Foreign Direct Investment, Access to Finance, and Innovation Activity in Chinese Enterprises

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A recent, comprehensive database is used to investigate the link between inward foreign direct investment (FDI) and innovation activity in China. The results of the analysis suggest that private and collectively owned firms with foreign capital participation and those with good access to domestic bank loans innovate more than other firms do. Among enterprises not owned by the state, inward FDI at the sectoral level is positively associated with domestic innovative activity only among firms that engage in their own research and development or that have good access to domestic finance. At the sector level the effect of inward FDI into technology transfer is distinguished from the effect on domestic credit opportunities. FDI affecting credit is of little significance for state-owned enterprises and is independent of their access to finance. In contrast, better access to credit is an important channel through which FDI affects the innovation of domestic private and collectively owned enterprises. JEL codes: O31, F23, G32

Since undergoing economic reforms beginning in 1979, China has emerged as a rapidly growing manufacturer and exporter. For economic development to continue apace, technological progress is crucial. In this regard, two features of the economy are notable. First, China has been an important location for research and development (R&D) and innovative activity by domestic enterprises since at least the mid-1990s (Jefferson and others 2006). Second, China

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has become an important host country for inward foreign direct investment (FDI). Indeed, according to the Organisation for Economic Co-operation and Development (OECD 2004), in 2003 China overtook the United States as the world's largest recipient of FDI.[1]

This article examines whether there is a link between increased levels of inward FDI and innovation activity by Chinese domestic enterprises. It draws on a particularly rich and recent firm-level data set for 1999–2005 provided by the China National Bureau of Statistics (see China National Bureau of Statistics 2006, for a description) paying particular attention to the importance of domestic access to finance.

China is an interesting case to study because of the juxtaposition of an impressive record in attracting FDI with a highly inefficient and state-dominated domestic financial system. The Chinese financial system is widely regarded as inefficient and skewed toward providing financial resources for (also largely inefficient) state-owned enterprises (Huang 2003). It is therefore of considerable policy interest to investigate whether this skewed allocation of financing is related to the ability of domestic firms to benefit (or not) from the increased influx of FDI into the economy.

Increased FDI could affect product innovation by domestic enterprises through many channels. First, a domestic firm receiving an injection of foreign capital faces looser financial constraints—constraints that could hinder innovation (Harrison and McMillan 2003). Second, FDI may bring an inflow of technology. Multinational enterprises are assumed to have better technology than domestic firms (Markusen 2002); foreign capital inflow through acquisition, joint venture, or some other form of capital transfer may thus lead to the installation of foreign technology in the domestic firm. The superior knowledge injected into the economy through FDI may leak to domestic firms (through, for example, worker mobility and imitation), in the same way that productivity improvements spill over (Görg and Greenaway 2004). These firms may then be able to engage in more innovation activity.

A rich panel data set of 239,085 domestic enterprises in Chinese manufacturing industries for 1999–2005 is used to investigate these issues empirically. The analysis contributes to the literature on innovation and technology adoption in developing and transition economies. This literature, reviewed by Keller (2004) and Pack (2006), has amassed a large body of evidence on a number of countries. Econometric work, however, particularly on China, remains limited, despite the immense interest by policymakers and academics.

Using firm-level data for 1997–99 on some 20,000 enterprises, Jefferson and others (2006) model a knowledge production function to estimate

1. See Amiti and Javorcik (2008), Wei (2003), and Lemoine (2000) for analyses of the increased inflow of FDI and its determinants.

the determinants of innovation activity in Chinese enterprises.[2] They find that firm size and own R&D expenditure are important determinants of innovation.

This article expands on their analysis in a number of ways. First, it investigates the impact of inward FDI and the role of firm characteristics on innovation activity at the firm and industry level. This issue, which is not covered by Jefferson and others (2006), is of considerable policy interest. Second, the article addresses the role of access to finance for innovation and the link between such access and a firm's ability to benefit from positive spillovers from inward FDI. This issue has not, to the authors' knowledge, been investigated elsewhere. Third, unlike Jefferson and others (2006), who include dummy variables for different types of ownership, this article investigates whether the determinants of innovation activity, particularly the effect of inward FDI, differ across firms by type of ownership (privately owned, collectively owned, or state owned). Fourth, the data set used here covers more firms and a more recent time period than that used by Jefferson and others (2006).

The results show, not unexpectedly, that firms with foreign capital participation and good access to finance innovate more than others do and that inward FDI at the sectoral level is positively associated with domestic innovative activity only if firms engage in their own R&D activities or have good access to domestic finance. Following up on the suggestion of a possible adverse effect of domestic credit constraints on firms' ability to benefit from inward FDI, further analysis shows that finance constraints adversely affects private and collectively owned firms but not state-owned firms, which enjoy preferential access to domestic financial resources. Again, when the effects of sector-level inward FDI into technology transfer and FDI affecting domestic credit opportunities are distinguished, FDI affecting domestic credit opportunities is found to be of little significance for state enterprises and is independent of their access to finance. By contrast, it is an important channel through which FDI affects domestic private and collectively owned enterprises.

The article is structured as follows. Section I describes the empirical approach, and section II introduces the data set and provides some summary statistics. Section III discusses the econometric results. The final section provides some concluding comments.

2. Other, more loosely related articles should be noted. Hu, Jefferson, and Qian (2005) estimate the determinants of firm-level productivity using a data set similar to that used by Jefferson and others (2006). They focus on the role of own-firm R&D as well as technology purchased from foreign or domestic sources on firm-level productivity. Girma and Gong (forthcoming) use a Chinese data set to investigate the link between inward FDI spillovers and the productivity of state-owned enterprises. Berthelemy and Demurger (2000) use regional data to investigate the effect of inward FDI on regional growth in China.

I. Empirical Approach

In the empirical model a domestic firm (indexed by i) either innovates at time t ($S_{it} > 0$) or it does not ($S_{it} = 0$). A Tobit model is formulated in terms of a latent variable model to determine the relation between FDI and the rate of product innovation:

$$(1) \quad \begin{aligned} S^*_{it} = {} & \alpha_1 FC_{it-1} + \alpha_2 FDI_{jt-1} + \alpha_3 FIN_{it-1} + \alpha_4 \mathbf{X}_{it-1} \\ & + \alpha_5 FIN_{it-1}{}^* \mathbf{FDI}_{jt-1} + \alpha_6 RD_{it-1}{}^* FDI_{jt-1} + D_r + D_j + D_t + \varepsilon_{it} \end{aligned}$$

$$\begin{aligned} S_{it} &= 0 \quad \text{if } S^*_{it} \leq 0 \\ S_{it} &= S^*_{it} \quad \text{if } S^*_{it} > 0 \end{aligned}$$

where the dependent variable S is defined as the share of innovation output products involving the use of new process innovation or novel technology in total output.[3] This variable, which measures the output of the innovation process, is a more suitable measure than R&D, which is an input into the innovation process (see Criscuolo, Haskel, and Slaughter 2005). The D variables in equation (1) are full sets of regional (r), industry (j), and time (t) dummy variables.

$\mathbf{X}$ is a vector of firm-level determinants of innovation. It includes R&D intensity, the ratio of employee training expenditure to the total wage bill, export intensity, subsidies, age, and the firm's market share within its three-digit industry. The choice of these firm-level covariates is guided by theoretical considerations as well as evidence from the empirical literature. R&D is an important input into the innovation process and thus is included in the model. Human capital is also an important determinant of innovation. One proxy for human capital is the amount of training provided by a firm, which is included in the empirical analysis. Criscuolo, Haskel, and Slaughter (2005) provide evidence that firms that are active on export markets are more innovative than others. The model here captures this notion by controlling for firms' export intensities. Because subsidies can help firms engage more in innovation (see Görg and Strobl 2007), a measure of the level of production-related grants is also included in the model. As Jefferson and others (2006) argue, the age of a firm may also be important in explaining innovation activity (as a proxy for a firm's experience) and hence the possibility for learning effects. Their approach is adopted here by including firm age in the equation. Aghion and others (2005) discuss the role of competition for innovation; Aitken and Harrison (1999) show that multinationals may affect the competitive landscape in the domestic economy, leading to an increase in competition for domestic firms.

3. Definitions of all variables, plus summary statistics, are provided in table 1, discussed in the next section.

To take account of these findings, the model includes a firm's market share as an indicator of its competitive position.

FIN is a measure of a firm's access to finance (measured by its ability to obtain loans from domestic banks). Financial constraints are a serious impediment to innovation activity (Hall 2002). This effect may be particularly pronounced in China, where the financial sector is highly regulated and inefficient, and lending is skewed toward inefficient state-owned enterprises (Huang 2003).

FC is a measure of foreign capital participation in firm *i*. It captures the central concern of this article—the impact of FDI on innovative activity in Chinese domestic firms. *FC* is included to allow for the fact that firms with some share of foreign capital may be more innovative than other firms, for the reasons discussed above.

FDI is a vector of industry-region-specific FDI indices. It captures the potential spillover or crowding-out effects of FDI at the industry level. The effect of **FDI** is allowed to vary based on a firm's R&D activity and access to finance by including two interaction terms in the empirical estimation of equation (1), namely **FDI** and R&D intensity and **FDI** and *FIN*. The interaction of **FDI** and R&D intensity captures the notion that firms with higher absorptive capacity are better able to benefit from the technology transferred by incoming FDI.[4] The interaction of **FDI** and *FIN* allows firms with better access to finance to benefit more from inward FDI; because they are less financially constrained, they may be better able to implement the new technology and less affected by reductions in the availability of domestic finance caused by demand for loans by foreign firms.

All covariates in the empirical model are lagged by one period to mitigate potential endogeneity concerns. Nevertheless, some firm-level variables in the specification may be endogenous. One is R&D intensity, which is a major input into the product innovation process. The choice of this input is likely to be correlated with factors that determine the firm's decision to innovate. Similar arguments can be made regarding the potential endogeneity of the other firm-level variables. To deal with this possible problem, all lagged firm-level variables except age are considered potentially endogenous. The instrumental variables technique for Tobit models developed by Smith and Blundell (1986) is used to estimate this model.[5]

4. See Girma (2005) for a discussion of the importance of absorptive capacity and an empirical illustration using firm-level data for the United Kingdom.

5. The estimation of Tobit models with endogenous regressors involves two steps. The first is to generate residual terms from linear regressions of each endogenous variable on the instrumental variables and all other exogenous regressors. The second is to estimate a standard Tobit model by including the residual terms from the first step in the list of covariates. The standard errors are bootstrapped to take account of the fact that residual terms are generated regressors. The residual terms are correction terms for the endogeneity problem; jointly statistically significant coefficients can be taken as evidence in favor of the hypothesis that instrumented variables are indeed endogenous. A one-step variant of this estimator involving stronger distributional assumptions is also available (Newey 1987). However, it fails to attain convergence in the data used here. This type of convergence problem is frequently encountered when there is more than one endogenous regressor.

Twice-lagged values of the potentially endogenous variables are used as instruments. The assumption is that conditional on the regressors, these variables are asymptotically uncorrelated with the error term of the model. Ultimately, of course, this is an empirical issue, tested using the Sargan–Hansen test for the validity of instrumental variables.

Additional instruments are also used. They include the share of state-owned enterprises in a region or industry, the share of loss-making state-owned enterprises in a region or industry, the level of regional financial development (bank loans to the private sector as a share of total loans), and whether the firm is politically affiliated with local, regional, or central governments. These instruments are designed to account for the endogeneity of sector-level FDI and access to finance. The share of the state sector, for example, is a proxy for state dominance in the region or industry; to the extent that access to finance is different for state-dominated sectors and regions, this is a reasonable instrument for firm-level access to finance. Similar arguments can be made for the share of loss-making state-owned enterprises and the level of regional financial development.

A large number of enterprises in China are affiliated with some level of government administration. The function of the relevant government body is to offer credit guarantees and political protection to the affiliated firms. This political affiliation variable is strongly related to firms' access to finance, because China's financial system remains dominated by the four large state banks. Different levels of political affiliation are used as instruments to reflect the realistic assumption that the main effect of political affiliation on innovation comes through its effects on finance. Ultimately, however, the relevance of the instruments is an empirical issue that is tested for in the estimation below.

II. Description of the Database and Construction of Variables

The econometric analysis draws on confidential micro data that underlie the *Annual Reports of Industrial Enterprise Statistics*, compiled by the China National Bureau of Statistics. The reports cover all firms with annual turnover of more than 5 million yuan (about $600,000). The firms in the data set account for an estimated 85–90 percent of total output in most industries.

The data set includes information on firm ownership structure, industry affiliation, geographic location, establishment year, employment, gross output, product innovation, R&D, value added, net fixed assets, exports, and employee training expenditures.[6] The whole sample (1.3 million observations from about 446,000 firms) is used to construct the variables of interest (such as the share of foreign firms in an industry or region or firms' market share).

6. Nominal values are deflated using industry-specific ex-factory price indices obtained from the *China Statistical Yearbook 2006* (China National Bureau of Statistics 2007).

The econometric work is confined to domestic-owned enterprises, the focus of this article.

The China National Bureau of Statistics assigns a categorical variable to each firm in the database indicating its ownership status. 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 by private (domestic and foreign) investors. This measure of ownership is used here. Firms are defined as state-owned, collectively owned, or privately owned based on majority ownership of the firm. The information necessary for the econometric estimation is available for 239,085 domestic firms (630,900 total observations).

The data set provides information on the extent of foreign capital participation at the level of the firm. This makes it possible to calculate the share of foreign ownership in the domestic enterprise and identify the direct effects of FDI on domestic firms' innovative activity. A different method is used to estimate the indirect (spillover) effect of FDI at the industry level. For each of the 171 three-digit industries and 31 provinces, the proportion of output accounted for by companies with foreign ownership in the industry and region is calculated.[7] Alternative measures of industry and region FDI are the proportion of new products accounted for by multinational companies (labeled FDI innovation), and the share of domestic bank loans extended to foreign multinationals (FDI loan).

The data reveal no substantial relation between firm ownership on the one hand and innovation activity or the level of R&D on the other (table 1). As expected, on average state-owned enterprises receive higher shares of bank loans and larger subsidies from the government. They are less export intensive and receive more modest inflows of foreign capital than privately or collectively owned firms.

The pattern of product innovation by state-owned enterprises across industries at the two-digit reveals three noteworthy points (table 2). First, the proportion of innovating firms rose over time in most sectors. In contrast, the share of new product sales in total sales, while generally significant, declined slightly in most sectors. Second, labor-intensive sectors (such as food manufacturing and paper products) have the lowest proportion of innovators. In contrast, export-competing labor-intensive sectors (such as textiles) exhibit a

7. Officially, foreign-owned multinationals are defined as enterprises with at least a 25 percent share of foreign capital. Domestically owned enterprises that have foreign capital participation of less than 25 percent are not considered in this definition. The richness of the data set is exploited by weighing the output of firms with foreign capital by the extent of their foreign participation, measured by the share of foreign capital at the firm level. Under this definition of sectoral FDI, firms classified as domestic but that have some foreign capital also contribute (proportionally) to the aggregate output of the foreign sector. The recent literature on productivity spillovers from FDI notes that domestic firms may benefit not only from horizontal but also from vertical spillovers through customer–supplier linkages (see Javorcik 2004). Vertical measures (backward and forward spillovers) were calculated by the authors but found not to be consistently statistically significant. They are therefore not included in the analysis that follows.

TABLE 1. Variable Definitions and Summary Statistics

Variable	Definition		State-owned enterprise		Private enterprise		Collective enterprise	
			Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Product innovation	Share of output involving new process or product innovation		0.041	0.150	0.034	0.151	0.021	0.116
	Restricted sample of firms with nonzero product innovation		0.319	0.295	0.390	0.350	0.369	0.331
R&D	R&D expenditure divided by sales		0.002	0.021	0.002	0.013	0.001	0.007
	Restricted sample of firms with nonzero R&D expenditure		0.013	0.046	0.012	0.337	0.008	0.018
Labor training	Employee training expenditure per employee		0.007	0.027	0.008	0.035	0.008	0.037
	Restricted sample of firms with nonzero labor training outlay		0.015	0.037	0.021	0.053	0.037	0.053
Export intensity	Share of exports in total sales		0.043	0.164	0.127	0.298	0.110	0.281
	Restricted sample of exporters		0.307	0.328	0.580	0.380	0.594	0.374
Market shares	Firm's share of sales in total three-digit industry region sales		0.044	0.134	0.022	0.082	0.021	0.073
Domestic finance	Domestic bank loans normalized by total assets		1.806	2.519	0.825	1.874	0.876	1.886
Subsidy	Log of production subsidy from local and central governments		0.983	2.335	0.642	1.843	0.796	2.052
Age	Log of years since establishment		3.147	0.914	1.848	0.935	2.569	0.806
Foreign capital	Share of foreign multinationals capital in firm's total capital		0.002	0.033	0.004	0.050	0.006	0.060
FDI	Share of foreign multinationals' sales in three-digit industry-region total sales		0.143	0.181	0.194	0.191	0.175	0.182
FDI innovation	Share of multinationals' innovative output in *three*-digit industry-region total innovation		0.097	0.196	0.140	0.212	0.127	0.206
FDI loan	Share of multinationals' domestic bank loans over total domestic bank loans		0.099	0.161	0.168	0.198	0.148	0.184
Number of firms		239,085	34,549		148,694		55,842	
Number of observations		630,900	125,357		316,461		189,082	

Source: Authors' analysis based on data from China National Bureau of Statistics.

TABLE 2. Sectoral and Temporal Pattern of Product Innovation by State-Owned Enterprises (percent)

	Share of innovators		New product sales as share of total sales	
Two-digit industry classification	1999	2005	1999	2005
13: Food processing	2.0	10.1	32.3	16.6
14: Food production	4.3	11.6	29.2	23.9
15: Beverage industry	6.0	12.0	27.2	25.1
16: Tobacco processing	12.3	21.1	14.9	15.2
17: Textile Industry	17.3	17.2	30.7	29.6
18: Garments and other fiber products	3.5	6.5	45.0	45.3
19: Leather, furs, down and related products	4.1	8.1	49.4	39.7
20: Timber processing	2.8	6.8	46.2	23.0
21: Furniture manufacturing	4.2	10.0	36.0	21.4
22: Papermaking and paper products	4.0	7.2	37.1	19.0
23: Printing and record medium reproduction	1.8	5.9	37.5	35.0
24: Cultural, educational, and sports goods	9.4	9.2	33.5	38.9
25: Petroleum refining and coking	5.0	6.4	28.9	20.9
26: Raw chemical materials and chemical products	9.2	10.7	31.3	33.2
27: Medical and pharmaceutical products	24	25.2	35.8	37.2
28: Chemical fiber	14.0	10.4	26.7	39.4
29: Rubber products	12	9.8	32.0	30.5
30: Plastic products	9.1	10.2	38.2	33.9
31: Nonmetal mineral products	3.7	10.7	38.1	23.0
32: Smelting and pressing of ferrous metals	5.8	6.9	29.6	24.8
33: Smelting and pressing of nonferrous metals	6.0	9.7	32.9	335
34: Metal products	6.1	7.9	33.4	31.1
35: Ordinary machinery	14.2	13.2	29.5	320
36: Special purpose equipment	17.8	17.2	34.8	37.3
37: Transport equipment	14.1	15.5	35.5	34.7
39: Other electronic equipment	14.8	14.0	36.1	41.8
40: Electric equipment and machinery	26.8	23.2	47.6	53.3
41: Electronic and telecommunications	25.7	25.7	35.3	46.0
42: Instruments and meters	5.7	7.0	39.2	33.0

Source: Authors' analysis based on data from China National Bureau of Statistics.

relatively large number of innovators. Third, the intensity of product innovation is remarkably similar across labor-intensive, capital-intensive, and technology-intensive sectors.

III. DISCUSSION OF THE RESULTS

The benchmark Tobit model controls for firm heterogeneity by allowing for firm random effects (table 3, column 1). The model also includes two additional dummy variables for private and collectively owned firms.

The estimation shows that R&D intensity exerts a positive and significant influence on the rate of product innovation. This is as expected, given that

TABLE 3. Innovation Spillovers from FDI and Access to Finance: Results from Alternative Estimators

Variable	(1) Random effects Tobit model	(2) Tobit instrumental variables model	(3) Linear generalized method of moment model
R&D	2.312*** (30.4)	4.323*** (19.0)	2.118*** (10.8)
Labor training	0.481*** (11.5)	0.862*** (7.22)	0.700*** (3.65)
Export intensity	0.252*** (39.3)	0.238*** (24.4)	0.217*** (18.5)
Market share	0.576*** (41.6)	0.600*** (29.7)	0.901*** (21.0)
Finance	0.0413*** (46.9)	0.0696*** (35.6)	0.0684*** (23.8)
Subsidy	0.0271*** (38.8)	0.0313*** (24.7)	0.0399*** (18.3)
Age	0.0505*** (27.4)	0.0487*** (19.2)	0.00197*** (6.69)
Foreign capital	0.135*** (6.85)	0.217*** (5.54)	0.168*** (3.65)
FDI	−0.643*** (−45.8)	−0.797*** (−35.3)	−0.500*** (−23.5)
FDI × R&D	1.428*** (88.1)	1.881*** (54.2)	1.241*** (26.1)
FDI × finance	0.153*** (8.22)	0.0922** (2.21)	−0.00929 (−1.51)
Private firms	0.0463*** (9.39)	0.0634*** (10.8)	0.0389*** (12.4)
Collective firms	−0.110*** (−21.9)	−0.0686*** (−11.5)	−0.0800*** (−7.15)
Number of observations	630,900	390,352	390,352
p-value from Hansen's test of overidentification			0.179

***Significant at the 1 percent level; **significant at the 5 percent level; *significant at the 10 percent level.

Note: All specifications include time, regional, and industry fixed effects. Numbers in parentheses are *t*-statistics. All regressors are lagged by one period in all regressions. The use of twice-lagged variables as instruments in the Tobit instrumental variables and linear generalized method of moments (GMM) models sharply reduced the number of observations in the estimations. State-owned firms form the base group in all regressions.

Source: Authors analysis based on data from China National Bureau of Statistics.

R&D intensity is a major input in the product innovation process. Firms that invest in employee training have higher innovation intensity, suggesting possible complementarity between human capital investment and innovation, as suggested by Redding (1996). Production innovation and exporting are positively correlated, and firms that enjoy higher market shares in their industry are more likely to engage in product innovation activity. Firms' receipt of subsidies is also positively related to innovation. These findings are in line with the literature. The results also suggest that older firms are more likely to engage in product innovation than their younger counterparts, possibly indicating the importance of experience in the innovation process.[8]

The results indicate that firms with some foreign capital participation are more likely to engage in product innovation. This effect may reflect the influx

8. In an analysis of a smaller sample of Chinese firms, Jefferson and others (2006) find no statistically significant relation between age and innovation. The sample used here is much larger and the estimation controls for a much larger number of covariates than the earlier study did.

of new technology or the reduction in financial constraints associated with the capital injection (the data do not allow the two hypotheses to be tested separately).[9] Access to finance is also positively associated with innovation. The magnitude of the effect of firm-level foreign capital is economically significant. A doubling of the foreign ownership share, for example, is associated with a 13.5 percentage point change in the share of new products in total output, all else equal. The economic significance of access to domestic finance is noteworthy: a one standard deviation (2.5 from table 1) increase in this variable leads to a 10 percentage point increase in innovation intensity.

Firms benefit from inward FDI only if they are actively engaged in R&D or have good access to domestic finance in the form of bank loans. If the point estimates are taken at face value, firms with R&D intensities of at least 0.45 (and no domestic bank loans) and firms with a ratio of bank loans to assets of at least 4.2 (and no R&D) benefit from FDI. These two threshold values are well beyond the mean values in the sample (reported in table 1).

The results in column 1 treat all variables as exogenous. This may not be too heroic an assumption, considering that all covariates are lagged one period, dummy variables for private and collectively owned firms are added, and unobserved firm-level heterogeneity is allowed for by including firm random effects. There may still be a lingering concern about endogeneity, however. This problem is addressed more formally by estimating the model using the endogenous Tobit model (column 2 in table 3). Of course, the reliability of the endogenous Tobit hinges on the validity of the instruments used. To the authors' knowledge, there are no formal tests of the validity of instruments within the context of these endogenous Tobit specifications. The appropriateness of the instruments is gauged by estimating a linear instrumental variables model (using the same set of instruments as in the endogenous Tobit) and obtaining a Sargan test statistic of the implied overidentifying restrictions. The test result, reported in column 3, suggests the validity of the instrumental variables. Reassuringly, the results of the estimations in both columns 2 and 3 are very much in line with the baseline equation in column 1, in terms of both the statistical significance and the magnitude of the coefficients. In the rest of the discussion the focus is therefore on estimations using the Tobit estimator allowing for firm random effects (column 1).

This estimation allows for firm-level heterogeneity, but it constrains the coefficients of the independent variables to be the same for all types of firms. This may be an unrealistic assumption given the large performance differences between state-owned and other types of enterprises in China. The ownership dimension of the data set is exploited to address the sample, which is broken into state-owned, private, and collectively owned enterprises (table 4).

9. Another reason why foreign-owned firms may be more innovative is that they tend to employ more highly skilled workers. The estimation partly controls for this possibility by controlling for the quality of the workforce using a variable on labor training.

TABLE 4. Estimates of FDI Spillovers and Access to Finance from Panel Tobit Models with Firm-Specific Heterogeneity

Variable	(1) State-owned firms	(2) Private firms	(3) Collectively owned firms	(4) Loss-making firms	(5) Profit-making firms
R&D	1.100*** (12.3)	2.857*** (24.3)	6.591*** (19.5)	1.034*** (8.27)	3.213*** (32.8)
Labor training	0.552*** (6.40)	0.464*** (7.84)	0.415*** (4.56)	0.345*** (2.99)	0.449*** (9.90)
Export intensity	0.363*** (25.5)	0.232*** (26.2)	0.274*** (19.2)	0.267*** (15.6)	0.252*** (36.4)
Market share	0.487*** (29.7)	0.535*** (22.8)	0.497*** (11.5)	0.435*** (14.8)	0.625*** (39.7)
Finance	0.0085*** (31.7)	0.0384*** (26.8)	0.0406*** (18.9)	0.0372 (0.66)	0.0470*** (46.7)
Subsidy	0.0235*** (24.3)	0.0335*** (29.8)	0.0163*** (9.69)	0.0243*** (14.7)	0.0268*** (34.9)
Age	0.0478*** (15.0)	0.0465*** (17.9)	0.0806*** (17.1)	0.0218*** (5.93)	0.0409*** (21.6)
Foreign capital	0.333*** (7.73)	0.0978*** (3.35)	0.135*** (3.45)	0.0816* (1.68)	0.123*** (5.68)
FDI	−0.502*** (−19.4)	−0.631*** (−32.0)	−0.838*** (−25.1)	−0.358*** (−10.9)	−0.684*** (−43.9)
FDI × R&D	1.106*** (42.8)	1.474*** (62.6)	1.560*** (38.5)	1.178*** (30.7)	1.478*** (82.2)
FDI × finance	0.0975 (1.42)	0.0575* (1.93)	0.250*** (5.50)	0.128 (1.21)	0.112*** (5.29)
Number of observations	125,357	316,461	189,082	117,001	513,899

***Significant at the 1 percent level; **significant at the 5 percent level; *significant at the 10 percent level.

Note: All specifications include time, regional, and industry fixed effects. Numbers in parentheses are t-statistics. All regressors are lagged by one period in all regressions.

Source: Authors' analysis based on data from China National Bureau of Statistics.

TABLE 5. Access to Finance by FDI Firms and Innovation Spillovers to Domestic Firms

Variable	(1) State-owned firms	(2) Private firms	(3) Collectively owned firms	(4) Loss-making firms	(5) Profit-making firms
R&D	0.823*** (7.99)	2.914*** (36.1)	5.197*** (24.1)	1.134*** (13.2)	2.591*** (42.0)
Labor training	0.250** (2.32)	0.338*** (8.32)	0.300*** (5.20)	0.294*** (3.71)	0.309*** (10.6)
Export intensity	0.247*** (13.3)	0.105*** (17.8)	0.133*** (15.5)	0.144*** (13.0)	0.119*** (27.0)
Market share	0.350*** (16.0)	0.460*** (27.4)	0.282*** (10.4)	0.347*** (17.1)	0.431*** (40.1)
Finance	0.0011*** (19.1)	0.0289*** (27.8)	0.0281*** (19.6)	0.028 (1.21)	0.0311*** (44.9)
Subsidy	0.0172*** (14.0)	0.0234*** (29.6)	0.0117*** (10.8)	0.0159*** (14.0)	0.0181*** (35.5)
Age	0.0309*** (7.51)	0.0404*** (21.6)	0.0590*** (19.2)	0.0383*** (13.6)	0.0437*** (30.8)
Foreign capital	0.205*** (3.23)	0.0542*** (2.64)	0.0737*** (2.92)	0.0698** (2.09)	0.0757*** (5.26)
FDI innovation	−0.0345** (−2.35)	−0.110*** (−9.01)	−0.0452*** (−2.72)	−0.091* (−1.82)	−0.034*** (−10.4)
FDI innovation × R&D	0.384*** (8.74)	0.518*** (24.3)	0.314*** (9.82)	0.409*** (11.7)	0.443*** (30.1)
FDI innovation × finance	−0.0191 (−0.91)	0.0205** (2.22)	0.0490** (2.75)	−0.0067 (−1.19)	0.0677** (2.46)
FDI loan	−0.190 (−1.49)	−0.493*** (−35.2)	−0.475*** (−22.3)	−0.277*** (−12.0)	−0.433*** (−42.1)
FDI loan × R&D	0.653*** (11.2)	0.828*** (36.3)	0.864*** (24.5)	0.735*** (17.8)	0.764*** (47.5)
FDI loan × finance	0.0026 (0.90)	0.0115** (2.03)	0.0378** (2.47)	−0.00185 (−0.26)	0.059** (2.57)
Number of observations	125,357	316,461	189,082	117,001	513,899

***Significant at the 1 percent level; **significant at the 5 percent level; *significant at the 10 percent level.

Note: All specifications include time, regional, and industry fixed effects. Numbers in parentheses are *t*-statistics. All regressors are lagged by one period in all regressions.

Source: Authors' analysis based on data from China National Bureau of Statistics.

Several striking differences are apparent across the three ownership types. First, the relation between access to finance and innovation is strongest among private and collectively owned firms, which receive less favorable treatment from China's financial system than state-owned enterprises do. Second, the coefficient on foreign capital is largest for state enterprises, suggesting that injections of foreign capital are associated with the highest positive impact on innovation for this type of firm. This may reflect the fact these state-owned firms are more inefficient than other firms and therefore offer the greatest opportunities for improvement as a result of the influx of foreign capital.[10] Third, and perhaps most striking, the interaction term of FDI and access to finance is positive for private and collectively owned firms but statistically insignificant for state-owned enterprises. Access to domestic finance plays no role in generating spillovers to state-owned enterprises, which are largely inefficient but enjoy preferential access to domestic financial resources.

Profit-making firms can be distinguished from loss-making firms, most of which are owned by the state (columns 4 and 5 in table 4). The results are in line with expectations: access to finance has no effect on innovation in loss-making enterprises, and also does not matter for indirect effects from sector-level inward FDI.[11]

Sector-level FDI can affect domestic innovation by transferring technology to or creating credit opportunities for domestic firms. The next step of the analysis tries to distinguish these two channels by calculating two different FDI measures. The first measure is aggregate innovation by foreign multinationals, calculated as innovation output by foreign multinationals in a sector or region divided by total innovation output. The second measure is aggregate borrowing by foreign multinationals, calculated as the share of domestic bank loans in total bank loans in the sector or region.

The results in columns 1–3 of table 5 show that the effects of the two variables are broadly similar to those for private and collectively owned firms. FDI has a positive effect only if the firm is active in R&D and has access to bank loans. State-owned enterprises that invest in their own R&D also benefit more from technology transfer by multinationals than those that do not, but the firms' financial position does not mitigate the effect of FDI technology. The effect of FDI on credit opportunities has no statistically significant relation with state enterprises' ability to innovate. This result suggests that preferential access to domestic financial resources means that finance is not a constraint for state enterprises.

In alternative estimations in columns 4 and 5, the data are broken into loss-making and profit-making enterprises. Results for loss-makers closely resemble

10. This result is in line with the work by Bartel and Harrison (2005) that shows state-owned enterprises in Indonesia benefit greatly from foreign ownership in the enterprise.

11. As a robustness check, table 4 was reestimated using the endogenous Tobit estimator. The results are very similar and hence not reported here.

those for state-owned enterprises, suggesting that access to finance has little effect on innovation for such firms.[12]

IV. Conclusions

The econometric analysis conducted here shows that access to finance is an important issue for firms' innovation activity and their ability to benefit from inward FDI. This is mainly the case for private and collectively owned firms, however. It is far less important for state-owned firms, which receive preferential treatment under the current domestic financial system.

Firms with foreign capital participation and those with good access to domestic bank loans—that is, firms with less binding financial constraints—innovate more than others. Inward FDI at the sectoral level is positively associated with domestic innovative activity only if firms engage in their own R&D activities (that is, have some absorptive capacity) or have good access to domestic finance. This finding points to the possible adverse effect of domestic credit constraints on firms' ability to benefit from inward FDI. Grouping firms by ownership type reveals that access to finance plays a role only among firms that are not state owned. Although state-owned enterprises are largely inefficient, they enjoy preferential access to domestic financial resources; access to finance thus provides no bottleneck for them.

Sector-level inward FDI has two effects. It transfers technology and may increase domestic credit opportunities. The effect on credit is of very little significance for state-owned enterprises and is independent of their access to finance. In contrast, it is an important channel through which FDI affects the innovation of domestic private and collectively owned enterprises.

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12. One other robustness check was conduced, which included squared terms of foreign capital, FDI innovation, and FDI loans in the estimations. The results, which are not reported here, are robust to this slight modification of the estimating equation.

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