	0.267	0.394
29-Rubber Products	0.102	0.098	0.320	0.305
30-Plastic Products	0.091	0.102	0.382	0.339
31-Nonmetal Mineral Products	0.037	0.107	0.381	0.230
32-Smelting and Pressing of Ferrous Metals	0.058	0.069	0.296	0.248
33-Smelting and Pressing of Nonferrous Metals	0.060	0.097	0.329	0.335
34-Metal Products	0.061	0.079	0.334	0.311
35-Ordinary Machinery	0.142	0.132	0.295	0.320
36-Special Purposes Equipment	0.178	0.172	0.348	0.373
37-Transport Equipment	0.141	0.155	0.355	0.347
39-Other Electronic Equipment	0.148	0.140	0.361	0.418
40-Electric Equipment and Machinery	0.268	0.232	0.476	0.533
41-Electronic and Telecommunications	0.257	0.257	0.353	0.460
42-Instruments and meters	0.057	0.070	0.392	0.330

Table 3
FDI and Innovation : Benchmark model

	(1)	(2)	(3)
Lagged innovation	0.436***	0.436***	0.436***
	(19.0)	(18.9)	(18.9)
Employment	0.139***	0.140***	0.139***
	(5.56)	(5.57)	(5.57)
Fixed capital	0.0493**	0.0494**	0.0495**
	(2.27)	(2.27)	(2.28)
R&D	0.170*	0.170**	0.170*
	(1.94)	(1.96)	(1.94)
Labour training	0.0180**	0.0182**	0.0182**
	(2.40)	(2.40)	(2.41)
Exporting	0.492**	0.491**	0.491**
	(2.45)	(2.45)	(2.45)
Industry concentration	0.146	0.150	0.150
	(1.11)	(1.14)	(1.14)
Age	0.0428***	0.0434***	0.0435***
	(5.25)	(5.32)	(5.32)
Foreign capital	0.174**	0.171**	0.172***
	(2.61)	(2.60)	(2.61)
Foreign capital squared	-0.145**	-0.147**	-0.148**
	(2.01)	(2.11)	(2.30)
Diaspora capital	0.128**	0.138**	0.138**
	(2.12)	(2.12)	(2.12)
Diaspora capital squared	0.119**	0.120**	0.123**
	(1.99)	(1.97)	(1.78)*
Foreign horizontal FDI	0.027*	0.028*	0.028*
	(1.83)	(1.86)	(1.88)
Diaspora horizontal FDI	-0.115**	-0.117**	-0.119**
	(-2.80)	(-2.88)	(-2.77)
Foreign backward FDI		-1.600	
		(-1.01)	
Diaspora backward FDI		-5.545	
		(-0.70)	
Foreign forward FDI		7.216	
		(0.84)	
Diaspora forward FDI		-0.0675	
		(-0.61)	
Foreign FDI outside region		-0.0176	0.107
		(-0.81)	(0.88)
Diaspora FDI outside region			-0.624
			(-1.03)
Sargan p-value	0.46	0.41	0.48
AR(2) Test p-value	0.37	0.30	0.38
Observations	67149	67149	67149
Number of firm	20761	20761	20761

Notes:

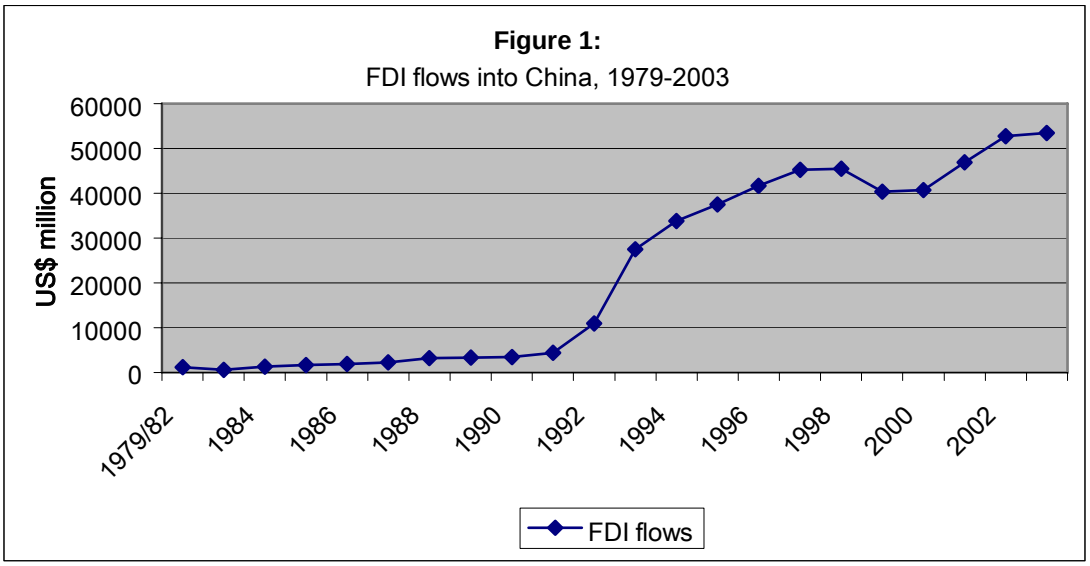
1. Dependent variable: share of innovation output in total output
2. Robust z statistic in parentheses
3. significant at 10%; ** significant at 5%; *** significant at 1%
4. All regressions include industry, region and time dummies

Table 4
Heterogeneity in FDI-innovation relationship

	(1)	(2)	(3)
Lagged innovation	0.436***	0.437***	0.436***
	(19.0)	(19.0)	(19.0)
Employment	0.139***	0.139***	0.139***
	(5.56)	(5.53)	(5.57)
Fixed capital	0.0491**	0.0494**	0.0493**
	(2.26)	(2.27)	(2.27)
R&D	0.170*	0.221***	0.0642
	(1.94)	(3.14)	(0.13)
Labour training	0.0180**	0.0689**	0.0106**
	(2.40)	(2.51)	(2.29)
Exporting	0.589***	0.492**	0.492**
	(2.59)	(2.45)	(2.45)
Industry concentration	0.144	0.146	0.146
	(1.10)	(1.11)	(1.11)
Age	0.0429***	0.0429***	0.0429***
	(5.26)	(5.25)	(5.25)
Foreign capital	0.171**	0.168**	0.169**
	(2.38)	(2.38)	(2.38)
Foreign capital squared	0.130**	0.118**	0.118**
	(2.15)	(2.11)	(2.11)
Diaspora capital	0.160**	0.160**	0.163**
	(2.43)	(2.46)	(2.44)
Diaspora capital squared	0.111**	0.111**	0.115**
	(2.16)	(2.23)	(2.34)
Foreign horizontal FDI	-0.247*	-0.268*	-0.275*
	(-1.84)	(-1.79)	(-1.84)
Foreign horizontal FDI * interacting variable	0.780**	0.679**	1.578**
	(2.24)	(2.39)	(2.81)
Diaspora horizontal FDI	-0.0858**	-0.0980*	-0.0910*
	(-2.56)	(-1.75)	(-1.81)
Diaspora horizontal FDI * interacting variable	0.602**	1.879**	1.141**
	(2.68)	(2.51)	(2.53)
Interacting variable	*Exporting*	*Labour training*	*R&D*
Sargan p-value	0. 61	0.51	0.68
AR(2) Test p-value	0.45	0.43	0.48
Observations	67149	67149	67149
Number of firm	20761	20761	20761

Notes:

1. Dependent variable: share of innovation output in total output
2. Robust z statistic in parentheses
3. significant at 10%; ** significant at 5%; *** significant at 1%
4. All regressions include industry, region and time dummies



Data Source: China Statistical Yearbook, various issues