Productivity Spillovers from FDI in the People's Republic of China: A Nuanced View

CHERYL XIAONING LONG, GALINA HALE, AND HIROTAKA MIURA*

Using panel data from the Chinese Industrial Surveys of Medium-sized and Large Firms for 2000–2006, we show that the presence and the magnitude of technological spillovers from FDI in the People's Republic of China are affected by the source of FDI, by the ownership type of a firm in consideration, as well as by industrial and provincial characteristics. Private firms are more likely to benefit from horizontal spillovers than other domestic firms, but are less likely to benefit from vertical ones. Presence of state-owned firms in the industry impedes technological spillovers in a way that is consistent with diversion of linkages from private to state-owned firms. Finally, horizontal spillovers are larger in industries that are more technologically sophisticated.

Keywords: L33, F23, O17
JEL codes: FDI, spillovers, forward-backward linkages, People's Republic of China

I. Introduction

The People's Republic of China (PRC) has been the world leader among developing countries in attracting foreign direct investment (FDI) over the past decade. During this period, the PRC economy has boomed. But to what extent have these FDI flows brought technologies, production techniques, and other management practices that have spilled over to indigenous firms from the PRC either in the same industry (horizontal externalities) or in upstream or downstream industries (vertical externalities)?

*Cheryl Xiaoning Long (corresponding author, cxlong@xmu.edu.cn): Professor at Xiamen University and Colgate University, 422 Siming South Road, Xiamen, PRC, 361005. Galina Hale is Research Advisor at the Federal Reserve Bank of San Francisco, while Hirotaka Miura is employed by GE Japan Corporation. The authors thank Ted Moran for his ideas and encouragement of this work at its various stages, Nick Lardy for productive discussions, Chris Candelaria for indispensable research assistance, and seminar participants at Hong Kong Institute for Monetary Research (HKIMR) for valuable comments. Ms. Hale acknowledges the hospitality of HKIMR during the part of the work on this project. Ms. Long thanks the National Science Foundation of China for financial support (Grant No. 71273217). The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or any other person associated with the Federal Reserve System.

The research on technological spillovers from FDI shows weak and inconclusive results.[1] A large body of the literature on technological spillovers from FDI in the PRC, too large to be fully reviewed in this paper, mostly focuses on horizontal spillovers, even though vertical spillovers are likely to be important (Moran 2007).[2] Hale and Long (2011b) provide a critical survey of research on FDI spillovers in the PRC, where potential econometric problems that arise in various studies are discussed in detail. Since that survey was written, numerous papers employed firm-level and industry-specific analysis to address the question.[3] Nevertheless, the results remain inconclusive due to variations in the choice of sample and methodology, in addition to the fact that, as we find out in this paper, spillover effects are heterogeneous across industries, ownership types, and sources.

In this paper, therefore, we try to reconcile some of these results by making use of the best available data, state-of-the-art methodology, and by taking into account industrial and provincial characteristics such as ownership composition and technological intensity that may affect the potential of FDI spillovers. Moreover, we distinguish between FDI from Hong Kong, China; Macau, China; and Taipei,China (hereinafter referred to as HMT); and that from the rest of the world. We allow the spillovers to occur not only within the industry in which foreign presence has changed, but also across industries. This disaggregate analysis is inspired by findings in Hale and Long (2012) that effects of foreign presence are distributed very unevenly across FDI sources, ownership types, and industries of firms. Finally, we compute FDI measures at the province-industry level to take advantage of additional variations such measures provide relative to industry-level measures.

One of the major difficulties in previous studies stems from the use of aggregate-level data, which often include both foreign and domestic firms, and thus cannot distinguish the higher productivity of foreign firms from the positive spillover effects on domestic firms. Even when the two groups of firms can be separated, one cannot reject the possibility that the observed positive effects are due to the initially more productive domestic firms in the group attracting more foreign capital. Such reverse causality or omitted variable bias is present even if a cross-section of firm-level data are used, due to potential "cherry-picking" by foreign investors of firms that have higher productivity which may not be observable by an econometrician. Moreover, if it takes time for positive FDI spillovers to take effect, a cross-section analysis will miss them.

[1] See the literature reviews by Görg and Strobl (2001), Lipsey (2002), Saggi (2002), Görg and Greenaway (2004), and Javorcik (2008). See also Lin and Kwan (2013), Qiu et al. (2009), Xu and Sheng (2012).

[2] To the best of our knowledge, the only two published studies that explored the vertical FDI spillovers for domestic firms from the PRC were Hale and Long (2011b), which did not detect any positive spillover effects based on a cross-sectional data set of private firms and state-owned enterprises (SOEs), and Girma and Gong (2008), which also failed to find evidence of positive spillovers for SOEs.

[3] While most published papers used industry-level data, Liu (2008) and Fu and Gong (2009) analyze firm-level data, with results that are conflicting due to different time periods analyzed, different statistical methods used, and different definitions of total factor productivity (TFP).

We employ firm-level panel data from the PRC Industrial Surveys of Medium-sized and Large Firms (2000–2006). Using firm-level panel data is essential for two reasons. First, firm fixed effects can be used so that the effect of FDI presence is identified by within firm changes in productivity variables, thus ruling out the possibility of reverse causality or selection, to the extent that foreigners' investment decisions are based on initial firm conditions that do not vary over time. Second, seven years of data allow for the study of dynamic effects, which is crucial as various kinds of FDI spillovers all need time to materialize. Importantly, to avoid contamination from the firms that actually received foreign capital, we exclude from our regression sample all firms that had a non-zero share of foreign capital in any year during our sample period.

Estimating total factor productivity (TFP) is not a straightforward task, although a number of approaches have been developed in the industrial organization literature. The main problems that need to be addressed are endogeneity of inputs and persistence of the variables. We use dynamic generalized method of moments (GMM) system with firm fixed effects to estimate production functions by industry, the approach that seems to have become the state of the art in the literature. System GMM uses lagged values of right-hand-side variables as instruments and allows for the lagged dependent variable to be included among the regressors, thus addressing both problems—endogeneity and persistence.[4] Many recent papers that analyze the firm-level panel data also use this method, which allows for comparisons.[5]

We further pursue our analysis in four dimensions. First, as we mentioned above, we do not limit our analysis to horizontal spillovers but also analyze the effects of upstream and downstream presence of foreign firms, which we refer to as "vertical spillovers." Second, we analyze the effects of the presence of firms with capital from HMT separately from the firms with capital from other countries. We do this for two reasons: to account for the fact that some of the recorded FDI is in fact round-tripping capital, and to acknowledge potentially different technological gaps. Third, we allow the effects of foreign presence to vary by ownership type of the firm. Fourth, we allow the effects of foreign presence to vary depending on the industry and province characteristics of each firm.

In the analysis, we find that private domestic firms tend to benefit more than state-owned or mixed-ownership domestic firms from the presence of FDI in the same industry, while they benefit less than other firms from the presence of FDI in the upstream industries. While the positive effects are expected as an indication of greater ability of private firms to adapt to foreign presence in their sector, negative

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[4] We also attempted semi-parametric methods à la Olley and Pakes (1996) or Levinsohn and Petrin (2003) but had to abandon that route due to data limitations. In the limited sample that we could use, the TFP measures obtained by these methods were highly correlated with the ones we obtained using system GMM.

[5] In a recent contribution, Brandt, Van Biesebroeck, and Zhang (2009) analyze dynamics of TFP in the PRC using a sample that is very similar to ours and very similar methodology. Main moments of our TFP estimates are very similar to theirs.

effects seem to be specific to the PRC. We hypothesize that negative effects are driven by the explicit or implicit requirement for foreign firms to contract with state-owned firms downstream. This hypothesis is supported by the fact that we also find negative effect of overall presence of state-firm industries on spillovers from foreign presence upstream on domestic private firms. In addition, we find that industries that are more technologically sophisticated experience larger horizontal spillovers from foreign presence, especially of HMT firms, while foreign (FRN) firms appear to guard their technological secrets to some extent.

This paper makes several contributions to the literature on FDI spillovers in the PRC. First, we are able to use the best possible data set—a large panel of manufacturing firms—which allows us to control for firm and year fixed effects, ruling out main concerns related to endogeneity of FDI presence. Second, we study both horizontal and vertical FDI spillover effects. Third, we are able to distinguish between FDI from the HMT and that from other foreign sources. Fourth, and most importantly, we investigate the patterns of FDI effects as they vary according to firm, industry, and province characteristics, shedding light on some of the reasons why the results of previous literature are inconclusive.

Admittedly, some of the existing publications have compared FDI spillovers in the PRC along several dimensions. For example, Wang and Zhao (2008), Lin et al. (2009), Du et al. (2012), and Lin et al. (2013) examine the horizontal versus vertical FDI spillovers. However, the current study is the first paper to simultaneously explore the various dimensions by which FDI spillover effects may differ, including source country (HMT vs FRN), industry, ownership, as well as by sector connection (horizontal and vertical). Furthermore, we also provide evidence on the mechanisms driving differences across industries and ownership types, which helps further our understanding of the driving forces behind the spillovers.

The paper is organized as follows. Section II presents the description of our data source and the variables we use in this study, as well as our empirical approach. Section III reports the results of our empirical analysis. Section IV concludes.

II. Data and Empirical Approach

Our data come from the Chinese Industrial Surveys of Medium-sized and Large Firms for 2000–2006. Commonly referred to as the National Bureau of Statistics (NBS) manufacturing survey, this data set includes all state-owned companies and private firms that are above certain size thresholds.

The full data set consists of about 1.5 million observations (half a million firms) and is an unbalanced panel with many more firms entering the sample in 2004, a census year. Unfortunately, we are forced to drop many observations due to missing crucial variables (such as county or industry code) or exact duplications. For the purposes of our analysis we also have to drop from our sample firms that switch provinces during our sample period, as most of our analysis is on spillovers within province-industry cells. We end up with a panel of 1,326,727 observations for 454,770 firms. Our regression analysis, however, includes only 580,748 observations for 221,572 firms, for which we can estimate TFP. The rest drop out due to missing values for capital, labor, intermediate inputs, sales, final goods inventory, and their lags.

While we use an unbalanced panel of firms, we give a snapshot of the composition of the sample in 2006, for clarity. The initial 2006 sample consists of 301,961 firms, of which 28,761 had positive shares of HMT ownership (HMT firms, henceforth) and 30,681 had positive shares of other foreign ownership (FRN firms).[6] The remaining 238,872 firms are fully domestic, with no HMT or FRN shares. Of these, 140,337 are majority privately owned and 15,127 are majority state owned. The rest have either no majority owners or have majority ownership by collective, legal person, or other types.

In studying FDI spillovers, we exclude from the sample both HMT firms and firms with investment from other foreign sources in any of the years in our sample period (2000–2006). Thus, only firms with 100% domestic ownership are included in the regression analysis. To explore the effects of domestic firms' ownership type on FDI spillovers, we single out two ownership types: private firms (defined as firms with majority private shares) and state-owned enterprises or SOEs (defined as firms with majority state shares). While these two groups do not span across all firms in our sample due to complicated ownership structures in the PRC, they represent the two "extreme" categories in the degree of governmental control.

After making a number of additional adjustments to the raw data, we ultimately have over 217,000 domestic firms in our FDI spillover regressions, of which about 112,000 are private and almost 105,000 are non-private. In the full sample, we have over 564,000 observations.[7] It is worth pointing out that we do not study firm exit decisions due to data limitations, thus we will not be able to explore the impact of FDI presence on the survival of domestic firms. Kokko and Thang (2014) provide evidence that domestic firms may be forced to exit at the presence of FDI, and we will consider the implications of this possibility in interpreting our empirical findings in section III.

A. Productivity Measures

Most literature on technological spillovers from FDI focuses on the effect on TFP. Similarly, we analyze the impact of FDI on TFP, which we define as the residual generated from estimating a dynamic production function of the form:

$$\begin{aligned} Y_{it} &= \alpha_0 + \alpha_1 y_{i,t-1} + \alpha_2 l_{it} + \alpha_3 k_{it} + \alpha_4 m_{it} + \eta_i + \upsilon_{it} \\ E[\eta_i] &= E[\upsilon_{it}] = E[\eta_i \upsilon_{it}] = 0 \end{aligned} \quad (1)$$

[6]These sets are not exclusive, because some firms have both HMT and FRN shares.

[7]The main reason for dropped observations is missing data.

where Y_{it} is log of output by firm i at time t, k_{it} is log of capital, l_{it} is log of employment, m_{it} is log of intermediate inputs, η_i captures firm-specific fixed effects, and υ_i is a random error term.[8] Note that because we include the lagged dependent variable in the right-hand side, the residual should be interpreted as a change in TFP, or the innovation to TFP, rather than the level of the TFP.

In designing the estimation approach, the following characteristics of our data need to be taken into account. First, there is autocorrelation in both left-hand-side and right-hand-side variables. Second, explanatory variables may be endogenously determined. Third, our panel is wide (large N) and short (small T). Moreover, firm fixed effects need to be included to account for unobserved time-invariant differences across firms.

Though a variety of methods exist that can be implemented to estimate (1), data limitations constrain our choice of estimators. Ordinary least squares (OLS) and fixed effect (FE) estimators are not optimal in accommodating the first and the third data features above.[9] We encounter several estimation issues when implementing the method, which include the lack of convergence in some industries and a persistent TFP measure. The Olley and Pakes (1996) method, which requires information on firm exits, would limit our time period since we do not have data on firm exits for the last year of our sample. Thus, in order to estimate model (1) and obtain residuals we have to rely on "internal" instruments that are based on lags of the instrumented variables, using the system GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998), which is now becoming a mainstream method for estimating such models.

System GMM combines equations in the first differences and in levels. The former eliminates firm-specific fixed effects and uses the lagged levels of variables as valid instruments. The latter exploits additional moment conditions in the levels equations, which enable the use of lagged differences of variables as valid instruments. The equations in levels address the problem of finite sample bias, which arises from the lagged levels of the variables providing weak instruments for first differences (see Alonso-Borrego and Arellano 1999). The exogeneity of instruments is tested using the Arellano-Bond (Arellano and Bond 1991) test for autocorrelation.[10]

[8]Output, capital, and intermediate inputs are all deflated to 2000 prices using the PRC's national headline CPI. Capital stock is generated by implementing the perpetual inventory method as in Brandt, Van Biesebroeck, and Zhang (2009).

[9]The asymptotic properties of OLS and fixed effects estimators can be modified to take into account the inclusion of the lagged dependent variable on the right-hand side (Greene 2008, sec.v4.9.6). However, the consistency of the estimators depends on $T \rightarrow \infty$ (Greene 2008, sec. 15.6.5).

[10]The Arellano-Bond (1991) test for autocorrelation tests the null of zero pth-order autocorrelation in the first-differenced error term ($\Delta \nu_{it}$). In general, AR(p) in first-differences must be checked in order to assess AR(p – 1) in levels, and thus the test statistic of main concern is AR(2). We do not report results of the Sargan (1958, 1959) test. The Sargan test of overidentifying restrictions, which tests the null that the instruments as a group are exogenous, is not robust to heteroskedasticity and autocorrelation and has been shown to over-reject in large samples with persistent series (Blundell and Bond 2000; Blundell, Bond, and Windmeijer 2001).

In conforming to established practices, we use the lags of levels and first-differences of covariates $y_{i,t-1}$, l_{it}, k_{it}, and m_{it} as GMM style instruments. We account for the endogeneity of $y_{i,t-1}$ by using instruments lagged by 3 years and more for equations in first-differences and $\Delta y_{i,t-2}$ for the levels equations. This is done to avoid the violation of moment conditions $E[y_{i,t-2}\Delta \upsilon_{it}] = 0$ and $E\Delta[y_{i,t-1}\upsilon_{it]} = 0$. For the other three covariates l_{it}, k_{it}, and m_{it}, all possible lags in levels are used as instruments in the first-differenced equations and first-differences Δl_{it}, Δk_{it}, and Δm_{it} are used in the levels equations. We estimate production functions for each industry based on two-step system GMM with robust standard errors.[11] There should be minimal first-order autocorrelation of υ_{it} and the moment conditions pertaining to our specified instruments should hold, thus we expect to not reject the Arellano-Bond test for AR(2). We also do not expect to reject the Wald test of constant returns to scale hypothesis: $\alpha_2 + \alpha_3 + \alpha_4 = 1$.

Estimation results are fairly consistent with our expectations. They are reported in Table A.1. For all industries, we fail to reject the Arellano-Bond test for AR(2) at the 5% level. Autocorrelation of the random error term in the levels equations has been removed and our specified instruments are valid. Only for a few industries can we reject the hypothesis of constant returns to scale at the 5% level, which suggest potentially inefficient scale of production.[12] Finally, for each firm, TFP is set equal to υ_{it}. In a recent paper, Brandt, Van Biesebroeck, and Zhang (2009) provide a very careful estimation of TFP using the same data set as we do, with fewer restrictions on the sample. Encouragingly, the descriptive statistics of our TFP measures are very close to theirs.

B. Measures of FDI Presence

To measure the presence of FDI, we construct the weighted average foreign shares of all firms located in the same province and in the same 2-digit CIC sector, with each firm's output as the weight. To distinguish the potentially different effects of investment from different foreign origins, we compute the FDI presence measure for investment from HMT separately from that of other foreign sources (FRN). We are able to do this because firms in our data report the share of their paid-up capital that belongs to firms from the HMT or to firms from the rest of the world. Specifically, the HMT and FRN FDI presence in sector j, in province p, at time t,

[11] We assume that production functions vary across industries. For textile and electric equipment industries, we drop outliers in the top and bottom 1%. In addition, we separate the plastic products industry into two subsectors: industrial and consumer plastics. On the other hand, we do not separately estimate TFP for private firms versus SOEs.

[12] These industries are agro products, food, beverage, fuel processing, mineral products, ferrous smelting, equipment, electric equipment, and electronics.

are defined as

$$HRHMT_{jpt} = \left[\sum_{i \in jp} HMT\ Share_{it} \cdot Y_{it}\right] \Big/ \sum_{i \in jp} Y_{it} \tag{2}$$

$$HRFRN_{jpt} = \left[\sum_{i \in jp} FRN\ Share_{it} \cdot Y_{it}\right] \Big/ \sum_{i \in jp} Y_{it} \tag{3}$$

where $HMT\ Share_{it}$ and $FRN\ Share_{it}$ are HMT and FRN capital as a share of total paid-up capital, respectively, and Y_{it} is the output of firm i at time t.

To study vertical FDI spillovers, we use the PRC's input-output table of 2002 (122-sectors) to compute the upstream FDI presence and downstream FDI presence for industry j.[13] Downstream FDI presence, or backward linkage, is computed following Javorcik (2004) as the sum of FDI presence in all the client industries of j, weighted by the output coefficients of industry j to these other industries.[14] That is, backward linkages are defined as

$$BRHMT_{jpt} = \sum_{k \text{ if } k \neq j} \delta_{jk} HRHMT_{kpt} \quad \text{and} \quad BRFRN_{jpt} = \sum_{k \text{ if } k \neq j} \delta_{jk} HRFRN_{kpt} \tag{4}$$

for HMT and FRN, respectively, where δ_{jk} is the proportion of sector j's output supplied to sector k. The proportion is then computed, including products supplied for final use and imported intermediate products.

Upstream FDI presence, or forward linkage, is calculated using the within industry FDI presence, excluding output destined for exports, of all 2-digit CIC industries that serve as suppliers to industry j. That is, the forward linkage measures are defined as

$$FRHMT_{jpt} = \sum_{m \text{ if } m \neq j} \delta_{jm} \left[\left[\sum_{i \in mp} HMT\ Share_{it} \cdot (Y_{it} - X_{it})\right] \Big/ \left[\sum_{i \in mp} (Y_{it} - X_{it})\right]\right] \tag{5}$$

$$FRF_{jpt} = \sum_{m \text{ if } m \neq j} \delta_{jm} \left[\left[\sum_{i \in mp} FRN\ Share_{it} \cdot (Y_{it} - X_{it})\right] \Big/ \left[\sum_{i \in mp} (Y_{it} - X_{it})\right]\right] \tag{6}$$

where δ_{jm} is the proportion of sector j's inputs purchased from sector m and X_{it} is exports.

[13] We aggregate the 122-sector input-output table to reflect 2-digit CIC sectors in our sample.

[14] Also see Girma et al. (2008) and Kneller and Pisu (2007) for studies on vertical FDI spillovers.

C. Regression Equation

Building to the full model piece by piece, we estimate the following regression,

$$TFP_{ijpt} = \alpha_i + \alpha_t + \Phi'_{jpt}\beta_1 + PR_{it} \cdot \Phi'_{jpt}\beta_2 + \Upsilon_j \cdot \Phi'_{jpt}b_3 + \Upsilon_p \cdot \Phi'_{jpt}b_4 + \varepsilon_{it},$$

where TFP is v_{it}, as constructed in section A for firm i in sector j, province p, and year t; α_i and α_t are firm and year fixed effects; Φ is a set of six industry-province-level FDI measures (*HRHMT*, *HRFRN*, *BRHMT*, *BRFRN*, *FRHMT*, *FRFRN*, as computed above); PR_{it} is the private ownership share of firm i in year t; Υ_j is a set of industry-level characteristics that include ownership composition of the industry and its patent propensity; and Υ_p is a set of province-level ownership composition measures.

Note that the stand-alone effects of industry-level and province-level measures are absorbed by firm fixed effects. Since our TFP measure is estimated using system GMM, we assume that the error term ε_{it} is independent and identically distributed. We also repeat our analysis limiting the sample to firms with private ownership shares exceeding 50%. And in these specifications, we omit the variable, PR_{it}, and its interactions. While the model above includes only linear terms of FDI shares (see Chen et al. 2011, for a study of nonlinear FDI spillovers), we also conduct estimations with foreign shares computed only including shares from majority foreign-owned firms, which allows for one form of nonlinearity.[15]

D. Summary Statistics

Table A.2 presents the composition of firms in our sample. Note that while the total share of firms with foreign capital (from any source) did not change much during our sample period, we do observe an increase in the share of firms with majority foreign ownership, especially those with foreign capital from sources other than HMT.

Table A.3 presents summary statistics for our key variables in the various samples. We will first describe the overall dynamics observed and then discuss differences across samples. The typical size of the PRC firms included in our sample has increased over the 2000–2006 period in terms of output, but has dropped in employment (see log of labor). The average level of fixed assets, however, remains relatively constant. This implies an upward trend in both labor productivity and capital intensity in the PRC firms during this period. As the PRC economy grows

[15] Unsurprisingly, the results are qualitatively the same, because in most cases FRN share is close to 0 or close to 100%. But it is worth clarifying here that all firms in the regression sample are 100% domestic.

over time, the number of large and medium-sized firms has also been increasing during this period.[16]

A seemingly paradoxical pattern is decreasing firm age over time. The reason is most likely the large number of new entrants into the survey. Note that these are not necessarily new firms. They may also be firms that have exceeded the threshold level and have been newly included into the survey or firms that changed names, and thus registration numbers, when going through restructuring. Market share tends to decrease over time, indicating more competition within industry on average, while export/total output ratio and new product sales/total output ratio fluctuate and show no clear trends during the period.

A comparison between domestic firms and foreign-invested firms highlights the following patterns:

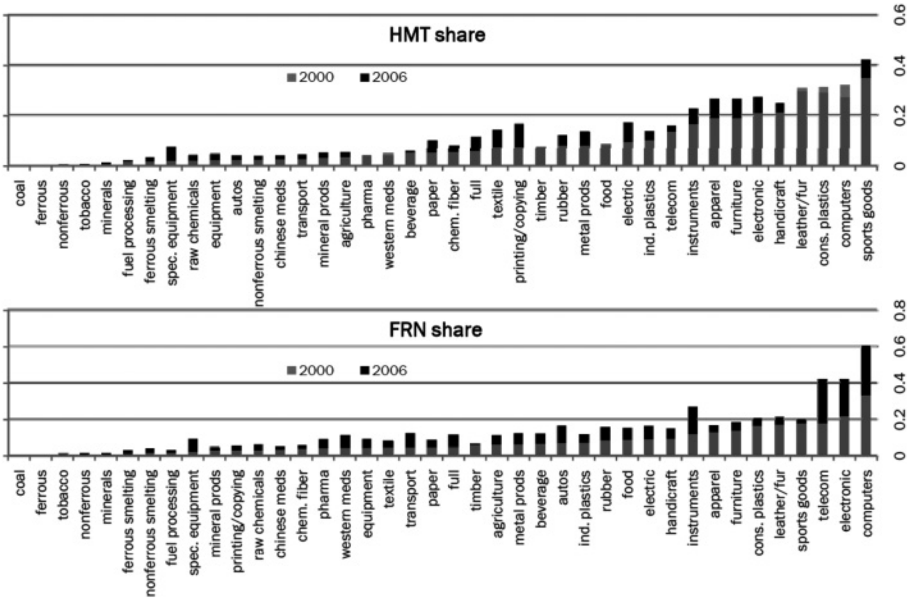
(i) Domestic firms are smaller than HMT firms, which are in turn smaller than firms with investment from other sources, regardless of how size is measured, whether in the amount of fixed assets, employment, or sales (see market share).
(ii) Domestic firms are less capital intensive than HMT firms, which are less capital intensive than other foreign firms.
(iii) Both HMT and FRN firms have a higher export/sales ratio than domestic firms.
(iv) Firms with foreign investment from sources other than HMT tend to have a higher percentage of sales made up by new products, while HMT firms are not different from domestic firms in this respect.

These differences between domestic and foreign firms confirm the conventional beliefs that foreign firms are more capital-intensive, more internationally oriented, and more technologically innovative.

The shares owned by FRN and HMT for each of the industries in our sample are presented in Figure 1. We can see that while FRN increased for all industries, HMT did not increase or actually declined in food manufacturing, leather/fur, timber processing, pharmaceuticals (western medicine in particular), consumer plastics, and computers. On average, FRN share more than doubled (increased by a factor of 2.4) while HMT share almost doubled (increased by a factor of 1.9). In such industries as coal, ferrous and nonferrous metals, tobacco, and minerals, the shares of both HMT and FRN were negligible, both at the beginning and at the end of our sample. This is important for our analysis since due to firm fixed effects, the identification in our regressions comes from over-time variations in TFP and FDI presence.

[16]The number of firms included for 2004 is larger than in the other years because it is a census year, while only firms over a certain size threshold are included in surveys conducted in the other years.

Figure 1. **FRN and HMT Shares in 2000 and 2006**



FRN = foreign, HMT = Hong Kong, China; Macau, China; Taipei,China.
Source: Authors calculations.

III. Empirical Results

Before we turn to the results of our empirical analysis, we briefly summarize the mechanisms behind technological spillover effects of FDI. Horizontal spillover effects may arise due to competition and demonstration effects. When foreign capital flows into the industry, domestic firms might find both input and output markets more competitive. Competition in the output markets may lower measured TFP (by lowering output prices) but may also increase actual TFP by creating incentives for the firms to increase efficiency. Competition in input markets such as the market for skilled labor (Hale and Long 2011a) is likely to lower measured TFP through an increase in input costs. Demonstration effects are expected to be positive, as they describe ways in which domestic firms can learn superior technology and/or managerial practices from foreign-invested firms through observation, worker mobility, and informal interaction.

Furthermore, we would expect private firms to gain more from the demonstration effects of FDI than state-owned firms, because the former are more profit-oriented than state-owned firms. They should also be in a better position to compete against foreign firms due to their flexibility in hiring and firing decisions. Thus, we would expect more positive horizontal spillovers for private firms and more negative horizontal spillovers for SOEs. Second, we should expect more technological spillovers from FRN than HMT firms because arguably, the technological differences between HMT and the PRC are not as large as those between the rest of the world and the PRC, while competition effects should be similar, resulting in relatively more positive spillovers from FRN than HMT.[17]

Spillovers through backward linkages occur because with foreign entry in the downstream industries, demand for output of upstream domestic firms is likely to increase, raising output volume and thus productivity if there are economies of scale. Moreover, foreign firms may help upstream firms improve their technology or management practices in order to produce inputs and parts more efficiently. In some cases, foreign firms even provide their suppliers with technological blueprints. According to a survey of firms from the PRC conducted by the World Bank in 2000, over 25% of domestic firms from the PRC that produced parts or other inputs for foreign firms used licensed technologies or processes provided by foreign firms to introduce new process improvements.[18]

There may be a negative impact as well, however, if foreign firms demand higher quality inputs, which may lower domestic firms' productivity if it takes them time to adjust or if some of their output are rejected. Downstream presence of foreign firms may also cause negative competition effects on the output market for domestic firms if foreign-invested firms prefer to source their inputs from overseas or from other foreign-invested firms. On the other hand, competition in input markets is unlikely in the case of backward linkages because firms operate in sufficiently different industries.

The most obvious reason for spillovers through forward linkages is the availability of higher quality inputs. In addition, more sophisticated inputs may be associated with higher TFP because they may allow for the adoption of superior technologies. Negative spillover effects may arise because some adjustment may be required to incorporate new inputs into production processes, which can be costly in the short run or because foreign investment may be driven by foreign firms' desire to produce supplies for their own firms downstream, thus creating competition effects for inputs of domestic firms.

We would expect both horizontal and vertical spillover effects to be most prominent for private firms that are more flexible and stand to gain more from foreign presence upstream and downstream. On the other hand, because foreign investment in the PRC is regulated, foreign-invested firms may be required to establish or maintain relationships with state-owned firms, thus limiting the potential for positive spillovers on private domestic firms.[19]

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[17] Alternatively, part of the FDI from HMT could represent round-tripping, which would not result in any spillovers and therefore may reduce the average spillover effect from HMT, biasing estimated effects of HMT downward.

[18] These are authors' computations based on the survey data from the Study of Competitiveness, Technology, and Firm Linkages conducted by the World Bank in 2000.

[19] Note that upstream and downstream FDI may also result in horizontal effects on local firms in the relevant industries. Thus, we are not able to separate the direct vertical FDI effects from the indirect vertical effects that

Table 1. **Summary of Main Regression Results**

	(1)	(2)	(3)
Full Sample			
HRHMT	0.05	0.02	**0.05**
HRFRN	**0.12**	**0.08**	0.02
BRHMT	**−0.27**	−0.04	−0.19
BRFRN	−0.11	**0.26**	−0.23
FRHMT	−0.01	−0.19	−0.24
FRFRN	**0.64**	0.20	−0.20
Private Firms			
HRHMT	0.04	0.01	**0.09**
HRFRN	**0.08**	0.04	0.03
BRHMT	−0.05	0.16	−0.11
BRFRN	−0.03	**0.31**	−0.14
FRHMT	−0.02	−0.14	−0.02
FRFRN	−0.05	**−0.44**	−0.01
Controls	None	Year FE	Year and firm FE

Source: Authors' calculations. Based on Tables A.4 and A.5 estimates.

A. Aggregate Effects of TFP

Tables A.4 and A.5 report the results from our regression analysis of the effects of FDI presence on the TFP of domestic firms. Table A.4 presents the results for the full sample of domestic firms (with over 200,000 firms), while Table A.5 presents the results for the sample of domestic firms that are majority private-owned (with over 100,000 firms).

The first column in each table reports the results from OLS regressions of TFP on our six measures of FDI presence and, following Javorcik (2004), controls for demand from downstream industries, and a measure of concentration of firms in the industry. These measures are intended to capture the price effects of TFP due to the fact that our dependent variable in the production function is output measured in domestic currency (RMB) rather than in physical units. As expected, the log of total demand for the industry's output has a positive effect on the measured TFP of the industry, while the degree of concentration has a negative impact, indicating that high concentration has a negative impact larger in size than its potential positive effect on price.

The results are also summarized in Table 1 for the convenience of the reader, with numbers in bold indicating that the coefficients are significant at least at the 10% significance level. The results of column (1) should be interpreted as raw correlations. They cannot be interpreted as causal, because they may be accounted for by common trends, by the cherry-picking phenomenon in case of horizontal

may occur if locally-owned suppliers or customers are forced to exit or expand thanks to strong horizontal spillover benefits. We thank the referee for pointing out this subtlety.

spillover effects, or by other industry-province-level selection effects. In the other columns of Table 1, we try to control for these effects.

We find that, both in the full sample and in the sample of private firms, a higher share of FRN firms in the same industry is associated with higher TFP of domestic firms (the coefficient on HRFRN is positive and statistically significant), indicating the potential for positive horizontal spillovers from the same-industry presence of FDI from FRN. In the full sample only, we also find statistically significant negative correlation of TFP with downstream presence of HMT firms, suggesting the possibility that domestic firms may lose their customers when downstream firms are purchased by foreign capital. Finally, in the full sample, we find statistically significant positive correlation of TFP with the presence of FRN-invested firms upstream, which is consistent with the possibility of improved quality of inputs when such inputs are provided by FRN-invested firms.

Column (2) includes year fixed effects and demonstrates their importance. While we still find the positive effect of HRFRN, the other two effects described above are no longer statistically significant. Instead, we now observe a positive and statistically significant effect of FRN presence downstream (BRFRN), both in the full sample and in the sample of private firms. For the private firms' sample, there is now a negative and statistically significant effect of FRN presence upstream, indicating potential competition effect for inputs.

Column (3) presents our true benchmark results. It includes year fixed effects as well as firm fixed effects, thus measuring within-firm effects of changes in FDI presence on changes in TFP. Both in the full sample and in the sample of private firms we only find one statistically significant effect of FDI presence on TFP—that of the presence of HMT firms in the same industry. This effect is positive and is twice as large in magnitude for private firms as it is for the full sample.

B. Effects of the Ownership Structure on Spillovers

As private ownership is likely to permit more flexibility to domestic firms in adapting to the presence of foreign firms, we expect private firms to benefit more on average than SOEs at the presence of foreign firms. On the other hand, there may be some additional effects specific to the PRC that give advantage to state-owned firms due to regulations on foreign investment, especially in terms of vertical spillovers. To further explore the role of firm ownership and to follow up on the last finding in the previous section, we allow for the effects of FDI presence to vary by ownership type of the firm, thus including in regressions reported in column (4) of Table A.4 each firm's share of private ownership and its interactions with our FDI measures.

The results are also summarized in the table below for the convenience of the reader, with numbers in bold indicating that the coefficients are significant at least at the 10% significance level. Consistent with the literature on TFP in the

Table 2. **Differential Effects for State-owned and Private Firms**

	Main Effect (0% Private)	Interaction Effect
HRHMT	0.03	**0.05**
HRFRN	0.02	−0.01
BRHMT	−0.14	−0.08
BRFRN	−0.21	−0.03
FRHMT	−0.15	**−0.18**
FRFRN	−0.11	**−0.18**

Source: Authors' calculations. Based on Tables A.4 and A.5 estimates.

PRC, we find that an increase in private ownership is associated with an increase in TFP—even after controlling for firm fixed effects, we find the coefficient on the private ownership share to be positive and strongly statistically significant.

We observe from the results reported in column (4) of Table A.4 that horizontal spillovers from HMT in the same industry is higher for private firms, consistent with our findings in column (3) of Tables A.4 and A.5. In fact, once we allow the coefficient on HRHMT to be different for private firms, the main effect is no longer statistically significant, indicating that for firms with zero private ownership, there is no statistically significant spillover from HRHMT. The results are summarized in Table 2.

However, we also find that higher private share is associated with larger negative spillovers from the presence of both FRN and HMT upstream. This result is consistent with the redirection of foreign-invested firms' output towards either foreign or state-owned firms. To test for such a mechanism, however, we need to allow for the effects of foreign presence to vary by ownership composition of industries. If the diversion of inputs or demand from private firms is indeed important, it will be more pronounced in industries with a larger share of state and foreign firms.

To test for this, we include in column (5) in Table A.4 and column (4) in Table A.5 interactions of our FDI variables with average share of state, HMT, and FRN firms in the same industry and in the same province. The interactions with province averages play a role of falsification tests, because they will not be reflective of the competition story.

Specifically, we compute for each industry and for each province the following six measures as of 2000: the output share of majority SOEs in the total output of domestic firms in the same industry or province, the output share of HMT firms in the total output of the same industry or province, and the output share of FRN firms in the total output of the same industry or province. The results are also summarized in Table 3 for the convenience of the reader, with numbers in bold indicating that the coefficients are significant at least at the 10% significance level.

Two main patterns emerge. The first finding suggests that the government may have undertaken measures to protect state-owned sector from the negative impact of foreign presence, especially in upstream industries. The second finding is

Table 3. **FDI Spillovers by and Share of FDI in Industry**

		Interactions with Industry Output Share of		
	Main Effect	**SOE Firms**	**HMT Firms**	**FRN Firms**
HRHMT	0.20	−0.23		−0.24
HRFRN	−0.18	0.08	0.08	
BRHMT	0.81	1.09	−1.32	2.86
BRFRN	**−1.89**	1.84	1.46	3.08
FRHMT	−1.11	−2.09	4.18	−3.84
FRFRN	1.53	**−4.17**	−0.56	−3.29

FDI = foreign direct investment, FRN = foreign, HMT = Hong Kong, China; Macau, China; and Taipei,China, SOE = state-owned enterprise.
Source: Authors' calculations. Based on Tables A.4 and A.5 estimates.

consistent with the possibility that foreign-invested firms prefer to deal with other foreign-invested firms, rather than with domestic firms.

We can see from the results of column (4) of Table A.5 that the higher share of SOEs in the industry reduces positive effects of horizontal spillovers from FDI, regardless of its origin, and also reduces positive spillovers from the presence of FRN firms upstream for the private firms. This suggests that the greater amount of government intervention in industries with a larger share of state firms obstructs the flow of technological spillovers. In particular, this evidence is consistent with the possibility that foreign investors are in some way incentivized to establish or maintain subcontracting or other arrangements with state-owned firms in the same or downstream industry of the firm they are investing in. If so, the more state-owned firms there are, the less likely other firms are to benefit from the foreign presence.

This negative effect of the presence of state-owned firms seems to be limited to industries and does not appear in the presence of SOEs in the province of the firm, which is expected if our conjecture of the mechanism behind the result described above is true. In fact, we find an almost significant positive effect of SOE share on vertical spillovers—through backward linkages of FRN firms and forward linkages of HMT firms. The latter is actually significant for the sample that is limited to private firms (see fourth column, Table A.5). The one exception to this is the effect of average share of state-owned firms in provinces having a statistically significant negative effect on the spillovers from HMT firms that are downstream from private domestic firms. Potentially, an overall large presence of state firms in the province is associated with a regulatory environment that is not conducive to technological spillovers from foreign-invested firms to potential suppliers of goods.[20]

[20]An alternative explanation for the finding of positive FDI spillovers for private firms but not for SOEs is based on FDI's impact on firm exits, which differs across ownership types. If weak private firms are forced out of the market due to competition from foreign firms but weak SOEs are able to remain, thanks to governmental support, then we would observe higher productivity for private firms that survive than those for SOEs. Due to lack of data on firm exits, however, we are not able to directly test this theory.

The share of foreign firms in the industry does not appear to have statistically significant effects on the FDI spillover potential, although some of the coefficients, especially those on vertical linkages, are close to being statistically significant and are broadly consistent with the hypothesis that foreign firms divert their inputs and outputs to foreign firms away from domestic firms. As a result, domestic firms in industries where foreign presence is larger are less likely to benefit from vertical spillovers.

Finally, we find statistically significant positive effects of FRN presence in the province on the spillovers from FRN presence downstream (BRFRN) in both the full sample and the sample of domestic firms. We also find in both samples a statistically significant negative effect of HMT presence in the same province on spillovers from upstream FRN presence. The first of these findings supports the hypothesis that the overall presence of foreign firms facilitates interactions and potentially allows for more active linkages between domestic firms and foreign firms downstream. The second effect, however, needs further investigation.

C. Patent Propensity

Another important dimension in which industries differ from one another is their technological sophistication. Quite obviously, we would expect FDI technological spillovers to depend on how technologically advanced an industry is. To allow for this, column (6) of Table A.4 and column (5) of Table A.5 present the results of our analysis where we add the interaction of all six FDI measures with the industry-level measure of patent propensity.

Patent propensity of the industry is calculated as the ratio of patents granted to sales during 1979–2000 for US publicly listed firms, and thus is a proxy of how important intellectual property is to a given industry. It might have a mixed effect on the extent of horizontal spillovers from FDI presence. On the one hand, the more important the intellectual property, the more likely technological spillovers through demonstration effects and imitation are going to help, and the bigger is likely to be the technological gap between foreign and domestic technologies. On the other hand, if intellectual property is important to the industry, foreign firms are more likely to guard their technological secrets which may limit potential spillover effects. The results are summarized in Table 4 for the convenience of the reader, with the number in bold indicating that the coefficients are significant at least at the 10% significance level.

Our data suggest that the first effect is likely to dominate, especially for spillovers from HMT firms. We find a positive and significant impact of the interaction term between HMT presence in an industry, and the patent propensity measure of the industry, implying that positive horizontal spillovers from HMT are larger in industries where intellectual property is more important. We also find a positive

Table 4. **Patent Propensity Effects**

Patent Propensity Interacted with:	Main Effect (0% Private)	Interaction Effect
HRHMT	3.93	2.03
HRFRN	1.81	1.16
BRHMT	−18.00	−7.83
BRFRN	−11.10	−13.70
FRHMT	−13.60	−8.09
FRFRN	7.67	**17.00**

Source: Authors' calculations. Based on Tables A.4 and A.5 estimates.

effect of the interaction term with the FRN presence, but it is not statistically significant and only is half as large in magnitude. Possibly, firms from the rest of the world are more careful in guarding their patented technologies than firms from HMT.

There are also likely differences in vertical spillovers depending on whether intellectual property is important for an industry exposed to increased foreign presence either upstream or downstream. For industries where intellectual property is important, spillovers from backward linkages (i.e., from FDI presence downstream) may be limited because foreign firms are likely to source patented products not from domestic firms from the PRC but from foreign firms located either in HMT or other countries such as the US or Japan.

For example, while iPhone is assembled in the PRC, firms there in upstream industries are unlikely to benefit, because all high-tech components going into its production are made in Japan, Germany, and the US (Xing and Detert 2010). Indeed we find evidence of a negative effect of high patent propensity on spillovers through backward linkages, although the effects are not quite statistically significant (the p-values are around 0.2 for interactions with HMT and FRN presence downstream).

To the extent that the importance of intellectual property correlates with technological sophistication, high-tech industries are more likely to gain from FDI presence upstream for two reasons: first, the quality of their components is likely to improve if they switch the sourcing from domestic to foreign firms; second, if they were previously importing components and other intermediate goods, they may now be able to buy them from a foreign firm operating domestically much more cheaply. Both of these possibilities are likely to increase the potential for spillovers from FDI for firms in industries where intellectual property is more important.

We find that spillovers through forward linkages tend to be higher for FRN presence, but lower for HMT presence.[21] We interpret this as evidence that FRN firms are more likely than HMT firms to be embodied with more advanced technologies. The positive effect of technological sophistication of the industry on the FRN spillovers is especially large and is statistically significant for the sample of private firms.

[21] Once again, these effects are not quite statistically significant, but p-values are below 0.2.

IV. Conclusion and Policy Implications

In this paper, we provide a nuanced look at technological spillovers from FDI on domestic firms from the PRC. We point out that such spillovers are distributed unevenly across firm ownership types, spillover types (horizontal versus vertical), origins of foreign capital, as well as the degree of technological sophistication of industries.

Compared to state-owned firms, domestic private firms in the PRC are more likely to benefit from horizontal FDI spillovers but are less likely to benefit from vertical ones. Furthermore, the ownership composition of the industry is also important, with domestic firms less likely to enjoy both positive horizontal FDI spillovers and positive spillovers from forward linkages, where there is more state ownership. In addition, between FDI from HMT, and that from other parts of the world, the former tends to produce more positive horizontal spillovers for private firms but also more negative forward linkage spillovers, again only for private firms. Finally, FDI presence in technologically sophisticated industries tends to produce more horizontal spillovers (in the case of HMT firms) and more forward linkages (in the case of FRN firms).

The fact that spillover effects are unevenly distributed across industries, ownership types, and sources of FDI helps us understand why there is such diversity of findings in the vast literature on FDI spillovers in the PRC. Results based on pooled or aggregate data depend on the sample of firms included in the study, the sample period, as well as additional control variables and specification restrictions. We believe our analysis provides good reasons for further studies at the disaggregated level, and we hope that it would encourage further empirical work in this direction.

On the policy front, we believe that our findings have at least the following three implications. First of all, the ability of private firms to obtain more positive spillovers in the presence of FDI offers an additional justification for renewed privatization effort in the PRC. Their greater adaptability allows more flexible employment practices, better production organization, and faster learning from their foreign suppliers, clients, as well as competitors. Thus, a host country with a viable private sector does not need to worry much about the threat of foreign firms taking over domestic industries.

Our second policy-related finding is that regulations probably aimed at protecting state-owned firms not only defeat their initial purpose but also become obstacles to private firms' obtaining positive spillovers. As we can see, private firms located in industries with more state-owned firms benefit significantly less from FDI presence in the downstream industries. A plausible explanation is the diversion of forward linkages from private firms to state-owned firms (or foreign firms) in industries where FDI is regulated. Although the message is less sanguine, it points to the same direction as our previous finding in that private firms should be the focus of governmental considerations evaluating FDI policies, not SOEs.

The third policy implication we can draw relates to the host country's intellectual property rights protection, or broadly speaking, innovation policies. As discussed above, an industry's patent propensity determines the extent of spillovers from FDI presence in some interesting ways. While indigenous firms in technologically more sophisticated industries tend to benefit more from HMT firm presence in the same industry, it is FRN presence in downstream industries that have positive spillovers on domestic firms. Given that FRN firms tend to be more technologically advanced, these findings are consistent with anecdotes that technologically sophisticated foreign firms guard their technologies in a way that restricts horizontal technological spillovers in the most advanced technology areas. As a result, a natural policy recommendation would be to further improve protection of intellectual property rights so that foreign investors, especially those with frontier technologies, will feel more comfortable sharing information and creating spillovers.

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Appendix

Table A.1. **System GMM Production Function Estimations—First Stage**

Sector	Constant	Lagged Output	Capital	Labor	Throughput	AR(2)	CRS	N	N_g	j
Nonmetals	−0.226 (0.224)	0.150*** (0.024)	0.192*** (0.039)	0.082*** (0.029)	0.703*** (0.023)	0.170	0.579	6,610	2,741	93
Agro products	−0.306*** (0.080)	0.106*** (0.010)	0.144*** (0.012)	0.121*** (0.013)	0.777*** (0.014)	0.950	0.004	40,450	16,261	93
Food	−0.376*** (0.137)	0.114*** (0.016)	0.194*** (0.023)	0.131*** (0.021)	0.719*** (0.022)	0.885	0.077	13,120	5,097	93
Beverage	−0.941*** (0.277)	0.136*** (0.020)	0.266*** (0.042)	0.142*** (0.026)	0.682*** (0.023)	0.403	0.040	11,110	4,106	93
Textiles	0.455*** (0.070)	0.104*** (0.008)	0.099*** (0.010)	0.051*** (0.010)	0.768*** (0.013)	0.128	0.000	53,347	20,286	93
Apparel	0.546*** (0.119)	0.101*** (0.012)	0.094*** (0.012)	0.111*** (0.014)	0.736*** (0.019)	0.842	0.001	19,995	7,849	93
Leather/Fur	0.478*** (0.101)	0.103*** (0.014)	0.072*** (0.015)	0.096*** (0.019)	0.770*** (0.024)	0.736	0.000	10,538	4,291	93
Timber	0.176 (0.122)	0.064*** (0.012)	0.113*** (0.024)	0.079*** (0.017)	0.815*** (0.022)	0.217	0.731	11,605	5,212	93
Furniture	0.659*** (0.118)	0.087*** (0.016)	0.080*** (0.019)	0.138*** (0.028)	0.741*** (0.028)	0.379	0.083	5,426	2,261	93
Paper	0.185* (0.099)	0.118*** (0.012)	0.106*** (0.016)	0.082*** (0.019)	0.756*** (0.021)	0.387	0.003	20,992	7,536	93
Printing	−0.053 (0.135)	0.168*** (0.023)	0.173*** (0.025)	0.137*** (0.022)	0.640*** (0.019)	0.341	0.122	15,085	5,151	93
Sports goods	0.796*** (0.203)	0.080*** (0.020)	0.091*** (0.031)	0.076*** (0.029)	0.751*** (0.034)	0.976	0.019	5,019	2,007	93
Fuel processing	0.638*** (0.112)	0.052*** (0.011)	0.089*** (0.020)	0.021 (0.020)	0.832*** (0.021)	0.367	0.000	4,833	1,957	93
Raw chemicals	−0.050 (0.088)	0.106*** (0.009)	0.136*** (0.015)	0.083*** (0.015)	0.772*** (0.014)	0.073	0.624	46,959	17,244	93
Meds. from the PRC	0.903*** (0.258)	0.187*** (0.029)	0.123*** (0.024)	0.085** (0.042)	0.591*** (0.030)	0.438	0.000	5,356	1,957	93
Western meds.	0.586*** (0.214)	0.166*** (0.020)	0.073*** (0.025)	0.085*** (0.029)	0.695*** (0.026)	0.383	0.000	7,252	2,607	93
Chemical fiber	1.023*** (0.303)	0.071** (0.028)	0.012 (0.017)	0.037 (0.037)	0.825*** (0.028)	0.710	0.024	2,466	971	93
Rubber prods.	−0.054 (0.200)	0.111*** (0.021)	0.163*** (0.030)	0.103*** (0.029)	0.732*** (0.029)	0.435	0.972	6,335	2,374	93
Ind. plastics	0.303* (0.163)	0.120*** (0.016)	0.132*** (0.029)	0.068*** (0.022)	0.732*** (0.026)	0.310	0.013	13,614	5,606	93
Cons. plastics	0.554*** (0.129)	0.123*** (0.016)	0.037** (0.016)	0.133*** (0.023)	0.752*** (0.024)	0.776	0.000	8,986	4,015	93
Mineral prods.	−0.234** (0.098)	0.138*** (0.009)	0.138*** (0.014)	0.078*** (0.012)	0.752*** (0.011)	0.355	0.055	63,103	22,235	93

Continued.

Table A.1. *Continued.*

Sector	Constant	Lagged Output	Capital	Labor	Throughput	AR(2)	CRS	N	N_g	j
Ferr. smelting	0.283*** (0.079)	0.042*** (0.008)	0.086*** (0.019)	0.071*** (0.018)	0.853*** (0.018)	0.207	0.505	15,716	6,523	93
Nonferr. smelt.	0.082 (0.122)	0.057*** (0.011)	0.079*** (0.023)	0.013 (0.017)	0.891*** (0.017)	0.293	0.505	10,516	4,240	93
Metal prods.	0.568*** (0.100)	0.129*** (0.011)	0.099*** (0.018)	0.124*** (0.017)	0.700*** (0.021)	0.244	0.000	27,990	11,348	93
Equipment	0.463*** (0.065)	0.158*** (0.010)	0.084*** (0.013)	0.050*** (0.010)	0.729*** (0.010)	0.395	0.000	45,059	17,062	93
Spec. equipment	0.513*** (0.118)	0.164*** (0.017)	0.069*** (0.020)	0.043** (0.018)	0.735*** (0.014)	0.160	0.000	22,319	8,537	93
Transport	0.358*** (0.096)	0.126*** (0.016)	0.088*** (0.018)	0.077*** (0.017)	0.752*** (0.014)	0.770	0.001	28,382	10,297	93
Electric eq.	0.264*** (0.083)	0.121*** (0.011)	0.108*** (0.017)	0.090*** (0.014)	0.749*** (0.018)	0.234	0.002	32,852	12,108	93
Electronics	1.073*** (0.167)	0.201*** (0.024)	0.018 (0.027)	0.121*** (0.028)	0.648*** (0.026)	0.454	0.000	10,428	4,086	93
Instruments	1.397*** (0.243)	0.160*** (0.042)	0.090*** (0.028)	0.054* (0.028)	0.625*** (0.028)	0.186	0.000	6,110	2,354	93
Handicraft	0.518*** (0.118)	0.106*** (0.016)	0.071*** (0.015)	0.098*** (0.017)	0.762*** (0.020)	0.547	0.000	9,175	3,735	93

* = $p < 0.10$, ** = $p < 0.05$, *** = $p < 0.01$, N = no. of complete observations, N_g = no. of firms, j = no. of instruments, GMM = generalized method of moments, AR(2) = p-value of the Arellano-Bond test statistic which tests the null of zero 2nd-order autocorrelation in the first-differenced error term, CRS = p-value from the Wald test of the constant returns to scale hypothesis, $\beta_k + \beta_l + \beta_m = 1$.

Note:

- 2-step system GMM estimations implemented using STATA XTDPD package. All variables in logs. Dependent variable is output. Fixed effects controlled for by first-differencing the equation, which is simultaneously estimated along with equations in the levels. Robust standard errors in parentheses.
- Firms with nonzero other foreign (FRN) share and Hong Kong, China; Macau, China; Taipei,China (HMT) share are excluded.
- All variables are deflated to 2000 prices using the PRC's national headline CPI.
- Capital stock is generated by implementing perpetual inventory method as in Brandt et al. (2009).
- For all GMM-SYS estimations, instruments for the endogenous lagged output variable are y_{t-3} and earlier in the differenced equations and Δy_{t-2} in the levels equations.
- For predetermined variables k, l, and m, instruments specified are k_{t-1}, l_{t-1}, m_{t-1} and earlier in the differenced equations and Δk_t, Δl_t, Δm_t in the levels equations.

Source: Authors' computations.

Table A.2. **Composition of Firms Used in Our Sample**

Year	2000	2001	2002	2003	2004	2005	2006
Total number of firms	134,710	139,167	147,438	159,754	240,882	236,786	267,990
Fully domestic firms	111,228	113,634	120,153	129,594	193,427	190,317	217,130
% of total	83%	82%	81%	81%	80%	80%	81%
Firms with foreign share	23,482	25,533	27,285	30,160	47,455	46,469	50,860
% of total	17%	18%	19%	19%	20%	20%	19%
Firms with HMT share	12,818	13,926	14,112	15,666	24,872	22,613	24,405
% of total	10%	10%	10%	10%	10%	10%	9%
Firms with FRN share	10,252	11,155	12,703	14,069	22,107	23,426	25,986
% of total	8%	8%	9%	9%	9%	10%	10%
Firms with majority FRN share	13,680	15,857	17,513	20,320	33,884	34,065	37,983
% of total	10%	11%	12%	13%	14%	14%	14%
Firms with majority HMT share	7,546	8,801	9,248	10,894	18,398	17,058	18,720
% of total	6%	6%	6%	7%	8%	7%	7%
Firms with majority FRN share	6,065	6,985	8,195	9,370	15,403	16,929	19,177
% of total	5%	5%	6%	6%	6%	7%	7%
Average foreign[a]	19.02%	20.67%	21.33%	23.31%	24.78%	24.62%	24.66%
Average HMT[a]	7.83%	8.37%	7.99%	8.36%	10.65%	9%	8.12%
Average FRN[a]	11.2%	12.3%	13.33%	14.95%	14.13%	15.62%	16.54%

FRN = foreign, HMT = Hong Kong, China; Macau, China; Taipei,China.
[a]Weighted by output.
Source: Authors' computations.

Table A.3. **Means of Key Variables in Subsamples**

Year	2000	2001	2002	2003	2004	2005	2006
				Means for Full Sample			
Log(output)	9.51	9.60	9.71	9.84	9.81	10.01	10.1
Log(capital)	11.84	11.87	11.90	12.00	11.92	12.08	12.10
Log(throughput)	12.49	12.58	12.67	12.95	13.07	13.26	13.35
Log(labor)	7.11	7.04	7.05	7.10	6.99	7.05	7.00
Capital/labor	390.66	628.03	694.33	585.21	1,246.38	1,779.26	1,660.90
Firm age (years)	31.47	19.09	18.07	17.07	14.56	15.01	14.70
Exports/output	13.48%	15.08%	14.92%	15.55%	16.58%	15.53%	14.63%
New product output/ output	2.59%	3.40%	2.44%	2.30%		3.60%	3.49%
Throughput/output	92.30%	98.82%	110.22%	78.46%	75.77%	75.71%	73.39%
Market share (sp)	0.84%	0.81%	0.76%	0.70%	0.47%	0.48%	0.42%
Market share (s)	0.03%	0.03%	0.03%	0.02%	0.02%	0.02%	0.01%
Herfindahl index (sp)	2,314.42	2,322.90	2,288.10	2,304.40	2,101.37	2,146.24	2,142.23
Herfindahl index (s)	178.48	179.12	315.60	331.80	174.44	169.41	153.43

Continued.

Table A.3. *Continued.*

Year	2000	2001	2002	2003	2004	2005	2006
			Means for Domestic Firms				
Log(output)	9.31	9.41	9.53	9.66	9.67	9.87	9.96
Log(capital)	11.76	11.72	11.71	11.82	11.80	11.89	11.86
Log(throughput)	12.19	12.18	12.20	12.47	12.75	12.89	12.97
Log(labor)	7.14	7.02	6.98	7.00	6.93	6.90	6.82
Capital/labor	352.71	480.35	748.32	569.80	642.87	1,726.15	1,465.18
Firm age (years)	42.43	23.60	22.29	20.74	17.59	17.66	17.11
Exports/output	7.21%	7.89%	8.35%	8.84%	9.29%	8.63%	8.18%
New product output/ output	2.32%	3.29%	2.24%	2.10%		3.51%	3.22%
Throughput/output	95.09%	103.48%	118.83%	79.03%	76.32%	76.38%	73.59%
Market share (sp)	0.81%	0.78%	0.74%	0.68%	0.46%	0.46%	0.41%
Market share (s)	0.02%	0.02%	0.0%	0.02%	0.01%	0.01%	0.01%
			Means for Firms with Majority HMT Share				
Log(output)	10.16	10.18	10.23	10.30	10.20	10.31	10.41
Log(capital)	10.73	10.94	11.01	11.04	11.13	11.38	11.16
Log(throughput)	12.04	12.19	12.31	12.43	12.85	13.20	12.74
Log(labor)	6.36	6.37	6.49	6.56	6.58	7.04	6.68
Capital/labor	259.85	899.12	714.37	898.87	392.27	333.57	355.43
Firm age (years)	7.44	7.36	7.94	7.82	7.34	7.83	7.90
Exports/output	50.15%	49.22%	49.01%	47.25%	49.66%	47.12%	45.47%
New product output/ output	1.77%	1.83%	1.56%	1.38%		2.65%	3.20%
Throughput/output	78.22%	76.30%	81.30%	76.48%	73.40%	73.71%	73.06%
Market share (sp)	0.62%	0.57%	0.54%	0.48%	0.30%	0.30%	0.27%
Market share (s)	0.04%	0.04%	0.03%	0.03%	0.02%	0.02%	0.02%
			Means for Firms with Majority FRN Share				
Log(output)	10.53	10.50	10.52	10.58	10.39	10.62	10.71
Log(capital)	11.73	11.80	11.92	12.01	11.91	12.01	12.22
Log(throughput)	12.98	13.24	13.46	13.87	13.76	13.76	14.03
Log(labor)	6.56	6.64	6.75	6.93	6.93	6.90	7.13
Capital/labor	400.73	1,390.57	690.83	589.13	535.25	526.43	505.19
Firm age (years)	7.11	7.40	7.24	7.55	7.37	7.92	7.90
Exports/output	47.66%	44.54%	44.39%	45.40%	47.90%	43.69%	41.79%
New product output/ output	3.77%	4.65%	3.09%	2.98%		3.90%	4.53%
Throughput/output	80.18%	77.33%	75.92%	75.35%	73.29%	72.18%	71.38%
Market share (sp)	1.06%	0.95%	0.90%	0.82%	0.51%	0.52%	0.48%
Market share (s)	0.06%	0.05%	0.05%	0.05%	0.03%	0.03%	0.02%

FRN = foreign, HMT = Hong Kong, China; Macau, China; Taipei,China.

Note: Log(capital), log(throughput), log(labor), capital/labor, and firm age (years) weighted by output. Market share (sp) is market share calculated at the sector-province level. Market share (s) is market share calculated at the sector level.

Source: Authors' computations.

Table A.4. **All Domestic Firms**

	(1)	(2)	(3)	(4)	(5)	(6)
L.HRHMT	0.0543	0.0207	0.0524[c]	0.0311	0.0706	0.172
	(0.0445)	(0.0385)	(0.0280)	(0.0320)	(0.139)	(0.184)
L.HRFRN	0.123[a]	0.0824[a]	0.0193	0.0245	0.174	0.108
	(0.0397)	(0.0314)	(0.0278)	(0.0301)	(0.177)	(0.168)
L.BRHMT	−0.273[b]	−0.0412	−0.188	−0.143	0.954	0.580
	(0.131)	(0.112)	(0.185)	(0.186)	(1.217)	(1.293)
L.BRFRN	−0.109	0.261[c]	−0.233	−0.205	−2.249[b]	−1.290
	(0.146)	(0.139)	(0.171)	(0.180)	(0.970)	(1.236)
L.FRHMT	−0.0114	−0.185	−0.241	−0.151	−1.371	−0.221
	(0.170)	(0.152)	(0.186)	(0.188)	(1.253)	(1.457)
L.FRFRN	0.640[a]	0.201	−0.194	−0.109	0.507	−0.527
	(0.186)	(0.166)	(0.155)	(0.161)	(0.991)	(1.186)
Log demand	0.0318[a]	−0.00461	0.0539[b]	0.0542[b]	0.0593[a]	0.0461
	(0.00418)	(0.00475)	(0.0229)	(0.0227)	(0.0226)	(0.0308)
Herfindahl index	−0.000404[a]	0.00000739	−0.000169	−0.000170	−0.000187	−0.000305[c]
	(0.000121)	(0.000114)	(0.000144)	(0.000143)	(0.000141)	(0.000184)
Private share				0.0140[a]	0.0140[a]	0.0137[b]
				(0.00425)	(0.00425)	(0.00554)
L.HRHMT ∗				0.0511[c]	0.0521[c]	0.0569[c]
Private share				(0.0283)	(0.0277)	(0.0325)
L.HRFRN ∗				−0.00921	−0.0124	0.0152
Private share				(0.0171)	(0.0172)	(0.0183)
L.BRHMT ∗				−0.0827	−0.0840	−0.0356
Private share				(0.0646)	(0.0652)	(0.0801)
L.BRFRN ∗				−0.0253	−0.0173	−0.205[a]
Private share				(0.0859)	(0.0861)	(0.0716)
L.FRHMT ∗				−0.182[c]	−0.172[c]	−0.206[c]
Private share				(0.100)	(0.100)	(0.115)
L.FRFRN ∗				−0.180[c]	−0.197[c]	−0.0603
Private share				(0.105)	(0.101)	(0.111)
L.HRHMT ∗ SOE					−0.410[b]	−0.335
share – ind					(0.204)	(0.221)
L.HRHMT ∗ SOE					0.196	−0.109
share – prov					(0.212)	(0.259)
L.HRHMT ∗ FRN					−0.378	−0.355
share – ind					(0.230)	(0.260)
L.HRHMT ∗ FRN					0.339	−0.0705
share – prov					(0.313)	(0.376)
L.HRFRN ∗ SOE					−0.570[c]	−0.481[c]
share – ind					(0.317)	(0.263)
L.HRFRN ∗ SOE					0.145	−0.0205
share – prov					(0.139)	(0.163)
L.HRFRN ∗ HMT					−0.559	0.0529
share – ind					(0.536)	(0.539)
L.HRFRN ∗ HMT					0.0606	0.127
share − prov					(0.264)	(0.304)
L.BRHMT ∗ SOE					0.253	0.450
share – ind					(1.621)	(2.035)
L.BRHMT ∗ SOE					−1.566	−1.057
share – prov					(1.876)	(1.853)

Continued.

Table A.4. *Continued.*

	(1)	(2)	(3)	(4)	(5)	(6)
L.BRHMT ∗ HMT share – ind					−3.587	−6.195
					(3.301)	(4.471)
L.BRHMT ∗ HMT share – prov					1.236	2.592
					(1.939)	(2.887)
L.BRHMT ∗ FRN share – ind					3.796	6.703
					(4.435)	(5.776)
L.BRHMT ∗ FRN share – prov					−2.628	−2.528
					(3.280)	(3.640)
L.BRFRN ∗ SOE share – ind					0.415	−0.125
					(1.254)	(1.621)
L.BRFRN ∗ SOE share – prov					2.009[c]	1.879
					(1.120)	(1.452)
L.BRFRN ∗ HMT share – ind					−2.004	−4.678
					(2.814)	(3.583)
L.BRFRN ∗ HMT share – prov					−2.956	−4.212
					(2.402)	(2.916)
L.BRFRN ∗ FRN share – ind					3.964	5.208
					(4.046)	(4.917)
L.BRFRN ∗ FRN share – prov					6.324[a]	4.564
					(2.268)	(3.289)
L.FRHMT ∗ SOE share – ind					−1.652	−4.527[c]
					(2.004)	(2.437)
L.FRHMT ∗ SOE share – prov					2.908	4.332
					(2.317)	(2.787)
L.FRHMT ∗ HMT share – ind					5.758	4.150
					(4.654)	(5.602)
L.FRHMT ∗ HMT share – prov					−2.183	−5.023[c]
					(1.993)	(2.637)
L.FRHMT ∗ FRN share – ind					−4.693	−5.962
					(3.510)	(4.452)
L.FRHMT ∗ FRN share – prov					4.424	5.504
					(3.506)	(4.845)
L.FRFRN ∗ SOE share – ind					−0.0883	−0.296
					(1.557)	(1.455)
L.FRFRN ∗ SOE share – prov					−0.942	1.664
					(1.512)	(1.482)
L.FRFRN ∗ HMT share – ind					3.490	5.163
					(3.397)	(3.451)
L.FRFRN ∗ HMT share – prov					−4.105[b]	−4.530[b]
					(1.699)	(1.863)
L.FRFRN ∗ FRN share – ind					−1.932	−3.599
					(3.334)	(3.741)
L.FRFRN ∗ FRN share – prov					−0.0895	1.302
					(1.940)	(2.945)
L.HRHMT ∗ Patent propensity						3.931[b]
						(1.625)
L.HRFRN ∗ Patent propensity						1.805
						(1.467)
L.BRHMT ∗ Patent propensity						−17.97
						(14.14)
L.BRFRN ∗ Patent propensity						−11.08
						(8.437)

Continued.

Table A.4. *Continued.*

	(1)	(2)	(3)	(4)	(5)	(6)
L.FRHMT ∗						−13.60
Patent propensity						(10.28)
L.FRFRN ∗						7.668
Patent propensity						(5.889)
I(2002)		0.0242[a]	−0.00177	−0.00222	−0.00325	0.00189
		(0.00429)	(0.00617)	(0.00616)	(0.00619)	(0.00875)
I(2003)		0.0593[a]	0.00872	0.00799	0.00677	0.0129
		(0.00455)	(0.0103)	(0.0103)	(0.0102)	(0.0159)
I(2004)		0.0927[a]	0.00932	0.00840	0.00643	0.0166
		(0.00597)	(0.0179)	(0.0177)	(0.0176)	(0.0257)
I(2005)		0.121[a]	−0.00602	−0.00711	−0.00668	0.00396
		(0.00628)	(0.0216)	(0.0214)	(0.0213)	(0.0305)
I(2006)		0.132[a]	−0.0124	−0.0135	−0.0143	−0.000884
		(0.00743)	(0.0262)	(0.0260)	(0.0258)	(0.0371)
Observations	580,748	580,748	580,748	580,748	579,829	428,636
Firms	221,572	221,572	221,572	221,572	221,213	186,651
Adjusted R^2	0.00666	0.0159	0.417	0.417	0.417	0.441

FDI = foreign direct investment, FRN = foreign, HMT = Hong Kong, China; Macau, China; Taipei,China, SOE = state-owned enterprise, BRHMT = downstream HMT FDI presence, BRFRN = downstream FRN FDI presence, FRHMT = upstream HMT FDI presence, FRFRN = upstream FRN FDI presence, HRHMT = HMT FDI presence in sector *j* and province *p*, HRFRN = FRN FDI presence, ind = industry, prov = province.

Note: Dependent variable is total factor productivity (TFP). Columns 1 and 2 pertain to OLS regressions and columns 3–6 to (firm) fixed effects regressions. Standard errors clustered on province-industry reported in parentheses.

[a]Significant at 1%. [b]Significant at 5%. [c]Significant at 10%.

Source: Authors' computations.

Table A.5. **Majority Private Firms Only**

	(1)	(2)	(3)	(4)	(5)
L.HRHMT	0.0396	0.0101	0.0941[b]	0.201	0.250
	(0.0446)	(0.0390)	(0.0377)	(0.183)	(0.204)
L.HRFRN	0.0823[c]	0.0390	0.0280	−0.181	−0.104
	(0.0475)	(0.0370)	(0.0292)	(0.141)	(0.152)
L.BRHMT	−0.0521	0.161	−0.108	0.805	0.984
	(0.126)	(0.114)	(0.220)	(1.019)	(1.063)
L.BRFRN	−0.0253	0.305[b]	−0.142	−1.894[c]	−1.859
	(0.151)	(0.148)	(0.196)	(1.032)	(1.184)
L.FRHMT	−0.0157	−0.142	−0.0227	−1.105	−0.914
	(0.167)	(0.160)	(0.240)	(1.143)	(1.411)
L.FRFRN	−0.0488	−0.441[b]	0.00510	1.531	0.347
	(0.181)	(0.176)	(0.207)	(1.044)	(1.236)
Log demand	0.0129[b]	−0.0184[a]	0.0208	0.0248	0.0325
	(0.00526)	(0.00658)	(0.0307)	(0.0300)	(0.0345)
Herfindahl index	−0.000319[c]	0.0000666	−0.0000647	−0.000118	−0.000316
	(0.000171)	(0.000149)	(0.000177)	(0.000175)	(0.000213)
L.HRHMT ∗ state share − ind				−0.229	−0.247
				(0.237)	(0.240)
L.HRHMT ∗ state share – prov				0.0834	−0.109
				(0.287)	(0.320)
L.HRHMT ∗ FRN share – ind				−0.241	−0.228
				(0.316)	(0.339)
L.HRHMT ∗ FRN share – prov				−0.327	−0.271
				(0.564)	(0.645)
L.HRFRN ∗ state share – ind				0.0762	0.00212
				(0.258)	(0.253)
L.HRFRN ∗ state share – prov				0.422[a]	0.104
				(0.156)	(0.165)
L.HRFRN ∗ HMT share – ind				0.0747	0.423
				(0.492)	(0.513)
L.HRFRN ∗ HMT share – prov				−0.133	−0.0912
				(0.339)	(0.367)
L.BRHMT ∗ state share – ind				1.093	1.003
				(1.697)	(1.832)
L.BRHMT ∗ state share – prov				−2.444[c]	−2.616[c]
				(1.352)	(1.420)
L.BRHMT ∗ HMT share – ind				−1.316	−3.315
				(3.896)	(4.473)
L.BRHMT ∗ HMT share – prov				0.210	2.389
				(2.468)	(2.597)
L.BRHMT ∗ FRN share – ind				2.864	6.377
				(5.192)	(5.757)
L.BRHMT ∗ FRN share – prov				−0.753	−3.260
				(2.525)	(2.261)
L.BRFRN ∗ state share – ind				1.844	1.033
				(1.462)	(1.596)
L.BRFRN ∗ state share – prov				0.314	0.468
				(1.190)	(1.329)
L.BRFRN ∗ HMT share – ind				1.459	−2.938
				(3.306)	(3.511)

Continued.

Table A.5. *Continued.*

	(1)	(2)	(3)	(4)	(5)
L.BRFRN ∗ HMT share – prov				−3.204	−2.845
				(2.943)	(3.145)
L.BRFRN ∗ FRN share – ind				3.081	7.443
				(4.800)	(5.225)
L.BRFRN ∗ FRN share – prov				5.387[c]	5.441[b]
				(2.943)	(2.735)
L.FRHMT ∗ state share – ind				−2.088	−3.399
				(2.033)	(2.278)
L.FRHMT ∗ state share – prov				4.057[c]	5.834[b]
				(2.122)	(2.683)
L.FRHMT ∗ HMT share – ind				4.176	3.134
				(5.023)	(6.108)
L.FRHMT ∗ HMT share – prov				–3.421	−4.694[c]
				(2.420)	(2.768)
L.FRHMT ∗ FRN share – ind				−3.838	−5.542
				(3.793)	(5.059)
L.FRHMT ∗ FRN share – prov				3.098	3.528
				(2.872)	(3.638)
L.FRFRN ∗ state share – ind				−4.166[b]	−2.560
				(1.869)	(2.066)
L.FRFRN ∗ state share – prov				1.057	2.214
				(1.535)	(1.579)
L.FRFRN ∗ HMT share – ind				−0.562	2.740
				(4.077)	(4.237)
L.FRFRN ∗ HMT share – prov				−6.231[a]	−5.064[b]
				(1.954)	(2.277)
L.FRFRN ∗ FRN share – ind				−3.288	−5.205
				(3.481)	(4.171)
L.FRFRN ∗ FRN share – prov				0.969	0.385
				(2.504)	(2.898)
L.HRHMT ∗ Patent propensity					2.029
					(2.975)
L.HRFRN ∗ Patent propensity					1.158
					(2.204)
L.BRHMT ∗ Patent propensity					−7.826
					(15.52)
L.BRFRN ∗ Patent propensity					−13.74
					(8.850)
L.FRHMT ∗ Patent propensity					−8.092
					(11.56)
L.FRFRN ∗ Patent propensity					17.01[b]
					(7.802)
I(2002)		0.00	0.00859	0.00767	0.00614
		(0.00)	(0.00572)	(0.00566)	(0.00896)
I(2003)		0.0272[a]	0.0162	0.0160	0.00663
		(0.00330)	(0.0133)	(0.0130)	(0.0171)
I(2004)		0.0544[a]	0.0109	0.0101	−0.00164
		(0.00544)	(0.0234)	(0.0231)	(0.0281)
I(2005)		0.0881[a]	0.0101	0.0108	−0.00161
		(0.00602)	(0.0285)	(0.0280)	(0.0335)

Continued.

Table A.5. *Continued.*

	(1)	(2)	(3)	(4)	(5)
I(2006)		0.101[a]	0.00444	0.00482	−0.00897
		(0.00745)	(0.0345)	(0.0338)	(0.0402)
Observations	297,437	297,437	297,437	297,200	240,770
Firms	138,883	138,883	138,883	138,751	122,824
Adjusted R^2	0.00201	0.0141	0.470	0.471	0.496

FDI = foreign direct investment, FRN = foreign, HMT = Hong Kong, China; Macau, China; Taipei,China, SOE = state-owned enterprise, BRHMT = downstream HMT FDI presence, BRFRN = downstream FRN FDI presence, FRHMT = upstream HMT FDI presence, FRFRN = upstream FRN FDI presence, HRHMT = HMT FDI presence in sector j and province p, HRFRN = FRN FDI presence, ind = industry, prov = province.

Note: Dependent variable is total factor productivity (TFP). Columns 1 and 2 pertain to OLS regressions and columns 3–5 to (firm) fixed effects regressions. Standard errors clustered on province-industry reported in parentheses.

[a] Significant at 1%. [b] Significant at 5%. [c] Significant at 10%.

Source: Authors' computations.