

**FDI SPILLOVERS, FIRM HETEROGENEITY AND DEGREE OF OWNERSHIP
EVIDENCE FROM CHINESE MANUFACTURING**

DRAFT

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Abstract:

Expecting positive spillovers on the domestic economy, the Chinese government attracts foreign investors by various investment programs. The empirical literature on productivity spillovers in transition economies finds however no or even negative spillovers on domestic firms. In this paper we study the direct and indirect effects of foreign direct investment in the Chinese manufacturing industry, using plant-level panel data. Our results indicate that the structure and origin of ownership matters for spillovers. Moreover, we find that firms that are far away from the technological frontier do not benefit from the presence of foreign firms, while firms operating close to the technological frontier enjoy positive spillovers.

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1 INTRODUCTION

China evolved in a couple of decades from a command economy to a ‘socialist market economy’ and became a major player in the world economy. The gradual liberalization of restrictions on foreign direct investment since 1978 has greatly improved the investment environment. Today China is the largest developing country recipient with \$61 billion in Foreign Direct Investment (FDI) inflows. China’s leaders are convinced that FDI plays a major role in the development of the domestic economy and offer supranational treatment to foreign firms in various ways (e.g. tax incentives that are unavailable to domestic firms). The literature identifies several potential FDI spillover channels, such as imitation, acquisition of human capital, exports, and competition effects. The need for strategic restructuring and the hardening of the soft budget constraints are additional reasons why foreign investment might be beneficial for the host economy in the case of transition economies. Despite the range of positive spillover effects predicted by theory and the strong conviction by policy makers that such spillovers are beneficial, the empirical literature finds no or even negative effects on the productivity of domestic firms in transition and developing economies (e.g. Aitken and Harrison, 1999, Konings, 2001, Smarzynska-Javorcik, 2004, Damijan et al, 2006).

This paper uses a unique panel dataset of almost 5,000 plants in the Chinese manufacturing sector between 2001 and 2004 to analyze whether such spillovers exist. In doing so, we extend the existing literature along various dimensions. First, we investigate whether the degree of ownership matters for the generation of spillovers to domestic firms. Foreign firms that have a majority shareholdership are likely to protect their superior technology better than foreign firms that have a minority stake. Recent evidence by Smarzynska-Javorcik and Spatareanu (2006) suggests that the degree of ownership matters. Second, recent theoretical work by Helpman et al. (2004) and others has highlighted the importance of firm heterogeneity in understanding foreign direct investment. In particular we analyze how the relative position of the domestic firm with respect to the frontier firm matters for absorbing potential spillovers from foreign firms. Finally, this is the first paper that analyzes FDI spillovers in China using micro data. Given the enormous inflow of FDI in China it seems that especially for a country like China it is important to assess whether foreign firms generate externalities to domestic firms.

We find evidence that the degree of ownership matters for spillovers. Moreover, we find that firms that are far away from the technological frontier do not benefit from the presence of foreign firms, while firms operating close to the technological frontier enjoy positive spillovers.

The rest of this paper is organized as follows. In the next section we provide some theoretical and empirical background. Section 3 gives the econometric model that we seek to estimate and discusses the data used. Section 4 reports and discusses the results, section 5 is a concluding one.

2 BACKGROUND

2.1 FDI in China

The promulgation of the Equity Joint Venture Law by the National People's Congress in 1978 marked the first step in the "open door" policy of the Chinese government. Four Special Economic Zones (Shenzhen, Zhuhai, Shantou, and Xiamen) were established in 1980 and were granted more autonomy over their economic policies and institutional environment. Gradually China continued on the path of encouraging foreign direct investment through carefully designed promotion policy measures, especially by creating a business-friendly environment and through preferential treatment of foreign investors. The renowned Southern tour of Deng Xiaoping in 1992 marked the deepening and widening of China's liberalization and was followed by the establishment of numerous coastal open cities and development zones in inland areas where foreign investment enjoyed various tax and non-tax benefits. This resulted in the growing recognition of China's economic potential and sparked off a boom in the number of FDI projects and their value at the beginning of the '90s (See Figure 1). A number of bilateral investment treaties signed in 1992 dealing with issues regarding market access and intellectual property rights protection, and the strong real depreciation of the Chinese Renminbi which made producing in China relatively more attractive, were two factors that further amplified the inflow of foreign capital. The actually utilized value of foreign investment expanded up to more than US\$60 billion in 2004. Only the figures for 1999 and 2000 show a slight slowdown. With 60 percent of inward FDI originating from Hong Kong and the other Asian Tigers, this slowdown of foreign investment inflows can be

attributed to the East Asian financial crisis and the slow adjustment of the Chinese domestic economy.²

[Figure 1: Foreign Direct Investment inflows in China (1991-2004)]

2.2 Spillover channels

Expecting positive spillovers on the domestic economy, governments around the world attract foreign investors through various investment programs. The underlying idea is that foreign firms bring in more advanced technological know-how, marketing and managing practices, distribution network, and export contacts. These intangible assets related to FDI are viewed as an engine of a plant's productivity growth. In addition this inflow of foreign capital fastens the process of strategic restructuring by bringing in fresh capital to replace outdated equipment and by updating old production practices. These benefits may not be restricted to the affiliate of the multinational, but spill over to other firms operating in the same region or sector. From the literature we can identify five main spillover channels: demonstration and imitation spillovers (related to products and technology, export, and managerial skills), acquisition of human capital, positive (reduction in X-inefficiencies and reduction of market distortions) and negative competition effects (crowding out), and the hardening of soft budget constraints.³

Local firms can learn about the products and technologies brought in by foreign investors, for example through personal contacts, reverse engineering or industrial spying. Such imitation spillovers are more likely to occur in countries where the protection of intellectual property rights (IPR) is insufficient. Chinese imitation of foreign goods is well-known and spread over all kinds of products, from luxury goods, clothes, medicines, music to even the car business. Since China joined the World Trade Organization, it has strengthened its legal framework and amended its IPR laws and regulations to comply with the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). Despite stronger statutory protection, China continues to be a haven for counterfeiters and pirates. On average, 20 percent of all consumer products in the Chinese market are counterfeit. Though

² China Statistical Yearbook 2000

³ See Blömstrom and Kokko (1998) for a detailed discussion of the various spillover channels.

Beijing committed to solve the problem, enforcement measures have not been sufficient to prevent massive IPR violations effectively. Several factors play a role in undermining the enforcement measures, including China's reliance on administrative instead of juridical measures to combat IPR infringements, corruption and local protectionism, limited resources and training available to enforcement officials, and lack of public education regarding the economic and social impact of counterfeiting and piracy.

Exports can be considered as another example of demonstration spillovers. Typically multinational corporations (MNCs) have already built up an extensive international distribution network and possess the knowledge and experience of international marketing. By simply imitating or collaborating with foreign enterprises, domestic firms may learn how to succeed in foreign markets. In addition domestic firms may benefit from increased market access achieved by the foreign company, such as infrastructure, trade organizations or reductions in trade barriers.

Imitation spillovers may also take place with regard to managerial and organizational practices. This is closely related to another spillover channel, namely the acquisition of human capital. Foreign firms typically invest considerably in the training of their workers. This acquired knowledge may spill over to local firms as employees of foreign firms change jobs or start their own company. Inter-firm mobility accelerates the spread of managing skills and production methods from foreign to domestic companies.

Increased competitive pressure caused by the entry of multinationals forces firms to use their inputs and the existing technology in a more efficient way to secure their market share and their profits. Besides the production gains related to these reductions in X-inefficiency, increased competition also stimulates faster adoption of new technologies and management practices. An additional positive competition effect related to the entry of foreign firms may come from the breakdown of a local monopoly. Such a monopolistic industry is typically characterized by high entry barriers which might be impossible to overcome for local firms. Multinationals on the other hand possess the necessary capital and scale, and the technological knowledge to enter the market and reduce the market distortions. A weakened power of the local monopolist engenders a more competitive and efficient environment in the domestic market.

Aitken and Harrison (1999) argue that the entry of a multinational may also generate negative competition effects on the domestic market. A foreign player who produces for the domestic market may attract demand away from local firms and force the least efficient plants - which are unable to face competition - out of business. A reduction of their market share might induce domestic firms to produce at a less efficient scale. If the fixed costs count for a considerable part of the production costs, average cost curves will be downward sloping, in which case a loss in market share will push firms up their average cost curves. The total spillover effect of increased competition will depend on the influence of the efficiency effect versus the crowding out effect.

An additional benefit from FDI is the potential hardening of budget constraints (e.g. Dewatripont and Maskin, 1995, and Roland, 2002). The soft-budget-constraints (SBC) problem is an important concern in transition countries and is related to the inability of social planners to commit not to bail out money-losing firms (Kornai, 1980). Continued subsidies may slow down the process of restructuring and sectoral reallocation. The presence of foreign firms and the inflow of foreign capital reduce the financial link between the government and the domestic firms, thereby hardening budget constraints and increasing efficiency.

2.3 Empirical literature

Despite the range of positive spillover effects predicted by theory, the empirical literature finds no or even negative effects on the productivity of domestic firms in developing and transition economies. An overview of the empirical literature can be found in Görg and Greenaway (2003). The few papers that look at the case of China confirm the existence of negative spillovers found in other studies. These studies, however, restrict their attention to a particular segment of the market (e.g. electronics and textile industry in Hu and Jefferson, 2002, and state-owned enterprises in Girma et al., 2005), or use industry or provincial data (Li et al., 2001, and Cheung and Lin, 2004 respectively). In this paper we broaden the analysis to all manufacturing sectors and take into account the heterogeneity by using firm-level data in our analysis.

Blömstrom et al. (2000) review the empirical literature and summarize the conditions that have to be fulfilled for externalities to take place. In particular, technology diffusion

seems be more than just an automatic consequence of the presence of other firms' knowledge stocks in the same sector or region and depends to a high extent on the absorptive capacity of the recipient firms.⁴ To that regard, Kinoshita (2001) looks at the relevance of R&D activities on enhancing the ability to absorb and to adopt the available technology and provides evidence for the Czech Republic that technology spillovers are limited to those firms that are more R&D intensive. Related to this, the amount and the quality of technology transferred through FDI may be dependent on the initial technology level of local firms relative to that of foreign firms. Findlay's (1978) theoretical model predicts that the rate of technological spillovers from FDI is an increasing function of the technological disparity between the backward and advanced region, provided that the gap is not too wide. That is, the further a region lags behind the technological leader, the greater the pressure to make technological progress and to exploit the available opportunities. Using firm-level data for the UK, Griffith et al. (2002) provide empirical evidence for this view of convergence in productivity. They find that establishments further behind the technological frontier experience faster rates of growth in total factor productivity and that the increased competitive pressure due to the presence of multinationals speeds up the catching-up rate of domestic firms.

Conversely, Glass and Saggi (1998) reason that if a firm is too far from the technology frontier it might be unable to imitate the available technology and consequently fail to capture the associated efficiency rents. The bigger the gap, the less likely the host country is to have the human capital, physical infrastructure and distribution networks to support inward investment. This decreases the potential for spillovers and lowers the quality of technology transferred. Evidence in favor of this hypothesis is provided by Girma et al. (2001). Firms located further away from the world efficiency standard exhibit a slower productivity spillover rate. On the other hand, Sabirianova et al. (2005) tested the distance-to-the-frontier hypothesis for Russia and the Czech Republic, but their results revealed no catching-up behavior in the domestic economy, not even by those establishments located closer to the frontier.

Instead of restricting a priori the relationship between a firm's absorptive capacity and FDI induced productivity spillovers to be linear, Girma (2005) allows the spillover impact to vary across firms according to their distance to the frontier. Technology spillovers turn out to be an increasing function of the absorptive capacity of the local firms, but they level off after

⁴ The importance of the absorptive capacity was first introduced by Cohen and Levinthal (1989).

a certain threshold of technological capacity is reached. If a firm is located too far from the frontier, no or even negative FDI spillovers are found.

An additional determinant of the magnitude of FDI induced spillovers that has been proposed by the literature is the degree of ownership.⁵ Firms that decide to exploit their technological advantage by providing the world market with their products can choose between exporting, licensing their technology or serving the market through local affiliates. With imperfect markets for technology, and hence high transaction costs to sell technology to outsiders, multinationals prefer to internalize certain transactions to shelter their technological innovations from being copied. While a joint-venture set-up allows a multinational to use its local partner's experience with the domestic markets, consumer preferences, and local business practices, it also increases the risk for undesired leakages of their technologies.⁶ The domestic partner comes in close contact with technological innovations and gets access to insider information that it could use in the production of other goods for which it does not cooperate with the multinational. Being confronted with this risk, the parent firm will be discouraged from transferring its most innovative technologies to its affiliate. On the other hand, foreign firms with greater control over their affiliate are better able to protect their intangible assets, and are expected to transfer more sophisticated technologies to their subsidiaries.⁷ On that account fewer FDI spillovers are expected from the presence of firms with a foreign majority not only because the technology is better protected, but also because domestic firms might not have the necessary absorptive capacity to copy the highly sophisticated technology that is transferred.

3 DATA AND ECONOMETRIC APPROACH

3.1 Data

The data used in this paper are drawn from the Oriana CD-ROM (version May 2006) compiled by Bureau van Dijk, which contains public and private financial company

⁵ Only few studies have paid attention to impact of ownership structure on FDI spillovers: Blomström and Sjöholm (1999), Dimelis and Louri (2001) and Smarzynska-Javorcik and Spatareanu (2006).

⁶ WFOEs are allowed in China since the promulgation of the Wholly Foreign-Owned Enterprise Law in 1986. The restrictions on foreign ownership still exist in the Chinese banking sector, where the share of foreign capital is not allowed to be bigger than 25%.

⁷ See Ramachandran (1993)

information for the Asia-Pacific region. The companies included in the database are either publicly listed or satisfy at least one of the following size criteria: minimum number of employees is 150, or annual turnover or total assets at least 10 million and 20 million USD, respectively. For the People's Republic of China the original dataset covers an unbalanced panel of 17,645 plants over the period 2002 and 2004. We restrict our attention to the manufacturing sector, based on the US SIC 1987 classification (sectors 20-39).

In section 4 we estimate the productivity levels using a Cobb-Douglas and translog production function. Given that a production function defines the maximum output attainable from a given vector of input, we need to assume that plants behave as profit maximizing market players. SOEs, however, seldom operate as independent business entities responding solely to market forces. Instead SOEs continue performing the dual tasks of producing goods and providing social welfare. The Chinese central government tends to use these firms as policy tools in their aim for social stability, and only gradually confers SOEs the formal right to make independent input decisions according to their production needs (Bai et al. 2000). Based on this information we decided to exclude the SOEs and collective enterprises from our analysis. The number of observations is further reduced to 7,862 plants due to missing values on some of the input factors (Appendix A with more details on the cleaning process – *to be added*).

Table 1 reports summary statistics for the basic variables employed in this paper. Sales and value added are deflated by a provincial producers' price index of industrial products. Capital is deflated by a provincial price index of investment in fixed assets, which takes into account the actual purchasing prices or balancing prices of investment in fixed assets. All price indices are taken from various editions of China Statistical Yearbook. When the size of a plant is measured by its sales, foreign plants are more than three times as big as their domestic counterparts. The descriptive statistics reveal that foreign plants are not only larger relative to domestic plants in terms of employment, sales and value added, but they are also more capital intensive and enjoy higher productivity. The disparity is even more pronounced when we consider Western companies only. However, these differences may result from a selection bias, which reflects the tendency of foreign plants to acquire more productive local plants or to invest in higher productive sectors and regions.

[Table 1: Summary statistics for domestic versus foreign manufacturing plants in China]

An overview of the sectoral and regional distribution of foreign plants in China is given in Appendix B en C. As can be seen in Appendix B, more than 90% of all foreign capital in China is located in the coastal region of China, and more precisely in three provinces: Shanghai, Guangdong and Jiangsu which received more than half of total FDI in China. This geographical concentration is partially attributable to the FDI promotion policies adopted in the past. At the beginning of the liberalization of the Chinese economy, the central government strategically directed FDI to the Special Economic Zones (SEZs) located in the Guangdong and Fujian provinces. Later on similar FDI policies were extended to other coastal industrial cities and ports, such as Shanghai, the Pearl River Delta, and the Yangtze Delta. Only since the beginning of the nineties China gradually started to target its inland. The southern coastal provinces benefit additionally from the geographical and cultural proximity to the overseas Chinese communities in Hong Kong, Macao, and Taiwan. However, as Cheng and Kwan (2000) argue, good infrastructure is another important determinant in foreign investors' location decisions. In particular the inland regions have inadequate and undeveloped infrastructure networks and facilities, a fact which reinforces the concentration of foreign capital and technology in the eastern part of China. Appendix C displays that also the sectoral composition of FDI in China is unevenly distributed. Until the end of the eighties the primary sector attracted the biggest share of FDI. Afterwards, the Chinese manufacturing sector fast became the most important sector for foreign investors. At this moment it accounts for more than 70% of the total actually utilized value of FDI in China.⁸ In addition, the investment focus moved from textile processing, chemicals, and mechanical and electronics industries to more technically advanced sectors. This shifting sectoral composition reflects changes in the origin of foreign investors. In the eighties the major part of inward FDI originated from Chinese investors based in Hong Kong, Macau and Taiwan. These overseas investors were mainly seeking to exploit the relatively low labour cost in the SEZs for export processing. Since the beginning of the nineties China attracted increasingly more technologically advanced Western and Japanese companies, interested in serving the huge domestic market through local production.

3.2 Econometric approach

We start from a general Cobb-Douglas production function,

⁸ China Statistical Yearbook 2005

$$Y_{it} = A_{it} F_i \left(L_{it}^{\alpha_L} K_{it}^{\alpha_K} M_{it}^{\alpha_M} \right) \quad (1)$$

where i and t indicate industry and time respectively. Y stands for output, while L , K and M represent the inputs used in production, being labor, physical capital stock and materials respectively. The index A_{it} is a measure of technical efficiency or Total Factor Productivity (TFP) of plant i at time t . We assume TFP to be a function of foreign participation and various spillover effects, and control for sector-, region-, and time-specific determinants of technical efficiency:

$$TFP_{it} = G_i \left(FDI_i, Spillover_{jt}, d_j, d_c, d_t \right) \quad (2)$$

The underlying idea is that foreign firms utilize more advanced technology and a more efficient organizational structure, which increases the efficiency of their production process. Additionally, as discussed in the previous sections, technical efficiency improvements are usually not limited to the receiving plant, but are likely to spillover to firms that come in contact with the multinational.

To analyze the direct and indirect effects of inward foreign investment we proceed in two steps. In a first step we estimate the plant-specific TFP levels using four different approaches, which we relate in a second step to the foreign presence in a particular sector. The first approach estimates a log-linear transformation of the Cobb-Douglas production function in equation (1), using ordinary least squares (OLS):

$$y_{it} = \alpha_0 + \alpha_L l_{it} + \alpha_K k_{it} + \alpha_M m_{it} + d_j + d_c + d_t + \varepsilon_{it}, \quad (3)$$

where the small letters stand for the natural logarithms of the respective variables and the α 's represent the elasticity of output with respect to the inputs. All variables are deflated by provincial price deflators and we control for fixed effects, by including year dummies (d_t), industry dummies (d_j) and city dummies (d_c). In addition, we correct for heteroskedasticity and cluster the standard errors to take into account potential correlation.

The relation between a plant's productivity and its input decisions creates however a simultaneity problem which causes the OLS estimates to be biased. Firms observe their own productivity and may respond to a positive productivity shock by using more inputs. Consider the case where ε_{it} can be decomposed into the plant's productivity ω_{it} , and an *i.i.d.* error term u_{it} . If ω_{it} is known to the plant, the optimal labor input choice will be a function of ω_{it} , and

since ω_{it} is not directly observable by the econometrician simple OLS estimation suffer from a simultaneity bias since $E[\varepsilon_{it} | l_{it}] \neq 0$. Olley and Pakes (1996) and Levinsohn and Petrin (2003) suggest a method to control for this simultaneity bias between productivity shocks and input choices. We have however no information on investment. In principle we could compute investment from our capital stock variable, but this means we would lose one year of data. Since we only have three years of data available, the cost of using Olley-Pakes instead of Levinsohn-Petrin becomes too high. We therefore follow the semi-parametric approach of Levinsohn and Petrin (2003).

Additionally, if firms have some pricing power the estimates of the α 's are still biased, since inputs are likely to be correlated with the price a firm charges. Ideally we would use physical output or sales deflated with firm-level price information to estimate our production function. Since this information is not available we opt for a second best solution and deflate sales using a provincial price index. The firm-level price deviations from the provincial price index used to deflate the firm-level sales end up in the error term ($\varepsilon_{it} + p_{it} - p_{it}$) and causes biased coefficients. To control for this omitted price variable bias we follow the approach suggested by De Loecker (2006). Controlling for the simultaneity bias and the omitted price bias is of particular importance in this study, since the TFP measure is simply the regression residual and therefore crucially dependent on the goodness of fit of the model.

In the first three approaches we use a Cobb-Douglas production function to estimate the firm-specific TFP-levels. The Cobb-Douglas production function is however restrictive in the properties it imposes upon the production structure, assuming that all firms have the same production elasticities, fixed returns to scale and an elasticity of substitution between the inputs equal to unity. To allow more flexibility we use a non-homogenous production function in the fourth approach. The translog functional form permits the elasticity of scale to vary for different input values:

$$y_{it} = \alpha_0 + \alpha_L l_{it} + \alpha_K k_{it} + \alpha_M m_{it} + \beta_1 l_{it}^2 + \beta_2 k_{it}^2 + \beta_3 m_{it}^2 + \beta_4 l_{it} * k_{it} + \beta_5 l_{it} * m_{it} + \beta_6 k_{it} * m_{it} + d_j + d_c + d_t + \varepsilon_{it} \quad (4)$$

We now relate the estimated plant-level TFP measures to the foreign presence in a particular sector to analyze the direct and indirect effects of FDI at the firm level. Based on equation (2) we estimate:

$$\ln TFP_{it} = \beta_1 F_i + \beta_2 Spillover_{jt} + \beta_3 Spillover_{jt} \times F_i + d_j + d_c + d_t + \eta_{it} \quad (5)$$

which allows us to analyze the various factors that affect the technical efficiency of a firm. Initially we define F_i as a foreign dummy variable being equal to one when a positive percentage of the plant's asset is owned by foreign shareholders.⁹ Since foreign firms are assumed to benefit from technological advantages, we expect a higher productivity level than the average plant in our sample and a positive coefficient β_1 . To evaluate the indirect efficiency impact of inward foreign investment at the sector level, the regression is extended by the variable $Spillover_{jt}$. $Spillover_{jt}$ is a measure for the presence of multinationals in the same sector and is defined as the share of foreign sales in total sales at the 3-digit US SIC87 industry-level.¹⁰ This variable measures the impact of foreign firms on the domestic market, i.e. either a negative competition effect or a positive imitation effect. A significant part of the production of foreign firms is however destined for export, which means that the effective competitive pressure on the domestic market is smaller than suggested by the sales variable. Therefore we follow Damijan and Knell (2005) and subtract the share of exports from a firm's total output to measure the real impact of foreign firms:

$$Spillover_{jt} = \frac{\sum_i Sales_{ijt} \times F_{ijt}}{\sum_i Sales_{ijt}} \times \left(1 - \sum_i \frac{Exports_{ijt}}{Sales_{ijt}} \right) \quad (6)$$

Depending on whether or not the negative competition effect related to foreign investment dominates the positive learning effect, β_2 will be either negative or positive. It might however be possible that foreign- and domestic-owned firms benefit in a different way from the presence of other multinationals in the same sector. Therefore we interact the foreign ownership dummy with the spillover variable ($Spillover_{jt} \times F_i$). Finally, the dummy variables d_j , d_c , and d_t are added to take into account unobserved industry-, region-, or time varying factors. This allows us to control partly for the endogeneity problem that the more productive firms, sectors or cities might attract more foreign capital.¹¹

⁹ The Oriana database does not allow us to see changes in ownership structure. The nationality of a shareholder is fixed over time and determined at the moment of reporting (i.e. year 2006).

¹⁰ In this study we concentrate on horizontal spillovers and do not touch upon vertical spillovers. Since foreign firms in China import an important part of their components and materials used in their production, the linkage effects to backward and forward sectors are expected to be rather limited (OECD, 2000).

¹¹ Year dummies take into account economy-wide shocks, while regional dummies and industry dummies control for productivity changes specific to a particular city or industry respectively (for instance, those resulting from improvements in infrastructure).

In this study we are particularly interested in the impact of the ownership structure on the magnitude of spillovers. To analyze this question into further detail, we differentiate in our second regression between foreign minority firms and foreign majority firms:

$$\ln TFP_{it} = \beta_1 F_Min_i + \beta_2 F_Maj_i + \beta_3 Spill_Min_{jt} + \beta_4 Spill_Maj_{jt} + \beta_5 Spill_Min_{jt} \times F_Min_i + \beta_6 Spill_Maj_{jt} \times F_Maj_i + d_j + d_c + d_t + \eta_{it} \quad (7)$$

The reason behind this distinction relates to the expected difference in spillovers related to WFOEs, and joint-ventures between foreign firms and their Chinese partners, as discussed in the previous section. The more a multinational controls the establishment, the greater its ability to protect its technology from spilling over to other plants. Hence we replace the dummy F_i with two dummies F_Min_i and F_Maj_i , which equal one if the share of foreign capital lies between 1 and 50%, and above 50% respectively. While a WFOE will be faster inclined towards using its most efficient production methods, the higher risk of undesired copying inhibits the parent company of a joint-venture to transfer its know-how to its affiliates. That is, production is presumed to be more efficient in the case of foreign majority (β_2 bigger than β_1). Since also the spillovers are expected to be different according to the degree of foreign participation, we distinguish between spillovers from foreign minority and foreign majority firms. We presume that the competition effect will be fiercer in the case of foreign majority, since these firms are less afraid to use their latest technological innovations, so that they are more likely to outperform local producers. In the case of foreign minority control the imitation spillovers might dominate the competition impact.

The final contribution of this paper to the literature is related to the impact of the distance to the frontier on spillovers. To analyze the importance of the absorptive capacity of a plant we construct a simple model of productivity catch-up, in which we assume that the total factor productivity of a plant is a function of its own past productivity, and the current and past productivity-level at the frontier (TFP_{jt}^{\max}):

$$\ln TFP_{it} = \alpha_1 \ln TFP_{it-1} + \alpha_2 \ln TFP_{jt}^{\max} + \alpha_3 \ln TFP_{jt-1}^{\max} + \eta_{it} \quad (8)$$

Then we subtract $\ln TFP_{it}$ from both sides of the equation

$$\Delta \ln TFP_{it} = (\alpha_1 - 1) \ln TFP_{it-1} + \alpha_2 \ln TFP_{jt}^{\max} + \alpha_3 \ln TFP_{jt-1}^{\max} + \eta_{it} \quad (9)$$

Adding and subtracting $\alpha_3 \ln TFP_{it-1}$ from the right hand side yields:

$$\Delta \ln TFP_{it} = \alpha_1^* \ln TFP_{it-1} + \alpha_2^* \ln TFP_{jt}^{\max} + \alpha_3^* \ln \left(TFP_i / TFP_j^{\max} \right)_{t-1} + \eta_{it}, \quad (10)$$

where $\alpha_1^* = (\alpha_1 + \alpha_3 - 1)$, $\alpha_2^* = \alpha_2$ and $\alpha_3^* = -\alpha_3$. This representation allows an intuitive interpretation of the TFP-growth in relation with the distance to the frontier. To assess the technology frontier TFP_{jt}^{\max} we use alternative measures. The frontier is either proxied by the most efficient plant at time t in industry j at the 3-digit US SIC87 level, or by the mean of the 90th (95th-99th) percentile most efficient plants at time t in industry j at the 3-digit US SIC87 level. The second proxy has the advantage of reducing the measurement error by taking into account more than one firm. The leading-edge technology in the sector, as captured by the second term, is expected to have a direct impact on the efficiency improvement of non-frontier plants. The third term in the equation denotes the technological gap between a non-frontier plant and the technology frontier in industry j at time $t-1$, and can be viewed as a measure for the absorptive capacity of a plant. The (inverse) distance implies that a firm approaches the frontier as the ratio moves towards 1. Hence, the coefficient α_3^* can be interpreted as the average catching-up rate in the manufacturing industry.

To analyze the relationship between a plant's absorptive capacity and FDI induced productivity spillovers we relate the TFP-estimates of the first step to the efficiency frontier and the presence of foreign firms, using specifications (2) and (10):

$$\begin{aligned} \Delta \ln TFP_{it} = & \alpha_1^* \ln TFP_{it-1} + \alpha_2^* \ln TFP_{jt}^{\max} + \alpha_3^* \ln \left(TFP_i / TFP_j^{\max} \right)_{t-1} + \beta_1 F_i + \\ & \beta_2 Spillover_{jt-1} + \beta_3 Spillover_{jt-1} \times F_i + \beta_4 Spillover_{jt-1} \times \ln \left(TFP_i / TFP_j^{\max} \right)_{t-1} \\ & + d_j + d_c + d_t + \eta_{it} \end{aligned} \quad (11)$$

One concern is the potential for serial correlation when TFP is measured with error, as TFP_{it-1} appears on both hand sides of our regression. We address this potential problem using detailed micro-level data and include industry-, region-, and time dummies to make abstract from the fixed effects. In addition, controlling for the simultaneity bias and/or the omitted price variable bias – using Levinsohn-Petrin (2003) and De Loecker (2006) – minimizes the measurement error in our TFP indices.

The most interesting variable is the last term in equation (11), namely the interaction term between the technology gap and the spillovers. This variable indicates whether spillovers depend on the capacity of a plant to absorb the technological innovations that are used in the production process of foreign-owned establishments. If our distance-to-the-frontier hypothesis is confirmed, β_4 should be positive, indicating that plants closer to the technology frontier possess the necessary knowledge to learn from multinationals. Analogously to the first part of our empirical analysis, we look at the impact of the ownership structure of foreign firms on the absorptive capacity of local firms:

$$\begin{aligned} \Delta \ln TFP_{it} = & \alpha_1^* \ln TFP_{t-1} + \alpha_2^* \ln TFP_{jt}^{\max} + \alpha_3^* \ln(TFP_i / TFP_j^{\max})_{t-1} + \beta_1 F_Min_i + \beta_2 F_Maj_i \\ & + \beta_3 Spill_Min_{jt-1} + \beta_4 Spill_Maj_{jt-1} + \beta_5 Spill_Min_{jt-1} \times F_Min_i \\ & + \beta_6 Spill_Maj_{jt-1} \times F_Maj_i + \beta_7 Spill_Min_{jt-1} \times \ln(TFP_i / TFP_j^{\max})_{t-1} \\ & + \beta_8 Spill_Maj_{jt-1} \times \ln(TFP_i / TFP_j^{\max})_{t-1} + d_j + d_c + d_i + \eta_{it} \end{aligned} \quad (12)$$

4 RESULTS

4.1 Spillovers and the role of ownership structure

Table 2 shows the baseline results for the FDI induced sectoral spillovers, with the dependent variable TFP calculated according to the four different methods discussed in the previous section: OLS estimation of the Cobb-Douglas production function (column 1), controlling for the simultaneity bias (Levinshon-Petrin, column 2), correcting both for the simultaneity bias and for the omitted price bias (De Loecker, column 3), and OLS estimation of the non-homogenous translog production function (column 4). These plant-level TFP-estimates are highly correlated over all four methods and yield the same pattern of key results.¹²

[Table 2: Sectoral spillovers in the Chinese manufacturing sector]

First of all, our results overall illustrate significant differences in the performance of domestic and foreign firms, with the magnitude differing with the used method. The positive and statistically significant coefficients on the foreign ownership dummy reveal that after

¹² The correlation matrix can be found in Appendix D, all correlations are significant at the 1% significance level.

controlling for firm-specific aspects, foreign firms produce with the same inputs about 3.5 to 5% more output than their domestic counterparts. This finding might however be due to the fact that foreign firms tend to take over the better performing domestic plants or locate in more productive sectors and regions. Data constraints on the change in ownership do not allow us to draw conclusions about the causality of the higher productivity. When we look at the indirect effect of foreign investment we find no significant spillover effect on domestic firms. Domestic firms seem not be able to learn from the foreign investors located in the same sector. On the other hand they also do not suffer from increased competition. Foreign firms on the contrary benefit slightly from the presence of other foreign companies in the same sector. The economic impact of a coefficient of 0.002 is however negligible, since this means that an increase in the foreign presence with 10 percentage points would increase productivity on average with only 0.02 percent.

We now look into more detail at the role of ownership in generating spillover effects and distinguish in Table 3 between foreign minority firms (foreign share in the Chinese affiliate between 1 and 50%) and foreign majority firms (share of more than 50%), and look at the different spillover effects they engender. Three out of the four specifications reveal a higher productivity for foreign minority firms. The statistical significance level decreases however with the LP and DL specification and the coefficient on F_Min becomes insignificant when using the translog specification. The productivity advantage of enterprises with a foreign minority share is therefore still rather doubtful. Conversely, firms that have a majority control over their Chinese affiliate are on average significantly more productive than domestic firms and foreign minority firms. The differences between the coefficients of foreign minority and foreign majority firms are statistically significant. These findings confirm our expectations, and suggest that the parent company is reluctant to transfer its know-how to joint-ventures over which they do not have full control.

In addition, our results in Table 3 show that local firms seem to be unable to capture the benefits from the presence of foreign firms in the same sector. Instead, there is a negative and highly significant competition effect induced by joint-ventures with a foreign minority share. A possible explanation is that the cost advantages these multinationals have, allow them to attract demand away from local producers. This forces domestic firms to reduce their production and pushes them up their average cost curve. The negative coefficients for all four

estimations reflect that on average the negative competition effect is stronger than the positive knowledge spillover effects associated with the presence of multinationals. In addition, this might be an indication that, notwithstanding the weak Chinese IPR-protection system, multinationals seems to be able to protect their strategic technological and managerial advantages from being imitated.

[Table 3: Spillovers and the role of ownership structure]

Foreign firms, on the other hand, do not seem to suffer from increased competitive pressure in their sector. On the contrary, our results reveal that other foreign firms benefit from the presence of foreign firms in the same sector. We can see however that the positive effect is bigger for foreign minority joint-ventures than for WFOEs.¹³ An increase from 0 to 10% percent in the share of foreign minority firms in the same industry boosts the production of other foreign plants with a minority share in their Chinese affiliate with 0.52 percentage points $[-(-0.033+0.085)*10]$, compared to 0.04 percentage points in the case of foreign majority firms (DL specification, column 3). The effects expressed in economic terms are rather small, but these findings confirm our expectations that because of the specific nature of joint-ventures, technology tends to spill over much more easily than in the case of WFOEs. A firm can learn from the experience of its foreign partner through for instance the mobility of workers.

As a robustness check we perform the analysis again, but with a slightly different measure for the presence of foreign firms. Instead of computing $Spillover_{jt}$ with sales, we define $Spillover_{jt}$ now as the share of foreign employment in total number of employees at the 3-digit US SIC87 industry-level. The results can be found in Appendix E. Overall the results above are confirmed by the results when spillovers are measured in terms of employment. One point that draws our attention is the insignificant coefficients of $Spillover_Min_{jt}$ en $Spillover_Maj_{jt}$. This supports our explanation above that domestic enterprises suffer from increased competition on the output market – as measured by sales – which draws demand away from them. The insignificant coefficients when measuring spillovers by the number of

¹³ We must be careful not to look separately at the t -statistic of the estimates of the coefficients on $Spillover_Min_{it}$ and $Spillover_Min_{it} \times F_Min_{it}$ to conclude whether we can reject the null hypothesis of both coefficients being equal to zero. Based on the F test for each of the specifications (OLS-LP-DL-Translog) we can reject the null hypothesis at the 5% level both for the foreign minority and foreign majority group.

employees, on the other hand, indicate that Chinese firms are not able to capture the benefits from inter-firm mobility of high-skilled workers between foreign and domestic firms.

4.2 Impact according to the origin of FDI

We observe a different pattern of foreign investment according to its country of origin. While Western companies usually invest in the more technologically advanced sectors, such as electronics, machinery, medicines, and automobiles, overseas Chinese in Hong Kong, Macau and Taiwan tend to relocate relatively simple, labor-intensive activities, like garments, footwear, and light electronics to China. Foreign investment differs according to its country of origin, not only in the degree of technological sophistication, but also in the underlying motives and production structure (Zhang, 2005). Since we expect these differences to have an impact on the spillover effects they engender, we divide FDI in our sample in two groups, one containing FDI coming from Western Countries, i.e. Europe, Canada or the United States, and a second group including investment originating from Hong Kong, Macau and Taiwan (HMT hereafter). To avoid an abundance of results and to maintain a clear overview, we discuss here only the results of the DL-specification which controls for both the simultaneity bias and the omitted price variable bias. Nevertheless, as shown in Table 2 the TFP-estimates are highly correlated and do not alter our conclusions. The results for the other specifications can be found in Appendix F.1 and F.2.

[Table 4: Spillovers according to the region of origin]

Table 4 shows a clear difference in productive efficiency for Western, domestic and HMT companies. While HMT are in general no more productive than Chinese firms, Western multinationals derive their advantages from leading-edge technological know-how and efficient marketing networks. The most interesting finding of this exercise is the difference in spillovers coming from Western companies and overseas investment from HMT. Hong Kong's role as an export entrepôt between China and the rest of the world, urged HK firms to relocate their labor-intensive activities to Mainland China when labor costs started rising at home. This involved in general the adaptation of more mature technologies, and small-scale activities with easily transferable skills. Since HMT regard China as an inexpensive production base, their investment is mainly export-driven and consequently triggers less negative competition effects on the domestic market. Additionally, the cultural and linguistic connection of overseas Chinese with Mainland China facilitates the negotiation and

cooperation with Chinese entrepreneurs. Precisely these characteristics of HMT investment promote positive spillovers on the domestic firms. Indeed, the positive coefficients on $Spillover_Min_{it}$ and $Spillover_Maj_{it}$ (Table 5, second column) indicate that Chinese companies benefit from the presence of HMT investors, regardless of the shares they hold in the company. Consistent with our expectations, minority joint-ventures generate moderately more positive spillovers for the domestic producers. The relatively high capital intensity and advanced and complex technology make it more difficult for Chinese firms to imitate the production of Western MNCs. Instead, the negative and significant coefficient of $Spillover_Min_{it}$ (Table 5, first column) suggests an important competition effect coming from these Western joint-ventures. Unlike their HMT counterparts, US and EU investors target the huge local Chinese market and compete directly with their domestic rivals. A large portion of Western sales enters the domestic market and in some sectors, such as for instance electronics and telecommunication equipment, foreign firms have gained prominent market shares (OECD, 2000).

[Table 5: Spillovers according to the region of origin and the role of ownership]

These results provide a first indication that the initial technology level of a firm relative to that of foreign firms is an important determinant of the extent to which local firms are able to absorb the FDI induced productivity spillovers. We will now investigate these findings into more detail and look in the next section at the empirical results of our distance-to-the-frontier hypothesis.

4.3 Distance to the frontier

As explained in Section 2.3, the negative results for domestic firms might signal an insufficient absorptive capacity which deprives them of assimilating the existing knowledge. To analyze this heterogeneity in FDI response across firms we look at the impact of the technology gap, and the relation between efficiency spillovers and a firm's distance to the frontier. Before moving to the results of our regression, we have a look at the mean productivity levels of domestic versus foreign firms across industries, and the mean distance to the technological frontier among domestic-owned plants. The first 3 columns show that in most sectors the mean TFP-level of foreign plants is higher than for their domestic counterparts. On the other hand, in most sectors we observe a bigger diversity in productivity among domestic plants than among multinationals (Column 4-6). The last two columns of

Table 6 report the mean distances of domestic establishments relative to the frontier ($=TFP_i/TFP_j^{\max}$). The percentages are calculated at the 3-digit USSIC industry-level, but presented as the mean within the 2-digit industries. On average domestic plants have efficiency levels that are 57% or 72% of frontier TFP, depending on whether the frontier is proxied by the most efficient plant (*frontier_max* here after), or by the mean of the 90th percentile of most efficient plants (*frontier_90* here after). The technology gap varies by sector with the largest gap observed in the sector “Electronic and other electric equipment” (mean technology gap compared to the most efficient plant is 47%), or in the sector “Chemicals and allied products (mean technology is 66% of the 90th percentile most efficient plants). The smallest gaps are observed in sectors where the foreign presence is smaller (“Printing and publishing” and “Lumber and wood products”).

[Table 6: Mean productivity and technology gap]

The results for the distance-to-the-frontier regression are presented in Table 7 and 8. We have to keep in mind that the TFP-levels from which we draw our conclusions are estimated variables, and may still contain some estimation errors. To minimize these errors we base our analysis on the TFP-estimates of the four approaches presented above, and proxy the frontier in different ways. Only the estimations of *frontier_max* and *frontier_90*, are presented here. Nevertheless, when we use different percentiles (i.e. 95th or 99th percentile) as proxies we obtain similar the results. The results tell us in the first place that plants with high productivity in the previous year tend to make less progressive efficiency improvements, indicated by the negative coefficient on the first variable in our regression, i.e. lagged productivity. Table 7 and 8 further indicate that foreign plants grow faster on average and that technological efficiency improvements at the frontier level have a positive and significant direct effect on the TFP growth in non-frontier firms.

[Table 7: Distance to the frontier]

[Table 8: Distance to the frontier and the role of ownership structure]

A first indication of the importance of the absorptive capacity is given by the positive coefficient on $\ln\left(TFP_i/TFP_j^{\max}\right)_{t-1}$. Only the gap with *frontier_90* is statistically significant, but this approach minimizes the measurement error (and to a further extent when using DL). Our main interest lies in the interaction term $Spillover_{t-1} \times \ln\left(TFP_i/TFP_j^{\max}\right)_{t-1}$, which gives

us information on the impact of the absorptive capacity on the magnitude of spillovers. Similar to the results in section 4.1, domestic firms do not benefit from the presence of foreign plants in their sector; there are only positive spillovers on other foreign plants producing in the same sector. For most of the specifications we find a positive and statistically significant coefficient on $Spillover_{t-1} \times \ln(TFP_i / TFP_j^{\max})_{t-1}$. This is a confirmation of the hypothesis of Glass and Saggi (1998) which postulates that the smaller the distance to the frontier the more a firm is able to benefit from the presence of multinationals in the same sector.¹⁴ Yet, in economic terms the effect is quite small and disappears when we distinguish between foreign minority and foreign majority firms (Table 8). This makes the evidence for the distance-to-the-frontier hypothesis for absorbing external knowledge rather weak and subject to further investigation.

5 CONCLUSION

In this paper we used a unique panel dataset of firms producing in China to analyze whether foreign investment in the Chinese manufacturing industry generates positive spillovers to the domestic economy. The policy of the Chinese central government influences in an important way the outcome of the impact of foreign investment on the Chinese economy. Measures such as the exemption from value-added tax on technology transfer for foreign enterprises encourage technological renovation. To increase the likelihood of positive spillovers it is written in the law on WFOEs that the establishment of foreign-funded enterprises should benefit the development of China's national economy in the sense that enterprises must either adopt international advanced technology and facility or export most or all products.

Our results reveal in the first place significant differences in the performance of domestic and foreign firms, and the importance of distinguishing according to the ownership structure when looking at the impact of foreign investment. It turned out that the parent company is reluctant to transfer its know-how to joint-ventures over which they do not have full control. When a multinational owns a majority stake in the affiliate, the risk of undesired

¹⁴ The null hypothesis that the coefficients on $Spillover_{t-1}$ and $Spillover_{t-1} \times \ln(TFP_i / TFP_j^{\max})_{t-1}$ are both equal to zero is rejected for all specifications.

knowledge spillovers is reduced to a minimum. Because of this these multinationals have the possibility to apply their most advanced production techniques, hereby generating negative competition effects on the local market. Second, this study made clear that the extent to which domestic firms are able to absorb the technological knowledge depends in an important way on the origin of FDI. While Western companies pose a competitive threat on Chinese firms, overseas investment coming from Hong Kong, Macau or Taiwan generates positive effects on their Chinese counterparts. Finally, we analyzed how the relative position of the domestic firm with respect to the frontier firm matters for absorbing potential spillovers from foreign firms. Our results confirm the hypothesis of Glass and Saggi (1998) that the smaller the distance to the frontier the more a firm is able to benefit from the presence of multinationals in the same sector. The evidence is however weak and subject to further investigation.

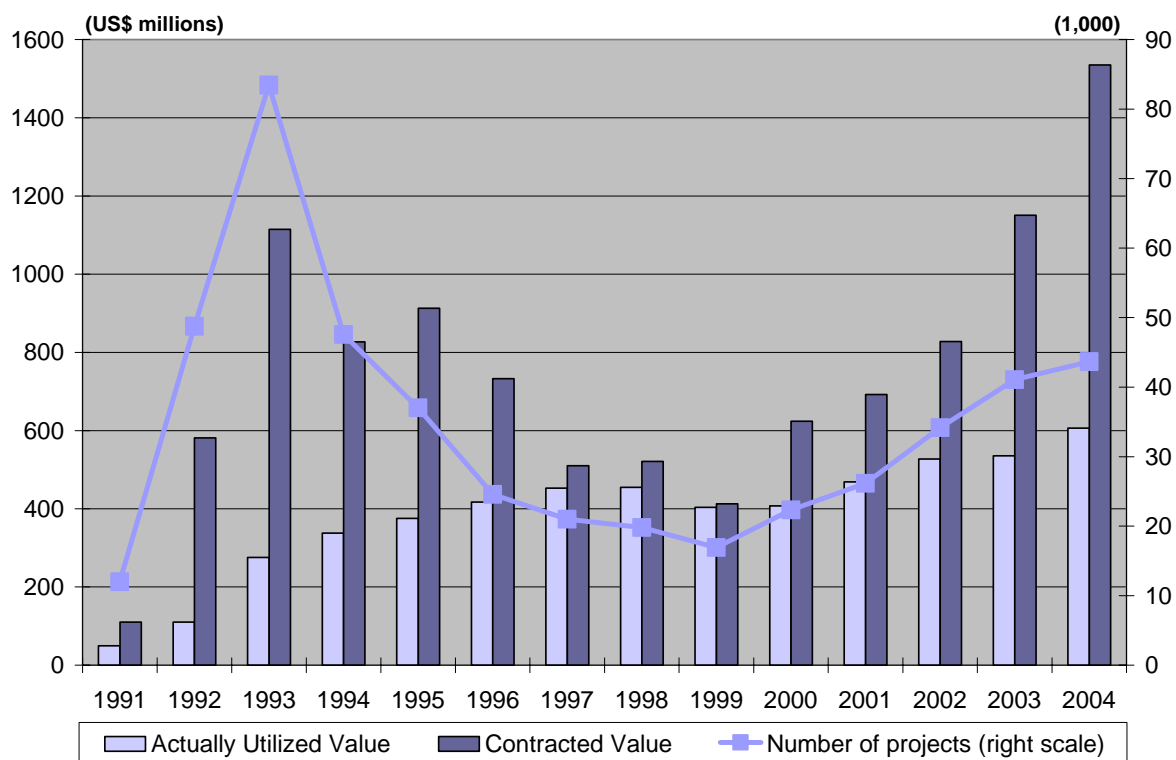
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Figure 1: Foreign Direct Investment inflows in China (1991-2004)



Note: Contracted value is the amount that investors plan to invest over a specified period at the time they apply for approval to invest. The actual or realized value is not bound by the contracted value and is typically much smaller. Government officials have however an incentive to encourage foreign investors to overstate the (not legally binding) contracted value, since the ability of local officials to attract foreign investment is often used by their superiors as an indicator of performance.

Source: China Statistical Yearbook

Table 1: Summary statistics for domestic versus foreign manufacturing plants in China

Variable	Domestic	Foreign	Western countries	HMT
Number of employees	1,010	1,549	1,116	1,907
Sales	40,318	148,981	181,742	123,347
Value added	6,548	20,091	24,291	18,080
Sales per worker	58.44	164.59	245.07	120.23
Value added per worker	7.44	20.43	27.37	16.00
Capital per worker	17.88	53.15	74.53	40.32
Labor productivity	59.10	166.43	246.21	123.14

- Notes:
- The number of employees is expressed in thousands of workers.
 - The remaining variables are expressed in thousands of US Dollars, using a provincial price index to deflate.
 - Western countries: EU-15, Norway, Sweden, Switzerland, Canada and US.
 - HMT: Hong Kong, Macau and Taiwan

Table 2: Sectoral spillovers in the Chinese manufacturing sector ^(a)

	OLS	LP	DL	Translog
$F^{(b)}$	0.053 (0.006)***	0.035 (0.006)***	0.035 (0.006)***	0.038 (0.006)***
<i>Spillover</i>	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
<i>Spillover x F</i>	0.002 (0.000)***	0.002 (0.000)***	0.002 (0.000)***	0.002 (0.000)***
Number of observations	20972	20972	20972	20972
R-squared	0.011	0.121	0.121	0.009

^(a) All regressions include sector, region, and time dummies - Robust standard errors in parentheses - ***/**/** significant at 10/5/1%.

^(b) F is a dummy equaling one if a positive percentage of the firm's asset is owned by foreign shareholders.

Table 3: Spillovers and the role of ownership structure ^(a)

	OLS	LP	DL	Translog
<i>F_Min</i> ^(b)	0.037 (0.010)***	0.017 (0.010)*	0.017 (0.010)*	0.013 (0.010)
<i>F_Maj</i> ^(b)	0.047 (0.007)***	0.030 (0.007)***	0.030 (0.007)***	0.036 (0.007)***
<i>Spillover_Min</i>	-0.032 (0.015)**	-0.033 (0.015)**	-0.033 (0.015)**	-0.033 (0.015)**
<i>Spillover_Maj</i>	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)
<i>Spillover_Min x F_Min</i>	0.086 (0.035)**	0.085 (0.035)**	0.084 (0.035)**	0.079 (0.037)**
<i>Spillover_Maj x F_Maj</i>	0.003 (0.000)***	0.003 (0.000)***	0.003 (0.000)***	0.003 (0.000)***
Number of observations	20972	20972	20972	20972
R-squared	0.010	0.121	0.121	0.008

(a) All regressions include sector, region, and time dummies - Robust standard errors in parentheses - */**/** significant at 10/5/1%

(b) Differentiation between foreign minority firms and foreign majority firms, with the share of foreign capital being between 1 and 50%, and more than 50% respectively.

Table 4: Spillovers according to the region of origin ^(a)

	Western countries ^(c)	HMT ^(d)
<i>F</i> ^(b)	0.105 (0.012)***	0.002 (0.008)
<i>Spillover</i>	-0.004 (0.004)	0.004 (0.002)*
<i>Spillover x F</i>	0.032 (0.005)***	0.014 (0.003)***
Number of observations	20972	20972
R-squared	0.129	0.118

(a) All regressions include sector, region, and time dummies - Robust standard errors in parentheses - */**/** significant at 10/5/1%.

(b) *F* is a dummy equaling one if a positive percentage of the firm's asset is owned by foreign shareholders.

(c) Western countries: EU-15, Norway, Sweden, Switzerland, Canada and US

(d) HMT: Hong Kong, Macau and Taiwan

Table 5: Spillovers according to the region of origin and the role of ownership ^(a)

	Western countries ^(c)	HMT ^(d)
<i>F_Min</i> ^(b)	0.033 (0.030)	-0.004 (0.012)
<i>F_Maj</i> ^(b)	0.107 (0.015)***	-0.003 (0.009)
<i>Spillover_Min</i>	-0.076 (0.042)*	0.050 (0.029)*
<i>Spillover_Maj</i>	0.006 (0.007)	0.005 (0.003)*
<i>Spillover_Min x F_Min</i>	0.232 (0.116)**	0.132 (0.068)*
<i>Spillover_Maj x F_Maj</i>	0.064 (0.009)***	0.021 (0.004)***
Number of observations	20972	20972
R-squared	0.129	0.119

(a) All regressions include sector, region, and time dummies - Robust standard errors in parentheses - */**/*** significant at 10/5/1%.

(b) Differentiation between foreign minority firms and foreign majority firms, with the share of foreign capital being between 1 and 50%, and more than 50% respectively.

(c) Western countries: EU-15, Norway, Sweden, Switzerland, Canada and US

(d) HMT: Hong Kong, Macau and Taiwan

Table 6: Mean productivity and technology gap ^(a)

USSIC	Description	Mean TFP ^(b)			Variance TFP ^(b)			Technology gap domestic firms	
		Domestic	Foreign	Difference	Domestic	Foreign	Difference	Max ^(c)	90 ^(d)
20	Food and kindred products	0.33	0.43	0.09	0.19	0.24	0.05	0.58	0.72
21	Tobacco products	0.54	0.60	0.06	0.26	0.00	-0.26	0.79	0.79
22	Textile mill products	0.24	0.22	-0.02	0.13	0.10	-0.03	0.60	0.79
23	Apparel and other textile products	0.32	0.30	-0.03	0.18	0.14	-0.05	0.51	0.69
24	Lumber and wood products	0.25	0.31	0.06	0.10	0.09	-0.01	0.82	0.86
25	Furniture and fixtures	0.30	0.26	-0.04	0.14	0.09	-0.05	0.73	0.79
26	Paper and allied products	0.27	0.29	0.02	0.11	0.11	0.00	0.73	0.81
27	Printing and publishing	0.34	0.28	-0.07	0.14	0.06	-0.09	0.83	0.85
28	Chemicals and allied products	0.39	0.43	0.05	0.25	0.27	0.02	0.53	0.66
29	Petroleum and coal products	0.31	0.47	0.16	0.13	0.17	0.04	0.73	0.78
30	Rubber and miscellaneous plastics products	0.30	0.31	0.01	0.16	0.13	-0.03	0.56	0.72
31	Leather and leather products	0.31	0.24	-0.07	0.17	0.07	-0.10	0.61	0.72
32	Stone, clay, and glass products	0.35	0.37	0.02	0.16	0.12	-0.05	0.68	0.74
33	Primary metal industries	0.25	0.26	0.01	0.13	0.09	-0.03	0.59	0.77
34	Fabricated metal products	0.31	0.33	0.02	0.14	0.17	0.03	0.64	0.74
35	Industrial machinery and equipment	0.37	0.31	-0.05	0.19	0.15	-0.04	0.54	0.70
36	Electronic and other electric equipment	0.34	0.30	-0.04	0.19	0.15	-0.04	0.47	0.68
37	Transportation equipment	0.31	0.37	0.05	0.16	0.13	-0.02	0.56	0.75
38	Instruments and related products	0.38	0.35	-0.03	0.16	0.21	0.04	0.69	0.75
39	Miscellaneous manufacturing industries	0.39	0.33	-0.07	0.24	0.13	-0.10	0.52	0.62
	All manufacturing industries	0.32	0.33	0.01	0.18	0.18	-0.01	0.57	0.72

(a) TFP-levels are the residuals taken from the De Loecker-estimation – All columns are means (variance) across 3-digit industry-level for the period 2002-2004

(b) Difference = Foreign - Domestic

(c) $(TFP_{it}/TFP_{jt}^{\max})$, with TFP_{jt}^{\max} the most efficient plant at time t in industry j at the 3-digit US SIC87 level, frontier = 1

(d) $(TFP_{it}/TFP_{jt}^{\max})$, with TFP_{jt}^{\max} the mean of 90th percentile most efficient plants at time t in industry j at the 3-digit US SIC87 level, frontier = 1

Table 7: Distance to the frontier ^(a)

$\Delta \ln TFP_{it}$ as dependent variable	TFP_{jt}^{\max} = most efficient plant				TFP_{jt}^{\max} = mean of 90 th percentile most efficient plants			
	OLS	LP	DL	Translog	OLS	LP	DL	Translog
$\ln TFP_{it-1}$	-0.291 (0.016)***	-0.261 (0.015)***	-0.261 (0.015)***	-0.289 (0.018)***	-0.348 (0.022)***	-0.319 (0.021)***	-0.320 (0.021)***	-0.350 (0.024)***
$\ln TFP_{jt}^{\max}$	0.036 (0.007)***	0.036 (0.006)***	0.036 (0.006)***	0.040 (0.007)***	0.148 (0.016)***	0.146 (0.015)***	0.147 (0.015)***	0.156 (0.017)***
$F^{(b)}$	0.014 (0.003)***	0.012 (0.003)***	0.012 (0.003)***	0.007 (0.003)**	0.013 (0.003)***	0.013 (0.003)***	0.013 (0.003)***	0.007 (0.003)**
$\ln(TFP_i/TFP_j^{\max})_{t-1}$	0.009 -0.007	0.004 -0.007	0.004 -0.007	0.009 -0.007	0.057 (0.015)***	0.050 (0.014)***	0.051 (0.014)***	0.060 (0.016)***
$Spillover_{t-1}$	0.001 (0.001)*	0.001 -0.001	0.001 -0.001	0.002 (0.001)***	0.000 0.000	0.000 0.000	0.000 0.000	0.001 (0.000)*
$Spillover_{t-1} \times F_Min$	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***
$Spillover_{t-1} \times \ln(TFP_i/TFP_j^{\max})_{t-1}$	0.002 (0.001)*	0.002 (0.001)*	0.002 (0.001)*	0.003 (0.001)***	0.002 (0.001)*	0.002 -0.001	0.002 -0.001	0.003 (0.001)***
Observations	11056	11056	11056	11056	11056	11056	11056	11056
R-squared	0.160	0.147	0.147	0.165	0.169	0.157	0.157	0.174

(a) TFP_{jt}^{\max} = mean of 90th percentile most efficient firms - All regressions include sector, region, and time dummies - Robust standard errors in parentheses - ***/** significant at 10/5/1%.

(b) F is a dummy equaling one if a positive percentage of the firm's asset is owned by foreign shareholders.

When the technology frontier is proxied by the mean of the 95th or 99th percentile of most efficient firms the results are similar.

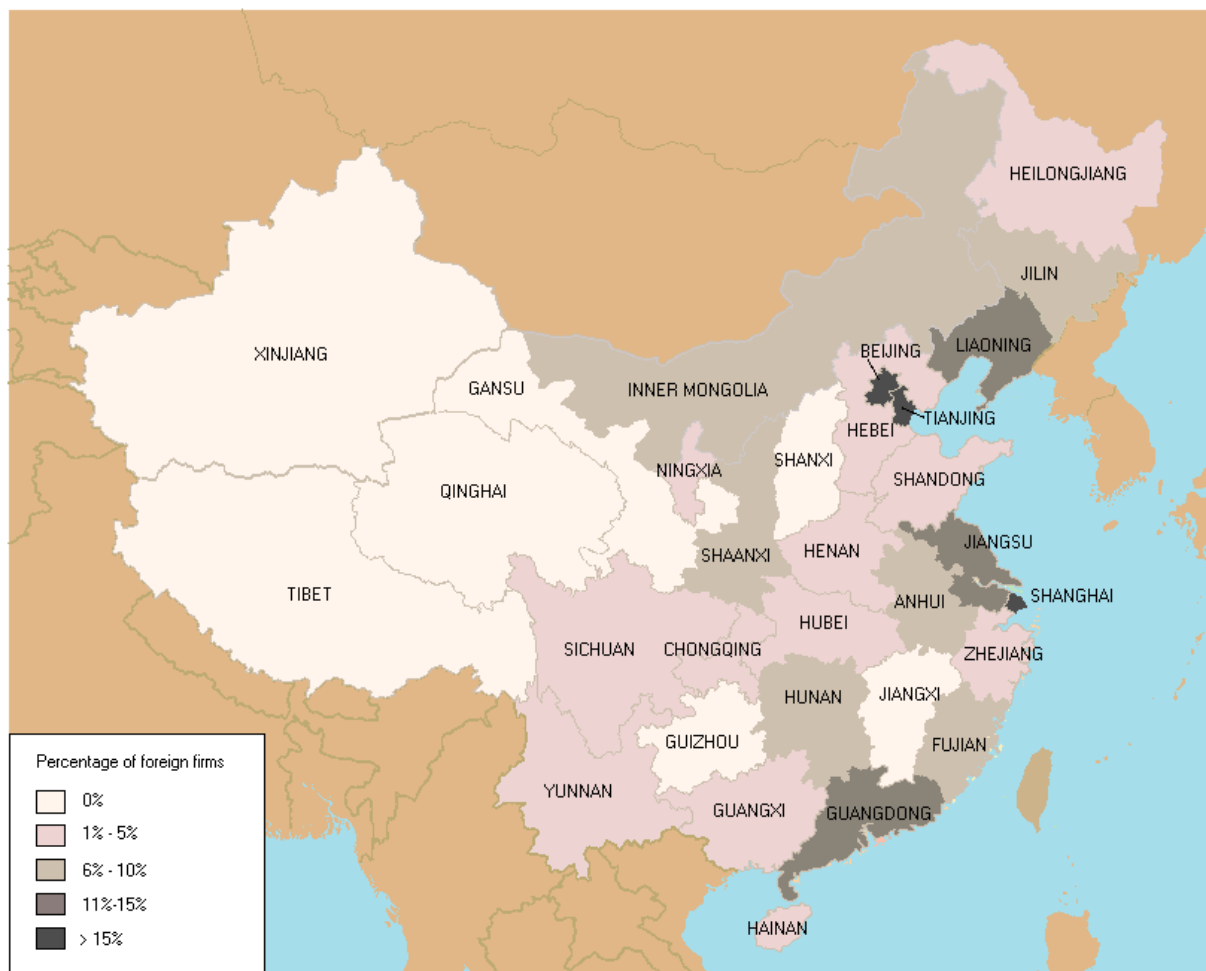
Table 8: Distance to the frontier and the role of ownership structure

$\Delta \ln TFP_{it}$ as dependent variable	TFP_{jt}^{\max} = most efficient plant				TFP_{jt}^{\max} = mean of 90 th percentile most efficient firms			
	OLS	LP	DL	Translog	OLS	LP	DL	Translog
$\ln TFP_{it-1}$	-0.291 (0.017)***	-0.261 (0.016)***	-0.261 (0.016)***	-0.290 (0.018)***	-0.346 (0.023)***	-0.319 (0.022)***	-0.319 (0.022)***	-0.348 (0.026)***
$\ln TFP_{jt}^{\max}$	0.036 (0.007)***	0.035 (0.006)***	0.035 (0.006)***	0.042 (0.007)***	0.147 (0.016)***	0.146 (0.015)***	0.146 (0.015)***	0.155 (0.018)***
F_Min	0.004	0.002	0.002	-0.004	0.005	0.003	0.003	-0.004
F_Maj	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004
$\ln(TFP_i/TFP_j^{\max})_{t-1}$	0.002	0.001	0.001	-0.002	0.002	0.001	0.001	-0.002
$Spillover_Min_{t-1}$	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
$Spillover_Maj_{t-1}$	0.010	0.004	0.004	0.010	0.056	0.050	0.051	0.057
$Spillover_Min_{t-1} \times F_Min$	-0.007	-0.007	-0.007	-0.007	(0.015)***	(0.014)***	(0.014)***	(0.017)***
$Spillover_Maj_{t-1} \times F_Maj$	-0.007	-0.012	-0.012	-0.030	0.010	0.007	0.007	-0.003
$Spillover_Min_{t-1} \times \ln(TFP_i/TFP_j^{\max})_{t-1}$	-0.041	-0.041	-0.041	-0.045	-0.047	-0.048	-0.048	-0.049
$Spillover_Maj_{t-1} \times \ln(TFP_i/TFP_j^{\max})_{t-1}$	0.005	0.005	0.005	0.009	0.001	0.001	0.001	0.003
$Spillover_Min_{t-1} \times F_Min$	-0.003	-0.003	-0.003	(0.003)***	-0.002	-0.002	-0.002	-0.002
$Spillover_Maj_{t-1} \times F_Maj$	0.007	0.011	0.011	-0.001	0.008	0.011	0.011	0.002
$Spillover_Min_{t-1} \times \ln(TFP_i/TFP_j^{\max})_{t-1}$	-0.020	-0.019	-0.019	-0.018	-0.021	-0.019	-0.019	-0.019
$Spillover_Maj_{t-1} \times \ln(TFP_i/TFP_j^{\max})_{t-1}$	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
$Spillover_Min_{t-1} \times \ln(TFP_i/TFP_j^{\max})_{t-1}$	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
$Spillover_Maj_{t-1} \times \ln(TFP_i/TFP_j^{\max})_{t-1}$	0.006	-0.001	-0.001	-0.055	0.055	0.053	0.054	0.003
$Spillover_Min_{t-1} \times \ln(TFP_i/TFP_j^{\max})_{t-1}$	-0.078	-0.074	-0.074	-0.090	-0.148	-0.148	-0.148	-0.162
$Spillover_Maj_{t-1} \times \ln(TFP_i/TFP_j^{\max})_{t-1}$	0.006	0.006	0.006	0.013	0.005	0.004	0.004	0.011
$Spillover_Min_{t-1} \times \ln(TFP_i/TFP_j^{\max})_{t-1}$	-0.005	-0.004	-0.004	(0.005)***	-0.006	-0.006	-0.006	(0.006)*
Observations	11056	11056	11056	11056	11056	11056	11056	11056
R-squared	0.159	0.145	0.145	0.164	0.168	0.156	0.156	0.173

Appendix A: Data cleaning process

To be added

Appendix B: Regional Distribution of FDI in China



Appendix C: Sectoral distribution of FDI in China

US SIC	Description	# of firms	% of Foreign firms	% of Foreign minority	% of Foreign majority
20	Food and kindred products	683	9.96%	1.90%	8.05%
21	Tobacco products	11	9.09%	0.00%	9.09%
22	Textile mill products	728	2.61%	0.82%	1.79%
23	Apparel and other textile products	592	4.56%	1.69%	2.87%
24	Lumber and wood products	60	5.00%	3.33%	1.67%
25	Furniture and fixtures	109	2.75%	0.00%	2.75%
26	Paper and allied products	191	13.09%	2.62%	10.47%
27	Printing and publishing	59	5.08%	1.69%	3.39%
28	Chemicals and allied products	711	12.52%	3.38%	9.14%
29	Petroleum and coal products	61	19.67%	6.56%	13.11%
30	Rubber and miscellaneous plastics products	381	11.29%	2.62%	8.66%
31	Leather and leather products	279	4.66%	0.36%	4.30%
32	Stone, clay, and glass products	415	2.89%	0.48%	2.41%
33	Primary metal industries	471	7.22%	1.49%	5.73%
34	Fabricated metal products	275	10.91%	2.18%	8.73%
35	Industrial machinery and equipment	660	17.88%	3.94%	13.94%
36	Electronic and other electric equipment	1224	22.55%	5.07%	17.48%
37	Transportation equipment	435	16.32%	5.29%	11.03%
38	Instruments and related products	152	13.16%	0.66%	12.50%
39	Miscellaneous manufacturing industries	365	4.93%	0.27%	4.66%
	Total	7862	11.26%	2.17%	6.20%

Note: A firm is a foreign firm when a positive percentage of the firm's asset is owned by foreign shareholders. Foreign minority firms and foreign majority firms have a share of foreign capital between 1 and 50%, and more than 50% respectively.

Appendix D: Correlation among the alternative measures of plant-level TFP measures

	OLS	LP	DL	Translog
OLS	1			
LP	0.9355	1		
DL	0.9354	0.9999	1	
Translog	0.9466	0.8856	0.8855	1

Appendix E: Spillovers measured by the share of foreign employment ^(a)

	OLS	LP	DL	Translog
<i>F</i> ^(b)	0.053 (0.006)***	0.035 (0.006)***	0.035 (0.006)***	0.038 (0.006)***
<i>Spillover</i>	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
<i>Spillover x F</i>	0.003 (0.000)***	0.003 (0.000)***	0.003 (0.000)***	0.003 (0.000)***
Number of observations	20972	20972	20972	20972
R-squared	0.011	0.121	0.121	0.009

	OLS	LP	DL	Translog
<i>F_Min</i> ^(c)	0.038 (0.010)***	0.018 (0.010)*	0.018 (0.010)*	0.013 (0.010)
<i>F_Maj</i> ^(c)	0.047 (0.007)***	0.030 (0.007)***	0.030 (0.007)***	0.036 (0.007)***
<i>Spillover_Min</i>	-0.020 (0.019)	-0.020 (0.019)	-0.020 (0.019)	-0.022 (0.018)
<i>Spillover_Maj</i>	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)**
<i>Spillover_Min x F_Min</i>	0.082 (0.041)**	0.084 (0.041)**	0.083 (0.041)**	0.077 (0.042)*
<i>Spillover_Maj x F_Maj</i>	0.004 (0.001)***	0.004 (0.001)***	0.004 (0.001)***	0.003 (0.001)***
Number of observations	20972	20972	20972	20972
R-squared	0.009	0.121	0.121	0.008

^(a) All regressions include sector, region, and time dummies - Robust standard errors in parentheses - ***/**/* significant at 10/5/1%.

^(b) *F* is a dummy equaling one if a positive percentage of the firm's asset is owned by foreign shareholders.

^(c) Differentiation between foreign minority firms and foreign majority firms, with the share of foreign capital being between 1 and 50%, and more than 50% respectively.

Appendix F.1: FDI coming from Western countries ^(a)

	OLS	LP	DL	Translog
<i>F</i> ^(b)	0.118 (0.012)***	0.106 (0.012)***	0.105 (0.012)***	0.098 (0.013)***
<i>Spillover</i>	-0.003 (0.004)	-0.004 (0.004)	-0.004 (0.004)	0.000 (0.003)
<i>Spillover x F</i>	0.026 (0.005)***	0.032 (0.005)***	0.032 (0.005)***	0.030 (0.005)***
Number of observations	20972	20972	20972	20972
R-squared	0.018	0.129	0.129	0.016

	OLS	LP	DL	Translog
<i>F_Min</i> ^(c)	0.046 (0.031)	0.033 (0.030)	0.033 (0.030)	0.004 (0.031)
<i>F_Maj</i> ^(c)	0.118 (0.014)***	0.108 (0.015)***	0.107 (0.015)***	0.106 (0.015)***
<i>Spillover_Min</i>	-0.054 (0.043)	-0.076 (0.042)*	-0.076 (0.042)*	-0.118 (0.041)***
<i>Spillover_Maj</i>	0.007 (0.006)	0.006 (0.007)	0.006 (0.007)	0.009 (0.006)
<i>Spillover_Min x F_Min</i>	0.314 (0.124)**	0.234 (0.116)**	0.232 (0.116)**	0.251 (0.103)**
<i>Spillover_Maj x F_Maj</i>	0.057 (0.009)***	0.064 (0.009)***	0.064 (0.009)***	0.055 (0.008)***
Number of observations	20972	20972	20972	20972
R-squared	0.017	0.129	0.129	0.016

^(a) Western countries: EU-15, Norway, Sweden, Switzerland, Canada and US

All regressions include sector, region, and time dummies - Robust standard errors in parentheses - */**/** significant at 10/5/1%.

^(b) *F* is a dummy equaling one if a positive percentage of the firm's asset is owned by foreign shareholders.

^(c) Differentiation between foreign minority firms and foreign majority firms, with the share of foreign capital being between 1 and 50%, and more than 50% respectively.

Appendix F.2: FDI coming from Hong Kong, Macau and Taiwan ^(a)

	OLS	LP	DL	Translog
<i>F</i> ^(b)	0.015 (0.008)*	0.002 (0.008)	0.002 (0.008)	0.011 (0.008)
<i>Spillover</i>	0.005 (0.002)**	0.004 (0.002)**	0.004 (0.002)*	0.006 (0.002)***
<i>Spillover x F</i>	0.010 (0.003)***	0.014 (0.003)***	0.014 (0.003)***	0.013 (0.003)***
Number of observations	20972	20972	20972	20972
R-squared	0.003	0.118	0.118	0.004

	OLS	LP	DL	Translog
<i>F_Min</i> ^(c)	0.011 (0.013)	-0.004 (0.012)	-0.004 (0.012)	0.007 (0.012)
<i>F_Maj</i> ^(c)	0.011 (0.009)	-0.002 (0.009)	-0.003 (0.009)	0.005 (0.009)
<i>Spillover_Min</i>	0.045 (0.029)	0.050 (0.029)*	0.050 (0.029)*	0.063 (0.029)**
<i>Spillover_Maj</i>	0.006 (0.003)*	0.005 (0.003)*	0.005 (0.003)*	0.008 (0.003)***
<i>Spillover_Min x F_Min</i>	0.142 (0.069)**	0.133 (0.067)**	0.132 (0.068)*	0.090 (0.068)
<i>Spillover_Maj x F_Maj</i>	0.017 (0.004)***	0.021 (0.004)***	0.021 (0.004)***	0.017 (0.004)***
Number of observations	20972	20972	20972	20972
R-squared	0.003	0.119	0.119	0.005

^(a) Western countries: EU-15, Norway, Sweden, Switzerland, Canada and US

All regressions include sector, region, and time dummies - Robust standard errors in parentheses - */**/** significant at 10/5/1%.

^(b) *F* is a dummy equaling one if a positive percentage of the firm's asset is owned by foreign shareholders.

^(c) Differentiation between foreign minority firms and foreign majority firms, with the share of foreign capital being between 1 and 50%, and more than 50% respectively.