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Essays on Foreign Investment, Agglomeration Economies, and Industrial Policy

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By

Luosha Du

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Committee in charge:

Professor Ann E. Harrison, Co-Chair
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Abstract

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Professor Ann E. Harrison, Co-Chair

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Since opening its economy to the outside world in late 1978, China has experienced a massive, protracted, and unexpected economic upsurge, which has attracted the attention of a large and diverse group of researchers. China's three-decade economic reforms have reshaped the economic structure from plan to market, through a variety of policy actions, such as openness to foreign investment and efforts to build economic zones. Economic growth and potential technology transfer are indeed the main rationale behind the Chinese government's aggressive efforts over the past three decades to enhance openness and to increase domestic competition.

This dissertation consists of three chapters. All chapters study firm behavior and their policy implications. However, the focus of each chapter is different. The first chapter (coauthored with Ann Harrison and Gary Jefferson) studies how institutions affect productivity spillovers from foreign direct investment (FDI) to China's domestic industrial enterprises. The second chapter separates the effect of agglomeration economies on firm performance (measured by total factor productivity) from the impact of competition and better transport infrastructure. The third chapter (coauthored with Philippe Aghion, Mathias Dewatripont, Ann Harrison, Patrick Legros) tests for the complementarity between competition and industrial policy.

The first Chapter (co-authored with Ann Harrison and Gary Jefferson) investigates how institutions affect productivity spillovers from foreign direct investment (FDI) to China's domestic industrial enterprises during 1998-2007. We examine three institutional features that comprise aspects of China's "special characteristics": (1) the different sources of FDI, where FDI is nearly evenly divided between mostly Organization for Economic Co-operation and Development (OECD) countries and Hong Kong (SAR of China), Taiwan (China), and Macau (SAR of China); (2) China's heterogeneous ownership structure, involving state- (SOEs) and non-state owned (non-SOEs) enterprises, firms with foreign equity participation, and non-SOE, domestic firms; and (3) industrial promotion via tariffs or through tax holidays to foreign direct investment. We also explore how productivity spillovers from FDI changed with China's entry into the WTO in late 2001. We find robust positive and significant spillovers to domestic firms via backward linkages (the contacts between foreign buyers and local suppliers). Our results suggest varied success with

industrial promotion policies. Final goods tariffs as well as input tariffs are negatively associated with firm-level productivity. However, we find that productivity spillovers were higher from foreign firms that paid less than the statutory corporate tax rate.

The second chapter separates the effect of agglomeration economies on firm performance (measured by total factor productivity) from the impact of competition and better transport infrastructure. Consequently, this paper primarily addresses the problem of omitted variable bias in estimating the impact of agglomeration economies on firm performance. The results suggest that firm productivity is improved only by the presence of other firms in the same sector (localization economies). The inclusion of information on road construction does not affect the importance of pure localization economies. However, including a measure of competition in the estimation significantly reduces the importance of localization externalities. The results also suggest that both road-building and competition are positively associated with productivity growth. The results for sub-samples indicate that exporting firms and firms financed by foreign investment benefit more from localization externalities than do their non-exporting and domestically-financed counterparts.

The third chapter (co-authored with Philippe Aghion, Ann Harrison, Mathias Dewatripont, and Patrick Legros) argues that sectoral state aid tends to foster productivity, productivity growth, and product innovation to a larger extent when it targets more competitive sectors and when it is not concentrated on one or a small number of firms in the sector. A main implication from our analysis is that the debate on industrial policy should no longer be for or against having such a policy. As it turns out, sectoral policies are being implemented in one form or another by a large number of countries worldwide, starting with China. Rather, the issue should be on how to design and govern sectoral policies in order to make them more competition-friendly and therefore more growth-enhancing. Our analysis suggests that proper selection criteria together with good guidelines for governing sectoral support can make a significant difference in terms of growth and innovation performance. Yet the issue remains of how to minimize the scope for influence activities by sectoral interests when a sectoral state aid policy is to be implemented. One answer is that the less concentrated and more competition-compatible the allocation of state aid to a sector, the less firms in that sector will lobby for that aid as they will anticipate lower profits from it. In other words, political economy considerations should reinforce the interaction between competition and the efficiency of sectoral state aid. A comprehensive analysis of the optimal governance of sectoral policies still awaits further research.

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Chapter 1 Do Institutions Matter for FDI Spillovers? The Implications of China's "Special Characteristics"

1.1 Introduction

Since opening its economy to the outside world in late 1978, China has absorbed an increasing amount of FDI. It is now among the world's largest hosts for foreign investment, and has in recent years consistently ranked number one as the largest developing country recipient of FDI inflows. Potential technology transfer is likely to have been an important rationale behind the Chinese government's aggressive efforts over the past two decades to attract foreign investment to China (Hu and Jefferson (2002)). Indeed, the Chinese government has intervened extensively to promote industrialization in China, relying on a range of policy instruments. These instruments include tariffs, tax subsidies, and promotion of foreign investors in key sectors.

One typical justification for subsidizing incoming foreign investment is an externality in the form of productivity spillovers. Productivity spillovers take place when the entry or presence of multinationals increases the productivity of domestic firms. If such spillovers occur, then multinationals do not fully internalize the value of these benefits. We define intra-industry spillovers (also called horizontal spillovers) as occurring when domestic firm productivity is positively affected by firms with foreign equity participation located in the same sector, while inter-industry spillovers (vertical spillovers) occur when domestic firms are affected by firms with foreign equity in the upstream (forward linkage) or downstream sectors (backward linkages).

A number of recent papers test for productivity spillovers from foreign investment. Most of these studies, such as papers by Haddad and Harrison (1993) on Morocco, Aitken and Harrison (1999) on Venezuela, and Konings (2001) on Bulgaria, Romania and Poland, either failed to find evidence of horizontal spillovers or reported negative horizontal spillover effects. More recently, Javorcik (2004) and Blalock and Gertler (2008) argued that since multinationals may simultaneously have an incentive to prevent information leakage that would enhance the performance of their local competitors, while at the same time possibly benefitting from transferring knowledge to their local suppliers or clients, spillovers from FDI are more likely to be negative along the horizontal dimension and positive along the vertical dimension[1]. Javorcik uses firm-level data from Lithuania and Blalock and Gertler (2008) use data for Indonesia to show that positive FDI spillovers take place through backward linkages (between foreign affiliates and their local suppliers); however, there is no robust evidence of positive spillovers occurring through either the horizontal or the forward linkage channel.

One recent manuscript that investigates both horizontal and vertical FDI spillovers in China is Lin, Liu, and Zhang (2009). In contrast to Javorcik (2004), Lin, Liu, and Zhang find bigger forward and smaller backward spillovers. Our results will differ from theirs, in part because we focus on total factor productivity and they examine value-added productivity and also use a different estimation method. We also expand the analysis to explore the relationship between trade policies, tax incentives, and externalities from foreign investment. To our knowledge, ours is the first study to explore—in China or elsewhere--how productivity gains from foreign investment vary with tax and tariff policies.

There are also a set of theoretical studies demonstrating that positive FDI spillovers are more likely to operate across industry rather than within an industry. These studies emphasize efforts to minimize the probability of imitation, especially under imperfect intellectual property rights in the host country. As Markusen and Venables (1998) point out, proximity to potential domestic competitors with absorptive capacity to reverse engineer proprietary technology would be detrimental to a multinational, thus motivating it to set up its subsidiaries where potential rivals cannot erode its market share. By contrast, the multinational can benefit from knowledge diffusion when it reaches downstream clients and upstream suppliers, which will encourage vertical flows of generic knowledge that lead to inter-industry spillovers.

This study goes further by investigating the implications of the institutional context for the nature of spillovers. In particular, we examine three institutional features that comprise aspects of China's "special characteristics": the different sources of FDI, which are nearly evenly divided between mostly OECD countries and Hong Kong (SAR of China), Taiwan (China) and Macau (SAR of China) (henceforth, Hong Kong-Taiwan-Macau for

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[1] Gorodnichenko, Svejnar, and Terrell (2007) use firm-level data and national input-output tables from 17 countries over the 2002-2005 period and find that inter-industry linkages are associated with greater productivity improvement than intra-industry linkage, which supports new hypotheses about the impact FDI on the efficiency of domestic firms in the host country. Gorodnichenko et al (2010) test for the effects of globalization through the impact of increased competition and foreign direct investment on domestic firms' efforts to raise their capability by upgrading their technology or their product/service, taking into account firm heterogeneity. They find support for the prediction that competition has a negative effect on innovation, especially for firms further from the frontier, and that the supply chain of multinational enterprises and international trade are important channels for domestic firm innovation.

short); China's extraordinarily heterogeneous ownership structure, involving state, foreign, and domestic ownership, and tax incentives such as income tax holidays and tariffs. Many foreign investors in China over the last ten years have faced much lower corporate tax rates; before 2008, foreign investors received a 15 percent corporate tax rate while domestic enterprises faced a regular 33 percent corporate tax rate[2]. This policy of promoting foreign investors and other favored firms in China was only discontinued in 2008.

In addition to exploring the differential effects of foreign investment linkages across special characteristics in explaining productivity performance, we also examine how globalization has affected Chinese firm performance. Until 1990, average tariffs on manufacturing in China were as high as 50 percent. There is a rich literature which examines the impact of trade liberalization on productivity, although there are fewer studies that disentangle the effects of input and output tariffs. One example is Amiti and Konings (2007), who use Indonesian manufacturing census data to show that the effect of reducing input tariffs significantly increases productivity, and that this effect is much higher than reducing output tariffs. For China, Brandt, Biesebroeck and Zhang (2008) focus specifically on the impact of trade liberalization on productivity. Using Chinese firm-level data (1998-2005), they suggest that a ten percentage point reduction in final good output tariffs results in an increase in TFP of 0.42 percent.

Our results suggest varied outcomes from promoting domestic productivity growth through these different instruments. The benefits via vertical linkages from foreign investment have been significant and positive, but the impact of tariffs on total factor productivity growth has been negative. We find some horizontal externalities from foreign direct investment (FDI), although the positive effect as well as the significance varies across specifications. We find particularly strong evidence of positive and significant vertical linkages to domestic firms via backward linkages. Productivity of domestically owned firms has been boosted primarily via contacts between domestic suppliers and foreign buyers of their products.

This paper also shows that firm ownership and sources of FDI significantly affect the magnitude of FDI spillovers. After we recalculate sector-level FDI based on its origin[3], we find that investors from Hong Kong-Taiwan-Macauand those from the rest of the world,

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[2] However, the government adjusted this preferential policy in 2008. Starting from Jan 1, 2008, the new corporate tax policy for foreign-invested firms is the following: foreign-invested firms that previously receive preferential corporate tax rates will return to the regular tax rate within 5 years. In 2008, the tax rate increases from 15% to 18%; in 2009, the rate keeps increasing to 20%; in 2010, the corporate tax rate is 22% and will finally reach 25% in 2012.

[3] This means that we will have two sets of sector-level FDI variables. One of them is calculated based on foreign investment contributed by Hong Kong-Taiwan-Macau investors and the other set is obtained based on foreign assets provided by investors from OECD countries.

largely the OECD region, generate completely different horizontal linkages for domestic firms. That is, OECD investors do help domestic firms located in the same industry whereas investors from Hong Kong-Taiwan-Macau hurt their domestic counterparts or have no impact.

For trade policy, our results suggest a negative, significant effect of final goods tariffs on domestic productivity. We also test for the effects of input tariffs on productivity, and find negative and significant effects of input tariffs on productivity. Exploiting the exogenous change in trade policies with China's entry into the WTO at the end of 2001, we find that the magnitude of backward linkages increased with trade liberalization. Since China's entry into the WTO put pressure to phase out domestic content rules (in order to comply with the WTO), we would have expected to find a reduction in backward linkages. Instead, backward linkages became stronger after WTO entry.

Finally, we explore the rationale for tax subsidies bestowed on foreign investors. If the Chinese government correctly targets, through tax concessions, those firms with greater potential for capturing spillovers, we would expect stronger linkages associated with tax breaks. We find statistically significant evidence of stronger productivity externalities associated with firms that received tax breaks.

Our empirical strategy follows Javorcik (2004) and Olley and Pakes (1996) (henceforth OP). First, we use Javorcik's (2004) empirical strategies to calculate *Backward* and *Forward* linkages and follow her estimation models to test whether there are vertical FDI spillovers in the manufacturing sector in China. We address the endogeneity of inputs by applying the strategy proposed by OP. We also apply a variety of specifications to take into account firm-specific fixed effects, and find that our results are robust to these alternative approaches.

The rest of paper is organized as follows. Section 1.2 describes the basic framework and the data used in this paper. We also review broad trends for the 1998 through 2007 period. Section 1.3 discusses the econometric issues and presents the empirical results. Section 1.4 concludes.

1.2 Basic Framework and Data

Section 1.2.1 describes the analytical framework, estimation equation, and measures for constructing the key spillover variables that we use. Section 1.2.2 describes the key features of our firm-level panel data set and the summary statistics for our sample period.

1.2.1 Basic Framework

To examine the impact of intra- and inter-industry FDI spillovers and trade policy across various institutional dimensions on firm productivity, we employ the following basic model, inspired by Aitken and Harrison (1999) and Javorcik (2004):

$$\ln Y_{ijt} = \alpha + \beta_1 \ln K_{ijt} + \beta_2 \ln L_{ijt} + \beta_3 \ln M_{ijt} + \beta_4 ForeignShareHKTM_{ijt} + \beta_5 ForeignShareFR_{ijt} + \beta_6 StateShare_{ijt} + \beta_7 Horizontal_{jt} + \beta_8 Backward_{jt} + \beta_9 Forward_{jt} + \alpha_i + \alpha_t + \varepsilon_{ijt} \quad (1.1).$$

Y_{ijt} is the quantity produced by firm i in sector j at time t. It is calculated by deflating the output value (quantities*prices) by the sector-specific ex-factory price index of industrial products in order to separately identify quantity[4]. K_{ijt}, capital, is defined as the value of fixed assets, which is deflated by the fixed assets investment index, and L_{ijt} is the total number of employees. M_{ijt} represents the intermediate inputs purchased by firms to use for production of final products, which is deflated by the intermediate input price index.[5] $ForeignShareHKTM_{ijt}$, $ForeignShareFR_{ijt}$ and $StateShare_{ijt}$ are defined as the share of the firm's total equity owned by Hong Kong-Taiwan-Macau investors, foreign investors, and the state respectively. The omitted share, the non-state domestically-owned share, is represented by the constant term. By construction, these three firm-level controls are continuous variables and range from 0 to 1 in value[6].

The motivation for separating foreign share into two types is two-fold. First, we would like to see whether some types of foreign investment are more likely to result in productivity spillovers than others. Second, anecdotal evidence suggests large quantities of so-called foreign investors in China are actually domestic investors who channel investment through Hong Kong–Taiwan-Macau in order to take advantage of special treatment for foreign firms (so-called "round tripping"). If this is the case, then we would expect that foreign investment of this type might have a smaller impact on domestic firms.

Following Javorcik (2004), we define three sector-level FDI variables. First, $Horizontal_{jt}$ captures the extent of foreign presence in sector *j* at time *t* and is defined as foreign equity participation averaged over all firms in the sector, weighted by each firm's share in sectoral output. In other words,

$$Horizontal_{jt} = \left[\sum_{i for all i \in j} ForeignShare_{it} * Y_{it} \right] / \sum_{i for all i \in j} Y_{it} \quad (1.2),,$$

[4] Sector-specific ex-factory price indices for industrial products came from China Urban Life and Price Yearbook (2008, Table 4-3-3). The price indices are published for 29 individual sectors.

[5] Price indices for fixed investment and industry-wide intermediate inputs are obtained from the Statistical Yearbook (2006) (obtained from the website of the National Bureau of Statistics of China).

[6] In some specifications, we run regressions with domestic firms only. In these cases, we use the sample of pure domestic firms, which have zero foreign investment. Then we regress either the log of the firm's output or productivity on sector-level FDI without the variable "Foreign Share".

where $ForeignShare_{it}$ is the sum of $ForeignShareHKTM$ and $ForeignShareFR$. Second, $Backward_{jt}$ captures the foreign presence in the sectors that are supplied by sector j[7]. Therefore, $Backward_{jt}$ is a measure for foreign participation in the downstream industries of sector j. It is defined as

$$Backward_{jt} = \sum_{k if k \neq j} \alpha_{jk} Horizontal_{kt} \; (1.3).$$

The value of α_{jk} is taken from the 2002 input-output table[8] representing the proportion of sector j's production supplied to sector k. Finally, $Forward_{jt}$ is defined as the weighted share of output in upstream industries of sector j produced by firms with foreign capital participation. As Javorcik points out, since only intermediates sold in the domestic market are relevant to the study, goods produced by foreign affiliates for exports (X_{it}) should be excluded. Thus, the following formula is applied:

$$Forward_{jt} = \sum_{m if m \neq j} \delta_{jm} \left[\left[\sum_{i for all i \in m} ForeignShare_{it} * (Y_{it} - X_{it}) \right] / \left[\sum_{i for all i \in m} (Y_{it} - X_{it}) \right] \right] (1.4).$$

The value of δ_{jm} is also taken from 2002 input-output table. Since $Horizontal_{jt}$ already captures linkages between firms within a sector, inputs purchased within sector j are excluded from both $Backward_{jt}$ and $Forward_{jt}$.

1.2.2 Data and Broad Trends

The dataset employed in this paper was collected by the Chinese National Bureau of Statistics. The Statistical Bureau conducts an annual survey of industrial plants, which includes manufacturing firms as well as firms that produce and supply electricity, gas, and water. It is firm-level based, including all state-owned enterprises (SOEs), regardless of size, and non-state-owned firms (non-SOEs) with annual sales of more than 5 million yuan. We use a ten-year unbalanced panel dataset, from 1998 to 2007. The number of firms per year varies from a low of 162,033 in 1999 to a high of 336,768 in 2007. The sampling strategy is the same throughout the sample period (all firms that are state-owned or have sales of more than 5 million yuan are selected into the sample); the variation of numbers of enterprises across years may be driven by changes in ownership classification or by increases (or reductions) in sales volume in relation to the 5 million yuan threshold. However, the data show that 5 million yuan is not a strict rule. Among non-SOEs, about 6

[7] For instance, both the furniture and apparel industries use leather to produce leather sofas and leather jackets. Suppose the leather processing industry sells 1/3 of its output to furniture producers and 2/3 of its output to jacket producers. If no multinationals produce furniture but half of all jacket production comes from foreign affiliates, the *Backward* variable will be calculated as follows: 1/3*0+2/3*1/2=1/3.

[8] Input-ouput tables of China (2002) Table 4.2, which divides manufacturing industry into 71 sectors.

percent of the firms report annual sales of less than 5 million yuan in 1998; this number rises to 8 percent by 1999 and falls after 2003. In 2007, only 1 percent of non-SOEs have annual sales below 5 million yuan. In terms of the full sample, the percent of firms with sales less than 5 million yuan stays at the same level for 1998 and 1999 and starts falling in 2000. In 2007, around 2 percent of the sample consists of firms with annual sales less than 5 million yuan.

The original dataset includes 2,226,104 observations and contains identifiers that can be used to track firms over time. Since the study focuses on manufacturing firms, we eliminate non-manufacturing observations. The sample size is further reduced by deleting missing values, as well as observations with negative or zero values for output, number of employees, capital, and the inputs, leaving a sample size of 1,842,786. Due to incompleteness of information on official output price indices, three sectors are dropped from the sample[9]. Thus, our final regression sample size is 1,545,626.

The dataset contains information on output, fixed assets, total workforce, total wages, intermediate input costs, foreign investment, Hong Kong-Taiwan-Macau investment, sales revenue, and export sales. These are the key variables from which we obtain measures of firm-level foreign asset shares and the FDI spillover variable, which are discussed in detail in the next section. In this paper, to test the impact of FDI spillovers on domestic firm productivity, we use the criterion of zero foreign ownership to distinguish domestic firms and foreign owned firms, that is, domestic firms are those with zero foreign capital in their total assets. In the dataset, 1,197,597 observations meet the criterion[10].

Table 1.1 reports the summary statistics for the main variables used in the regressions. The summary statistics indicate the mean of the ratios, which is different than weighted means which would give more weight to larger firms. The first three columns report means for levels and the last three columns report means for growth rates of the key variables used in the analysis.

The statistical means highlight the remarkable growth rates exhibited by the manufacturing sector during this period, with average real output growing 13.5 percent a year, and the net capital stock growing 10.7 percent per year. Labor input grew significantly slower, with average annual increases of only 1.3 percent per year. Total

[9] They are the following sectors: processing food from agricultural products; printing, reproduction of recording media; and general purpose machinery.

[10] Actually, the international criterion used to distinguish domestic and foreign-invested firms is 10%, that is, the share of subscribed capital owned by foreign investors is equal to or less than 10%. In the earlier version of the paper, we tested whether the results are sensitive to using zero, 10%, and 25% foreign ownership. Our results show that between the zero and 10% thresholds, the magnitude and the significance levels of the estimated coefficients remain close, which makes us comfortable using the more restrictive sample of domestic firms for which the foreign capital share is zero. The results based on the 25% criterion exhibit small differences, but the results are generally robust to the choice of definition for foreign versus domestic ownership.

factor productivity grew on average 5.6 percent per year, implying a forty percent contribution to overall growth. The means also document that on average foreign-invested assets have been almost evenly split between sources in Hong Kong-Taiwan-Macau and foreign investment originating in other locations. The state continues to play an important role in manufacturing, with a mean asset share of 8.9 percent during the sample period; over the sample period the share of total foreign investment in manufacturing is significantly larger, at 16.8 percent. For the sample as a whole, the average state share during this period fell by approximately 0.7 percentage point per year.

In Tables 1.2,1, 1.2.2, 1.2.3, and 1.2.4, we provide summary statistics for the four sets of spillover variables. Table 1.2.1 shows that the share of foreign-invested assets at the sector level, the horizontal foreign share, increased over the sample period from 20.4 to 26.7 percent. To take into account the sources of FDI for sectoral spillovers, we re-calculate sector-level FDI variables from two broad geographic categories. To explore the importance of the source of foreign investment within the firm for productivity, we calculate firm-level foreign investment, horizontal foreign shares, and vertical foreign shares for Hong Kong-Taiwan-Macau FDI, and for foreign investment originating in other locations, i.e. principally the OECD countries. Table 1.2.2 shows basic summary statistics for these two sets of sectoral spillover variables. The basic summary statistics show that the two sets have exhibited different trends over time. FDI shares for Hong Kong-Taiwan-Macau investment steadily increased over the period of 1998-2003. In contrast, FDI from other regions shows an even faster and steadily increasing pattern of growth over the entire time period, with more than a doubling of foreign investment shares. It is clear from Tables 1.2.2 that most of the increase in foreign investment over 1998-2007 originated inside the OECD countries.

Table 1.2.3 reports trends in subsidized and non-subsidized foreign investment. While the standard tax rate across all firms during the sample period was 33 percent, a large share of foreign-owned firms were granted tax subsidies, thus facing tax rates that were significantly lower. In the left panel of Table 1.2.3, we redefine our sector-level foreign share variables by restricting them to only those foreign firms who paid less than the statutory tax rate. In the right panel of Table 1.2.3, we redefined sector-level foreign share to restrict it to those firms who paid the full rate. The trends show a steady increase in subsidized foreign investment between 1998 and 2007. By the end of the sample period, the majority of foreign investors received some form of a tax subsidy.

Figure 1.1 shows the distribution of taxes paid by different types of enterprises for the year 2004. The top left-hand side quadrant shows that a large share of non-SOEs paid the 33 percent tax rate. However, only a small minority of foreign-invested firms paid the statutory rate, as indicated by the bottom right-hand side quadrant. In 2004, 7 percent of foreign-invested firms paid the statutory rate, compared to almost 40 percent for domestically-owned enterprises. In figure 1.2, we re-plot the tax distribution with the domestic non-SOEs (non-foreign and non-SOE enterprises) and find that more than 35% of firms paid the 33 percent tax rate.

Table 1.2.4 reports the percentage of firms who were subsidized based on value-added taxes, which are reported separately from income taxes on profits. Fewer firms receive subsidies in the form of exemptions on value-added taxes. These exemptions increased until 2003, then declined. It is clear from these tables that income tax holidays were a more pervasive form of incentives until the 2008 tax reform.

1.3 Estimation and Results

1.3.1 Baseline Results

We begin the analysis by estimating the model described in equation (1.1) using ordinary least square (OLS) with and without firm fixed effects. Columns (1) and (2) of Table 1.3 are estimated with the dependent variable as the log of the firm's deflated output. To study the impact of FDI spillovers on the performance of domestic firms, we are interested in how FDI invested in other firms affect the domestic firms located in the same sector. Therefore, the key parameters in the above specification are β_7, β_8 and β_9.

One possibility that has not been explored in the literature on vertical and horizontal linkages is that foreign investment shares are proxying for different trade policies across sectors. Protected sectors may be more likely to receive foreign investment as these firms may be motivated to relocate in order to circumvent tariff or non-tariff barriers ("tariff-jumping" foreign investment, which leads to immiserizing effects as modeled by Diaz Alejandro (1977)). In this case, the gains from foreign investment could be under-estimated due to omitted variable bias.

To control for the effects of trade policies, we have created a time series of tariffs, obtained from the World Integrated Trading Solution (WITS), maintained by the World Bank. We aggregated tariffs to the same level of aggregation as the foreign investment data, using output for 2003 as weights. We also created forward and backward tariffs, to correspond with our vertical FDI measures. Table 1.1 and Appendix 1.5 show basic summary statistics for these tariff variables. During the sample period, average tariffs fell nearly 9 percentage points, which is a significant change over a short time period. While the average level of tariffs during this period, which spans the years before and after WTO accession, was nearly 13 percent, this average masks significant heterogeneity across sectors, with a high of 41 percent in grain mill products and a low of 4 percent in railroad equipment.

We initially pool the data to include both firms with and without foreign investment, reporting results with and without firm fixed effects. The first column of Table 1.3, with the application of fixed effects, shows that firm productivity levels are higher for firms with participation from other (OECD) investors than those from Hong Kong-Taiwan-Macao, and lower for firms with state-owned assets. There are no significant horizontal spillovers, but backward vertical linkages are positive and statistically significant. Final goods tariffs are negative and significantly associated with productivity in the OLS fixed effect specifications, but not in the fixed effect specifications. This suggests that tariffs are imposed in sectors where productivity is lower, but the association between changes in tariffs and changes in productivity across all firms is weak. We will see that the negative significance of tariffs is stronger when we split the sample based on ownership differences later in the paper.

Comparing the fixed effects results in the first column with the second column (where firm fixed effects are omitted), the results are consistent across the two specifications. As expected, the coefficient on capital's output elasticity is attenuated with the fixed effect estimator. While foreign-invested firms are much more efficient and state-invested enterprises are much less efficient than the non-state-domestically-invested enterprises that represent the reference, once firm fixed effects are controlled for the differences are much smaller. Such differences suggest important differences between productivity levels and growth rates of state owned and foreign enterprises versus other types of enterprises.

Also using the entire sample, the third and fourth columns of Table 1.3 compare OLS and fixed effect estimates using Olley and Pakes (1996)[11] to correct for the potential endogeneity of input choice. The earlier literature on production function estimation shows that the use of OLS is inappropriate when estimating productivity, since this method treats labor, capital and other input variables as exogenous. As Griliches and Mairesse (1995) argue, inputs should be considered endogenous since they are chosen by a firm based on its productivity. Firm-level fixed effects will not solve the problem, because time-varying productivity shocks can affect a firm's input decisions.

Using OLS will therefore bias the estimations of coefficients on the input variables. To solve the simultaneity problem in estimating a production function, we employ the procedure suggested by Olley and Pakes (1996) (henceforth OP), which uses investment as

[11] Gorodnichenko (2007) criticizes popular TFP estimators (such as by Olley-Pakes and Levinsohn-Petrin) ignore heterogeneity and endogeneity in factor/product prices, assume perfect elasticity of factor supply curves or neglect the restrictions imposed by profit maximization (cost minimization) so that estimators are inconsistent or poorly identified. The author argues that simple structural estimators can address these problems. Specifically, the paper proposes a full-information estimator that models the cost and the revenue functions simultaneously and accounts for unobserved heterogeneity in productivity and factor prices symmetrically. The strength of the proposed estimator is illustrated by Monte Carlo simulations and an empirical application.

a proxy for unobserved productivity shocks. OP address the endogeneity problem as follows. Let us consider the following Cobb-Douglas production function in logs:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \varepsilon_{it}.$$

y_{it}, k_{it} , l_{it} , and m_{it} represent log of output, capital, labor, and materials, respectively. $\omega_{it}$is the productivity and ε_{it} is the error term (or a shock to productivity). The key difference between ω_{it} and ε_{it} is that ω_{it} affects firm's input demand while the latter does not. OP also make timing assumptions regarding the input variables. Labor and materials are free variables but capital is assumed to be a fixed factor and subject to an investment process. Specifically, at the beginning of every period, the investment level a firm decides together with the current capital value determines the capital stock at the beginning of the nest period, i.e.

$$k_{it+1} = (1-\sigma)k_{it} + i_{it}.$$

The key innovation of OP estimation is to use firm's observable characteristics to model a monotonic function of firm's productivity. Since the investment decision depends on both productivity and capital, OP formulate investment as follows,

$$i_{it} = i_{it}(\omega_{it}, k_{it}).$$

Given that this investment function is strictly monotonic in ω_{it}, it can be inverted to obtain

$$\omega_{it} = f_t^{-1}(i_{it}, k_{it}).$$

Substituting this into the production function, we get the following,

$$\begin{aligned} y_{it} &= \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + f_t^{-1}(i_{it}, k_{it}) + \varepsilon_{it} \\ &= \beta_l l_{it} + \beta_m m_{it} + \phi_t(i_{it}, k_{it}) + \varepsilon_{it} \end{aligned}.$$

In the first stage of OP estimation, the consistent estimates of coefficients on labor and materials as well as the estimate of a non-parametrical term (ϕ_t) are obtained. The second step of OP identifies the coefficient on capital through two important assumptions. One is the first-order Markov assumption of productivity, ω_{it} and the timing assumption about k_{it}.

The first-order Markov assumption decomposes ω_{it} into its conditional expectation at time t-1, $E[\omega_{it} \mid \omega_{it-1}]$, and a deviation from that expectation, ζ_{it}, which is often referred to the "innovation" component of the productivity measure. These two assumptions allow it to construct an orthogonal relationship between capital and the innovation component in productivity, which is used to identify the coefficient on capital.

The biggest disadvantage of applying the OP procedure is that many firms report zero or negative investment. To address this problem, we also explore the robustness of our results to using the Levinsohn Petrin (2003, henceforth LP) approach. With the OP correction, we can get an unbiased estimate of the firm's productivity. Therefore, the independent variable then becomes total factor productivity (TFP) instead of the log of output. Specifically, this is a two-stage estimation procedure when using TFP as the dependent variable. The first step is to use OP to obtain unbiased coefficients on input variables and then calculate TFP (residual from the production function). Estimates of input coefficients from the first step using both OLS with firm fixed effects as well as the OP procedure are reported in Appendix 1.1. The second step is to regress TFP on firm-level controls and FDI variables.

Moulton showed that in the case of regressions performed on micro units that also include aggregated market (in this case industry) variables, the standard errors from OLS will be underestimated. As Moulton demonstrated, failing to take account of this serious downward bias in the estimated errors results in spurious findings of the statistical significance for the aggregate variable of interest. To address this issue, the standard errors in the paper are clustered for all observations in the same industry.

As a robustness check, we also employed the procedure suggested by LP, which uses intermediate inputs as a proxy for unobserved productivity shocks. With LP's correction, the estimation procedure is also two-stage. In the first stage, we obtain input shares and calculate the firm's total factor productivity (TFP) (i.e., the residuals from production function). In the second stage, we regress TFP on the remaining independent regressors in this initial specification. However, to save on space we only report the results using the OP, and not the LP procedure. The results are qualitatively similar using both approaches. The results in the last two columns of Table 1.3 present the pooled estimates using the OP method. Across all specifications, the coefficient on the backward measure varies between .8 and 1.1. The coefficient, which is significant across specifications, implies that a one percentage point increase in backward FDI would be associated with between a .8 and 1.1 percentage point increase in output. These magnitudes are twice as large as those found by Blalock and Gertler (2008) for Indonesia but smaller than in Javorcik (2004) for Lithuania.

Javorcik (2004) found that a comparable 1 % increase in the share of FDI through backward linkages would boost TFP by 3 to 4 %, which is 3 to 4 times bigger.

The coefficients on horizontal and forward are generally not significant. The point estimates, at 0.16, imply that a 1 percentage point increase in the share of (horizontal or forward) FDI would be associated with a .16 percentage point increase in output.

The specifications in Table 1.3 do not distinguish between domestic firms or foreign-invested enterprises. In all the results which follow, we separate firms into foreign-invested firms—those with some positive foreign ownership—and domestically-owned firms—defined as enterprises with zero foreign ownership. The baseline results, which incorporate firm fixed effects, are presented in Table 1.4. Comparing the results across three different samples (all, foreign-invested, and domestic firms) shows differences in the patterns of FDI spillovers across different groups. Horizontal spillovers are significantly positive only for domestic firms. The coefficient estimate, at .19, indicates that a 1 percentage point increase in horizontal FDI would be associated with a .19 percentage point increase in output.

Backward linkages are similar in magnitude to the previous results. The coefficient estimates, around .8, indicate that a percentage point increase in backward FDI would lead to an increase in output for domestic enterprises of .8 percentage points. Foreign-invested enterprises benefit from other foreign investment through both backward and forward linkages, indicating benefits to foreign-invested enterprises from purchasing inputs from other foreign firms. The magnitudes of the vertical linkages are generally larger for foreign-invested firms, suggesting that firms with foreign equity are even more likely to benefit from being near other joint ventures.

The F-tests listed at the bottom of the Table 1.4 identify whether these differences are statistically significant. As reported in the F-tests, the magnitudes are significantly larger for foreign-invested firms vis-à-vis forward linkages but not significantly different with regards to backward linkages. This implies that foreign-invested firms benefit more than domestically-invested firms from interacting with upstream foreign suppliers. Due to these significant differences, in the rest of the paper we separately report the effects of horizontal and vertical spillovers on firms according to their degree of foreign asset participation.

Our results show that positive externalities are operating via all of the linkages: horizontal, forward and backward. The positive forward linkages imply that enterprises benefit from foreign firms that are upstream to their operations. The evidence is also consistent with strong backward linkages, suggesting that enterprises benefit from foreign firms that are downstream, who may use domestic firms as input suppliers. With the sample of all and domestic firms, the coefficient on the state's share in equity in Table 1.4 is negative and statistically significant, indicating that increases (decreases) in state-invested shares are associated with falling (increasing) productivity. We discuss the different effects of spillovers across ownership categories in more detail in subsection C below. The results on the state share are consistent with rising productivity for privatizing enterprises. We also find that the coefficients on the final goods tariff measures are generally negative and statistically significant; our expanded discussion on the role of trade policy is in subsection D below.

Our results differ significantly from Javorcik (2004) and other studies of vertical linkages through foreign investment; all previous studies find significant and positive coefficients for "*Backward*" but not for "*Forward*", and they explain that the vertical spillovers occurred through contracts between multinational consumers and domestic suppliers. In our case, an additional linkage occurs—vertical spillovers take place through contracts between domestic firms who source inputs from multinational suppliers as well.

One possible explanation is that the foreign participation in the upstream sectors may increase the variety of inputs and provide more sources of inputs to the downstream firms and thus lead to a higher productivity in downstream firms. Ethier (1982) provides theoretical support for this argument, showing that access to a greater variety of inputs results in a higher productivity of downstream industries. Arnold, Javorcik and Mattoo (2008) also show that FDI can improve the performance of downstream firms by increasing the range of intermediate inputs available. Since costs of intermediate inputs account for a much larger share of output than is typically the case in other countries, it is not surprising that access to lower cost or higher quality inputs has such a significant impact on domestic firm productivity.

To the extent that foreign investors induced additional competition among supplying enterprises, we would expect that foreign firms would have led to downward pressure on prices in those sectors where backward linkages are greatest. Without proper deflators, this would have appeared as falling productivity in those sectors, with falling prices being misinterpreted as falling output instead. One way to test if this possibility is correct is to examine whether sector-level prices during the sample period were systematically related to foreign activity. Appendix 1.2 shows that this is indeed the case. Price levels fell significantly in sectors where foreign firms exerted a significant downward pressure via backward linkages. Since industry-level fixed effects are included in the estimation, the results can be interpreted to suggest that one important vehicle through which foreign firms played a key role was by exerting downward pressure on prices of domestic suppliers. The evidence on the competition effect induced by foreign firms on prices of input suppliers reported in Appendix 1.2 is also useful in another respect. It illustrates the importance of using sector-specific price deflators (or prices) when identifying the spillovers from foreign investment, and explains why previous work on China failed to identify backward spillovers.

In Appendix 1.1, we compare the coefficient estimates using OLS with firm fixed effects and the OP approach. OP, as well as LP predict, after implementing these two-stage procedures, that the coefficient on L should decrease, the coefficient on intermediate inputs should decrease and the coefficient on capital should increase. The results are generally consistent with these predictions across ownership classes. The coefficient on capital inputs is higher using OP across all specifications. We also generally find that the coefficient on the labor shares and material shares are lower with OP. What is unusual across all specifications is that the labor share is very low, compared to estimates for other countries, while the coefficient for input costs is very high. As a robustness check, we performed two tests. First, we calculated the share of labor expenditures in total output—the labor share in output according to the data. Under certain plausible restrictions (i.e., Cobb-Douglas production function, perfect competition) the coefficients on the factor inputs in our estimating equations should equal the factor shares. Imposing these restrictions, the estimate of labor's share over the sample period is around 10 percent (reported in column (5) of Appendix 1.3), which is similar to the underlying OLS fixed effect estimates reported in Appendix 1.1. Second, we compare the implied average wages from our sample (calculated by dividing total wages by the number of employees with average wages reported in the Chinese Statistical Yearbook for 1998 through 2007. The results are listed in Appendix 1.3. From Appendix 1.3, we can see that the average wages from the dataset are close to that from the statistical yearbook, although there are some differences. We also compute in column (6) of Appendix 1.3 the ratio of both wages and non-wage costs to total output, and the average is not much different than 10 percent. While labor's share could be too low and the share of intermediate inputs too high, we feel confident that the factor shares implied by the OLS and OP coefficient estimates are broadly consistent with the factor shares in our data as well as external evidence.

1.3.2 The Effects of Different Sources of Foreign Investment

In many FDI spillover studies, all domestic firms are assumed to benefit equally from FDI. However, different indigenous firms have varying absorptive capacities and the effectiveness of technology diffusion depends on technological capacities of indigenous firms as well as the characteristics of the foreign investors. To provide insights into the effect of this externality of FDI spillovers, we divide sector-level FDI variables into two groups based on their sources. The results are reported in Table 1.5.

The results point to significant and large differences in vertical as well as horizontal linkages which depend on the origin of the foreign investors. While horizontal linkages, which are not differentiated by country of ownership of the foreign investors, are sometimes insignificant, this average hides significant and contrasting effects. Horizontal linkages are negative but not significant for sectors with large shares of foreign investors originating in Hong Kong-Taiwan-Macau, suggesting that these firms act as competitors for domestically-owned firms. In contrast, horizontal linkages are positive and significant for foreign investment originating in other countries, suggesting that there are positive linkages within the same sector for foreign investment coming from further afield. The coefficient estimate, at .35, indicates that a 1 percentage point increase in horizontal FDI from sources other than Hong Kong-Taiwan-Macau is associated with an increase in output of .35 percent.

The results are also different for vertical linkages. There are strong, positive and significant backward and forward linkages for foreign investors originating from OECD countries. These differences are statistically significant for horizontal and vertical forward linkages, as indicated by the formal tests of equality reported at the bottom of Table 1.5. These results point to clear differences in the pattern of productivity spillovers depending on the source of foreign investment. Foreign firms coming from nearby regions act as competition in the same industry. Firms coming from further away are not direct competitors and convey positive horizontal and vertical externalities.

1.3.3 The Effect of State Ownership

In China, state-owned firms include firms that are formally classified as state-owned enterprises (SOEs), state-owned jointly operated enterprises and wholly state-owned companies. Non-state-owned enterprises (non-SOEs) include collectively- and privately-owned firms. Compared to non-SOEs, SOEs are typically larger and often technically competitive but less market-oriented; they also face softer budget constraints and limited access to private financial capital. Indigenous Chinese firms of different ownership typically behave differently with respect to imitation, innovation and competition, and have different technological capabilities for knowledge absorption from the presence of foreign firms (Li et al. 2001).

In Tables 1.3 and 1.4, we saw that the coefficient on the state's share in equity in Table 1.4 is generally negative and statistically significant, indicating that increases (decreases) in state-invested shares are associated with falling (increasing) productivity. The coefficient estimates, which vary from -.02 to -.13, suggest that after controlling for other factors, moving from 100 percent SOE to 100 percent private would be associated with a gain in productivity of 2 to 13 percentage points. Now we will explore whether productivity spillovers differ with ownership type.

In Table 1.6, we divide the sample of all, foreign-invested, and domestic firms into two groups, SOEs and non-SOEs, to test whether the formal ownership structure and the composition of asset ownership matter for FDI spillover effects and trade policies. In columns (1) and (2), which present the results from OLS regressions with firm fixed effects, both enterprises with and without foreign equity participation are included in the analysis together. Columns (3) and (4) show the results using the sample of foreign-invested firms, and columns (5) and (6) present the results using the sample of purely domestic firms, defined as enterprises with zero foreign equity participation. All specifications allow for firm-specific effects and year effects.

The first two columns allow us to compare the impact of firm-level equity participation by foreign investors on the productivity of SOEs relative to non-SOEs. The coefficient on foreign participation from foreign investors outside of Hong Kong-Taiwan-Macau for SOEs is .098 relative to .0052 for non-SOEs. This suggests that foreign equity participation is associated with an improvement in productivity which is twenty times greater for SOEs. The much larger and statistically significant coefficient associated with foreign equity participation in SOEs is consistent with the hypothesis that firms with foreign equity have played an important role in improving the performance of some SOEs.

There is also evidence that SOEs benefit more from vertical linkages, as the magnitudes on backward as well as forward linkages are greater for SOEs. The coefficients are larger for SOEs, suggesting that foreign investment has played a particularly large role in enhancing productivity of SOEs, including those without foreign equity participation. The only exception is with horizontal spillovers. Horizontal spillovers are restricted to domestic non-SOEs, suggesting that SOEs may not be able to benefit from productivity spillovers through firms with foreign equity participation located in the same sector.

1.3.4 Trade and FDI Spillovers

While there is a large literature which investigates the impact of FDI on productivity, as well as an even larger literature that explores the relationship between trade policies and productivity (for an overview of both these topics, see Harrison and Rodriguez-Clare (2010)), we are not aware of any study which examines how changing trade policies affect the magnitude of FDI spillovers. In this section, we begin by summarizing the impact of tariffs on firm-level productivity from the previous tables, then explore the interaction between productivity spillovers from foreign investment and changes in trade policy.

The coefficient on the final good tariff measure in Tables 1.3 through 1.5 is generally negative and statistically significant. These results are somewhat different from Brandt et al. (2008), who found weak evidence of a significant relationship between tariffs and total factor productivity for Chinese enterprises. There are several reasons why the negative impact of input or final goods tariffs on productivity may be under-estimated. A large fraction of firms are granted exemptions from paying tariffs; without additional information on which firms pay input tariffs, it is difficult to identify the negative effect of tariffs on inputs. Second, average tariffs may be imposed for a number of reasons. If tariffs are successfully imposed in sectors where there are externalities in production, then the average effect of tariffs reflects both (beneficial) targeting and (harmful) disincentives associated with x-inefficiency. Third, to the extent that Melitz (2003) is correct, then many of the productivity gains associated with trade reform occur through reallocation of production towards more efficient firms, rather than within-firm productivity increases associated with greater exposure to international competition.

In Table 1.6, we do find significant but different responses across SOEs and non-SOES to trade policy. Higher final goods tariffs are associated with significantly lower productivity for SOEs, relative to non-SOEs. The point estimates on final goods tariffs, which is -.0676 for SOEs with foreign investment and -.0519 for those with no foreign assets, suggests that a 1 percent reduction in tariffs (ceteris paribus) would increase productivity by .05 to .07 percent. One possible interpretation of the larger effect of final goods tariffs on SOE performance is the greater importance of international competition for SOEs, which are often shielded from competition or supported by the government through a variety of subsidies.

In Table 1.7, we report the basic specification (column 5 of Table 1.6) in the first column. In the second column, we interact the vertical and horizontal FDI measures with our tariff measures. The three interaction terms are all negative, indicating that higher tariffs are associated with lower vertical and horizontal spillovers from FDI. The addition of the interaction term for the horizontal measure doubles its magnitude. To the extent that horizontal FDI is likely to have stronger positive effects on productivity when tariffs are low, then omitting the interaction term can lead to under-estimating horizontal linkages.

We continue to explore the role of trade in understanding the importance of vertical and horizontal linkages in columns (3) and (4) of Table 1.7. We divide the sample across exporting and non-exporting firms. Since exporters are more likely to benefit from associations with firms in other countries, we might expect smaller linkages. On the other hand, exporters may be more likely to exploit knowledge gained from association with foreign investors. The results in Table 1.7 suggest that backward linkages are no different across exporting and non-exporting enterprises. However, horizontal linkages are much larger for non-exporters and only significant for that group. These results suggest that horizontal linkages in China were highest for firms which would not normally have had contact with international markets through export sales.

In Table 1.8, we explore how vertical and horizontal linkages vary over the ten-year sample period. With China's entry into the WTO in the middle of the sample period, at the end of 2001, domestic content rules became illegal and tariffs were significantly reduced. The results in Table 1.8 suggest that vertical linkages were strengthened during the second half of the sample period, when tariffs were lowered and domestic content restrictions relaxed. Backward linkages only become large in magnitude and significant with China's entry into the WTO. Forward linkages also become significant and positive later in the sample period.

1.3.5 The Effects of Tax Incentives for FDI

In Tables 1.9 and 1.10 we explore the extent to which subsidized foreign investment is more likely to convey spillovers relative to unsubsidized foreign investment. While the standard tax rates across all firms during the sample period was 33 percent, a large share of foreign-owned firms were granted tax subsidies and faced tax rates that were significantly lower. Indeed, the means reported in Tables 1.2.3 and 1.2.4 suggest that the majority of foreign investment in China during the sample period benefited from income tax subsidies and a significant fraction benefited from subsidies on value-added taxes. To the extent that the Chinese government was able to target successfully firms more likely to convey positive externalities, we would expect different effects for these subsidized firms.

To test for this possibility, we split our sector-level foreign share variables into two groups: one is calculated based on foreign investment being subsidized (those paid less than the statutory tax rate)[12] and the other one is computed based on non-subsidized foreign investment. The results based on income tax incentives are presented in Table 1.9.

There is strong evidence that foreign firms receiving tax subsidies are more likely to generate positive externalities than other kinds of foreign firms. While the coefficients on backward linkages are positive and statistically significant for foreign firms which received incentives in the form of lower income taxes, the coefficients on backward linkages for other types of foreign firms are negative. These differences are significant for backward linkages but not for forward or horizontal linkages, where the formal F-tests fail to reject that the effects are the same.

In Table 1.10, we test whether the results are different when we explore tax holidays on value-added taxes as a form of fiscal incentive instead. We define firms as subsidized when they were exempted from paying value-added taxes altogether. The results in Table 1.10 are consistent with differences in the effects of foreign investment based on income tax incentives. In particular, forward linkages are significantly stronger when foreign investors received tax incentives in the form of exemptions on value-added taxes.

1.3.6 Robustness Tests

Since our dependent variable is firm-level productivity and the focus of the analysis is on how sector-level foreign investment affects domestic firm productivity, endogeneity is

[12] As discussed earlier, the statutory tax rate in China is 33%. However, foreign-invested firms receive a preferential tax break of 15%. In this paper, we use the cut-off of 20% to distinguish whether a foreign-invested firm is being subsidized.

less likely to be an issue. It is difficult to make a case that firm-level productivity affects sector-level foreign investment, particularly upstream and downstream foreign investment. To the extent that foreign ownership could be attracted to sectors where suppliers or users are more productive, this is accounted for by the use of firm-level fixed effects. However, some critics might argue that foreign investors are drawn to sectors where they expect higher productivity growth in the future. To address this unlikely but nevertheless potential source of endogeneity, we apply instrumental variables (IV) techniques. We use future tariffs (tariffs at time t+1) as instruments. For instance, *lnTariff* (at time t+1) is used to instrument *Horizontal*; *lnTariff_backward* (at time t+1) is used to instrument *Backward*; and *lnTariff_forward* (at time t+1) is used to instrument *Forward*. Since our tariff data is from 1998-2007, we lose one year of observations when we apply the future tariffs as instruments. All identification tests show that the equations are exactly identified.

The results are reported in Appendix 1.4. The point estimates are magnified for backward linkages, confirming the importance of the linkages between domestic suppliers and foreign-owned buyers of their inputs. However, the coefficients for non-SOE domestic enterprises on both forward and horizontal linkages become negative and statistically significant. The negative and significant coefficient on the horizontal variable confirms previous work by Aitken and Harrison (1999) and others suggesting that foreign firms in the same sector act as competitors for domestic enterprises. The switch in sign for the coefficient on horizontal FDI calls into question the positive coefficient for horizontal FDI in other specifications reported elsewhere in this paper, but confirms the positive vertical linkages between domestic suppliers and foreign users of their products.

1.4 Concluding Comments

In this paper, we explore the ways in which a range of institutional features, some general and some unique to China, affect the direction and magnitude of FDI spillovers. Specifically, we examine the role played by foreign investors in generating productivity spillovers via horizontal and vertical linkages, as these spillovers affect the reform of state enterprises through joint venture activity. We also explore the different impacts of spillovers that originate from FDI aggregations that embody different mixes of investment from Hong Kong-Taiwan-Macau on the one hand and largely OECD sourced investment on the other. Finally, our study investigates the implications of tariff protection for the nature of productivity spillovers and explores whether the Chinese government's targeting through the selective imposition of tax holidays to attract foreign investors is consistent with larger externalities. The focus on the heterogeneity of spillovers across different policies, such as differences in the tax and tariff regime, is a primary innovation of this paper.

We use a firm-level dataset from China for the 1998-2007 period, Across a variety of specifications, and controlling for firm and year effects, we find that positive productivity spillovers from FDI take place through contacts between foreign affiliates and their local clients in upstream (backward) or downstream sectors (forward linkages). We also find evidence that positive productivity spillovers occur through horizontal foreign investment, but these types of spillovers are less robust, and become negative when we instrument for FDI.

We also highlight the different effects played by the sources of sectoral foreign direct investment on domestic firm productivity. While at the firm level foreign equity participation is generally associated with higher productivity, this is not the case for foreign equity participation that originates in Hong Kong-Taiwan-Macau. There are several possible explanations for this. One major reason could be that such investments actually originate in China, and are simply rechanneled through nearby locations to take advantage of special incentives offered to foreign investors. Another possible explanation is that nearby foreign investors are not sufficiently different technologically during the last decade for which we have data.

Finally, we also take into account trade policies and tax policies. Controlling for differential tariffs across sectors is useful because some foreign investors may have invested in China in order to access protected domestic markets, which could have led to a bias in estimating the effects of foreign investment linkages on firm productivity. We find that tariffs are associated with negative and significant effects on firm productivity. We also find that backward and forward linkages were much stronger after China's entry into the WTO, and that tariffs are associated with a dampened effect of vertical and horizontal linkages. Finally, we also explore the extent to which foreign investors who were targeted via special tax incentives generated different effects on domestic firms than others. We find significantly higher effects of targeted FDI on productivity growth relative to other kinds of FDI.

In several respects the Chinese experience with FDI has been unique. Our results indicate that the institutional framework is critical for understanding the presence as well as the magnitude of gains from FDI. The example of how foreign investment originating from Hong Kong-Taiwan-Macau, is associated with zero spillovers, while foreign investment from other regions generates significant vertical and horizontal linkages is one vital example of the important role of this institutional analysis.

To our knowledge, this is the first study to examine whether fiscal incentives in the form of tax subsidies are associated with stronger linkages from foreign firms to domestic enterprises. We find strong evidence that subsidized foreign investment generates greater productivity spillovers than unsubsidized firms. The magnitudes imply that a 1 percentage point increase in the share of foreign investors in downstream sectors raises the supplying firm's productivity by 2 to 3 percentage points. The evidence also suggests that foreign firms put significant downward pressure on the prices of the supplying firms. Across our sample spanning a ten year period, vertical linkages accounted for an important source of productivity gains for all types of enterprises.

References

[1] Amiti, Mary and Jozef Konings. (2007) Trade Libralization, Intermediate Inputs and Productivity. The American Economic Review, Vol. 97(5): 1611-1638.

[2] Arnold, Jens, Beata Javorcik and A Mattoo. (2008) Do Manufacturing Firms Benefit from Foreign Direct Investment in Services Industries? Evidence from the Czech Republic. Mimeo.

[3] Aitken, Brian and Ann Harrison. (1999) Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela. The American Economic Review, Vol. 89 (3): 605-18.

[4] Aitken, Brian, Harrison, Ann and Robert Lipsey. (1996) Wages and Foreign Ownership. A comparative study of Mexico, Venezuela and the United States. Journal of International Economics, Vol . 40: 345-371.

[5] Brandt, Loren, Johannes Van Biesebroeck and Yifan Zhang. (2008) The Impact of Trade Libralization on Productivity in Chinese Industry. Working paper

[6] Brecher, Richard and Dias Alejandro Carlos. (1997) Tariffs, Foreign Capital and Immiserizing Growth. Journal of International Economics, Vol. 7: 317-322.

[7] Blalock, Garrick and Paul Gertler. (2008) Welfare Gains from Foreign Direct Investment through Technology Transfer to Local Suppliers. Journal of International Economics, Vol. 74(2): 402–421.

[8] Blomstrom, M. (1986) Foreign Investment and Productive Efficiency: The Case of Mexico. Journal of Industrial Economics, Vol. 35: 97-110.

[9] Borensztein, E, J, De Gregorio and J-W, Lee. (1998) How does Foreign Direct Investment Affect Economic Growth?. Journal of International Economics, Vol. 45: 115-135.

[10] Caves, Richard. (1974) Multinational Firms, Competition and Productivity in Host-Country Markets. Economica, Vol. 41 (162): 176-193.

[11] Ethier, Wilfred. (1982) National and International Returns to Scale in the Model Theory of International Trade. The American Economic Review, Vol. 72: 389-405.

[12] Globerman, S. (1979) Foreign Direct Investment and 'Spillover' Efficiency Benefits in Canadian Manufacturing Industries. Canadian Journal of Economics, Vol. 12: 42-56.

[13] Gorodnichenko, Yuriy. (2007) Using Firm Optimization to Evaluate and Estimate Returns to Scale. NBER Working Paper 13666.

[14] Gorodnichenko, Yuriy, Jan, Svejnar, and Katherine Terrell. (2007) When Does FDI Have Positive Spillovers? Evidence from 17 Emerging Market Economies. IZA Discussion Paper No. 3079.

[15] Gorodnichenko, Yuriy, Jan, Svejnar, and Katherine Terrell. (2010) Globalization and Innovation in Emerging Markets. American Economic Journal-Macroeconomics, Vol. (2): 194-226.

[16] Griliches, Zvi and Mairesse, Jacques. (1995) Production Functions: The Search for Identification. National Bureau of Economic research (Cambridge, MA) Working Paper No. 5067.

[17] Haddad, Mona and Ann Harrison. (1993) Are There Positive Spillovers from Direct Foreign Investment? Evidence from Panel Data for Morocco. Journal of Development Economics, Vol. 42 (1): 51-74.

[18] Harrison, Ann, and Andres Rodriguez-Clare. (2010) Trade, Foreign Investment, and Industrial Policy for Developing Countries, in Handbook of Development Economics, Vol. 5, edited by Dani Rodrik and Mark Rosenzweig, North Holland, pp. 4039-4214.

[19] Hu, Albert and Gary Jefferson. (2002) FDI Impact and Spillover: Evidence from China's Electronic and Textile Industries, *World Economy,* Vol. 25 (8): 1063-76.

[20] Javorcik, Beata. (2004) Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages. The American Economic Review, Vol. 94 (3): 605-627.

[21] Lin, Ping, Liu, Zhoumin, and Yifan Zhang. (2009) Do Chinese Domestic Firms Benefit from FDI Inflow? Evidence of Horizontal and Vertical Spillovers. China Economic Review, Vol. 20: 677-691.

[22] Konings, Jozef. (2001) Effects of Foreign Direct Investment on Domestic Firms. Economics of Transition, Vol. 9 (3): 619-33.

[23] Kokko, Ari. (1999) Technology, Market Characteristics and Spillovers. Journal of Development Economics, Vol. 43: 279-93.

[24] Levinsohn, James, and Amil Petrin. (2003) Estimating Production Functions Using Inputs to Control for Unobseravbles. Review of Economic Studies, Vol. 70: 317-41.

[25] Lin, Justin Yifu. (2009) Economic Development and Transition: Thought, Strategy, and Viability, Cambridge: Cambridge University Press.

[26] Lin, Justin Yifu, and Celestin, Monga (2010) Growth Identification and Facilitation: The Role of the State in the Dynamics of Structural Change. The World Bank Policy Research Working Paper 5313

[27] Markusen, J, and A. Venables. (1998) Multinational Firms and the New Trade Theory, Journal of International Economics, Vol. 46 (2): 183-203.

[28] Moulton, Brent R. (1990). An Illustration of a Pitfall in Estimating the Effects of Aggregate Variables on Micro Units, Review of Economics and Statistics, Vol. 72 (2): 334-38.

[29] Nunn, N, and Trefler, D. (2006) Putting the Lid on lobbying: Tariff Structure and Long-Term Growth when Protection is for Sale, NBER Working Paper No. 12164.

Appendix

Appendix 1.1 Summary of Estimated Elasticities of Input Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Coefficients on Input Variables Estimated by OLS with firm Fes and time dummies									
	Full	FIE	Domestic	Full_ nonSOEs	Full_SOEs	FIE_nonSOEs	FIE_SOEs	Domestic _nonSOEs	Domestic _SOEs
logL	0.0918***	0.122***	0.0818***	0.0920***	0.0828***	0.122***	0.0798***	0.0809***	0.0820***
	(0.00413)	(0.00765)	(0.00336)	(0.00434)	(0.00575)	(0.00772)	(0.0207)	(0.00360)	(0.00593)
logK	0.0278***	0.0374***	0.0249***	0.0285***	0.0193***	0.0374***	0.0303*	0.0255***	0.0182***
	(0.00159)	(0.00266)	(0.00152)	(0.00157)	(0.00311)	(0.00267)	(0.0152)	(0.00156)	(0.00306)
logM	0.766***	0.732***	0.776***	0.768***	0.742***	0.732***	0.844***	0.781***	0.740***
	(0.00683)	(0.00709)	(0.00735)	(0.00732)	(0.0107)	(0.00713)	(0.0359)	(0.00811)	(0.0110)
Obs	1,545,626	348,029	1,197,597	1,418,632	126,994	345,694	2,403	1,073,001	124,596
Coefficients on Input Variables Estimated by Olley and Pakes Regression									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Full	FIE	Domestic	Full_ nonSOEs	Full_SOEs	FIE_nonSOEs	FIE_SOEs	Domestic _nonSOEs	Domestic _SOEs
logL	0.0888***	0.153***	0.068***	0.0951***	0.012**	0.154***	0.0231	0.0743***	0.012**
	(0.0019)	(0.0035)	(0.0019)	(0.0022)	(0.005	(0.004)	(0.0245)	(0.0022)	(0.005)
logK	0.0436***	0.0427***	0.044***	0.0464***	0.0205***	0.0428***	0.0644*	0.0473***	0.0202***
	(0.0018)	(0.003)	(0.0016)	(0.0015)	(0.004)	(0.0024)	(0.027)	(0.0018)	(0.004)
logM	0.771***	0.725***	0.785***	0.770***	0.772***	0.725***	0.836***	0.786***	0.771***
	(0.004)	(0.006)	(0.005)	(0.0048)	(0.010)	(0.007)	(0.046)	(0.005)	(0.009)
Obs	779,148	192,146	587,002	724,371	54,777	191,006	1,140	533,365	53,637

Notes: In this table, we compare the input coefficients computed by two methods: OLS with firm fixed effects and Olley and Pakes regression. Since many firms report zero or negative investment, we construct our own investment measure by using capital accumulation equation (investment at current period equals the sum of the growth of capital and capital depreciation at the current period). However, we still lose many firms (note the changes in observations between two methods). When we calculate TFP using OP method, we actually apply those input coefficients to all firms in each sample. Therefore, there is no loss in efficiency in the second stage.

Appendix 1.2 FDI Effect on Price Level

Dependent variable: log of price index		
Horizontal	0.008	-0.008
	(0.017)	(0.014)
Backward	-0.097**	-0.097**
	(0.046)	(0.045)
Forward	-0.024	-0.024
	(0.016)	(0.015)
Robust Standard Error	No	Yes
Year Dummies	Yes	Yes
Industry fixed effect	Yes	Yes
Number of observations	610	610
R-squared	0.58	0.58

Appendix 1.3 Average Wages Comparison

Year	(1) Mean of average wages from the data	(2) Average wages from the National Statistical Yearbook (for the manufacturing industry)	(3) Average wages from the National Statistical Yearbook (for SOEs manufacturing firms)	(4) Mean of average wages and non-wage cost from the data	(5) The ratio of total wages to output value	(6) The ratio of total cost on labor (wages and non-wage cost) to output value
1998	9,795	7,064	6,981	11,654	0.118	0.146
1999	8,072	7,794	7,611	9,653	0.122	0.151
2000	9,038	8,750	8,554	13,556	0.120	0.147
2001	10,329	9,774	9,590	11,858	0.130	0.150
2002	10,586	11,001	10,876	12,181	0.105	0.123
2003	11,002	12,496	12,601	12,602	0.101	0.116
2004	13,588			16,543	0.098	0.123
2005	14,087	15,757	16,963	17,472	0.087	0.108
2006	16,925	17,966	20,317	21,069	0.090	0.112
2007	19,957	20,884	23,913	24,720	0.083	0.100

Notes: Wages are measured in yuan/year for one person. To obtain means of average wages of the sample, we first calculate the average wage for each firm in each year by dividing total wages by the number of total employees then take the means of these averages. The official information on average wage is missing for the year of 2004, therefore we leave them with blank. In column (3) and (4), we calculate the total cost of wage and non-wage and get the mean of average cost for each year. For the year of 1998-2003, non-wage cost includes unemployment insurance and other welfare. Starting from the year of 2004, information on medical insurance and housing subsidies becomes available; therefore we include these two additional costs when we calculate the non-wage cost for the year of 2004-2007. In column (5), we calculate the ratio of total wages to output value (at current price, both wages and output value are in nominal term). To take non-wage cost into account, we re-calculate the ratio using the sum of wages and non-wage cost as the numerator, which are shown in column (6).

Appendix 1.4 Robustness Tests for Table 6 (Instrumental Variable Estimation)

	All		Foreign-invested firms		Domestic firms	
	Non-SOEs	SOEs	Non-SOEs	SOEs	Non-SOEs	SOEs
Foreign share (by HK-Taiwan-Macau)	-0.0011	-0.205	-0.0011	-0.0351		
	(0.0035)	(0.772)	(0.0056)	(0.149)		
Foreign share (by other countries)	0.0060	0.103	0.0072	0.0344		
	(0.0039)	(0.221)	(0.0056)	(0.120)		
State share	-0.0063*	-0.0441	0.0032	0.0175	-0.0080*	-0.0312*
	(0.0037)	(0.0516)	(0.0090)	(0.0455)	(0.0042)	(0.0168)
Horizontal	-0.744**	9.953	0.420	4.683	-0.682**	5.830
	(0.296)	(19.16)	(0.594)	(11.85)	(0.318)	(6.988)
Backward	3.469***	-39.11	1.201	-2.416	3.042***	-19.10
	(0.755)	(100.4)	(1.466)	(16.56)	(0.715)	(41.75)
Forward	-0.479***	-18.06	0.101	-2.951	-1.156***	-11.18
	(0.0899)	(35.40)	(0.166)	(7.440)	(0.154)	(14.08)
lnTariff	-0.209***	-1.064	-0.0383	-0.491	-0.191***	-0.679
	(0.0246)	(1.802)	(0.0490)	(0.752)	(0.0207)	(0.670)
lnTariff_backward	-0.0507***	-0.304	-0.0579*	0.00305	-0.112***	-0.343*
	(0.0133)	(0.239)	(0.0296)	(0.304)	(0.0196)	(0.187)
lnTariff_forward	0.0791***	0.290	0.00983	0.257	0.109***	0.213
	(0.0135)	(0.422)	(0.0112)	(0.394)	(0.0173)	(0.175)
Observations	915,545	83,453	241,372	1,490	661,978	81,570
R-squared	0.098	-4.630	0.194	-0.597	0.046	-1.598

Notes: We keep the same structure as in Table 1.6. To address the potential endogeneity of sector-level FDI variables, we apply instrumental variables (IV) technique. We use future tariffs (tariffs at time t+1) as instruments. Since our tariff data is from 1998-2007, we will lose one year of observations when we apply future tariff as instruments. All identification tests show that the equations are exactly identified.

Appendix 1.5 Summary Statistics on Tariffs (by sectors)

	Tariff		Tariff_backward	Tariff_forward
Industry names	Mean	Diff b/w 1998 and 2007	Mean	Mean
1.Grain mill products	41.002	-18.29 (means fall by 18 percentage)	11.410	19.799
2.Forage	13.501	-7.87	19.654	1.932
3.Vegetable oil refining	19.85	-21.77	2.752	8.796
4.Sugar manufacturing	37.101	10.710	5.837	14.656
5.Slaughtering and meat processing	18.949	-4.510	10.705	15.193
6.Fish and fish products	16.052	-12.419	12.196	10.698
7.All other food manufacturing	22.206	-13.238	17.262	12.642
8.Wines, spirits and liquors	27.569	-34.290	16.811	4.384
9.Soft drink and other beverages	28.916	-20.560	16.372	1.328
10.Tobacco products	49.584	-24.000	4.275	
11.Cotton textiles	14.96	-13.88	4.168	14.558
12.Woolen textiles	14.96	-13.88	7.638	11.505
13.Hemp textiles	14.96	-13.88	5.044	8.632
14.Textiles products	17.674	-15.005	12.643	12.958
15.Knitted and crocheted fabrics and articles	20.082	-17.936	12.841	13.452
16.Wearing apparel	21.997	-16.212	14.651	11.568
17.Leather, fur, down and related products	19.176	-8.271	7.629	3.691
18.Products of wood, bamboo, cane, palm, straw	8.849	-8.346	4.591	8.130
19.Furniture	11.7	-18.51	10.835	12.740
20.Paper and paper products	11.975	-12.734	4.862	13.265
21.Printing, reproduction of recording media	13.584	-14.950	10.897	15.092
22.Stationary and related products	18.112	-5.306	11.426	9.624
23.Toys, sporting and athletic and recreation products	12.120	-14.198	11.291	1.494
24.Petroleum and nuclear processing	6.499	-0.930	6.647	11.159

25.Coking	5.479	-0.080	9.099	7.447
26.Basic chemicals	6.848	-3.13	5.342	10.513
27.Chemical fertilizers	7.511	3.15	8.390	2.418
28.Chemical pesticides	8.974	-2.07	7.906	1.169
29.Paints, varnishes and similar coatings, printing ink	9.242	-3.71	6.644	10.096
30.Man-made chemical products	10.043	-6.108	6.844	11.981
31.Special chemical products	12.661	-5.804	6.906	10.784
32.Chemical products for daily use	16.088	-11.882	9.763	7.675
33.Medical and pharmaceutical products	6.535	-4.599	6.911	1.817
34.Chemical fibers	9.825	-12.423	6.639	11.829
35.Rubber products	16.167	-3.752	8.967	12.782
36.Plastic products	12.583	-8.299	7.137	12.860
37.Cement, lime and plaster	11.811	-2.741	10.929	9.913
38.Glass and glass products	15.457	-4.890	7.790	10.669
39.Pottery, china and earthenware	18.236	-12.03	9.899	6.928
40.Fireproof materials	9.777	-3.671	9.550	7.751
41.Other nonmetallic mineral products	10.030	-2.355	7.801	8.187
42.Iron-smelting	6.601	-3.76	6.809	7.720
43.Steel-smelting	6.601	-3.76	7.538	9.424
44.Steel pressing	6.601	-3.76	6.700	11.368
45.Alloy iron smelting	6.601	-3.76	6.318	6.282
46.Nonferrous metal smelting	6.189	-2.382	5.554	7.897
47.Nonferrous metal pressing	5.63	-2.33	6.356	11.921
48.Metal products	12.788	-4.814	6.043	12.599
49.Boiler, engines and turbine	10.081	-4.635	7.551	10.693
50.Metalworking machinery	10.978	-5.201	8.875	8.637
51.Other general industrial machinery	10.869	-6.203	7.562	11.131
52.Agriculture, forestry, animal husbandry and fishing machinery	8.253	-5.070	9.018	1.163
53.Other special industrial equipment	9.871	-5.426	8.575	9.798
54.Railroad transport equipment	4.082	-1.34	8.528	2.403
55.Motor vehicles	29.126	-26.921	11.348	7.771
56.Parts and accessories for motor vehicles and their engines	17.584	-18.57	6.907	13.769

57.Ship building	7.365	-1.151	9.258	2.488
58.Other transport equipment	25.944	-9.094	8.338	3.349
59.Generators	10.725	-6.465	9.211	9.195
60.Household electric appliances	18.441	-7.963	9.438	7.640
61.Other electric machinery and equipment	15.103	-5.202	8.425	12.144
62.Telecommunication equipment	10.992	-13.480	6.546	4.279
63.Electronic computer	8.422	-14.87	6.629	5.235
64.Other computer peripheral equipment	8.352	-14.828	6.780	7.261
65.Electronic element and device	4.912	-7.01	7.641	10.988
66.Radio, television and communication equipment and apparatus	21.374	-13.97	8.162	5.635
67.Other electronic and communication equipment	9.528	-5.450	8.450	5.169
68.Instruments, meters and other measuring equipment	10.097	-5.150	8.621	8.603
69.Cultural and office equipment	10.460	-9.548	8.647	4.231
70.Arts and crafts products	16.980	-7.374	10.600	6.483
71.Other manufacturing products	19.324	-5.036	10.777	9.855
Average (all sectors)	12.691	-8.862	8.191	9.185

Appendix 1.6 Summary Statistics on foreign investment (by sectors)

Industry names	Mean of firm-level foreign share (range from 0 to 100)	Diff b/w 1998 and 2007	Mean of horizontal (range from 0 to 100)	Diff b/w 1998 and 2007
1.Grain mill products	1.5	0.2	4.0	-2.0
2.Forage	8.3	1.2	20.1	-10.7
3.Vegetable oil refining	4.8	1.3	28.1	13.4
4.Sugar manufacturing	3.4	2.9	7.7	5.3
5.Slaughtering and meat processing	5.7	1.3	16.9	4.9
6.Fish and fish products	19.7	7.6	19.7	3.4
7.All other food manufacturing	16.6	4.8	28.8	2.2
8.Wines, spirits and liquors	6.4	3.5	15.3	1.2
9.Soft drink and other beverage	15.0	1.6	41.2	8.2
10.Tobacco products	1.1	1.1	0.2	-0.1
11.Cotton textiles	10.0	0.7	14.4	1.7
12.Woolen textiles	15.6	-2.8	21.9	0.7
13.Hemp textiles	5.9	3.1	8.7	4.6
14.Textiles products	20.3	4.7	24.7	3.4
15.Knitted and crocheted fabrics and articles	26.0	-3.3	31.4	-2.2
16.Wearing apparel	32.1	-1.4	36.0	-2.6
17.Leather, fur, down and related products	30.9	0.3	42.3	-0.9
18.Products of wood, bamboo, cane, palm, straw	12.0	-2.9	17.2	-7.6
19.Furniture	24.5	4.1	39.6	8.4
20.Paper and paper products	11.8	3.8	24.6	8.0
21.Printing, reproduction of recording media	9.5	3.0	22.4	1.9
22.Stationary and related products	25.3	6.1	34.6	12.2
23.Toys, sporting and athletic and recreation products	42.0	-1.5	54.4	3.2
24.Petroleum and nuclear processing	7.2	2.8	7.5	4.2
25.Coking	2.2	1.0	5.1	5.1
26.Basic chemicals	6.2	2.4	9.7	9.7

27.Chemical fertilizers	3.1	3.3	3.1	3.1
28.Chemical pesticides	5.5	3.7	8.8	2.0
29.Paints, varnishes and similar coatings, printing ink	17.5	8.0	30.3	16.8
30.Man-made chemical products	18.6	6.5	25.3	12.8
31.Special chemical products	10.0	2.1	18.3	9.8
32.Chemical products for daily use	20.4	8.8	48.3	18.9
33.Medical and pharmaceutical products	10.4	3.1	16.8	4.4
34.Chemical fibers	14.9	0.9	18.5	0.7
35.Rubber products	17.0	6.8	27.9	8.1
36.Plastic products	21.7	0.5	33.0	1.0
37.Cement, lime and plaster	5.3	2.8	9.4	3.7
38.Glass and glass products	12.4	0.6	18.4	5.9
39.Pottery, china and earthenware	17.1	-0.1	23.5	-1.1
40.Fireproof materials	4.8	3.0	7.4	2.7
41.Other nonmetallic mineral products	7.9	2.7	13.5	0.5
42.Iron-smelting	3.2	-0.3	5.6	-4.5
43.Steel-smelting	4.7	1.6	6.7	6.8
44.Steel pressing	6.3	4.0	10.9	8.0
45.Alloy iron smelting	2.5	-0.2	4.8	-2.2
46.Nonferrous metal smelting	5.8	1.5	6.1	0.3
47.Nonferrous metal pressing	9.5	3.9	15.7	4.5
48.Metal products	15.2	2.6	25.9	2.2
49.Boiler, engines and turbine	5.6	3.6	11.1	0.9
50.Metalworking machinery	10.8	5.4	12.6	5.0
51.Other general industrial machinery	10.1	4.4	20.9	5.7
52.Agriculture, forestry, animal husbandry and fishing machinery	3.3	6.3	3.8	6.2
53.Other special industrial equipment	14.2	10.6	18.6	14.7
54.Railroad transport equipment	3.7	4.9	2.9	4.3
55.Motor vehicles	6.7	3.1	24.0	3.9

56.Parts and accessories for motor vehicles and their engines	13.3	10.8	27.9	21.4
57.Ship building	12.6	0.9	12.0	4.9
58.Other transport equipment	13.4	3.0	19.0	2.3
59.Generators	15.3	6.0	25.5	10.5
60.Household electric appliances	22.9	4.6	31.5	7.5
61.Other electric machinery and equipment	23.0	4.2	36.2	3.6
62.Telecommunication equipment	27.6	10.4	55.5	16.3
63.Electronic computer	43.5	22.1	81.8	54.2
64.Other computer peripheral equipment	59.5	11.9	85.8	14.5
65.Electronic element and device	44.3	10.2	68.7	27.1
66.Radio, television and communication equipment and apparatus	46.1	10.8	54.4	19.4
67.Other electronic and communication equipment	35.7	5.2	59.6	10.3
68.Instruments, meters and other measuring equipment	23.7	3.0	36.5	7.7
69.Cultural and office equipment	45.8	8.9	85.7	9.0
70.Arts and crafts products	25.9	3.7	30.7	1.1
71.Other manufacturing products	25.6	4.0	36.1	-3.8
Overall (all sectors)	15.9	3.8	25.3	6.0

Tables

Table 1.1 Summary Statistics for All Years, 1998-2007

	Levels			Growth Rates		
	Number of observations	Mean	Std. Dev.	Number of observations	Mean	Std. Dev.
logY	1,545,626	10.015	1.343	1,086,616	0.135	0.563
logL	1,545,626	4.808	1.152	1,086,616	0.013	0.503
logK	1,545,626	8.468	1.719	1,086,616	0.107	0.753
lnTFP	1,545,626	1.828	0.367	1,086,616	0.056	0.308
Foreign share (contributed by HK-Taiwan-Macau investors)	1,545,626	0.089	0.267	1,086,616	0.012	0.377
Foreign share (contributed by other investors)	1,545,626	0.079	0.249	1,086,616	0.0003	0.146
Stateshare	1,545,626	0.089	0.272	1,086,616	-0.007	0.147
Horizontal	1,545,626	0.254	0.142	1,086,616	0.004	0.046
Backward	1,545,626	0.077	0.046	1,086,616	0.002	0.015
Forward	1,545,626	0.103	0.173	1,086,616	0.004	0.066
Tariff	1,545,626	12.691	6.600	1,086,616	-0.869	2.295
Tariff_backward	1,545,626	8.191	3.769	1,086,616	-0.319	1.611
Tariff_forward	1,545,626	9.185	4.064	1,086,616	-0.359	2.066

Notes: We define firm-level foreign share according to its different sources. Foreign share contributed by HK-Taiwan-Macau is defined as the share of firms' total equity owned by investors from HK-Taiwan-Macau. Foreign share contributed by other countries is defined as the share of firms' total equity owned by investors outside HK-Taiwan-Macau, principally from OECD countries. State share is defined as the proportion of the firm's state assets to its total equity. Horizontal captures the intra-industry FDI spillover while backward and forward represent inter-industry FDI spillovers. We define horizontal, backward, and forward in equation (2), (3), and (4) respectively. The unit for the tariff variable is percentage.

Table 1.2.1 Summary Statistics for Spillover Variables

		Horizontal		Backward		Forward	
Year	Number of Observations	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1998	96,135	0.204	0.125	0.059	0.034	0.068	0.103
1999	104,253	0.220	0.132	0.066	0.038	0.077	0.120
2000	102,745	0.233	0.134	0.071	0.040	0.085	0.136
2001	114,735	0.240	0.135	0.071	0.041	0.089	0.142
2002	122,464	0.242	0.132	0.073	0.042	0.090	0.143
2003	138,377	0.250	0.139	0.075	0.044	0.099	0.166
2004	202,735	0.270	0.146	0.082	0.049	0.109	0.180
2005	194,274	0.273	0.149	0.083	0.049	0.117	0.199
2006	217,062	0.275	0.146	0.085	0.048	0.120	0.201
2007	255,042	0.267	0.143	0.083	0.048	0.119	0.199

Table 1.2.2 Summary Statistics for Spillover Variables that are calculated based on sources of FDI

Year	Number of Obs	Horizontal_HK		Backward_HK		Forward_HK		Horizontal_FR		Backward_FR		Forward_FR	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1998	95,879	0.097	0.068	0.026	0.015	0.033	0.037	0.059	0.069	0.033	0.021	0.037	0.059
1999	103,945	0.106	0.070	0.030	0.016	0.036	0.041	0.075	0.073	0.036	0.023	0.041	0.075
2000	102,465	0.112	0.072	0.033	0.018	0.038	0.048	0.089	0.077	0.038	0.024	0.048	0.089
2001	114,461	0.114	0.070	0.033	0.017	0.038	0.049	0.095	0.086	0.038	0.026	0.049	0.095
2002	122,218	0.112	0.070	0.032	0.018	0.041	0.052	0.097	0.082	0.041	0.026	0.052	0.097
2003	138,158	0.117	0.073	0.033	0.018	0.042	0.057	0.113	0.089	0.042	0.029	0.057	0.113
2004	202,551	0.116	0.067	0.034	0.019	0.048	0.065	0.126	0.102	0.048	0.033	0.065	0.126
2005	194,120	0.115	0.068	0.034	0.020	0.048	0.071	0.135	0.102	0.048	0.031	0.071	0.135
2006	216,924	0.114	0.067	0.034	0.019	0.051	0.074	0.144	0.104	0.051	0.032	0.074	0.144
2007	254,905	0.109	0.063	0.033	0.018	0.050	0.074	0.139	0.103	0.050	0.031	0.074	0.139

Table 1.2.3 Summary Statistics for Subsidized and non-Subsidized Spillover Variables (calculated based on income tax)

		Subsidized						Non-Subsidized					
		Horizontal		Backward		Forward		Horizontal		Backward		Forward	
Year	Number of Obs	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1998	95,879	0.076	0.060	0.022	0.015	0.024	0.047	0.112	0.068	0.033	0.018	0.038	0.050
1999	103,945	0.083	0.067	0.025	0.018	0.027	0.056	0.125	0.069	0.040	0.020	0.046	0.064
2000	102,465	0.096	0.072	0.029	0.020	0.033	0.070	0.130	0.070	0.041	0.021	0.049	0.068
2001	114,461	0.102	0.075	0.031	0.020	0.034	0.057	0.130	0.067	0.039	0.021	0.052	0.083
2002	122,218	0.107	0.080	0.035	0.025	0.041	0.091	0.128	0.066	0.037	0.018	0.047	0.059
2003	138,158	0.110	0.078	0.034	0.023	0.042	0.083	0.131	0.069	0.039	0.021	0.053	0.080
2004	202,551	0.132	0.090	0.041	0.027	0.054	0.110	0.129	0.063	0.038	0.020	0.051	0.070
2005	194,120	0.132	0.096	0.041	0.028	0.055	0.110	0.131	0.064	0.039	0.021	0.058	0.092
2006	216,924	0.138	0.094	0.043	0.028	0.057	0.101	0.126	0.061	0.039	0.020	0.057	0.097
2007	254,905	0.138	0.089	0.044	0.026	0.062	0.111	0.119	0.061	0.036	0.021	0.054	0.086

Table 1.2.4 Summary Statistics for Subsidized and non-Subsidized Spillover Variables (calculated based on value added tax)

		Subsidized						Non-Subsidized					
		Horizontal		Backward		Forward		Horizontal		Backward		Forward	
Year	Number of Obs	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1998	95,879	0.053	0.062	0.014	0.011	0.009	0.018	0.151	0.078	0.045	0.024	0.059	0.085
1999	103,945	0.049	0.056	0.013	0.012	0.007	0.012	0.169	0.089	0.052	0.027	0.069	0.107
2000	102,465	0.049	0.053	0.013	0.011	0.009	0.019	0.182	0.094	0.058	0.030	0.076	0.118
2001	114,461	0.049	0.050	0.013	0.011	0.008	0.017	0.187	0.095	0.057	0.029	0.080	0.123
2002	122,218	0.063	0.064	0.017	0.014	0.008	0.016	0.178	0.088	0.055	0.028	0.081	0.127
2003	138,158	0.070	0.075	0.018	0.018	0.013	0.038	0.177	0.083	0.056	0.027	0.085	0.130
2004	202,551												
2005	194,120	0.061	0.058	0.017	0.015	0.014	0.035	0.207	0.102	0.064	0.034	0.101	0.162
2006	216,924	0.054	0.054	0.015	0.014	0.015	0.045	0.214	0.103	0.069	0.034	0.102	0.153
2007	254,905	0.047	0.056	0.013	0.015	0.012	0.038	0.214	0.097	0.068	0.032	0.105	0.159

Notes: Since the information on value added is missing for 2004, we leave the summary statistics for 2004 with blank.

Table 1.3 OLS and Olley-Pakes Regression with Contemporaneous Spillover Variables with Tariff controls: with vs. without firm-fixed effects (sample: all firms)

	Dependent variable: logY		Dependent variable: lnTFP	
LogL	0.0914***	0.0755***		
	(0.0036)	(0.0041)		
LogK	0.0278***	0.0347***		
	(0.0016)	(0.0024)		
LogM	0.766***	0.865***		
	(0.0069)	(0.0042)		
Foreignshare (by HK-Taiwan-Macau)	-0.0018	-0.0018	-0.00353	0.0231***
	(0.0031)	(0.0052)	(0.0031)	(0.0049)
Foreignshare (by other countries)	0.0076**	0.0644***	0.0054*	0.115***
	(0.0032)	(0.0057)	(0.0032)	(0.0089)
Stateshare	-0.0168***	-0.0586***	-0.0201***	-0.126***
	(0.0036)	(0.0060)	(0.0032)	(0.0108)
Horizontal	0.162*	0.128	0.164*	0.0771
	(0.088)	(0.116)	(0.0871)	(0.110)
Backward	0.813***	0.956***	0.807***	1.096***
	(0.259)	(0.331)	(0.256)	(0.328)
Forward	0.163*	0.185	0.160*	0.190
	(0.0869)	(0.114)	(0.0865)	(0.119)
lnTariff	-0.0385**	0.00198	-0.0381**	-0.0129
	(0.0150)	(0.0319)	(0.0151)	(0.0319)
lnTariff_backward	-0.0276	-0.0061	-0.0289	-0.0236
	(0.0188)	(0.0312)	(0.0189)	(0.0319)
lnTariff_forward	-0.0064	-0.0396**	-0.0066	-0.0410**
	(0.0080)	(0.0173)	(0.0079)	(0.0178)
Constant	1.921***	0.956***	1.721***	1.749***
	(0.0704)	(0.123)	(0.0577)	(0.118)
Firm-fixed effect	Yes	No	Yes	No
Observations	1,545,626	1,545,626	1,545,626	1,545,626
R-squared	0.831	0.949	0.179	0.237

Notes: Robust clustered standard errors are presented in parentheses. In estimates using logY (i.e., in column (1) and (2) as the dependent variable, logL, logM, and logK are included as regressors along with the firm-level controls, sector-level FDI and tariff variables. When the dependent variable is lnTFP (i.e. as in column (3) and (4)), the estimation procedure is two-stage. In the first stage, we use the OP regression method to obtain estimates for the input coefficients and then calculate lnTFP (the residual from the production function). In the second stage, we regress lnTFP on the remaining controls (firm-level foreign share, state share, sector-level FDI variables, and tariff variables).

*Significant at 10-percent level

**Significant at 5-percent level

***Significant at 1-percent level

Table 1.4 Olley and Pakes Regressions with Contemporaneous Spillover Variables and Tariff Controls: all firms, foreign-invested, domestic firms with zero foreign investment

	All firms	Foreign-invested firms	Domestic firms (0 foreign share)
Foreign share (by HK-Taiwan-Macau)	-0.0035	0.003	
	(0.0031)	(0.0048)	
Foreign share (by other countries)	0.0054*	0.0132***	
	(0.0032)	(0.0049)	
State share	-0.0201***	0.0023	-0.0193***
	(0.0032)	(0.0075)	(0.0034)
Horizontal	0.164*	0.115	0.191**
	(0.0871)	(0.0991)	(0.0883)
Backward	0.807***	0.860***	0.801***
	(0.256)	(0.276)	(0.268)
Forward	0.160*	0.246***	0.0920
	(0.0865)	(0.0876)	(0.0920)
lnTariff	-0.0381**	-0.0241	-0.0417**
	(0.0151)	(0.0182)	(0.0164)
lnbwTariff	-0.0289	-0.0167	-0.0350
	(0.0189)	(0.0176)	(0.0211)
lnfwTariff	-0.0066	-0.0203*	-0.0027
	(0.0079)	(0.0116)	(0.0072)
Constant	1.721***	2.002***	2.053***
	(0.0577)	(0.0598)	(0.0416)
Observations	1,545,626	348,029	1,197,597
R-squared	0.179	0.204	0.166
Horizontal*dummy		-0.124***	
		(0.046)	
F-stat (Horizontal*dummy=0)		7.14	
Prob > *F*		0.010	
Backward*dummy		0.011	
		(0.009)	
F-stat (Backward*dummy=0)		0.62	
Prob > *F*		0.433	
Forward*dummy		-0.011*	
		(0.006)	
F-stat (Forward*dummy=0)		19.81	
Prob > *F*		0	
F-stat (interaction term jointly zero)		7.76	
Prob > *F*		0.0002	

Notes: Robust clustered standard errors are presented in parentheses. The dependent variable lnTFP. Each regression includes firm-fixed effects and year dummies. The bottom of the table reports the results of tests, which compares whether three sector-level FDI variables are different across the two sub-samples of foreign-invested firms and domestic firms. The dummy is defined as 1 if firm i has non-zero foreign share at period t, 0 otherwise.

Table 1.5 Olley and Pakes Regressions with Contemporaneous Spillover Variables and Tariff controls: all firms, foreign-invested, and domestic firms with zero foreign investment (sector-level FDI are calculated based on sources of FDI)

	All firms	Foreign-invested firms	Domestic firms (0 foreign investment)
Foreign share (HK-Taiwan-Macau)	-0.0028	0.00312	
	(0.003)	(0.0047)	
Foreign share (by other countries)	0.0059*	0.013***	
	(0.0032)	(0.0048)	
Horizontal_HK	-0.0198	0.0143	-0.0647
	(0.099)	(0.106)	(0.105)
Backward_HK	0.570	0.339	0.697
	(0.580)	(0.581)	(0.659)
Forward_HK	-0.227	-0.241	-0.162
	(0.177)	(0.154)	(0.217)
Horizontal_FR	0.284**	0.183	0.350***
	(0.132)	(0.149)	(0.131)
Backward_FR	0.872*	1.110**	0.764*
	(0.445)	(0.522)	(0.437)
Forward_FR	0.332**	0.457***	0.214
	(0.148)	(0.116)	(0.179)
lnTariff	-0.0263*	-0.00987	-0.0313*
	(0.0154)	(0.0180)	(0.0165)
lnTariff_backward	-0.0379	-0.0265	-0.0413*
	(0.0231)	(0.0259)	(0.0245)
lnTariff_forward	-0.0037	-0.0153	-0.0008
	(0.0078)	(0.0118)	(0.0071)
Constant	1.715***	1.997***	2.046***
	(0.0638)	(0.0703)	(0.0440)
Observations	1,545,626	348,029	1,197,597
R-squared	0.180	0.205	0.167
F-stat (HHK=HFR)	3.01	0.80	5.42
Prob>*F*	0.088	0.374	0.023
F-stat (BHK=BFR)	0.11	0.61	0
Prob>*F*	0.736	0.438	0.944
F-stat (FHK=FFR)	3.61	10.63	1.02
Prob>*F*	0.062	0.002	0.32
F-stat (three conditions jointly)	4.64	6.99	4.16
Prob>*F*	0.006	0.004	0.009

Notes: Robust clustered standard errors are presented in parentheses. The dependent variable for each regression is lnTFP. Each regression includes firm-fixed effects and year dummies. HHK = Horizontal (by HK-Taiwan-Macau investors), HFR = Horizontal (by other countries). BHK = Backward (by HK-Taiwan-Macau investors), BFR = Backward (by other countries). FHK = Forward (by HK-Taiwan-Macau investors), FFR = Forward (by other countries).

Table 1.6 Olley and Pakes Regressions with Contemporaneous Spillover Variables and Tariff controls: non-SOEs vs. SOEs (with the sample of all firms, foreign-invested, and domestic firms with zero foreign share)

	All firms		Foreign-invested firms		Domestic firms (zero foreign share)	
	Non-SOEs	SOEs	Non-SOEs	SOEs	Non-SOEs	SOEs
Foreign share (by HK-Taiwan-Macau)	-0.0037	0.0348	0.0033	-0.0734		
	(0.003)	(0.0545)	(0.0048)	(0.0663)		
Foreign share (by other countries)	0.0052	0.098**	0.013***	0.082		
	(0.0031)	(0.0393)	(0.0049)	(0.0692)		
State share	-0.0016	-0.0256***	0.0037	0.0172	-0.0017	-0.0259***
	(0.0030)	(0.0041)	(0.0078)	(0.0305)	(0.0033)	(0.0041)
Horizontal	0.164*	0.109	0.117	-0.506	0.194**	0.111
	(0.088)	(0.100)	(0.099)	(0.444)	(0.089)	(0.100)
Backward	0.785***	1.027***	0.850***	2.893***	0.765***	1.005***
	(0.253)	(0.349)	(0.275)	(0.844)	(0.262)	(0.350)
Forward	0.162*	0.166	0.245***	0.483**	0.0867	0.169
	(0.0851)	(0.128)	(0.0875)	(0.219)	(0.0882)	(0.132)
lnTariff	-0.0349**	-0.0526**	-0.0237	-0.0676**	-0.0375**	-0.0519**
	(0.0154)	(0.0198)	(0.0183)	(0.0312)	(0.0171)	(0.0198)
lnTariff_backward	-0.0285	-0.0163	-0.0169	0.00579	-0.0354*	-0.0159
	(0.0185)	(0.0337)	(0.0176)	(0.0705)	(0.0207)	(0.0338)
lnTariff_forward	-0.0086	0.0065	-0.0205*	0.0705***	-0.0046	0.006
	(0.0082)	(0.0077)	(0.0115)	(0.0245)	(0.0074)	(0.0077)
Constant	1.721***	2.545***	1.913***	1.413***	1.663***	2.550***
	(0.0576)	(0.0690)	(0.0723)	(0.118)	(0.0598)	(0.0701)
Observations	1,418,632	126,994	345,631	2,398	1,073,001	124,596
R-squared	0.186	0.078	0.204	0.222	0.173	0.077
Horizontal*ownership	-0.184**		-0.030		-0.201**	
	(0.091)		(0.193)		(0.095)	
F-stat (Horizontal * ownership = 0)	4.06		0.02		4.4	

Prob>*F*	0.048	0.879	0.04
Backward*ownership	-0.018	-0.236	-0.042
	(0.220)	(0.350)	(0.233)
F-stat (Backward * ownership = 0)	0.01	0.46	0.03
Prob>*F*	0.934	0.502	0.857
Forward*ownership	0.007	-0.100	0.043
	(0.064)	(0.109)	(0.065)
F-stat (Forward * ownership = 0)	0.01	0.85	0.44
Prob>*F*	0.915	0.36	0.51
F-stat (interaction terms jointly zero)	6.55	1.46	6.68
Prob>*F*	0.001	0.235	0.001

Notes: Robust clustered standard errors are presented in parentheses. The dependent variable for all regression is lnTFP. All regressions include firm fixed effects and year dummies. Ownership is a dummy variable, which equals one if a firm is a SOE and zero otherwise.

Table 1.7 Olley and Pakes Regressions: Allowing for Differential Spillovers with Differences in Trade Exposure

Dependent Variable	lnTFP	lnTFP	lnTFP	lnTFP
	(1)	(2)	(3)	(4)
	Domestic nonSOEs	Domestic nonSOEs	Non-exporting firms	Exporters
State share	-0.00174	-0.00240	-0.000923	-0.0108
	(0.00332)	(0.00318)	(0.00406)	(0.00822)
Horizontal	0.194**	0.550**	0.211**	0.121
	(0.0897)	(0.230)	(0.0992)	(0.0727)
Backward	0.765***	0.987	0.764***	0.752***
	(0.262)	(0.712)	(0.286)	(0.235)
Forward	0.0867	0.502	0.0687	0.130
	(0.0882)	(0.369)	(0.0912)	(0.0827)
lnTariff	-0.0375**	0.0124	-0.0364*	-0.0422***
	(0.0171)	(0.0309)	(0.0192)	(0.0141)
lnbwTariff	-0.0354*	-0.0285	-0.0392*	-0.0133
	(0.0207)	(0.0384)	(0.0218)	(0.0219)
lnfwTariff	-0.00458	0.000476	-0.00262	-0.0145
	(0.00742)	(0.00578)	(0.00764)	(0.00881)
Horizontal*lnTariff		-0.154*		
		(0.0809)		
Backward*lnbwTariff		-0.189		
		(0.332)		
Forward*lnfwTariff		-0.226		
		(0.140)		
Constant	1.663***	1.541***	1.855***	1.669***
	(0.0598)	(0.0777)	(0.0448)	(0.0616)
Observations	1,073,001	1,073,001	856,297	216,704
R-squared	0.173	0.174	0.163	0.204

Notes: In this table, we implement several extension based on the results shown in column 5 in Table 1.6. In column 1, we reproduce results from column 5 in Table 1.6. In column 2, we add three interaction terms. In column 3, we restrict the sample to non-exporting firms. We re-do the results with exporting firms in column 4. Firm fixed effect and year dummy variables in all regression. Robust clustered standard errors in parentheses.

Table 1.8 Exploration of FDI Productivity Effects Prior to and Following WTO Entry at the end of 2001

	All		Foreign-invested firms		Domestic firms	
	Non-SOEs	SOEs	Non-SOEs	SOEs	Non-SOEs	SOEs
Foreign share (by HK-Taiwan-Macau)	-0.00444	0.0389	0.00610	-0.0477		
	(0.00287)	(0.0564)	(0.00483)	(0.0671)		
Foreign share (by other countries)	0.00418	0.107***	0.0159***	0.0844		
	(0.00300)	(0.0376)	(0.00499)	(0.0713)		
State share	-0.00351	-0.0252***	0.00191	0.0155	-0.00320	-0.0255***
	(0.00289)	(0.00440)	(0.00827)	(0.0307)	(0.00331)	(0.00439)
Hor_1998	0.199**	0.0630	0.296***	-0.731	0.119	0.0676
	(0.0815)	(0.112)	(0.0787)	(0.528)	(0.0895)	(0.112)
Hor_1999	0.158**	0.0463	0.186**	-0.719	0.126	0.0479
	(0.0781)	(0.0948)	(0.0772)	(0.526)	(0.0832)	(0.0946)
Hor_2000	0.216***	0.123	0.170**	-0.561	0.217***	0.121
	(0.0699)	(0.0779)	(0.0656)	(0.550)	(0.0721)	(0.0767)
Hor_2001	0.158**	0.0866	0.0992	-0.820	0.157**	0.0889
	(0.0744)	(0.0708)	(0.0735)	(0.542)	(0.0750)	(0.0699)
Hor_2002	0.0835	0.0422	0.0217	-0.344	0.0862	0.0480
	(0.0782)	(0.0974)	(0.0730)	(0.480)	(0.0789)	(0.0955)
Hor_2003	0.0598	0.0217	-0.0145	-0.424	0.0884	0.0238
	(0.0801)	(0.0887)	(0.0753)	(0.496)	(0.0821)	(0.0890)
Hor_2004	0.188*	0.0596	0.142	0.386	0.200*	0.0476
	(0.104)	(0.134)	(0.0969)	(0.422)	(0.113)	(0.134)
Hor_2005	0.196	0.0872	0.171	0.148	0.216	0.0741
	(0.123)	(0.143)	(0.118)	(0.359)	(0.130)	(0.142)
Hor_2006	0.244*	0.118	0.263**	0.423	0.253*	0.106
	(0.129)	(0.164)	(0.131)	(0.456)	(0.133)	(0.163)
Hor_2007	0.289*	0.227	0.322**	0.176	0.309*	0.207
	(0.163)	(0.186)	(0.151)	(0.491)	(0.175)	(0.184)
Back_1998	-0.251	-0.162	-0.644***	1.473*	0.0298	-0.229
	(0.225)	(0.380)	(0.179)	(0.841)	(0.304)	(0.389)

Back_1999	-0.236	-0.278	-0.376**	1.411	-0.0847	-0.333
	(0.194)	(0.326)	(0.164)	(0.974)	(0.243)	(0.330)
Back_2000	-0.0749	-0.111	-0.104	1.526	0.0289	-0.168
	(0.153)	(0.229)	(0.134)	(0.970)	(0.174)	(0.230)
Back_2001	0.194	0.0457	0.155	2.234**	0.327*	-0.0218
	(0.165)	(0.220)	(0.152)	(1.043)	(0.188)	(0.219)
Back_2002	0.415**	0.262	0.509***	1.298	0.432**	0.205
	(0.167)	(0.287)	(0.155)	(0.885)	(0.185)	(0.282)
Back_2003	0.602***	0.602**	0.662***	1.928**	0.665***	0.555**
	(0.184)	(0.242)	(0.158)	(0.842)	(0.213)	(0.248)
Back_2004	0.769***	1.183***	0.721***	0.496	0.841***	1.228***
	(0.234)	(0.338)	(0.201)	(0.768)	(0.272)	(0.345)
Back_2005	0.836***	1.314***	0.798***	1.465**	0.902***	1.355***
	(0.269)	(0.407)	(0.232)	(0.642)	(0.314)	(0.414)
Back_2006	0.761**	1.460***	0.685**	1.543*	0.825**	1.462***
	(0.295)	(0.487)	(0.265)	(0.840)	(0.340)	(0.502)
Back_2007	0.820**	1.706***	0.769**	1.641**	0.879**	1.757***
	(0.371)	(0.487)	(0.319)	(0.810)	(0.430)	(0.497)
For_1998	-0.0176	-0.00245	-0.0459	-0.0493	0.0266	0.0126
	(0.0873)	(0.149)	(0.0801)	(0.269)	(0.105)	(0.159)
For_1999	0.0180	0.0423	0.0135	0.107	0.0458	0.0686
	(0.0723)	(0.109)	(0.0580)	(0.283)	(0.0877)	(0.110)
For_2000	0.00939	0.0250	0.0412	0.0764	0.00315	0.0423
	(0.0423)	(0.0737)	(0.0307)	(0.278)	(0.0541)	(0.0759)
For_2001	0.0672	0.109	0.0901**	0.260	0.0720	0.117*
	(0.0500)	(0.0659)	(0.0417)	(0.286)	(0.0571)	(0.0685)
For_2002	0.136***	0.140**	0.173***	0.0465	0.123**	0.152**
	(0.0494)	(0.0686)	(0.0437)	(0.271)	(0.0586)	(0.0705)
For_2003	0.167***	0.134**	0.211***	0.161	0.146**	0.143**
	(0.0467)	(0.0518)	(0.0402)	(0.260)	(0.0566)	(0.0546)
For_2004	0.143**	0.201**	0.200***	-0.00693	0.0887	0.216**

	(0.0629)	(0.0885)	(0.0514)	(0.221)	(0.0762)	(0.0912)
For_2005	0.133*	0.153	0.203***	0.0120	0.0632	0.170
	(0.0776)	(0.115)	(0.0601)	(0.178)	(0.0960)	(0.121)
For_2006	0.154*	0.169*	0.217***	0.00373	0.0841	0.180*
	(0.0781)	(0.0999)	(0.0638)	(0.218)	(0.0949)	(0.104)
For_2007	0.163*	0.163*	0.227***	0.178	0.0860	0.180*
	(0.0911)	(0.0922)	(0.0718)	(0.236)	(0.111)	(0.0957)
lnTariff	-0.0200	-0.0322*	-0.00861	-0.0332	-0.0241	-0.0321*
	(0.0172)	(0.0177)	(0.0148)	(0.0431)	(0.0190)	(0.0179)
lnbwTariff	-0.0267	-0.00377	-0.0126	0.00929	-0.0334*	-0.00161
	(0.0172)	(0.0283)	(0.0136)	(0.0711)	(0.0200)	(0.0284)
lnfwTariff	-0.00712	0.00314	-0.0150**	0.0910***	-0.00488	0.00220
	(0.00780)	(0.00735)	(0.00711)	(0.0160)	(0.00795)	(0.00727)
Constant	1.740***	2.393***	1.927***	1.221***	1.682***	2.394***
	(0.0561)	(0.0644)	(0.0511)	(0.144)	(0.0652)	(0.0656)
Observations	1,418,632	126,994	345,631	2,398	1,073,001	124,596
R-squared	0.190	0.083	0.212	0.274	0.175	0.082

Notes: We keep the same structure as in Table 1.6. In this table, we explore time effects of sector-level spillover variables on firms' productivity. We use year dummies to multiply *Horizontal*, *Backward*, and *Forward* separately; therefore, we have 30 interactions. Hor_interact1 = Horizontal * time dummy (when year = 1998).

Table 1.9 Olley and Pakes Regressions for Grouped Data with Contemporaneous Subsidized and non-Subsidized Spillover Variables (constructed based on income tax) and Tariff Controls: non-SOEs vs. SOEs (All firms, foreign-invested, and domestic firms with zero foreign investment

	All firms		Foreign-invested firms		Domestic firms (0 foreign investment)	
	non-SOEs	SOEs	non-SOEs	SOEs	non-SOEs	SOEs
Foreign share (by HK-Taiwan-Macau)	-0.00381	0.0363	0.00368	-0.0766		
	(0.00302)	(0.0543)	(0.00484)	(0.0675)		
Foreign share (by other countries)	0.00522	0.0986**	0.0137***	0.0807		
	(0.00313)	(0.0388)	(0.00498)	(0.0690)		
State share	-0.00174	-0.0254***	0.00420	0.0180	-0.00206	-0.0257***
	(0.00290)	(0.00420)	(0.00767)	(0.0307)	(0.00331)	(0.00421)
Hor_subsidized	0.117	0.103	0.0512	-0.595	0.163	0.103
	(0.107)	(0.133)	(0.109)	(0.511)	(0.111)	(0.134)
Bw_subsidized	2.189***	2.833***	2.065***	3.203***	2.286***	2.822***
	(0.644)	(0.611)	(0.475)	(0.986)	(0.799)	(0.628)
Fw_subsidized	0.165	0.203	0.238***	0.526**	0.0817	0.213
	(0.107)	(0.151)	(0.0859)	(0.259)	(0.141)	(0.158)
Hor_non_subsidized	0.189*	-0.0729	0.179*	-0.429	0.188	-0.0702
	(0.104)	(0.117)	(0.103)	(0.355)	(0.114)	(0.119)
Bw_non_subsidized	-0.934	-1.173**	-0.649	2.287*	-1.051	-1.175**
	(0.623)	(0.464)	(0.474)	(1.239)	(0.749)	(0.471)
Fw_non_subsidized	0.184**	0.222**	0.261***	0.403**	0.132	0.221**
	(0.0885)	(0.105)	(0.0683)	(0.163)	(0.122)	(0.110)
lnTariff	-0.0346**	-0.0458**	-0.0262*	-0.0712**	-0.0366**	-0.0451**
	(0.0144)	(0.0184)	(0.0155)	(0.0329)	(0.0163)	(0.0185)
lnTariff_backward	-0.0170	0.00734	-0.00343	0.0123	-0.0249	0.00716
	(0.0179)	(0.0305)	(0.0175)	(0.0727)	(0.0200)	(0.0306)
lnTariff_forward	-0.00981	0.00613	-0.0211*	0.0695***	-0.00610	0.00561
	(0.00782)	(0.00679)	(0.0110)	(0.0233)	(0.00716)	(0.00680)
Constant	1.728***	2.499***	1.920***	1.431***	1.673***	2.504***
	(0.0531)	(0.0632)	(0.0654)	(0.118)	(0.0577)	(0.0645)

Observations	1,418,632	126,994	345,631	2,398	1,073,001	124,596
R-squared	0.187	0.079	0.205	0.223	0.174	0.078
F-stat (HS=HNS)	0.28	0.96	0.98	0.42	0.03	0.88
Prob>F	0.596	0.332	0.327	0.518	0.862	0.351
F-stat (BS=BNS)	6.72	19.12	10.39	0.42	5.01	18.02
Prob>*F*	0.012	0.0001	0.002	0.52	0.029	0.0001
F-stat (FS=FNS)	0.02	0.02	0.14	0.74	0.06	0
Prob>*F*	0.882	0.889	0.705	0.394	0.813	0.955
F-stat (three conditions jointly)	2.61	7.46	3.92	0.32	1.99	6.85
Prob>*F*	0.06	0.0003	0.013	0.808	0.126	0.0005

Notes: Robust clustered standard errors are presented in parentheses. The dependent variable for all regressions is lnTFP. All regressions include firm fixed effect and year dummy variables. HS = subsidized horizontal, and HNS = non-subsidized horizontal; BS = subsidized backward, and BNS = non-subsidized backward; FS = subsidized forward, and FNS = non-subsidized forward.

Table 1.10 Olley and Pakes Regressions for Grouped Data with Contemporaneous Subsidized and non-Subsidized Spillover Variables (calculated based on value added tax) and Tariff Controls: non-SOEs vs. SOEs (all firms, foreign-invested, domestic firms)

	All firms		Foreign-invested firms		Domestic firms	
	non-SOEs	SOEs	non-SOEs	SOEs	non-SOEs	SOEs
Foreign share (by HK-Taiwan-Macau)	-0.0041	0.0371	0.003	-0.0765		
	(0.0031)	(0.0579)	(0.0044)	(0.0716)		
Foreign share (by other countries)	0.0050*	0.121***	0.0130***	0.0829		
	(0.0026)	(0.0357)	(0.0048)	(0.0698)		
State share	-0.001	-0.0250***	-0.0016	0.0312	0.0007	-0.0253***
	(0.0033)	(0.0045)	(0.0091)	(0.0318)	(0.0035)	(0.0046)
Hor_subsidized	0.0398	0.230*	0.0177	-0.683	0.0662	0.249*
	(0.0871)	(0.134)	(0.0865)	(0.416)	(0.0963)	(0.135)
Bw_subsidized	0.831	1.133**	1.138*	2.560***	0.636	1.086**
	(0.534)	(0.523)	(0.572)	(0.793)	(0.574)	(0.535)
Fw_subsidized	1.068***	0.685***	1.161***	0.785***	0.943***	0.659***
	(0.130)	(0.114)	(0.140)	(0.183)	(0.147)	(0.118)
Hor_non_subsidized	0.240**	0.116	0.214**	-0.518	0.255**	0.117
	(0.0928)	(0.111)	(0.0966)	(0.497)	(0.0978)	(0.112)
Bw_non_subsidized	0.765**	0.695	0.666**	2.763**	0.842*	0.663
	(0.376)	(0.527)	(0.314)	(1.109)	(0.456)	(0.537)
Fw_non_subsidized	-0.0597	0.00991	-0.00319	0.408	-0.105	0.0161
	(0.102)	(0.136)	(0.111)	(0.258)	(0.0990)	(0.144)
lnTariff	-0.0394**	-0.0515**	-0.0295*	-0.0408	-0.0424**	-0.0510**
	(0.0165)	(0.0209)	(0.0175)	(0.0355)	(0.0187)	(0.0209)
lnTariff_backward	-0.0324	-0.0135	-0.0263	0.0151	-0.0361	-0.0122
	(0.0198)	(0.0369)	(0.0185)	(0.0737)	(0.0223)	(0.0371)
lnTariff_forward	-0.00487	0.0129*	-0.0134	0.0568**	-0.0017	0.0123
	(0.0079)	(0.0076)	(0.0110)	(0.0242)	(0.0072)	(0.0076)
Constant	2.074***	2.472***	1.939***	1.390***	1.672***	2.553***
	(0.0401)	(0.0650)	(0.0723)	(0.127)	(0.0666)	(0.0721)

Observations	1,225,481	117,594	299,177	2,323	926,304	115,271
R-squared	0.205	0.084	0.233	0.213	0.185	0.083
F-stat (HS=HNS)	6.36	0.64	8.51	0.34	4.14	0.8
Prob>F	0.014	0.428	0.005	0.563	0.046	0.374
F-stat (BS=BNS)	0.01	0.26	0.42	0.04	0.05	0.23
Prob>*F*	0.932	0.61	0.521	0.848	0.823	0.632
F-stat (FS=FNS)	29.45	14.94	24.17	1.9	26.52	11.24
Prob>*F*	0	0.0003	0	0.173	0	0.001
F-stat (three conditions jointly)	13.49	8.08	11.09	1.14	10.22	6.34
Prob>*F*	0	0.0001	0	0.341	0	0.001

Notes: Robust clustered standard errors are presented in parentheses. The dependent variable for all regressions is lnTFP. All regressions include firm fixed effect and year dummy variables. Since the information on value added is missing for the year of 2004, we exclude the year of 2004 from regressions. HS = subsidized horizontal, and HNS = non-subsidized horizontal; BS = subsidized backward, and BNS = non-subsidized backward; FS = subsidized forward, and FNS = non-subsidized forward.

Figures

Figure 1.1 Tax Rate Distribution with Groups of firms (2004)

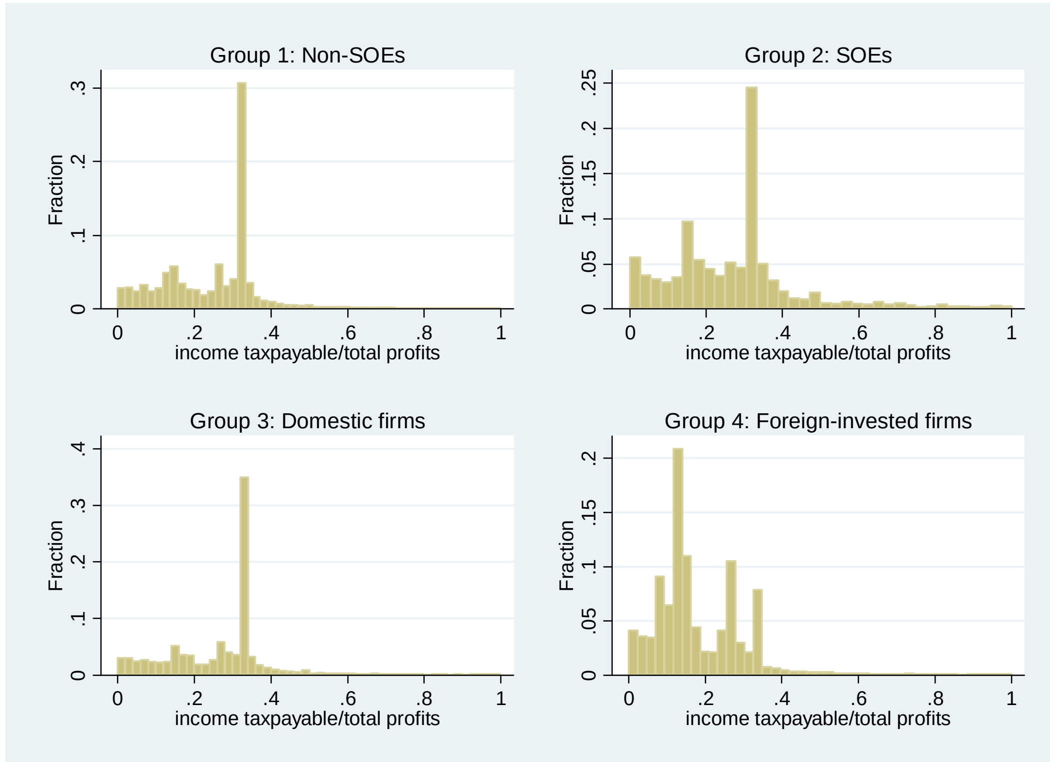
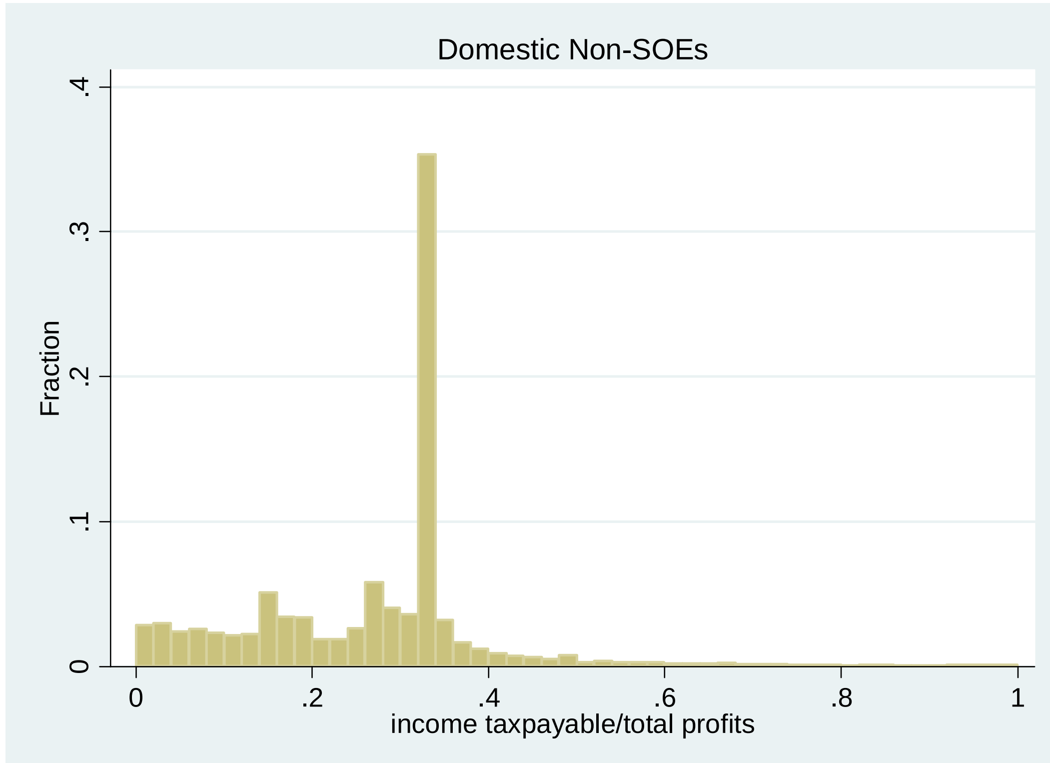


Figure 1.2 Tax Rate Distribution with Domestic Non-SOEs (2004)



Chapter 2 Agglomeration, Road Building, and Growth: Evidence from Mainland China 1998-2007

2.1 Introduction

Since opening its economy to the outside world in late 1978, China has experienced a massive, protracted, and unexpected economic upsurge, which has attracted the attention of a large and diverse group of researchers. China's three-decade economic reforms have reshaped the economic structure from plan to market, through a variety of policy actions, such as openness to foreign investment, efforts to build economic zones, and privatization of state-owned enterprises. In the early 1980s, five special economic zones (SEZs) were set up and 14 coastal cities were further opened to overseas investment in 1984. In the late 1980s and early 90s, China's opening to the outside world was extended to other coastal provinces and also some inland regions. In addition, 15 free trade zones, 32 state-level economic and technological development zones, and 53 high-tech industrial development zones have been established in large and medium cities. These first-developed areas played an important role in economic transition and became industrial clusters of economic development, then drivers of regional, or eventually, national growth. Agglomeration externalities are the main justification for the aggressive efforts by both national and local governments in building economic zones.

The goal of this paper is to separate the effect of agglomeration economies on firm performance (measured by total factor productivity (TFP)) from the gains due to more competition and better transport infrastructure. We do this by constructing separate measures for agglomeration, competition, and infrastructure. To measure the impact of infrastructure inputs separately from agglomeration, we are able to exploit the fact that a major road building project (the National Expressway Network) occurred during the period of the analysis. Competition and transport infrastructure are two important confounding factors in agglomeration economies, but are also determinants of productivity growth. Without explicitly taking into account changes in competition and transport infrastructure, the role of agglomeration economies will be measured incorrectly. This has implications for the cluster policies, promoted by many developed and developing countries. To take an extreme example, if the effects of agglomeration economies disappear after we control for competition (or transport infrastructure), then governments should promote competition (or invest in roads) rather than implementing cluster policies.

Rosenthal and Strange (2004) survey the empirical literature on the nature and sources of agglomeration economies and summarize existing empirical approaches that evaluate the effect of agglomeration economies on productivity. Their survey and other recent work by Combes et al (2010) emphasize, that until recently, estimates of agglomeration externalities suffered omitted variable and simultaneity biases. The issue of missing variables is particularly severe since it applies to any variable that affects productivity either directly or indirectly through agglomeration economies.

Ciccone and Hall (1996)[13] are the first to address directly and carefully these endogeneity issues. They study the impact of county employment density on American state labor productivity. The authors argue that if unmeasured and/or unobserved differences in the determinants of productivity across states are correlated with counties employment density within states, the measure of the returns to density by simple OLS may be problematic. They take the examples of climate or transportation infrastructures, which will enhance both workers' productivity and the attractiveness of the place. To address the identification problem, they use population centers in the 18th and the middle of 19th century as instruments for today's populated areas. After controlling for the average level of education within the state, they find that a doubling of local employment density increases labor productivity by 5%-6%.

Ciccone and Hall (1996) improve the methodology in addressing the potential endogeneity of agglomeration economies; however, they rely on city aggregate productivity data. The use of panel micro-level data allows us to obtain more reliable estimation and also to construct agglomeration measures closer to micro theory. To the best knowledge of this author, Henderson (2003) and Martin, Mayer, and Mayneris (2011) are the only two papers using plant level data to evaluate effects of agglomeration economies; these are the closest to the methodologies presented below. Henderson (2003) estimates a plant level production function for two broad sectors: machinery industries and high-tech industries. Based on a plant/location fixed effect model, he finds that the number of other own-industry plants (localization effects) has strong productivity effects in high-tech but not in machinery industries. To address the simultaneity issue, Martin, Mayer, and Mayneris (2011) adopt a GMM approach. They start by first-differencing each variable and then instrument first-differenced independent variables by their level at time *t*-2. Martin et al (2011) show that French plants benefit from localization economies, but not from urbanization economies.

Although previous studies have made progress in addressing the endogeneity of agglomeration economies, challenges remain especially in the area of omitted variables. This paper primarily focuses on addressing the omitted variable problem by separating the impact of agglomeration on TFP from the gains from increasing competition and better transport infrastructure. Specifically, this paper makes two major contributions. First, this is the first research to disentangle the importance of infrastructure projects (in particular, road construction) from agglomeration economies in the economics literature. Roads have been mentioned as an important omitted variable, but no paper actually incorporates data on roads and empirically separates their impact on TFP from agglomeration economies. Second, this analysis adds new empirical evidence on the linkages between trade and

[13] Replicating Ciccone and Hall's strategy for France and Italy, Combes et al. (2008) and Mion and Natichioni (2009) find similar results. Following Rosenthal and Strange (2008) in a slightly different context, Combes et al (2010) also use the geological characteristics of regions. Fertile soils certainly drove the location of populations when agriculture was a major part of the economy. That soil characteristics still affect the productivity and wages of manufacturing and service sectors is more difficult to imagine. Finally, Combes et al. (2008) also use some measure of geographical periphery.

agglomeration. In particular, we examine whether firms that participate in international trade or foreign investment benefit more from agglomeration economies than firms with domestic markets and financing.

Across different specifications, we find that localization economies are the only persistent source of agglomeration externalities. This finding emphasizes the importance of intra-industry externalities. This does not mean that urbanization economies are not important, but they may be a more long-run phenomenon, which is difficult to detect with a ten-year panel data. Second, our results suggest that the inclusion of information on road construction does not affect the importance of pure agglomeration economies (localization economies). However, including a measure of competition in the estimation significantly reduces the importance of agglomeration economies. The coefficient on agglomeration becomes 40 percent smaller. To test Porter's (1998) idea about agglomeration and competition, Martin et al (2011) introduce competition and find that competition has zero effect on firms' performance. Martin et al (2011) also find that the inclusion of competition does not change the effect of localization economies. In our case, however, competition seems an important confounding factor in agglomeration economies, particularly for localization economies. Meanwhile, we also find that both road-building and competition are positively associated with productivity growth.

Lastly, to test the role of trade and foreign investment in facilitating agglomeration economies, we split the sample into exporters vs. non-exporters, and into foreign-invested vs. domestic firms. The results suggest that exporters and foreign-invested firms benefit more from localization externalities than do their non-exporting and domestically-financed counterparts. This result emphasizes the importance of export processing zones and hi-tech industrial zones (which have a high concentration of foreign investment) in formulating local industrial clusters.

The rest of the paper is organized into five sections. Section 2.2 discusses the theoretical model, moving from theory to empirics. Section 2.3 then describes the data and defines key variables. Section 2.4 details empirical strategies. Section 2.5 presents results based on the baseline model and also on alternative specifications. Section 2.6 concludes the paper.

2.2 The Model: from Theory to Empirics

A natural way to evaluate the impact of agglomeration economies on firm's productivity is to estimate the classic Cobb-Douglas production function, treating agglomeration economies as external shifters of an establishment's production function and assuming agglomeration economies are Hicks Neutral[14]. Specifically, we write a firm's production function as the following,

$$Y_{ijrt} = A_{ijrt} L_{ijrt}^{\alpha_l} K_{ijrt}^{\alpha_k} M_{ijrt}^{\alpha_m} \quad (2.1).$$

[14] In section 5.5, we relax the Hicks Neutrality assumption and allow agglomeration economies to interact with input variables.

Y_{ijrt} is output of establishment i operating in sector j and region r at time t. $L_{ijrt}, K_{ijrt}, M_{ijrt}$ represent a set of traditional inputs: labor, capital, and intermediate input. A_{ijrt} is firm-level TFP (firm-specific index of Hicks neutral technical progress). α_l, α_k, and α_m are input shares for labor, capital, and materials respectively.

We further define the firm-level productivity as a function of agglomeration variables, competition, transport infrastructure, firm-level controls, and a vector of industry, city, and time components:

$$A_{ijrt} = Agglomeration_{ijrt}^{\beta_1} Competition_{jrt}^{\beta_2} Transport_{rt}^{\beta_3} C_{ijrt}^{\beta_4} E_i E_{jt} E_{rt} E_t \text{ (2.2).}$$

We follow Martin et al (2011) to incorporate competition to test Porter's (1989) idea about competition and agglomeration: competition stimulates innovation so that more intense competition within clusters improves firms' performance (Porter, 1998). There are also many theoretical and empirical works showing that competition has a positive impact on firm performance. In addition, transportation infrastructure, particularly road building, has been proposed as an important omitted variable when assessing the effect of agglomeration economies on firm performance. Meanwhile, a number of empirical studies have shown the impact of transport infrastructure improvements on productivity (Fernald (1999); Donaldson (2008)). Thus, it is important to separate these two important confounding factors from agglomeration economies.

Taking log transformation of equation (2.1) and (2.2), we obtain the following,

$$lnY_{ijrt} = lnA_{ijrt} + \alpha_l lnL_{ijrt} + \alpha_k lnK_{ijrt} + \alpha_m lnM_{ijrt}$$

$$\Rightarrow lnA_{ijrt} = lnY_{ijrt} - \alpha_l lnL_{ijrt} - \alpha_k lnK_{ijrt} - \alpha_m lnM_{ijrt} \text{ (2.3).}$$

$$lnA_{ijrt} = \beta_1 \ln{(Agglomeration)_{ijrt}} + \beta_2 ln(Competition)_{jrt} + \beta_3 \ln{(Transport)_{rt}}$$

$$+ \beta_4 lnC_{ijrt} + e_i + e_{jt} + e_{rt} \text{ (2.4)}$$

Thus, the TFP (A_{ijrt})[15] is indeed the residual after excluding the effects of inputs from output. C_{ijrt} indicates a vector of firm-level characteristics, which include foreign share and state share. State share is defined as the proportion of the firm's state assets to its total equity; foreign share is defined as the share of the firm's assets contributed by foreign investors[16]. Due to the construction of the variables, foreign share and state share lie between 0 and 1. e_i is firm-specific effect and e_{jt} and e_{rt} are industry*time effects and city*time effect respectively. Based on equation (2.3) and (2.4), the estimation strategy begins by obtaining an unbiased estimation of firm-level TFP. Rather than doing a simple OLS estimation of equation (2.3), our results are based on the Olley-Pakes (1996) method,

[15] As addressed by earlier concerns raised by Gorodnichenko (2007) and Foster et al (2008), this firm-level technology term might be interpreted more broadly as revenue generating ability.

16 Here, we define "foreign" as the region of Hong Kong (SAR of China), Macau (SAR of China), Taiwan (China), and foreign countries, mainly OECD countries.

which is detailed in section 2.4.1. In the second stage, we regress firm-level TFP on agglomeration variables and on other controls.

2.3 Data and Variables

Section 2.3.1 discusses the data we use, while Section 2.3.2 shows the construction of the key variables. Section 2.3.3 presents the summary statistics of the key variables.

2.3.1 Data

The main dataset employed for the analysis was collected by the Chinese National Bureau of Statistics. The Statistical Bureau conducts an annual survey of industrial plants, which includes manufacturing firms as well as firms that produce and supply electricity, gas, and water. It is based at the firm-level and includes all state-owned enterprises and non-state-owned firms with annual sales of more than 5 million Yuan[17]. It is a ten-year unbalanced panel dataset, covering the period from 1998 to 2007. The number of firms per year varies from a low of 162,033 in 1999 to a high of 336,768 in 2007. The sampling strategy is the same throughout the sample period (all firms that are state-owned or have sales more than 5 million yuan are selected into the sample); the variation in the numbers of enterprises across years may be driven by a change in ownership classification or a decrease in sales volume to a level below the 5 million yuan threshold. The dataset contains information on output, fixed assets, total workforce, total wages, intermediate input costs, foreign investment, sales revenue, and export sales. The data also include information on industry classification (Chinese Industry code at 4-digit level), and firm's location (administrative county code at 6-digit level).

The original dataset includes 2,226,104 observations and contains identifiers that can be used to track firms over time. Since the study focuses on manufacturing firms, we eliminate non-manufacturing observations. The sample size is further reduced by deleting missing values, as well as observations with negative or zero values for output, number of employees, capital, and inputs, leaving a sample size of 1,842,786. Due to incompleteness of information on official output price indices, three sectors are dropped from the sample[18]. Thus, our final regression sample size is 1,542,797.

To take into account transport infrastructure, we incorporate the use of a geographic information systems (GIS) dataset on the Chinese road network, which was obtained from the Australian Consortium for the Asian Spatial Information and Analysis Network (ACASIAN; www.asian.gu.edu.qu). The base network consists of 20,899 line segments with attribute information indicating the type of road represented by each link. After including the expressway network, the complete database was 31,538 segments. The data on National Expressway Network (NEN) are provided for the years 1998, 2002, 2005, and 2007; this will allow us to track the development of NEN over our sample period. Figure 2.1 shows the expressway network completed by the end of 1998, 2002, 2005, and 2007,

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17 The current exchange rate between US dollars and Chinese Yuan is around 6.3. Therefore, 5 million yuan is roughly equal 790,000 dollars.

18 They are the following sectors: processing food from agricultural products; printing and reproduction of recording media; and general purpose machinery.

respectively. As we can see from the maps, the NEN experienced tremendous development over the sample period. In the late 1990s, the NEN was mostly concentrated at the region level (within provinces). By 2007, most coastal cities and cities in the central area have been connected by the NEN. We merge the two datasets based on administrative county codes. A detailed discussion on the NEN project is introduced in section 2.4.2.

2.3.2 The Variables

Following Martin, Mayer and Mayneris (2011), we define measures of agglomeration economies as follows.

Localization economies: to deal with intra-industry externalities, we define, for each firm, the number of other employees working in the same industry in the same area. In math,

$$loc_{ijrt} = \ln\left(employees_{jrt} - employees_{ijrt}\right).$$

Again, index i, j, r, t, represents firm, sector, county, and time respectively.

Urbanization economies: to capture the scale of economic activity outside own industry. Mathematically, we have

$$Urb_{jrt} = \ln\left(employees_{rt} - employees_{rjt}\right).$$

Theory suggests that firms in the same industry that are subject to localization economics will cluster together; empirical evidence supports the notion of spatial clustering of like activity (Ellison and Glaeser 1997). The earliest precise discussion of the microfoundations of agglomeration stemming from localization is in Marshall (1920). Famous modern examples of highly localized industries include computers (Silicon Valley; Route 128 in Boston) and carpets (Dalton, Georgia). There are also less well-known concentrations, such as furniture manufacturing in High Point North. An equally influential discussion of microfoundations related to the industrial scope of spatial concentration is found in Jacobs (1969). In contrast to Marshall's treatment of urban specialization, Jacobs stresses the importance of urban diversity. Her argument is that diversity fosters cross-fertilization of ideas.

In addition to two agglomeration variables, we also control for competition on the right-hand side. We use the inverse of Herfindahl index as a measure of the competition effect. The Herfindahl index of industry j, region r, time t is defined as below,

$$Competition_{jrt} = \ln\left(\frac{1}{Herf_{jrt}}\right), \text{where } Herf_{jrt} = \left(\frac{Sales_{ijrt}}{Sales_{jrt}}\right)^2.$$

Lastly, we define transport infrastructure "*Road*" as a dummy variable, which equals one if the city (or county) r is connected by the NEN or zero otherwise. Our baseline estimation equation is the following,

$$lnTFP_{ijrt} = \beta_1 \ln(Loc)_{ijrt} + \beta_2 \ln(Urb)_{jrt} + \beta_3 \ln(Comp)_{jrt} + \beta_4 \ln(Road)_{rt}$$
$$+\beta_5 lnC_{ijrt} + \alpha_i + \alpha_{jt} + \alpha_{pt} + \varepsilon_{ijrt} \quad (2.5).$$

α_i is the firm fixed-effect, α_{jt} and α_{pt} indicate industry * year and province * year effects respectively. Before going further, let us clarify the sector and region categories on which we focus in this paper. There are three levels of industry categories: 2-digit, 3-digit, and 4-digit. There are also three levels of administrative divisions: province, prefecture-level city (city for short), and county. We calculate agglomeration variables at four levels: 2-digit/city, 3-digit/city, 2-digit/county, and 3-digit/county. The results are quantitatively similar across different levels. In the rest of the paper, we present the results using 3-digit/city level.

2.3.3 Summary Statistics

Table 2.1.1 reports the summary statistics for the main variables used in the regressions. The summary statistics indicate the mean of the ratios, which is different than weighted means which would give more weight to larger firms. First note that most variables exhibit strong variability, as shown by the large values of standard deviations respective to their mean. In Table 2.1.2, we represent the descriptive statistics of the key variables for the year of 1998, 2002, 2005, and 2007. Moving from the left to the right part of the table, we observe that average real output, materials, and productivity are growing over time. The growth rate of real output, materials, and productivity are 9%, 5%, 29% between the year of 2007 and the year 1998, respectively. Labor input is declining over time and net capital stock stays at the same level between the last and the initial year. Both "*Localization*" (tripled between 2007 and 1998) and "*Urbanization*" (doubled between 2007 and 1998) are growing rapidly over time. This result must be driven by the increase in the number of firms, because the average employment declines during the sample period. Local competition also increased; competition is three times higher between the end of period and the beginning of the period. The numbers for "*Road*" represent the percentage of firms that are covered by the NEN. By the end of the sample period, 95% of the firms have been covered by the NEN. Lastly, firm-level foreign share steadily increases over the sample period until they experience a slight decline between the year of 2005 and 2007. By contrast, firm-level state share falls significantly, from 25% in 1998 to 2% in 2007, which is due to massive privatization of state-owned enterprises during the sample period.

2.4 Empirical Strategies

2.4.1 Estimation of Firm-level Productivity

As shown in the Section 2.2, the first stage of the empirical strategy is to obtain an estimate of firm-level TFP. The earlier literature on production function estimation shows that the use of OLS is inappropriate when estimating productivity, because this method treats labor, capital, and other input variables as exogenous. As Griliches and Mairesse (1995) argue, inputs should be considered endogenous since they are chosen by a firm based on its productivity. Firm-level fixed effects will not solve the problem, because time-varying productivity shocks can affect a firm's input decisions. Therefore, the first estimation bias that we need to address is the potential endogeneity of input choice.

To solve the simultaneity problem in estimating a production function, we employ the procedure suggested by Olley and Pakes (1996, henceforth OP), which uses investment as a proxy for unobserved productivity shocks. OP address the endogeneity problem as follows. Let us consider the following Cobb-Douglas production function in logs:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \varepsilon_{it} \text{ (2.6).}$$

y_{it}, k_{it}, l_{it} , and m_{it} represent log of output, capital, labor, and materials, respectively. ω_{it} is productivity and ε_{it} is the error term (or a shock to productivity). The key difference between ω_{it} and ε_{it} is that ω_{it} affects firm's input demand while ε_{it} does not. OP also make timing assumptions regarding the input variables. Labor and materials are free variables but capital is assumed to be a fixed factor and subject to an investment process. Specifically, at the beginning of every period, the investment level a firm chooses together with the current capital value determines the capital stock at the beginning of the next period, i.e.

$$k_{it+1} = (1-\sigma)k_{it} + i_{it} \text{ (2.7).}$$

The key innovation of OP estimation is to use a firm's observable characteristics to model a monotonic function of the firm's productivity. Because the investment decision depends on both productivity and capital, OP formulate investment as follows,

$$i_{it} = i_{it}(\omega_{it}, k_{it})\text{(2.8).}$$

Given that this investment function is strictly monotonic in ω_{it}, it can be inverted to obtain

$$\omega_{it} = f_t^{-1}(i_{it}, k_{it}) \text{ (2.9).}$$

Substituting this into the production function, we get the following,

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + f_t^{-1}(i_{it}, k_{it}) + \varepsilon_{it} = \beta_l l_{it} + \beta_m m_{it} + \varphi_t(i_{it}, k_{it}) + \varepsilon_{it} \text{ (2.10).}$$

In the first stage of OP estimation, the consistent estimates of coefficients on labor and materials as well as the estimate of a non-parametrical term (φ_t) are obtained. The second step of OP identifies the coefficient on capital through two important assumptions. One is the first-order Markov assumption of productivity, ω_{it} and the other is the timing assumption about k_{it}. The first-order Markov assumption decomposes ω_{it} into its conditional expectation at time $t-1$, $E[\omega_{it}|\omega_{it}-1]$, and a deviation from that expectation, ξ_{it}, which is often referred to the "innovation" component of the productivity measure. These two assumptions allow OP to construct an orthogonal relationship between capital and the innovation component in productivity; this relationship is used to identify the coefficient on capital.

The biggest disadvantage of applying the OP procedure is that many firms report zero or negative investment. To address this problem, we construct investment using a capital accumulation equation[19], where investment at period t equals the growth of capital between t+1 and t and depreciation at period t. With the Olley and Pakes correction, we can

[19] The capital accumulation equation is given by $k_{it+1} = (1-\delta)k_{it} + i_{it} \Rightarrow i_{it} = (k_{it+1} - k_{it}) + \delta k_{it}$. Therefore, investment at period t equals to the sum of the growth of capital between t+1 and t and depreciation at period t.

get an unbiased estimate of the firm's productivity. Therefore, the independent variable becomes firm-level TFP instead of the log of output. Specifically, when using TFP as the dependent variable, this is a two-stage estimation procedure. The first step is to use OP to obtain unbiased coefficients on input variables and then calculate TFP (residual from the production function). The second step is to regress TFP on agglomeration variables and other controls.

Appendix 2.3 presents a comparison of estimated coefficients of input variables by two methods: one is OLS with firm fixed effects and year dummies and the other is the OP procedure. In the table, we show the coefficients estimated using all industries and also for each industry respectively. As it shows, the OP correction appears to be working quite well. If the procedure successfully corrects for biases, one would expect to find a decrease in coefficients on labor and material inputs and an increase in the capital coefficients relative to the OLS results. It is worth pointing out that output, capital, and material are all deflated by their respective price indices before the estimation procedure. Thus, they are quantity based rather than value based. Appendix 2.1 explains how output and input variables are obtained.

2.4.2 The Omitted Variable Problem

As Rosenthal and Strange (2004) note, agglomeration economies enhance plant productivity, but successful entrepreneurs also seek out productive locations. If overachieving entrepreneurs were disproportionately found in agglomerated areas, this would cause one to overestimate the relationship between agglomeration and productivity. A firm's location choice is affected by many firm-, industry-, and city-specific characteristics. Unfortunately, most of these characteristics are unmeasured and unobserved by an econometrician. Even worse, these unmeasured characteristics also have impacts on firm performance. Let us take the examples of climate and transport infrastructure. Places endowed with better climate and well-established transport infrastructure attract firms to locate; meanwhile, climate and transportation infrastructure also enhance firm performance.

These unobserved (or unmeasured) heterogeneity issues are very important omitted variable problems. Recall our baseline specification described in equation (2.5),

$$lnTFP_{ijrt} = \alpha_0 + \beta_1 \ln(Loc)_{ijrt} + \beta_2 \ln(Urb)_{jrt} + \beta_3 \ln(Comp)_{jrt} + \beta_4 \ln(Road)_{rt} + \beta_5 lnC_{ijrt} + \alpha_i + \alpha_{jt} + \alpha_{pt} + \varepsilon_{ijrt} .$$

A major advantage of using a firm-level panel data-set is that we are able to control for all firm-specific time-constant characteristics that potentially could bias the results. α_i is the firm fixed-effect, which absorbs any permanent heterogeneity at the firm, city, or industry level. I also add industry * year and province * year effects, indicated by α_{jt} and α_{pt} [20]. Industry * year effects absorb any industry-specific time-varying shocks that are shared by all firms in the same industry. Similarly, province * year effects absorb any province-

20 Moretti (2004) uses industry * year and state * year effects to control for industry-specific and time-varying (state-specific and time-varying) shocks.

specific time-varying shocks (part of e_{rt}). $lnTFP_{ijrt}$ is obtained from the OP procedure described in the last section.

What are examples of situations that the current approach takes into account? Consider a government policy that promotes the electronics sector nationwide. This positive shock will both promote the growth of employment in the electronics industry and improve firms' productivity. However, this kind of industry-specific variation is addressed by the inclusion of industry * time effects. Another example could be a region-specific shock. For instance, the national government promotes economic and social progress in the central and western areas by providing differential policies regarding land prices. A lower land price makes the western and the central area attractive to investors, although they are far away from ports, and major consumer markets. The inclusion of province * year dummies addresses this concern.

What are the remaining concerns? Some shocks happen at the local level, which cannot be captured by province * time effect. For instance, an update of the road network creates huge variations across cities (or counties) and time. During the period we study in China, there was tremendous improvement in transport infrastructure. A number of existing studies have emphasized that transport infrastructure is an important omitted variable when assessing the impact of agglomeration economies on firm performance. The road condition in a city or county is an important factor when firms consider opening a factory or moving their plants there (Ciccone and Hall (1996), Holl 2004). The improvement in road infrastructure might also change the structure of industrial production distribution because it shortens the travel time between two cities, so that it is not as important for firms to locate near markets or source of inputs.

Between 1990 and 2005, China invested approximately US$600 billion, or US$40 billion per year, to upgrade its road system. The centerpiece of this massive infrastructure program was the building of a 41,000 kilometer National Expressway Network (NEN; World Bank 2007). This highway network, which is second in length only to the US Interstate Highway System, is designed to eventually connect all cities of more than 200,000 people[21] and its construction has formed an important part of China's national development strategy. Along with trade facilitation, one of its goals has been to promote the faster development of China's poorer inland regions, thereby helping them their catch

21 On Jan 13, 2005, it was announced by Zhang Chunxian, minister of communications, that China would build a network of 85,000 km of expressways over the next three decades, connecting all provincial capitals and cities with a population of over 200,000.

up with more prosperous coastal areas[22]. This aim has come to be seen as increasingly pressing in Chinese policy discourse in light of wide and growing regional disparities[23].

The national expressway network (NEN) is also known as National Trunk Highway System (NTHS). The total length of China's expressways was 74,000 kilometers (46,000 miles) at the end of 2010, the world's second longest, after the United States and slightly longer than the total expressway length in the European Union. Expressways in China are a fairly recent addition to a complex network of roads. China's first expressway was built in 1988. Until 1993, very few expressways existed. At the beginning of 1998, the total length of the network was 8,978 kilometers (5,611 miles); the ten years starting in1998 witnessed a more than five-fold increase in mileage. By the end of 2007, the total length of the network was 55,571 kilometers (34,731 miles). Figure 2.1 shows the expressways network completed by the end of 1998, 2002, 2005, and 2007 respectively. As we can see from the maps, the NEN experienced tremendous development over the sample period. In the late 1990s, the NEN was mostly concentrated at the region level (within provinces). By 2007, most coastal cities and cities in the central area had been connected by the NEN.

As described in equation (2.5), to further address the omitted variable problem, we include road infrastructure (which is usually omitted from existing studies on agglomeration economies) as an additional independent variable. *Road* is defined as a dummy variable taking value of one if the city r is connected by the NEN at time t and zero otherwise. In addition to the NEN, we also have information on other kinds of roads (such as provincial highways and local roads). However, in the data, these road networks do not experience changes during our sample period. With the firm fixed effect approach, they essentially will be dropped from the regression. To control for firm-specific heterogeneity, we also include a vector of time-varying firm-level characteristics, represented by C_{ijrt}.

2.5 Results

2.5.1 Baseline Results

Table 2.2 presents results based on equation (5). From column (1) to column (6), we gradually add additional controls to see how stable the coefficients on agglomeration variables are. In column (1), we only include "*localization*" and firm-level controls: state share and foreign share. To take into account different roles played by sources of foreign investment, we further divide firm-level foreign share into two types: foreign investment

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22 "In the light of the national development strategy, planning and building a national expressway network will facilitate the establishment of a unified market in the country, thus promoting commodities and various other resources to flow and compete freely around the country, which is of great importance in narrowing down the development gaps between different regions, increasing job opportunities and pushing the development of related industries. Based on a summary of the experiences of economic and social development in the developed countries, the national expressway network plan is an urgent need for the building of an all-around well-off society and for the realization of modernization….." (http://www.crcc.cn/536-1712-4102.aspx.)

23 Roberts, Deichmann, Fingleton, and Shi (2010) use the dataset on the NEN to evaluate its short-run impacts on China's aggregate economic activity and regional disparities. They find that aggregate Chinese real income was approximately 6 percent higher than it would have been in 2007 had the expressway network not been built.

contributed by investors from Hong Kong (SAR of China), Taiwan (China), and Macau (SAR of China) and that contributed by investors from other foreign countries (mostly Organization and Economic Co-operation and Development (OECD))[24]. After controlling for firm fixed-effects, industry*time effects, and province*time effects, the results show that the coefficient on "*localization*" is positive and significant, indicating that the growth of workers locating in the same industry (within the same city) is associated with increasing productivity. As we expected, foreign investment originating outside of Hong Kong, Taiwan, and Macau generates greater productivity improvement. By contrast, the results on "*state share*" show that increasing the share of state assets to firm's total equity is negatively associated with productivity.

In column (2), we include "*urbanization*" and find that an increase in the number of workers in other industries (within the same city) reduces firm-level TFP. The coefficients and signs on other variables stay the same. In column (3), to test Porter's idea about competition and agglomeration, we introduce "*competition*" into the estimation equation. The results show that the inclusion of "*competition*" reduces the coefficient of "*localization*" by 40% (the point estimate of the coefficients on "*localization*" changes from 0.022 to 0.013) and the effect of urbanization economies remains. Therefore, at least for China, competition is one important confounding factor to separate from agglomeration economies. Otherwise, the role of agglomeration economies will be mis-measured, mistakenly attributing much of the benefit of clustering to agglomeration when in fact there were significant gains from increasing competition. What's more, our results show that the coefficient on "*competition*" is positive and statistically significant, suggesting that more competition is associated with TFP improvement.

In column (4), we exclude "*competition*" but add "*road,*" holding everything else the same. As previous studies emphasize that transport infrastructure is an important omitted variable when assessing the impact of agglomeration economies on firm performance, we should expect a lower effect of localization and urbanization economies after taking into account "road." However, surprisingly, we find that the inclusion of transport infrastructure does not make the coefficient on "localization" lower (the coefficient on "urbanization" also stays at the same). In Appendix 2.4, we show the correlation between "*road*" and "*logLoc*" is about .3. One possible explanation is that this specific road building project is focusing on the promoting the faster development in China's poorer inland regions, where the concentration of manufacturing activities is low. However, "*road*" does have an independent effect on TFP improvement. In column (6), to test the robustness of the results, we replace contemporary "road" with lagged "road" and find the results are consistent. The point estimate on "*localization*", at 0.014, indicates that a standard deviation with respect to the mean of the number of employees in the other plants from the same industry-city is associated with a 1% increase of firm-level productivity.

[24] The motivation for separating foreign share into two types is two-fold. First, we would like to see whether some types of foreign investment are more likely to result in productivity improvement than others. Second, anecdotal evidence suggests that large number of so-called foreign investors in China are actually domestic investors who channel investment through Hong Kong in order to take advantage of special treatment for foreign firms (so-called "round tripping"). If this is the case, then we would expect that foreign investment of this type might have a smaller impact on domestic firms (Du, Harrison, Jefferson 2011).

Compared to Henderson (2003) and Martin et al (2011), our study provides both similar finding and new evidence. Similar to previous studies, we find that localization economies are the only persistent source of agglomeration externalities. To test Porter's (1998) idea about agglomeration and competition, Martin et al (2011) first introduce competition and find that competition has zero effect on firms' performance. Also, the inclusion of competition does not change the effect of localization economies. In our case, however, competition seems an important confounding factor in agglomeration economies, particularly for localization economies. This could be due to continuing high barriers to entry from imports during the sample period or to the fact that China is larger country, or that factor mobility is limited throughout the country.

In Table 2.3, we allow competition to enter non-parametrically. Column (1), (2), and (3) of Table 3 replicate the results in column (3), (5), and (6) in Table 2.2, respectively. The first finding to emphasize is that the estimates of agglomeration economies remain after quadratic and cubic terms of competition enter the estimation equation. Second, there is a positive and significant coefficient (around 0.03) on the quadratic term of competition and a negative and significant coefficient (-0.003) on the cubic term of competition; this suggests that the relationship between firm productivity and competition is non-linear. Specifically, more competition is good for productivity improvement at the beginning but after a certain point, the net effect of competition becomes negative[25].

2.5.2 Who Generates Localization Economies?

In this section, we would like to test whether the localization externalities come from, firms or employees. Theory offers several possible channels for localization economies. A notable alternative is whether externalities transit through firms or workers. For a firm, is it the same to have in the neighborhood one firm in the industry with a hundred employees or ten firms, each of them employing ten workers? The question has important policy implications regarding industrial clusters: the answer determines whether an extensive or an intensive development strategy is preferable (Martin et al 2011). To test whether localization economies transit through firms or workers, we decompose "*localization*" into two parts: number of other firms located in the same industry-city cluster and average employment within the same industry-city classification. The results are presented in Table 2.4.

Henderson (2003) finds that localization economies arise specifically from the count of own industry plants, not from the local scale of own industry employment. If we consider each plant as a source of knowledge, Henderson's finding supports the importance of information spillover. In contrast to Henderson (2003)'s results, Martin et al (2011) suggest that the number of employees is a better predictor than the number of plants, which points to an interpretation under which localization economies are due to the "thickness" of the industry around the plant.

[25] Aghion et al (2005) investigates the relationship between product market competition and innovation using a flexible nonlinear estimator. We find evidence that the competition innovation relationship takes the form of an inverted-U shape, with industries distributed across both the increasing and decreasing sections of the U-shape.

Our results shown in Table 2.4 suggest that localization economies transit through firms. Table 2.4 replicates the results in Table 2.2 but decompose "*localization*" into "*logNumfirms*" and "*logAvgEmployment*". The coefficient on "*logNumfirms*" is positive and significant but the effect of average employment on firm's productivity is almost zero. These differences are statistically significant, as indicated by the formal tests of equality reported at the bottom of Table 2.4. Our results have interesting policy implications; they suggest that boosting externalities within clusters involves multiplying the number of firms rather than promoting the internal growth of existing plants or attracting big plants. This may suggest the potential importance of smaller firms in generating localization externalities.

2.5.3 Do Similar Industries Generate Different Externalities?

In Table 2.2, we find that increases in the scale of economic activities outside the same industry (namely urbanization economies) are negatively associated with firm-level TFP. Rosenthal and Strange (2004) point out that one disadvantage of measurement of urbanization economies is that the definition of "all other industries" is too broad; it is difficult to figure out which industries (such as upstream, downstream, similar industries) dominate the aggregate effect. To shed light on their concerns, I decompose "other industries" into two parts: similar industries and completely different industries. For example, "electronics-computers" is similar to "electronics-elements and devices," but cotton textile is a distinct industry from electronic elements and devices.

The results in Table 2.5 show that both similar industries and different industries generate negative effect on firms' productivity; however, the point estimates of the negative effect of "*logUrb_similar*" are half the magnitude of the negative effect of "*logUrb_diff*". The formal tests of equality presented at the bottom of Table 2.5 verify that the differences between similar and completely distinct industries are statistically significant. Our results suggest that the aggregate negative effect of urbanization economies is dominated by dissimilar industries. For instance, the increases in the employment in textile sector hurts more to productivity of firms that are producing electronic device; however, adding more workers producing computers within the cluster hurts less.

2.5.4 Do Exporters and Foreign-invested Firm Perform Differently?

Since opening its economy to the outside world in late 1978, the state government has intervened extensively to promote industrialization in China, by encouraging participation in trade, attracting foreign direct investment, building all kinds of economic zones, and so on. Openness to international trade and foreign investment are two important policy instruments in the economic transformation of China. Economic Zones played a key role for promoting trade, attracting foreign direct investment, catalyzing development of industrial clusters, and acting as test sites for economic reforms. Exposure to trade and foreign investment helps firms absorb the benefits from agglomeration economies, because they stimulus technology transfer and promote inter-firm trade and collaboration in the exporting activities.

In this section, we take into account heterogeneity of firms in their capacity to absorb agglomeration externalities. We do this by splitting the full sample into exporters vs. non-exporters[26], and into foreign-invested and domestic firms[27]. The motivation is two-fold. First, as discussed at the beginning of this section, openness to trade and attraction of foreign investment have played a key role in fostering industrial clusters; we would like to see if exporter or foreign-invested firms perform differently than their non-exporting and domestic counterparts in absorbing the benefits of agglomeration economies. Second, we want to test whether the key evidence found in the baseline regressions is dominated by certain groups of firms.

Panel A of Table 2.6 replicates the baseline results using the sample of exporters; Panel B is based on the sample of non-exporters. The comparison of the two panels suggests the following patterns. First, exporters in general benefit more from localization externalities than do their non-exporting counterparts. Take column (6) as an example. The point estimates of "*localization*" for exporters are five times larger than the point estimates for non-exporting firms, respectively 0.03 and 0.006; we also implement the cross-equation test, and the *F*-statistics show that the differences are statistically significant. Second, exporters are less sensitive to the inclusion of competition. Comparing column (2) with column (3) in Panel A of Table 2.6, the coefficients on "*localization*" stay at the same level. On the other hand, in Panel B, from column (1) to (3), we observe a large decline of the localization effect after competition is introduced. What's more, the coefficient on "*competition*" for non-exporting firms is 0.06, relative to 0.036 for exporting firms. This suggests that competition is associated with an improvement in productivity that is twice as great for non-exporters. Third, the inclusion of "*road*" does not change the magnitude of "*localization*" in either of the samples. However, after splitting the sample between exporters and non-exporters, access to roads is associated with an improvement in productivity only for non-exporters.

Results in Table 2.7 show similar patterns. First, foreign-invested firms benefit more from localization economies than do their domestic counterparts. In column (5), the point estimate on "*localization*" for foreign-invested firms is 0.03, relative to 0.008 for domestic firms. Second, in the sample of foreign-invested firms, the magnitude of localization economies does not change after competition is included. In Panel A, from column (2) to (3), the coefficients on "*localization*" move from 0.047 to 0.034; the coefficients on "*localization*" reduce from 0.019 to 0.007 from column (2) to (3) in Panel B. Similarly, competition generates a stronger effect on productivity improvement for domestic firms, but the difference between foreign-invested and domestic firms is smaller than the difference between exporting and non-exporting firms. Lastly, road building is positively associated with productivity improvement only for domestic firms.

The finding summarized above provides empirical justification for promotion of cluster policies for exporters and foreign-invested firms. The fact that exporting and foreign-

26 We define a dummy variable, which equals one if firm's export value is greater than zero at time t, and zero otherwise. Then, we split the sample into two parts: exporter and non-exporters.

27 There are different thresholds to distinguish between foreign-invested from domestic firms. Here, we define domestic firms as those firms that have zero foreign assets and foreign-invested firms as those that have foreign assets greater than zero.

invested firms benefit more from industrial clusters emphasizes the importance of export processing zones and Hi-tech industrial development zones. The evidence, which is that competition does not reduce the magnitude of localization externalities generated by exporters and foreign-invested enterprises, suggests that both exporting and foreign-invested firms are sufficiently exposed to competition globally. Consequently, domestic competition matters more for non-exporters and domestic firms. Furthermore, to improve the productivity growth of domestic and non-exporting firms, policies that increase local competition are more important than policies that promote agglomeration economies.

2.5.5 Other Production Function Specifications

In this section, we relax the Hicks Neutrality assumption to allow localization economies to interact with input variables. Agglomeration economies are generally assumed to improve TFP through localization economies and urbanization economies, but they could also affect factor prices. The estimation equation becomes the following,

$$lnY_{ijrt} = \alpha_l lnL_{ijrt} + \alpha_k lnK_{ijrt} + \alpha_m lnM_{ijrt} + \gamma_1 lnL_{ijrt} * \ln{(Loc)_{ijrt}} + \gamma_2 lnK_{ijrt} * \ln(Loc)_{ijrt} + \gamma_3 lnM_{ijrt} * \ln(Loc)_{ijrt} + \beta_1 \ln(Loc)_{ijrt} + \beta_2 \ln(Urb)_{jrt} + \beta_3 \ln{(Comp)_{jrt}} + \beta_4 \ln{(Road)_{rt}} + \beta_5 C_{ijrt} + \alpha_i + \alpha_{pt} + \alpha_{jt} + \varepsilon_{ijrt} \quad (2.11)$$

Table 2.8 shows results based on equation (2.11). Comparing coefficients on labor, capital, and materials in Table 2.8 with those in Appendix 2.3, we find that labor share is cut in half (from 0.09 to 0.04) but estimated coefficients on capital and materials remain the same. This suggests that localization does reduce labor share, as the competition reduces rents to workers. The effects on localization economies are quantitatively similar to the baseline results.

2.6 Conclusions

Compared to previous work on agglomeration economies, the focus of this paper is on the importance of omitted variable bias in estimating the impact of agglomeration economies. Specifically, we separate the effect of agglomeration economies on TFP from the potential benefits from more competition and better transport infrastructure. Across different specifications, we find that TFP is improved only by the presence of other firms in the same sector (localization economies). The inclusion of information on road construction does not affect the importance of pure localization economies. However, including a measure of competition in the estimation significantly reduces the importance of localization externalities. To explore the role of trade and foreign investment, we split the sample into exporters vs. non-exporters, and foreign-invested vs. domestic firms. The results on sub-samples indicate that exporter and foreign-invested firms benefit more from localization externalities than do their non-exporting and domestic counterparts. The results also suggest that positive and significant effects of road-building and competition on productivity growth are stronger for domestic firms.

Aside from its academic interest, the analysis of agglomeration economies has potentially important policy implications. Our analysis provides empirical evidence regarding why government intervention is important in fostering industrial clusters and how the central and local governments can promote growth through agglomeration economies. Agglomeration brings private costs to individual firms because agglomeration increases competition. Competition has tremendous social benefits but it also hurts firms' profits. Although firms benefit from agglomeration externalities (such as knowledge spillovers), firms would rather locate in less competitive areas. Therefore, the level of agglomeration is not at its social optimum if firms make individual decisions about clustering. To maximize the social benefits of agglomeration externalities, policy interventions are necessary.

Our results indicate that exporting and foreign-invested firms are more likely to choose to agglomerate without policy interventions. For domestic firms, however, the benefits from localization economies are weakened by increasing competition within the clusters. To encourage domestic firms to cluster, government should subsidize them more. Our results also indicate that simply investing in roads is insufficient to generate the full benefits of agglomeration; as a result, a direct subsidy-oriented approach may be necessary. Given the results on sub-samples, in order to promote productivity growth, the government should encourage exporting and foreign-invested firms to cluster, particularly firms that produce the same or similar products. But the message is different for domestic and non-exporting firms. Compared to exporting and foreign-invested firms, competition creates higher productivity growth than localization economies. Thus, to promote growth of domestic firms, policies that reduce entry barriers to a sector or encourage more firms to enter would be important.

Some issues remain unanswered in this paper but are worth pursuing. For instance, what is the role that local governments play in formulating industrial clusters? In field trips conducted in the Beijing, Shanghai, and Yunnan province, we learned that local governments have played important roles in fostering industrial clusters. To promote economic growth (and thereby achieve certain political goals), local governments aggressively accelerate the industrialization process by adopting preferential policies for particular industries (imitating successful experiences in neighboring counties or determined by local natural resources). For example, Wuxi in Jiang Su province promoted solar energy related industries and Su Zhou in Jiang Su province supported the electronic device industry. These are very interesting and special phenomena in the Chinese economy, but beyond the scope of this study. We believe that, given a similar environmental endowment (such as natural resources, labor force, infrastructure, and market accessibility), local industrial policies and local leadership are important as complementary policies to help foster industrial clusters.

References

[1] Aghion, P., Bloom, N., Blundell, B., Griffith, R., and Peter, H. (2005) Competition and Innovation: An Inverted-U Relationship. The Quarterly Journal of Economics, Vol. 120: 701-728.

[2] Ciccone, A. (2002) Agglomeration Effects in Europe. European Economic Review, Vol. 46: 213-227.

[3] Ciccone, A. and Hall, R. (1996) Productivity and Economic Density. The American Economic Review, Vol. 86: 54-70.

[4] Combes, P.-P., Duranton, G., Gobillon, L. (2011) Identification of agglomeration economies. Journal of Economic Geography, Vol. 11: 253-266.

[5] Combes, P. –P., Durantoon, G., Gobillon, L. (2008) Spatial wage disparities: Sorting Matters!. Journal of Urban Economics, Vol. 63: 723-742.

[6] Combes, P. –P., Durantoon, G., Gobillon, L., Roux, S. (2010) Estimating agglomeration effects with history, geology, and worker fixed-effects. In E. L. Glaeser (ed.) The Economics of Agglomeration. Cambridge, MA: National Bureau of Economic Research.

[7] Du, L., Harrison, A., Jefferson, G. (2011) Do Institutions Matter for FDI Spillovers? The Implications of China's "Special Characteristics". NBER Working Paper 16767

[8] Ellison, Glenn., and Glaeser, Edward. (1997) Geographic Concentration in U.S. Manufacturing Industries: A Dartboard Approach. Journal of Political Economy, Vol. 105: 889-927.

[9] Ellison, Glenn., Glaeser, Edward., and Kerr, William. (2009) What Causes Industry Agglomeration? Evidence from Coagglomeration Patterns. NBER Working paper.

[10] Fernald, John. (1999) Roads to Prosperity? Assessing the Link between Public Capital and Productivity. The American Economic Review, Vol. 89: 619-638.

[11] Foster, Lucia., John, Haltiwanger., and Chad Syverson. (2008) Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability? The American Economic Review, Vol. 98 (1): 394-425

[12] Hansen, Eric R. (1990) Agglomeration Economics and Industrial Decentralization: The Wage-Productivity Trade-Offs. Journal of Urban Economics, Vol. 28: 140-59.

[13] Henderson, John. (1986) Efficiency of Resource Usage and City Size. Journal of Urban Economics, Vol. 19: 47-70.

[14] Henderson, John. (1997) Externalities and Industrial Development. Journal of Urban Economics, Vol. 35: 83-104.

[15] Henderson, John. (2003) Marshall's Scale Economies. Journal of Urban Economics, Vol. 53: 1-28.

[16] Holl, A. (2004) Transport Infrastructure, Agglomeration Economies, and Firm Birth: Empirical Evidence from Portugal, Journal of Regional Science, Vol. 44: 693-712.

[17] Griliches, Zvi and Mairesse, Jacques. (1995) Production Functions: The Search for Identification. National Bureau of Economic research (Cambridge, MA) Working Paper No. 5067.

[18] Levinsohn James., and Petrin, Amil. 2003. "Estimating Production Functions Using Inputs to Control for Unobservable." Review of Economic Studies, Vol. 70: 317-41.

[19] Martin, Philippe, Mayer, T., and Mayneris, F. (2011) Spatial Concentration and Firm-level Productivity in France. Journal of Urban Economics, Vol. 69: 182-195.

[20] Mion, G., Naticchioni, P. (2009) The spatial sorting and matching of skills and firms. Canadian Journal of Economics, Vol. 42: 28-55.

[21] Montolio, D. and Sole-Olle, A. (2009) Road Investment and Regional Productivity Growth: The Effects of Vehicle Intensity and Congestion. Papers in Regional Science, Vol. 88: 99-118.

[22] Moretti, E. (2004) Workers' Education, Spillovers, and Productivity: Evidence from Plant-Level Production Function. The American Economic Review, 94: 656-690

[23] Olley, Steven., and Pakes, Ariel. (1996) The Dynamics of Productivity in the Telecommunications Equipment Industry. Econometrica, Vol. 6: 1263-1297.

[24] Porter, M. (1998) Clusters and Competition: New Agendas for Companies, Governments, and Institutions. In On Competition, Harvard Business School Press.

[25] Roberts, M., Deichmann, U., Fingleton, B., and Shi Tuo. (2010) On the Road to Prosperity? The Economic Geography of China's National Expressway Network. Policy Research Working Paper 5479, The World Bank

[26] Rosenthal, Stuart., and Strange, William. (2001) The Determinants of Agglomeration. Journal of Urban Economics, Vol. 50: 191-229.

[27] Rosenthal, Stuart., and Strange, William. (2003) Geography, Industrial Organization, and Agglomeration. The Review of Economics and Statistics, Vol. 85: 377-393.

[28] Rosenthal, S.S., Strange, W.C. (2004) Evidence on the nature and sources of agglomeration economies. In: Henderson, J.V., Thisse, J.F. (Eds.), Handbook of Regional and Urban Economics, Vol. 4: 2119–2171.

[29] Rosenthal, S. S., Strange, W. C. (2008) The attenuation of human capital spillovers. Journal of Urban Eocnomics, Vol. 64: 53-82.

[30] Rosenthal, S.S., Strange, W.C., (2010) Small establishments/big effects: agglomeration, industrial organization and entrepreneurship. In: Agglomeration Economics. NBER Chapters. National Bureau of Economic Research, Inc., pp. 277–302.

Appendix

Appendix 2.1 Input variables

Y_{ijrt} is the quantity produced by firm i in sector j at city r at time t. It is calculated by deflating the output value (quantities*prices) by the sector-specific ex-factory price index of industrial products in order to separately identify quantity. K_{ijt}, capital, is defined as the value of fixed assets, which is deflated by the fixed assets investment index, and L_{ijt} is the total number of employees. M_{ijt} represents the intermediate inputs purchased by firms to use for production of final products, which is deflated by the intermediate input price index. Sector-specific ex-factory price indices for industrial products came from China Urban Life and Price Yearbook (2008, Table 4-3-3). The price indices are published for 29 individual sectors. Price indices for fixed investment and industry-wide intermediate inputs are obtained from the Statistical Yearbook (2006) (obtained from the website of the National Bureau of Statistics of China). Due to incompleteness of information on official output price indices, processing food from agricultural products (industry code 1-6); printing, reproduction of recording media (industry code 21); and general purpose machinery sectors (industry code 49-51) are dropped from the sample.

Appendix 2.2 Industry Code

1	Grain mill products
2	Forage
3	Vegetable oid refining
4	Sugar manufacturing
5	Slaughtering and meat processing
6	Fish and fish productions
7	All other food manufacturing
8	Wines, spirits and liquors
9	Soft drink and other beverage
10	Tobacco products
11	Cotton textiles
12	Woolen textiles
13	Hemp textiles
14	Textiles productions
15	Knitted and crocheted fabrics and articles
16	Wearing apparel
17	Leather, fur, down and related products
36	Plastic products
37	Cement, lime and plaster
38	Glass and glass products
39	Pottery, china and earthenware
40	Fireproof materials
41	Other nonmetallic minetal products
42	Iron-smelting
43	Steel-smelting
44	Steel pressing
45	Alloy iron smelting
46	Nonferrous metal smelting
47	Nonferrous metal pressing
48	Metal products
49	Boiler, engines and turbine
50	Metalworking machinery
51	Other general industrial machiney
52	Agriculture, forestry, animal husbandry and fishing

18 Products of wood, bamboo, cane, palm, straw
19 Furniture
20 Paper and paper products
21 Printing, reproduction of recording media
22 Stationary and related products
23 Toys, sporting and athletic and recreation products
24 Petroleum and nuclear processing
25 Coking
26 Basic chemicals
27 Chemical fertilizers
28 Chemical pesticides
29 Paits, varnishes and similar coatings, printing ink and mastics
30 Man-made chemical products
31 Special chemical products
32 Chemical products for daily use
33 Medical and pharmaceutical products
34 Chemical fibers
35 Rubber products

machinery
53 Other special industrial equipment
54 Railroad transport equipment
55 Motor vehicles
56 Parts and accessories for motor vehicles and their engines
57 Ship building
58 Other transport equipment
59 Generators
60 Household electric appliances
61 Other electric machinery and equipment
62 Telecommunication equipment
63 Electronic computer
64 Other computer peripheral equipment
65 Electronic element and device
66 Radio, television and communication equipment and apparatus
67 Other electronic and communication equipment
68 Instruments, meters and other measuring eqiupment
69 Cultural and office equipment
70 Arts and crafts products
71 Other manufacturing products

Appendix 2.3 Summary of Estimated Elasticities of Input Variables

Panel A Coefficients on Input Variables Estimated by OLS with Firm FEs and Time Dummies

Sector code	All sectors	7	8	9	10	11	12	13	14	15	16	17	18
logL	0.092	0.0691	0.088	0.065	0.103	0.073	0.049	0.06	0.066	0.073	0.08	0.064	0.064
logK	0.028	0.0204	0.006	0.022	0.009	0.026	0.026	0.02	0.015	0.026	0.036	0.025	0.027
logM	0.766	0.797	0.796	0.81	0.805	0.8	0.837	0.834	0.81	0.79	0.736	0.807	0.812
Sector code	19	20	22	23	24	25	26	27	28	29	30	31	32
logL	0.099	0.068	0.095	0.096	0.094	0.025	0.061	0.073	0.135	0.088	0.087	0.061	0.077
logK	0.039	0.024	0.028	0.025	0.023	0.004	0.023	0.015	0.033	0.033	0.048	0.025	0.024
logM	0.741	0.796	0.764	0.745	0.782	0.912	0.804	0.803	0.701	0.75	0.736	0.789	0.811
Sector code	33	34	35	36	37	38	39	40	41	42	43	44	45
logL	0.09	0.053	0.087	0.1	0.073	0.118	0.057	0.062	0.073	0.044	0.037	0.055	0.044
logK	0.029	0.015	0.047	0.035	0.02	0.027	0.015	0.017	0.015	0.016	0.002	0.025	0.001
logM	0.769	0.865	0.735	0.729	0.789	0.737	0.827	0.843	0.816	0.858	0.927	0.809	0.877
Sector code	46	47	48	52	53	54	55	56	57	58	59	60	61
logL	0.079	0.092	0.103	0.081	0.105	0.11	0.089	0.115	0.124	0.076	0.113	0.075	0.097
logK	0.015	0.026	0.039	0.02	0.027	0.0002	0.01	0.039	0.003	0.029	0.033	0.018	0.032
logM	0.837	0.787	0.698	0.803	0.747	0.665	0.816	0.715	0.704	0.803	0.743	0.841	0.771
Sector code	62	63	64	65	66	67	68	69	70	71			
logL	0.14	0.134	0.265	0.153	0.157	0.142	0.142	0.147	0.068	0.059			
logK	0.015	0.032	0.059	0.04	0.03	0.022	0.022	0.022	0.021	0.023			
logM	0.73	0.766	0.557	0.696	0.715	0.619	0.676	0.69	0.777	0.807			

Panel B Coefficients on Input Variables Estimated by Olley and Pakes Method

Sector code	All sectors	7	8	9	10	11	12	13	14	15	16	17	18
logL	0.0888	0.064	0.046	0.078	0.072	0.064	0.03	0.021	0.058	0.072	0.098	0.082	56
logK	0.771	0.04	0.052	0.043	0.007	0.045	0.027	0.023	0.039	0.045	0.056	0.046	0.041

logM	0.044	0.795	0.79	0.811	0.793	0.799	0.862	0.867	0.847	0.799	0.706	0.795	0.815
Sector code	19	20	22	23	24	25	26	27	28	29	30	31	32
logL	0.111	0.057	0.091	0.113	0.129	0.047	0.043	0.037	0.118	0.084	0.125	0.054	0.08
logK	0.05	0.048	0.03	0.034	0.031	0.007	0.026	0.015	0.031	0.034	0.068	0.037	0.036
logM	0.761	0.808	0.779	0.714	0.724	0.85	0.829	0.816	0.71	0.761	0.69	0.821	0.78
Sector code	33	34	35	36	37	38	39	40	41	42	43	44	45
logL	0.087	0.054	0.093	0.126	0.029	0.131	0.068	0.035	0.045	0.041	0.039	0.044	0.03
logK	0.07	0.036	0.057	0.039	0.028	0.038	0.059	0.051	0.047	0.028	0.003	0.035	0.04
logM	0.762	0.893	0.719	0.7	0.082	0.719	0.858	0.906	0.843	0.872	0.928	0.844	0.88
Sector code	46	47	48	52	53	54	55	56	57	58	59	60	61
logL	0.086	0.126	0.116	0.05	0.08	0.035	0.024	0.116	0.067	0.079	0.101	0.111	0.12
logK	0.001	0.035	0.051	0.111	0.048	0.017	0.037	0.073	0.058	0.076	0.049	0.029	0.05
logM	0.791	0.706	0.683	0.814	0.782	0.753	0.885	0.747	0.886	0.828	0.777	0.816	0.73
Sector code	62	63	64	65	66	67	68	69	70	71			
logL	0.142	0.175	0.339	0.203	0.166	0.268	0.128	0.177	0.071	0.074			
logK	0.044	0.035	0.05	0.066	0.036	0.031	0.044	0.047	0.034	0.039			
logM	0.743	0.76	0.589	0.732	0.745	0.564	0.731	0.7	0.761	0.828			

Notes: Significance levels are ignored to save spaces. Most of them are significant at 1 percent level.

Appendix 2.4 Summary of Development of Expressway Network

	Until the end of 1998	2002	2005	2007
Length (in kilometers)	8,978	27,215	41,596	55,571

Appendix 2.5 Correlation Matrix Between Key Variables

	LogLoc	LogUrb	Comp_sales	Road
LogLoc	1			
LogUrb	0.6019	1		
Comp_sales	0.553	0.4161	1	
Road	0.2861	0.4291	0.2434	1

Tables

Table 2.1.1 Overall Summary Statistics

	Obs	Mean	Std. Dev.
logY	1,542,797	10.018	1.341
logL	1,542,797	4.809	1.151
logK	1,542,797	8.469	1.717
logM	1,542,797	9.537	1.376
TFP_OP	1,542,797	1.854	0.536
Employment	1,542,797	280	1,045
Localization: # of employees, other firms, same industry-area	1,542,797	25,557	38,937
Localization: # of firms, other industry-same area	1,542,797	114	159
Urbanization: # other employees, other industry-same area	1,542,797	561,453	549,040
Urbanization: # other firms, other industry-same area	1,542,797	1,777	1,619
Competition	1,542,797	36.883	53.111
Foreign Share_HK (contributed by HK-Taiwan-Macau)	1,542,797	0.089	0.267
Foreign Share_FR (contributed by other foreign investors)	1,542,797	0.079	0.249
State share	1,542,797	0.09	0.272

Notes: Localization is defined as, for each firm, the number of other employees working in the same industry and the same area. Urbanization captures inter-industry externalities of agglomeration economies, which is defined as the total employment of other industries within the clusters. We use the classic Herfindahl index (of industrial sales) to define industrial concentration. Competition is the inverse of the Herfindal index, with a higher value indicating more intense competition. We define firm-level foreign share according to its different sources. Foreign share contributed by HK-Taiwan-Macau is defined as the share of firms' total equity owned by investors from HK-Taiwan-Macau. Foreign share contributed by other countries is defined as the share of firms' total equity owned by investors outside HK-Taiwan-Macau, principally from OECD countries. State share is defined as the proportion of the firm's state assets to its total equity.

Table 2.1.2 Summary Statistics for the Year of 1998, 2002, 2005, and 2007

	1998		2002		2005		2007	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
logY	9.580	1.436	9.916	1.347	10.140	1.265	10.339	1.284
logL	5.030	1.237	4.915	1.135	4.755	1.106	4.659	1.097
logK	8.509	1.724	8.544	1.729	8.416	1.693	8.496	1.691
logM	9.262	1.506	9.542	1.387	9.591	1.299	9.708	1.335
TFP_OP	1.597	0.517	1.734	0.505	1.941	0.497	2.057	0.524
Employment	373	1,362	305	1,057	254	869	234	1,009
Localization	13,115	17,271	17,383	23,374	29,774	41,452	36,153	53,889
Urbanization	362,951	341,537	403,248	347,173	626,915	544,552	747,364	716,537
Competition	18.356	25.968	25.318	33.688	42.978	57.097	49.626	64.127
Road	59%		77%		90%		95%	
Foreign Share_HK	0.074	0.233	0.087	0.260	0.095	0.279	0.088	0.271
Foreign Share_FR	0.060	0.207	0.074	0.237	0.089	0.267	0.087	0.267
State Share	0.251	0.414	0.112	0.299	0.038	0.180	0.021	0.135

Notes: Localization and Urbanization are based on employment measure. The numbers for "road" represent the percentage of firms covered by the national expressway network. The number of firms for the years 1998, 2002, 2005, and 2007 are 93,820, 122,205, 193,978, and 255,476 respectively.

Table 2.2 Baseline Results: The Effect of Agglomeration Economies on TFP

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: lnTFP (based on Olley-Pakes method)					
LogLoc	0.0224***	0.0249***	0.0127***	0.0249***	0.0127***	0.0137***
	(0.00153)	(0.00163)	(0.00167)	(0.00163)	(0.00167)	(0.00179)
LogUrb		-0.0498***	-0.0555***	-0.0499***	-0.0556***	-0.0537***
		(0.00651)	(0.00651)	(0.00652)	(0.00652)	(0.00715)
Comp_sales			0.0536***		0.0536***	0.0502***
			(0.00419)		(0.00420)	(0.00442)
Road				0.0108***	0.00850**	
				(0.00365)	(0.00370)	
Road_lag						0.000773
						(0.00408)
ForeignshareHK	-0.00403	-0.00321	-0.00242	-0.00312	-0.00234	-0.00727*
	(0.00337)	(0.00338)	(0.00336)	(0.00339)	(0.00336)	(0.00407)
ForeignshareFR	0.00729*	0.00767*	0.00850**	0.00776*	0.00858**	0.00247
	(0.00403)	(0.00402)	(0.00400)	(0.00403)	(0.00401)	(0.00443)
Stateshare	-0.0212***	-0.0180***	-0.0179***	-0.0177***	-0.0177***	-0.0195***
	(0.00266)	(0.00262)	(0.00261)	(0.00261)	(0.00260)	(0.00301)
Observations	1,542,797	1,542,797	1,542,762	1,542,797	1,542,762	1,085,741
R-squared	0.167	0.168	0.173	0.168	0.173	0.170

Notes: Robust clustered standard errors are represented in parentheses. Each regression includes firm fixed effect, industry * time, and province * time effects.

*Significant at 10 percent level

**Significant at 5 percent level

***Significant at 1 percent level

Table 2.3 Baseline Results: Non-parametric Specification of Competition Measure

	(1)	(2)	(3)
	Dependent variable: lnTFP (based on Olley-Pakes method)		
LogLoc	0.0166***	0.0166***	0.0182***
	(0.00201)	(0.00201)	(0.00215)
LogUrb	-0.0596***	-0.0598***	-0.0584***
	(0.00634)	(0.00636)	(0.00690)
Comp_sales	-0.0297	-0.0301	-0.0459**
	(0.0190)	(0.0190)	(0.0205)
Comp_quadratic	0.0291***	0.0291***	0.0340***
	(0.0102)	(0.0102)	(0.0109)
Comp_cubic	-0.00282*	-0.00282*	-0.00336**
	(0.00155)	(0.00154)	(0.00165)
Road		0.00972***	
		(0.00364)	
Road_lag			0.00211
			(0.00398)
ForeignshareHK	-0.00250	-0.00242	-0.00739*
	(0.00336)	(0.00336)	(0.00407)
ForeignshareFR	0.00855**	0.00863**	0.00252
	(0.00400)	(0.00400)	(0.00443)
Stateshare	-0.0186***	-0.0183***	-0.0202***
	(0.00261)	(0.00261)	(0.00301)
Observations	1,542,762	1,542,762	1,085,741
R-squared	0.173	0.173	0.171

Notes: Robust clustered standard errors are represented in parentheses. Each regression includes firm fixed effect, industry * time, and province * time effects.

*Significant at 10 percent level

**Significant at 5 percent level

***Significant at 1 percent level

Table 2.4 Localization Economies: Transit Through Firms or Workers

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: lnTFP (based on Olley-Pakes method)					
LogNumfirms	0.0769***	0.0844***	0.0664***	0.0843***	0.0664***	0.0671***
	(0.00439)	(0.00467)	(0.00569)	(0.00467)	(0.00569)	(0.00598)
LogAvgemployment	-0.00927***	-0.00233	0.00226	-0.00222	0.00235	0.00362
	(0.00298)	(0.00304)	(0.00284)	(0.00305)	(0.00284)	(0.00304)
LogUrb		-0.069***	-0.0690***	-0.0687***	-0.069***	-0.0702***
		(0.00739)	(0.00736)	(0.00741)	(0.00738)	(0.00798)
Comp_sales			0.0250***		0.0249***	0.0221***
			(0.00477)		(0.00477)	(0.00505)
Road				0.0100***	0.00938**	
				(0.00388)	(0.00388)	
Road_lag						0.00197
						(0.00422)
ForeignshareHK	-0.00386	-0.00279	-0.00248	-0.00270	-0.00240	-0.00771*
	(0.00340)	(0.00341)	(0.00340)	(0.00341)	(0.00340)	(0.00409)
ForeignshareFR	0.00771*	0.00820**	0.00848**	0.00828**	0.00856**	0.00211
	(0.00404)	(0.00403)	(0.00403)	(0.00403)	(0.00403)	(0.00444)
Stateshare	-0.0223***	-0.018***	-0.0181***	-0.0180***	-0.018***	-0.0193***
	(0.00273)	(0.00267)	(0.00267)	(0.00266)	(0.00266)	(0.00307)
Observations	1,515,489	1,515,489	1,515,489	1,515,489	1,515,489	1,067,698
R-squared	0.175	0.177	0.178	0.177	0.178	0.175
F-stat (LogNumfirms=LogAvgemployment)	288	306	129	305	129	112
Prob > *F*	0.00	0.00	0.00	0.00	0.00	0.00

Notes: Robust clustered standard errors are represented in parentheses. Each regression includes firm fixed effect, industry * time, and province * time effects. We decompose "*logLoc*" in Table 2 into two parts: number of other firms located in the same industry-city cluster, denoted by "*logNumfirms*", and average employment, denoted by "*logAvgemployment*" within the same industry-city classification.

Table 2.5 Urbanization Economies: Similar vs. Different Industries

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: lnTFP (based on Olley-Pakes method)					
LogLoc	0.0127***	0.0142***	0.00662***	0.0142***	0.00661***	0.00757***
	(0.00139)	(0.00143)	(0.00153)	(0.00143)	(0.00152)	(0.00164)
LogUrb_similar		-0.0102***	-0.0101***	-0.0102***	-0.0101***	-0.0100***
		(0.00171)	(0.00177)	(0.00171)	(0.00177)	(0.00190)
LogUrb_diff		-0.0245***	-0.0282***	-0.0247***	-0.0283***	-0.0259***
		(0.00629)	(0.00623)	(0.00632)	(0.00626)	(0.00672)
Comp_sales			0.0352***		0.0351***	0.0318***
			(0.00394)		(0.00394)	(0.00419)
Road				0.0131***	0.0117***	
				(0.00378)	(0.00380)	
Road_lag						0.00336
						(0.00421)
ForeignshareHK	-0.00447	-0.00401	-0.00347	-0.00391	-0.00338	-0.00863**
	(0.00345)	(0.00344)	(0.00342)	(0.00344)	(0.00342)	(0.00421)
ForeignshareFR	0.00716*	0.00735*	0.00793**	0.00747*	0.00804**	0.00283
	(0.00401)	(0.00401)	(0.00399)	(0.00401)	(0.00399)	(0.00450)
Stateshare	-0.0189***	-0.0168***	-0.0168***	-0.0165***	-0.0165***	-0.0181***
	(0.00274)	(0.00268)	(0.00268)	(0.00267)	(0.00267)	(0.00308)
Observations	1,443,807	1,443,807	1,443,772	1,443,807	1,443,772	1,017,824
R-squared	0.162	0.163	0.165	0.163	0.165	0.163
F-stat (LogUrb_similar = LogUrb_diff)		4.76	7.64	4.79	7.65	5.06
Prob > *F*		0.03	0.006	0.029	0.0057	0.024

Notes: Robust clustered standard errors are represented in parentheses. Each regression includes firm fixed effect, industry * time, and province * time effects. We decompose "*logUrb*" into two parts: similar industries, denoted by "*logUrb_similar*", and completely different industries, represented by "*logUrb_diff*".

Table 2.6 Exporters vs. Non-Exporters

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: lnTFP (based on Olley-Pakes method)					
	Panel A: Exporters					
LogLoc	0.0350***	0.0417***	0.0312***	0.0417***	0.0312***	0.0330***
	(0.00349)	(0.00368)	(0.00447)	(0.00368)	(0.00447)	(0.00462)
LogUrb		-0.0983***	-0.0994***	-0.0983***	-0.0994***	-0.0953***
		(0.00998)	(0.0102)	(0.00997)	(0.0102)	(0.0115)
Comp_sales			0.0367***		0.0367***	0.0358***
			(0.00839)		(0.00840)	(0.00869)
Road				0.00406	0.00256	
				(0.00532)	(0.00544)	
Road_lag						0.0175**
						(0.00746)
ForeignshareHK	-0.00441	-0.00342	-0.00282	-0.00340	-0.00280	-0.00302
	(0.00479)	(0.00480)	(0.00476)	(0.00480)	(0.00476)	(0.00546)
ForeignshareFR	0.0114**	0.0109**	0.0114**	0.0109**	0.0114**	0.00813
	(0.00548)	(0.00546)	(0.00544)	(0.00546)	(0.00544)	(0.00579)
Stateshare	-0.0285***	-0.0187***	-0.0182***	-0.0186***	-0.0181***	-0.0218***
	(0.00513)	(0.00509)	(0.00508)	(0.00509)	(0.00508)	(0.00552)
Observations	460,246	460,246	460,246	460,246	460,246	350,407
R-squared	0.196	0.200	0.202	0.200	0.202	0.196
	Panel B: Non-Exporters					
LogLoc	0.0173***	0.0184***	0.00618***	0.0184***	0.00618***	0.00628***
	(0.00127)	(0.00134)	(0.00125)	(0.00134)	(0.00125)	(0.00137)
LogUrb		-0.0268***	-0.0356***	-0.0270***	-0.0358***	-0.0321***
		(0.00705)	(0.00697)	(0.00709)	(0.00700)	(0.00747)
Comp_sales			0.0595***		0.0594***	0.0559***
			(0.00368)		(0.00368)	(0.00387)

Road				0.00816**	0.00594	
				(0.00382)	(0.00386)	
Road_lag						-0.00519
						(0.00422)
ForeignshareHK	-0.00668	-0.00639	-0.00555	-0.00635	-0.00552	-0.0120**
	(0.00490)	(0.00491)	(0.00487)	(0.00491)	(0.00488)	(0.00605)
ForeignshareFR	-0.000271	6.41e-05	0.00106	0.000186	0.00115	-0.00544
	(0.00625)	(0.00624)	(0.00621)	(0.00624)	(0.00621)	(0.00741)
Stateshare	-0.0196***	-0.0185***	-0.0186***	-0.0183***	-0.0185***	-0.0193***
	(0.00306)	(0.00303)	(0.00302)	(0.00301)	(0.00301)	(0.00355)
Observations	1,082,551	1,082,551	1,082,516	1,082,551	1,082,516	735,334
R-squared	0.156	0.156	0.162	0.156	0.162	0.161

Notes: Robust clustered standard errors are represented in parentheses. Each regression includes firm fixed effect, industry * time, and province * time effects. Cross equation tests indicate that the coefficients on "*logLoc*", "*Comp_sales*", and "*Road*" are statistically different between two groups of firms.

Table 2.7 Sub-sample Results: Foreign-invested vs. Domestic Firms

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: lnTFP (based on Olley-Pakes method)					
	Panel A: Foreign-invested Firms					
LogLoc	0.0409***	0.0476***	0.0337***	0.0476***	0.0337***	0.0366***
	(0.00411)	(0.00449)	(0.00441)	(0.00449)	(0.00441)	(0.00464)
LogUrb		-0.0801***	-0.0803***	-0.0800***	-0.0802***	-0.0703***
		(0.00862)	(0.00850)	(0.00862)	(0.00850)	(0.0103)
Comp_sales			0.0445***		0.0445***	0.0426***
			(0.00595)		(0.00595)	(0.00629)
Road				0.00331	0.00270	
				(0.00556)	(0.00574)	
Road_lag						0.00226
						(0.00657)
ForeignshareHK	0.00710	0.00778	0.00838	0.00779	0.00839	0.0110*
	(0.00575)	(0.00577)	(0.00576)	(0.00577)	(0.00576)	(0.00641)
ForeignshareFR	0.0196***	0.0196***	0.0201***	0.0196***	0.0201***	0.0222***
	(0.00570)	(0.00568)	(0.00567)	(0.00568)	(0.00567)	(0.00631)
Stateshare	0.00277	0.0103	0.0112	0.0103	0.0112	0.00870
	(0.00858)	(0.00855)	(0.00858)	(0.00855)	(0.00858)	(0.0101)
Observations	347,338	347,338	347,337	347,338	347,337	260,290
R-squared	0.181	0.183	0.187	0.183	0.187	0.184
	Panel B: Domestic Firms					
LogLoc	0.0173***	0.0190***	0.00760***	0.0190***	0.00759***	0.00792***
	(0.00129)	(0.00135)	(0.00140)	(0.00135)	(0.00140)	(0.00151)
LogUrb		-0.0414***	-0.0493***	-0.0420***	-0.0498***	-0.0494***
		(0.00700)	(0.00704)	(0.00707)	(0.00710)	(0.00773)
Comp_sales			0.0550***		0.0549***	0.0508***
			(0.00401)		(0.00402)	(0.00424)
Road				0.0127***	0.0104**	
				(0.00401)	(0.00406)	

Road_lag						-9.57e-05
						(0.00452)
ForeignshareHK						
ForeignshareFR						
Stateshare	-0.0229***	-0.0208***	-0.0210***	-0.0206***	-0.0208***	-0.0220***
	(0.00278)	(0.00274)	(0.00273)	(0.00273)	(0.00272)	(0.00314)
Observations	1,195,459	1,195,459	1,195,425	1,195,459	1,195,425	825,451
R-squared	0.163	0.164	0.169	0.164	0.169	0.167

Notes: Robust clustered standard errors are represented in parentheses. Each regression includes firm fixed effect, industry * time, and province * time effects. Cross equation tests indicate that the coefficients on "*logLoc*", "*Comp_sales*", and "*Road*" are statistically different between two groups of firms.

Table 2.8 One-stage Specification: Relax Hicks Neutrality Assumption of Agglomeration Economies

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: logY					
LogL	0.0404***	0.0458***	0.0455***	0.0466***	0.0463***	0.0488***
	(0.00728)	(0.00712)	(0.00707)	(0.00714)	(0.00709)	(0.00837)
LogK	0.00998**	0.00908**	0.00859**	0.00845**	0.00799**	0.0131***
	(0.00404)	(0.00404)	(0.00405)	(0.00402)	(0.00403)	(0.00471)
LogM	0.828***	0.827***	0.827***	0.826***	0.826***	0.805***
	(0.0125)	(0.0124)	(0.0125)	(0.0124)	(0.0125)	(0.0147)
LogL*logLoc	0.00579***	0.00542***	0.00550***	0.00534***	0.00542***	0.00554***
	(0.000939)	(0.000927)	(0.000926)	(0.000930)	(0.000928)	(0.00109)
LogK*logLoc	0.00197***	0.00207***	0.00212***	0.00213***	0.00218***	0.00147***
	(0.000485)	(0.000485)	(0.000486)	(0.000483)	(0.000485)	(0.000539)
LogM*logLoc	-0.00698***	-0.00685***	-0.00694***	-0.00681***	-0.00689***	-0.00632***
	(0.00176)	(0.00176)	(0.00176)	(0.00176)	(0.00176)	(0.00195)
LogLoc	0.0228**	0.0241**	0.0206**	0.0234**	0.0200**	0.0211**
	(0.00943)	(0.00942)	(0.00940)	(0.00943)	(0.00941)	(0.0102)
LogUrb		-0.0298***	-0.0315***	-0.0301***	-0.0317***	-0.0245***
		(0.00409)	(0.00404)	(0.00409)	(0.00405)	(0.00459)
Comp_sales			0.0151***		0.0150***	0.0123***
			(0.00165)		(0.00165)	(0.00172)
ForeignshareHK	-0.00208	-0.00170	-0.00148	-0.00155	-0.00133	-0.00666*
	(0.00304)	(0.00304)	(0.00304)	(0.00305)	(0.00304)	(0.00366)
ForeignshareFR	0.00743**	0.00753**	0.00777**	0.00769**	0.00792**	0.00373
	(0.00368)	(0.00368)	(0.00368)	(0.00368)	(0.00368)	(0.00399)
Stateshare	-0.0169***	-0.0153***	-0.0153***	-0.0148***	-0.0149***	-0.0184***
	(0.00245)	(0.00243)	(0.00243)	(0.00242)	(0.00242)	(0.00280)
Road				0.0179***	0.0173***	
				(0.00312)	(0.00310)	
Road_lag						0.00779**
						(0.00336)

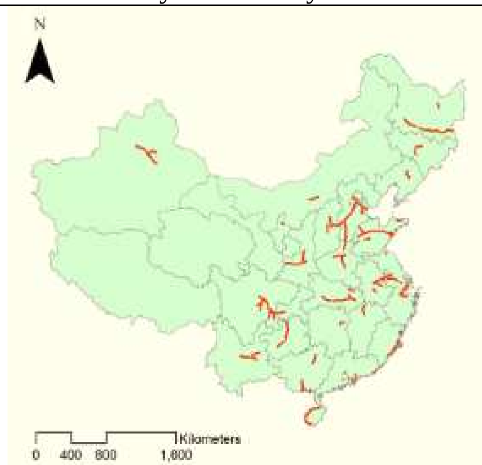
Observations	1,542,797	1,542,797	1,542,797	1,542,797	1,542,797	1,085,741
R-squared	0.833	0.833	0.833	0.833	0.833	0.811

Notes: Robust clustered standard errors are represented in parentheses. Each regression includes firm fixed effect, industry * time, and province * time effects.

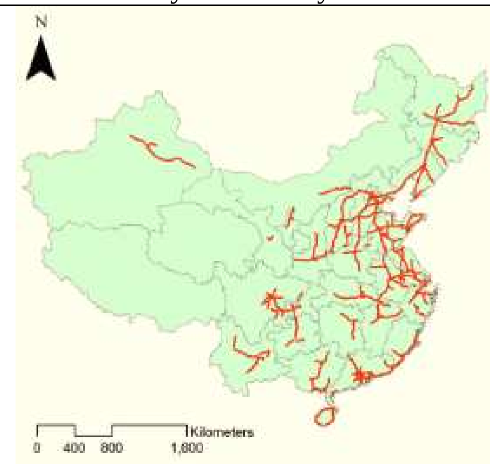
Figures

Figure 2.1 Expressway Network Development

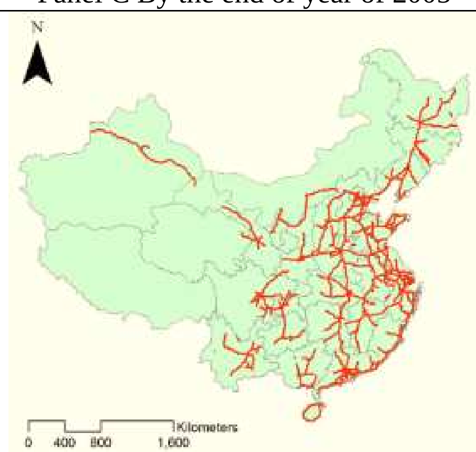
Panel A By the end of year of 1998



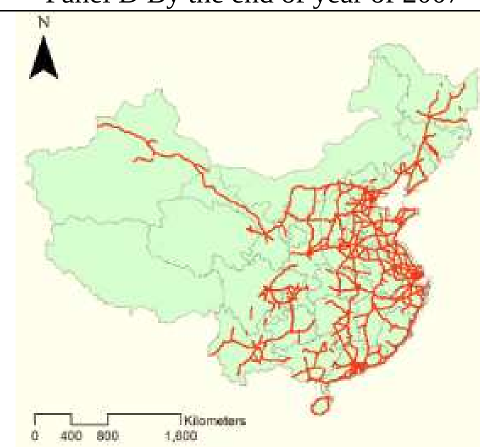
Panel B By the end of year of 2002



Panel C By the end of year of 2005



Panel D By the end of year of 2007



Chapter 3 Industrial Policy and Competition

3.1 Introduction

In the aftermath of WWII, several developing countries opted for policies aimed at promoting new infant industries or at protecting local traditional activities from competition by products from more advanced countries. Thus several Latin American countries advocated import substitution policies, whereby local industries would more fully benefit from domestic demand. East Asian countries like Korea or Japan, rather than advocating import substitution policies, would favor export promotion, which in turn would be achieved partly through tariffs and non-tariff barriers and partly through maintaining undervalued exchange rates. For at least two or three decades after WWII, these policies, which belong to what is commonly referred to as "industrial policy," remained fairly noncontroversial as both groups of countries were growing at fast rates.

However, the economic slowdown in the 70s in Latin America and Japan in the late 90s generated a growing skepticism about the role of industrial policy in the process of economic development. On the empirical front, the debate was launched by Krueger and Tuncer (1982) who analyzed the effects of industrial policy in Turkey in the 60s, and "show" that firms or industries not protected by tariff measures were characterized by higher productivity in growth rates than protected industries28. On the theoretical front, the provision by domestic governments of subsidies or trade protection targeted to particular firms or industries, has come under disrepute among academics mainly on the ground that it prevents competition and allows governments to pick winners (and, more rarely, to name losers) in a discretionary fashion, thereby increasing the scope for capture of governments by vested interests. This argument appears to have won over traditional counteracting considerations, in particular those based upon the infant industry idea (e.g.,see Greenwald and Stiglitz (2006)).[29] This disrepute has affected not only the

[28] However, see Harrison (1994).

[29] For an overview of infant-industry models and empirical evidence, see Harrison and Rodriguez-Clare (2010). The infant-industry argument could be summarized as follows. Consider a local economy that includes both a traditional sector (especially agriculture) and an industry in its infancy. Production costs in industry are initially high, but "learning by doing" decrease these costs over time, even faster as the volume of activity in this area is high. In addition, increased productivity which is a consequence of this learning by doing phase has positive spillovers on the rest of the economy, ie it increases the potential rate of growth also in the traditional sector. In this case, a total and instantaneous liberalization of international trade can be detrimental to the growth of the local economy, as it might inhibit the activity of the local industry whose production costs are initially high: what will happen in this case is that the local demand for industrial products will turn to foreign importers. It means that learning by doing in the local industry will be slowed itself, which will reduce the externalities of growth from this sector towards the traditional sector.

selection and promotion of national champions – what could be termed industrial policy in the narrow sense - but also any kind of public intervention going beyond horizontal supply-side policies with the aim to influence sectoral developments and the composition of aggregate output. a first argument against industrial policy and the infant industry argument, is that governments are not particularly good at picking winners, and providing them with an excuse to subsidize particular firms or sectors might end up favoring the emergence of industrial lobbies.

Yet, new considerations have emerged over the recent period, which invite us to revisit the issue. First, climate change and the increasing awareness of the fact that without government intervention aimed at encouraging clean production and clean innovation, global warming will intensify and generate negative externalities (droughts, deforestations, migrations, conflicts) worldwide. Beyond the pricing of this externality through cap-and-trade systems or carbon taxation, many governments have engaged in targeted intervention to encourage the development of alternative technologies in the production (e.g., from renewables) or the use (e.g. by efficient housing) of energy. Second, the re- cent financial crisis has prompted several governments, including the US, to provide support to particular industries (e.g., the automobile or green sectors). Also, an increasing number of scholars (in particular in the US) are denouncing the danger of laissez-faire policies that lead developed countries to specialize in upstream R&D and in services while outsourcing all manufacturing tasks to developing countries where unskilled labor costs are lower. They point to the fact that countries like Germany or Japan have better managed to maintain intermediate manufacturing segments through pursuing more active industrial policies, and that this in turn has allowed them to benefit more from outsourcing the other, less human capital-intensive segments.

In this paper we argue that the debate on industrial policy should no longer be "existential", i.e., about whether sectoral policies should be precluded altogether or not, but rather on how such policies should be designed and governed so as to foster growth and welfare. Our focus is on the relationship between sectoral policy and product market competition. In the first part of the paper we develop a theoretical framework in which two firms may choose either to operate in the same "higher-growth" sector (we refer to this as the choice to focus on the same technology) or they may choose to operate in different sectors, including in "lower-growth" sectors in order to reduce the intensity of competition among them (we refer to this as the choice to diversify). When firms focus on the same high-growth sector they generate more innovation and growth for two reasons: first, because the size of innovations, and therefore the post-innovation rents, are higher in a higher-growth sector; second, because when the two firms choose to operate in the same sector they compete more intensely, which in turn induces both firms to invest more in innovation in order to escape competition with the rival firm (see Aghion et al (2005)). The more intense competition within a sector, the more firms innovate if they operate in the same sector. At the same time, more intense competition within sectors may induce firms to choose diversity as an alternative way to avoid competition. This is where industrial policy comes into play: by inducing the two firms to operate in the same sector, the government induces firms to innovate "vertically" rather than differentiate "horizontally" in order to escape competition with the other firm.

The more intense within-sector competition, the more growth-enhancing it is to induce both firms to operate in the same "high-growth" sector. In other words, there is a complementarity between product market competition and sectoral policy in fostering innovation and growth.

In the second part of the paper we test for the complementarity between competition and industrial policy. We use a panel of medium and large Chinese enterprises for the period 1998 through 2007. Our measures of industrial policy are: (1) subsidies, allocated at the firm level, and (2) trade tariffs, which are determined at the sector level. We measure competition in two ways: using industry-level Lerner indices, which capture the degree of markups over cost, and the extent to which industrial policies preserve or increase competition. We then look at the effect on productivity, productivity growth, and product innovation, of policies that preserve or increase competition through the sectoral dispersion of subsidies.

Our results suggest that if subsidies are allocated to competitive sectors (as measured by the Lerner index) and allocated in such a way as to preserve or increase competition, then the net impacts of subsidies on productivity, productivity growth, and product innovation measured by the share of new products in total sales, become positive and significant. In other words, targeting can have beneficial effects depending on both the degree of competition in the targeted sector as well as depending on how the targeting is done.

Most closely related to our analysis in this paper are Nunn and Trefler (2010). Using cross-country industry-level panel data, they analyze whether, as suggested by the argument of "infant industry", the growth of productivity in a country is positively affected by the measure in which tariff protection is biased in favor of activities and sectors that are "skill-intensive", that is to say, use more intensely skilled workers. They find a significant positive correlation be- tween productivity growth and the "skill bias" due to tariff protection. As the authors point out though, such a correlation does not necessarily mean there is causality between skill-bias due to protection and productivity growth: the two variables may themselves be the result of a third factor, such as the quality of institutions in countries considered. However, Nunn and Trefler show that at least 25% of the correlation corresponds to a causal effect. Overall, their analysis suggests that that adequately designed (here, skill-intensive) targeting may actually enhance growth, not only in the sector which is being subsidized, but in other sectors as well. [30]

The paper is organized as follows. Section 3.2 presents our model of the complementarity between competition and sectoral policy. Section 3.3 presents the empirical analysis. Section 3.4 discusses endogeneity issues. Section 3.5 concludes.

[30] The issue remains whether industrial policy comes at the cost of a lowering of competition, e.g., between high and low skill intensive sectors or within a high skill sector. As we show in this paper, industrial policy in the form of targeting may in fact take the form of enhancing competition in a sector and serves the dual role of increasing consumer surplus and growth (see Appendix A).

3.2 Model

3.2.1 Basic setup

Demand. The model focuses on two technologies or goods, denoted by A and B. Denote the quantity consumed on each technology by x^A and x^B. The representative consumer has income 2E and utility $\log(x^A) + \log(x^B)$ when consuming x^A and x^B. This means that, if the price of good i is p^i, demand for good i will be $x^i = E/p^i$.

Supply. The production can be done by one of two 'big' firms 1, 2, or by 'fringe firms'. Fringe firms act competitively and have a marginal cost of production of c_f while firms j = 1, 2 have an initial marginal cost of c. Marginal costs are firm-specific and are independent of the technology in which production is undertaken. Price competition is postulated.

We make the following assumption: $E > c_f \geqslant c$. The assumption $c_f \geqslant c$ reflects the cost advantage of firms 1, 2 with respect to the fringe and the assumption E > c insures that equilibrium quantities can be greater than 1.

Innovation. For simplicity, we assume that only firms 1, 2 can innovate. In- novation can reduce the cost of production of these firms, but the cost reduction is different in the two technologies A and B. Without loss of generality, we assume technology A is the better' one, in that innovation leads the cost level to become $c/\gamma_A = c/(\gamma + \delta)$ while on technology B it becomes $c/\gamma_B = c/(\gamma - \delta)$; obviously, we assume $\gamma - \delta > 1$ or $\delta < \gamma - 1$.

In order to allow innovators to earn rents (and thus have an incentive to reduce costs), we make the simple assumption that, with equal probability, each firm can be chosen to be the potential innovator; it then chooses the probability q at cost $q^2/2$ with which cost reduction will be realized. This is like saying that each firm has an exogenous probability of getting a patentable idea, which then has to be turned into cost reduction thanks to effort exerted by the firm.

Within sector competition. Let ϕ be the probability that two firms in the same sector can collude when they have the same cost, and let us assume that when colluding each firm can achieve a price of c_f. In this case, the expected profit of a firm with cost $c < c_f$ is $\phi/2 \cdot \frac{c_f - c}{c_f} E$ since when collusion fails firms compete Bertrand.

Laissez-faire/targeting. Finally, we assume that, while under laissez-faire, firms choose the technology on which they want to produce (A or B), a planner may impose (or induce via tax/subsidies) such technology choices. Laissez-faire can lead to diversification (different technology choices by the two firms) or focus (same choice, be it A or B), while targeting is planner-enforced focus.

3.2.2 Informational assumptions

We restrict attention to the case where there is perfect information about γ_i. Under laissez-faire, firms will either choose diversity or focus. Under focus, both firms choose the better technology A. Under diversity, one firm (call it firm 1) chooses A and the other (call it firm 2) chooses B (this is a coordination game and which firm ends up with technology A is random). Diversity is stable if the firm ending up with technology B does not want switch to technology A; if it does then we are back to a focus configuration.

We shall first compare between equilibrium innovations rates under diversity and under focus respectively. This will tell us about whether diversity or focus is growth-maximizing. Then, we shall derive conditions under which diversity arises under laissez-faire. We show for sufficiently high degree of competition within sectors, focus is always growth-maximizing whereas there exists $\delta^L > 0$ such that diversity is privately optimal if $\delta \leqslant \delta^L$. In the Appendix we compare the laissez-faire choice between diversity and focus with the social optimum.

At the end of this theory section, we shall also briefly discuss cases with imperfect information about γi. We shall consider two extreme cases, respectively when firms know which is the better technology but the planner does not, and when neither the firms nor the planner knows which technology is best.

3.2.3 Equilibrium profits and innovation intensities.

3.2.3.1 Diversity

Under diversity, firm 1 is on technology A and firm 2 is on technology B and both firms enjoy a cost advantage over their competitors. Let e denote the representative consumer's expense on technology A, p1 the price charged by firm 1 and c_f the limit price imposed by the competitive fringe.

The representative consumer purchases x_1^A, x_f^A in order to maximize $\log(x_1^A + x_f^A)$ subject to $p_1 x_1^A + c_f x_f^A \leq e$. The solution leads to $x_1^A > 0$ only if $p_1 \leq c_f$. The consumer spends e and since firm 1's profit is $e - c_1 x_1^A$, firm 1 indeed chooses the highest price (hence the lowest quantity x_1^A) consistent with $p_1 \leq c_f$, that is $p_1 = c_f$. It follows that $x^A = x_1^A$ and therefore $x^A = e/c_f$.

The problem is symmetric on the other technology and since the representative consumer has total income 2E she will spend E on each technology, yielding $x^A = x^B = E/c_f$.

If the firm is not a potential innovator (which happens with probability 1/2), its profit is therefore:

$$\pi^{D_0} = \frac{c_f - c}{c_f} E \text{ (3.1).}$$

If the firm on technology i is chosen to be a potential innovator and chooses a probability q, it will get a profit margin of $c_f - c/\gamma_i$ if it innovates and a profit margin of $c_f - c$ if it does not. Hence, the profit function conditional on being chosen to be a potential innovator is:

$$\pi = q\left(c_f - \frac{c}{\gamma_i}\right)x^i + 1(1-q)\left(c_f - c\right)x^i - \frac{1}{2}q^2 \text{ (3.2)}$$

or

$$\pi = q\frac{\gamma_i - 1}{\gamma_i}cx^i + (c_f - c)x^i - \frac{1}{2}q^2 \text{ (3.3).}$$

Using $x^A = E/c_f$, the optimal probability of innovation under diversity q_i^D and the corresponding ex ante equilibrium profit when chosen to be a potential innovator $\pi_1{}^{D_1}$, are respectively given by

$$q_i^D = \frac{\gamma_i - 1}{\gamma_i}\frac{c}{c_f}E \text{ (3.4) (}$$

and

$$\pi_i^{D_1} = \frac{1}{2}\left(\frac{\gamma_i - 1}{\gamma_i}\right)^2\left(\frac{c}{c_f}\right)^2 E^2 + \frac{c_f - c}{c_f}E \text{ (3.5).}$$

Therefore the expected profit of diversifying on technology is $1/2(\pi^{D_0} + \pi_i^{D_1})$, or

$$\pi_i^{D_1} = \frac{1}{4}\left(\frac{\gamma_i - 1}{\gamma_i}\right)^2\left(\frac{c}{c_f}\right)^2 E^2 + \frac{c_f - c}{c_f}E \text{ (3.6).}$$

We shall denote by $\pi^D(\delta)$ the profit under diversity for the firm on technology A, that is, with cost reduction $\gamma_A = \gamma + \delta$, and by $\pi^D(-\delta)$ the profit under diversity for the firm on technology B, that is, with cost reduction $\gamma_B = \gamma - \delta$. Similarly, we denote by $q^D(\delta)$, $q^D(-\delta)$ the innovation intensities under diversity for firms on the good technology A and the bad technology B respectively.

3.2.3.2 Focus

Consider first the case with full Bertrand competition within the same sector or technology (A or B). If the two large firms decide to locate on the same technology, it is optimal for them to choose the best technology, namely technology A. Now, the next best competitor for firm 1 is firm 2 rather than the fringe, so the price is always equal to c which is lower than c_f by assumption. Hence, in this case, $x^A = E/c$ while $x^B = E/c_f$ since the consumer buys from the fringe on technology B.

If firm 1 is chosen to be a potential innovator, its profit is

$$\pi^{F_1} = q\left(c - \frac{c}{\gamma + \delta}\right)\frac{E}{c} - \frac{1}{2}q^2 \text{ (3.7).}$$

Note that if the firm does not innovate its profit margin is zero since firms 1 and 2 have the same marginal cost. It follows that the optimal probability of innovation is

$$q^F = \frac{\gamma + \delta - 1}{\gamma + \delta}E \text{ (3.8).}$$

If the firm is not chosen to be a potential innovator, its profit is zero since it has necessarily a (weakly) higher cost than its next best competitor. Hence the expected profit of each firm under focus is

$$\pi^F = \frac{1}{4}\left(\frac{\gamma+\delta-1}{\gamma+\delta}\right)^2 E^2 \text{ (3.9).}$$

Now suppose that two firms with the same cost within the same sector, collude with probability ϕ and thereby sustain a price of c_f. In this case, the expected profit of firms with cost c is $\phi/2 \cdot (c_f - c)/c_f \cdot E$ since when they do not succeed colluding they play a Bertrand game.

The expected profit of a firm called upon to innovate under focus, is equal to:

$$q\frac{\gamma+\delta-1}{\gamma+\delta}E + (1-q)\phi\frac{1}{2}\frac{c_f - c}{c_f}E - \frac{1}{2}q^2 \text{ (3.10)}$$

and therefore the profit maximizing degree of innovation is

$$q^F(\phi) = \left(\frac{\gamma+\delta-1}{\gamma+\delta} - \frac{\phi}{2}\frac{c_f - c}{c_f}\right)E \text{ (3.11).}$$

In particular, as ϕ decreases, that is as the competitiveness of the sector increases, innovation increases. This captures an "escape competition" effect: the more intense within-sector competition, the higher the firms' incentives to innovate to escape competition.

The corresponding ex ante equilibrium profit is given by:

$$\pi^F = \frac{1}{4}\left(\frac{\gamma+\delta-1}{\gamma+\delta} - \frac{\phi}{2}\frac{c_f - c}{c_f}\right)^2 E^2 + \frac{1}{4}\frac{c_f - c}{c_f}E \text{ (3.12).}$$

3.2.4 Growth-maximizing choice between diversity and focus

Focus is the growth-maximizing strategy whenever

$$2q^F(\phi) > q^D(\delta) + q^D(-\delta) = \left(\frac{\gamma+\delta-1}{\gamma+\delta} + \frac{\gamma-\delta-1}{\gamma-\delta}\right)\frac{c}{c_f}E \text{ (3.13).}$$

This condition is more likely to be satisfied the lower ϕ, i.e., the more intense the degree of within-sector competition, and it always holds for ϕ sufficiently small.

3.2.5 Laissez-faire choice between diversity and focus

Despite the lower cost reduction from innovation for a firm that diversifies on technology B instead of competing with the other firm on technology A, the firm that diversifies on B may prefer to stick to this technology precisely because diversity shields it from competition: even if it does not innovate, the diversified firm obtains a positive profit equal to $\pi^{D_0} > 0$.

Comparing the ex ante equilibrium profits $\pi^D(-\delta)$ and $\pi^F(\phi)$ under diversity and focus for a firm initially diversified on the low technology B, diversity is an equilibrium outcome under laissez-faire whenever

$$\left(\frac{c_f - c}{c_f}\right)\left(1-\frac{\phi}{4}\right) \geq \frac{1}{4}E\left[\left(\frac{\gamma+\delta-1}{\gamma+\delta}-\frac{\phi}{2}\frac{c_f-c}{c_f}\right)^2-\left(\frac{\gamma-\delta-1}{\gamma-\delta}\right)^2\left(\frac{c}{c_f}\right)^2\right] \quad (3.14)$$

where the LHS is the competitive benefit of diversity and the RHS the innovation disadvantage of technology B. The RHS is increasing in δ, and therefore there exists a maximum cutoff δL above which diversity cannot be an equilibrium outcome, leading to the following Proposition:

Proposition 1 There exists a unique cutoff value δ^L such that diversity is chosen under laissez-faire if, and only if, $\delta \leqslant \delta^L$. This cutoff is decreasing in E and in ϕ.

In particular, the lower ϕ, i.e., the more intense within-sector competition, the higher the cutoff δ^L, i.e., the higher firms' incentives to diversify. On the other hand, we have seen before that for sufficiently small ϕ focus is always growth maximizing, and the more so the lower ϕ. This in turn yields one of our main empirical predictions, namely that government intervention to induce several (in our model, two) firms instead of one firm to focus on the same activity, is more growth-enhancing the higher the degree of (ex post) within-sector product market competition. Our analysis also suggests that government intervention aimed at focusing on a particular sector, is more likely to be growth- enhancing if it preserves or increases competition, which, in our model, amounts to subsidizing entry on an equal footing between the two firms rather than providing a wedge to one firm (for example by subsidizing entry in sector A for only one firm, not the other).

3.3 Empirical analysis

3.3.1 Basic estimating equation

The theory presented so far suggests that targeting is more likely to be growth-enhancing when competition is more intense within a sector or when competition is preserved by sectoral policy. To test this theory, we need measures of targeting, competition, and outcomes. We propose to measure outcomes using a variety of measures: total factor productivity (TFP) in both levels and growth rates, and the share of new products in total sales. To capture targeting, we will primarily focus on the effects of subsidies given to individual firms, but we will also explore how the effects of tariffs vary with competition. Subsidies are allocated at the firm level, while tariffs are set on a sectoral basis. To measure competition, we will calculate a Lerner index at the sector level, which is a measure of markups of prices over marginal cost.

The basic estimating equation will be the following:

$$\ln TFP_{ijt} = \beta_1 Z_{ijt} + \beta_2 S_{jt} + \beta_3 SUBSIDY_{ijt} + \beta_4 COMP_{jt} + \beta_5 SUBSIDY_{ijt} * COMP_{jt} + \alpha_i + \alpha_t + \epsilon_{ijt} \quad (3.15)$$

The vector Z includes a range of firm-level controls including state and foreign equity ownership at the firm level. The vector S includes sector-level controls, such as output and input tariffs, as well as sector-level foreign shares both within the same sector j as well as upstream and downstream. The specification above includes firm fixed effects α_i as well as time effects α_t. The question of critical interest for our framework is whether benefits from targeting, captured by our variable SUBSIDY , are positive when there is greater competition. If this is the case, then we would expect the coefficient on the interaction of subsidies and competition, β_5, to be positive and significant.

3.3.2 Data and alternative estimation strategies

The dataset employed in this paper was collected by the Chinese National Bureau of Statistics. The Statistical Bureau conducts an annual survey of industrial plants, which includes manufacturing firms as well as firms that produce and supply electricity, gas, and water. It is firm-level based, including all state-owned enterprises (SOEs), regardless of size, and non-state-owned firms (non-SOEs) with annual sales of more than 5 million yuan. We use a ten-year unbalanced panel dataset, from 1998 to 2007. The number of firms per year varies from a low of 162, 033 in 1999 to a high of 336, 768 in 2007. The sampling strategy is the same throughout the sample period (all firms that are state-owned or have sales of more than 5 million yuan are selected into the sample).

The original dataset includes 2,226,104 observations and contains identifiers that can be used to track firms over time. Since the study focuses on manufacturing firms, we eliminate non-manufacturing observations. The sample size is further reduced by deleting missing values, as well as observations with negative or zero values for output, number of employees, capital, and the inputs, leaving a sample size of 1,842,786. Due to incompleteness of information on official output price indices, three sectors are dropped from the sample[31] . This reduces the sample size to 1,545,626.

The dataset contains information on output, fixed assets, total workforce, total wages, intermediate input costs, public ownership, foreign investment, Hong Kong-Taiwan-Macau investment, sales revenue, and export sales. Because domestically owned, foreign, and publicly owned enterprises behave quite differently, for this paper we restrict the sample to firms that have zeros foreign ownership and are not classified as state owned enterprises. In the dataset, 1,072,034 observations meet the criterion.[32]

To control for the effects of trade policies, we have created a time series of tariffs, obtained from the World Integrated Trading Solution (WITS), maintained by the World Bank. We aggregated tariffs to the same level of aggregation as the foreign investment data, using output for 2003 as weights. We also created forward and backward tariffs, to correspond with our vertical FDI measures. During the sample period, average tariffs fell

[31] They are the following sectors: processing food from agricultural products; printing, reproduction of recording media; and general purpose machinery.

[32] Actually, the international criterion used to distinguish domestic and foreign-invested firms is 10%, that is, the share of subscribed capital owned by foreign investors is equal to or less than 10%. In the earlier version of the paper, we tested whether the results are sensitive to using zero, 10%, and 25% foreign ownership. Our results show that between the zero and 10% thresholds, the magnitude and the significance levels of the estimated coefficients remain close, which makes us comfortable using the more restrictive sample of domestic firms for which the foreign capital share is zero. The results based on the 25% criterion exhibit small differences, but the results are generally robust to the choice of definition for foreign versus domestic ownership.

nearly 9 percentage points, which is a significant change over a short time period. While the average level of tariffs during this period, which spans the years before and after WTO accession, was nearly 13 percent, this average masks significant heterogeneity across sectors, with a high of 41 percent in grain mill products and a low of 4 percent in railroad equipment.

The earlier literature on production function estimation shows that the use of OLS is inappropriate when estimating productivity, since this method treats labor, capital and other input variables as exogenous. As Griliches and Mairesse (1995) argue, inputs should be considered endogenous since they are chosen by a firm based on its productivity. Firm-level fixed effects will not solve the problem, because time-varying productivity shocks can affect a firm's input decisions.

Using OLS will therefore bias the estimations of coefficients on the input variables. To solve the simultaneity problem in estimating a production function, we employ the procedure suggested by Olley and Pakes (1996) (henceforth OP), which uses investment as a proxy for unobserved productivity shocks. OP addresses the endogeneity problem as follows. Let us consider the following Cobb-Douglas production function in logs:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \epsilon_{it} \quad (3.16)$$

y_{it}, k_{it}, l_{it}, m_{it} represent log of output, capital, labor, and materials, respectively. ω_{it} is the productivity and ϵ_{it} is the error term (or a shock to productivity). The key difference between ω_{it} and ϵ_{it} is that ω_{it} affects firms' input demand while the latter does not. OP also makes timing assumptions regarding the input variables. Labor and materials are free variables but capital is assumed to be a fixed factor and subject to an investment process. Specifically, at the beginning of every period, the investment level a firm decides together with the current capital value determines the capital stock at the beginning of the nest period, i.e.

$$k_{it+1} = (1 - \sigma)k_{it} + i_{it} \quad (3.17)$$

The key innovation of OP estimation is to use firms' observable characteristics to model a monotonic function of a firm's productivity. Since the investment decision depends on both productivity and capital, OP formulate investment as follows,

$$i_{it} = i_{it}(\omega_{it}, k_{it}) \quad (3.18)$$

Given that this investment function is strictly monotonic in ω_{it}, it can be inverted to obtain

$$\omega_{it} = f_t^{-1}(i_{it}, k_{it}) \quad (3.19)$$

Substituting this into the production function, we get the following,

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + f_t^{-1}(i_{it}, k_{it}) + \epsilon_{it} = \beta_l l_{it} + \beta_m m_{it} + \phi_t(i_{it}, k_{it}) + \epsilon_{it} \quad (3.20)$$

In the first stage of OP estimation, the consistent estimates of coefficients on labor and materials as well as the estimate of a non-parametrical term (φ_t) are obtained. The second step of OP identifies the coefficient on capital through two important assumptions. One is the first-order Markov assumption of productivity, ω_{it} and the timing assumption about k_{it}, The first-order Markov assumption decomposes ωit into its conditional expectation at time t - 1, $E[\omega_{it}|\omega_{it-1}]$, and a deviation from that expectation, ζ_{it}, which is often referred to the "innovation" component of the productivity measure. These two assumptions allow it to construct an orthogonal relationship between capital and the innovation component in productivity, which is used to identify the coefficient on capital.

The biggest disadvantage of applying the OP procedure is that many firms report zero or negative investment. To address this problem, we also explore the robustness of our results to using the Levinsohn Petrin (2003) approach. Both approaches involve a two-stage estimation procedure when using TFP as the dependent variable. The first step is to use OP or LP to obtain unbiased coefficients on input variables and then calculate TFP (as the residual from the production function). The second step is to regress TFP on firm-level controls, sector-level controls, and our targeting measures.

Moulton showed that in the case of regressions performed on micro units that also include aggregated market (in this case industry) variables, the standard errors from OLS will be underestimated. As Moulton demonstrated, failing to take account of this serious downward bias in the estimated errors results in spurious findings of the statistical significance for the aggregate variable of interest. To address this issue, the standard errors in the paper are clustered for all observations in the same industry.

3.3.3 Baseline results

We begin with the baseline estimates from (3.15). The critical parameter is the coefficient β_5 which indicates the impact of subsidies interacted with competition. Table 3.2 reports the coefficient estimates. The dependent variable is the log of TFP, using the OP method as outlined above. As indicated earlier, all specifications include both time and firm fixed effects. We define subsidy as the ratio of subsidies received to industrial sales at the firm level. The subsidy variable is our measure of "targeting", while our measure of industry-level competition is 1−the Lerner index. Summary statistics for all the variables, including sample means and standard deviations, are reported in Table 3.1. The Lerner index is defined as the ratio of operating profits less capital costs to sales. We first aggregate operating profits, capital costs, and sales at the industry-level. Under perfect competition, there should be no excess profits above capital costs, so the Lerner Index should equal zero and the COMP measure should equal 1. A value of 1 indicates perfect competition while values below 1 suggest some degree of market power.

Columns (1) and (2) of Table 3.2 report the impact of subsidies on TFP, but do not take into account differences in competition across sectors. The association between subsidies and total factor productivity is negative and highly significant, indicating that subsidies are associated with a twenty percent poorer productivity performance. However, when we add an interaction between competition and subsidies, in columns (3) through (6), the interaction term is positive and significant. Evaluated at the sample means, the net impact of subsidies on TFP, taking into account both the negative impact of subsidies alone and the positive impact of subsidies interacted with competition, varies across specifications. In columns (5) and (7), the net impact of subsidies taking into account the beneficial effects of competition is still negative, but small. In columns (3) and (5), the net impact of subsidies when there is perfect competition is positive, but again the magnitudes are small.

If, however, subsidies are allocated to competitive sectors (as measured by the Lerner index) and allocated in such a way as to preserve or increase com- petition, then the net impact of subsidies becomes positive and significant. In other words, targeting can have beneficial effects depending on both the degree of competition in the sector as well as depending on how the targeting is done. We measure policies that preserve or increase competition through the sectoral dispersion of subsidies.

To identify sectoral dispersion, we construct a Herfindahl index using the share of subsidies a firm receives relative to the total subsidies awarded to one industry. We define a measure of concentration, Herf_subsidy, where:

$$Herf\_subsidy_{jt} = \sum_{i \in j} \left(\frac{Subsidy_{ijt}}{Sum\_subsidy_{jt}} \right)^2 \quad (3.20)$$

As with standard Herfindahl indices, a smaller number indicates more dispersion of subsidies. In Table 3.3, we redo the specification from Table 3.2 but divide the sample into four groups based on the percentiles of the *Herf_subsidy*. Table 3.3 compares the results from the second quartile, where subsidies are more dispersed, with the fourth quartile, which represents sectors where subsidies are more concentrated on fewer enterprises. The results are quite different. The bottom panel of Table 3.3, which reports the results when subsidies are more concentrated, indicates that the impact of subsidies are negative even when there is perfect competition in the sector. In column (6), for example, the sum of 6.238 and −6.338 is negative. The top panel of Table 3.3, however, indicates that the net impact of subsidies is positive when there is perfect competition. For example, the net impact of subsidies in columns (3) and (5) is positive, and the coefficients indicate that a one standard deviation increase in the level of subsidies would lead to an increase in productivity of .7 percentage points, using the coefficients in column (3).

Table 3.4 replaces the interaction of competition and subsides with our mea- sure of the dispersion of subsidies, which can be defined as the inverse of our *Herf_subsidy* term, or *InvSubsidyHerf*. To the extent that greater dispersion of subsidies within a sector induces greater focus by encouraging more firms to innovate within a specific sector, we would expect the coefficient on that variable to positively affect productivity. The results in Table 3.4 show that this is indeed the case. The coefficient on *InvSubsidyHerf* is positive and statistically significant. The coefficient estimates indicate that a one standard deviation increase in the variable leads to an increase in TFP of 1.4 percentage points.

While not reported here, the results presented in Tables 3.2 through 3.4 are qualitatively the same if we transform the equations into differences and estimate the impact of changes in competition and subsidies on TFP growth. It should not be surprising that the results are robust to taking first differences, as all the specifications in Tables 3.2 through 3.4 include firm and year fixed effects. Next, in Tables 3.5 and 3.6, we replace TFP as our performance measure with an alternative measure of innovation. We identify as our new measure the share of a firm's output value generated by new products. This new product ratio, which we define as "*Ratio_newproduct*", is an alternative proxy for innovation by the firm.

In Table 3.5, we report the results for all observations, with the dependent variable *Ratio_newproduct*. Competition as measured by the Lerner index is significantly and positively associated with the share of new products in total sales, and the subsidy is associated with a negative but insignificant impact on new products. The interaction term is insignificant across all specifications. Without taking into account targeting policies that preserve or enhance competition (which we measure using the dispersion of subsidies), the net impact of subsidies on the share of new products even in a competitive environment is not statistically significant.

In Table 3.6, we separate the sample according to the dispersion of subsidies. As we saw in Table 3.3, the positive effects of subsidies are only apparent when there is both significant competition and significant dispersion, as proxied by the inverse of the subsidy herf. The second quartile, which indicates greater dispersion of subsidies, shows that while subsidies alone are associated with either insignificant or negative effects on the share of new products in sales, when coupled with greater competition the impact is positive and significant. The net impact of subsidies when there is significant competition, as indicated by the coefficients in column (6), suggest that a one standard deviation increase in subsidies is associated with a small net increase in the share of new products in sales. However, in the fourth quartile, where subsidies are concentrated on very few firms, there is no significant positive impact of subsidies on new product sales even when there is perfect competition.

The results in Tables 3.2 through 3.6 together indicate that innovation, as measured by either total factor productivity or the share of new products in total sales, is increasing with subsidies only when two conditions hold. First, there must be sufficiently high competition, as measured by [1– Lerner index]. Second, how the promotion is done is equally important: promotion tools must be sufficiently widespread across many firms.

One issue which could be raised is the potential endogeneity of targeting. What if targeting is applied to firms already likely to succeed? Conversely, what if targeting is only for firms likely to fail, and is in fact a bailout or soft budget constraint masquerading as industrial policy? In the former case, we are likely to over-state the benefits of industrial policy, while in the latter case we are likely to under-estimate them. In the next section, we propose one approach to address potential endogeneity.

3.3.4 Addressing endogeneity: an alternative specification

In this part, we propose an alternative approach to understanding the importance of competition and focus in making industrial policy work. In particular, we test whether a pattern of subsidies focused on more competitive sectors, using the pattern of competition across different industrial sectors at the beginning of the sample period, explains differential success of industrial policies. We then introduce an alternative targeting measure, tariffs, which address some of the endogeneity concerns at the firm level because they are set nationally.

We begin by measuring the pattern of subsidies at the city-year level, employing one method developed in Nunn and Trefler (2010). To test whether subsidies are more effective when introduced in a competitive setting, we propose to measure the correlation of subsidies with competition and then see whether the strength of that correlation raises firm performance. To measure whether subsidies are biased towards more competitive sectors in city r in year t , we calculate the correlation between the industry-city level initial degree of competition and current period t subsidies in sector j and city r:

$$\Omega_{rt} = Corr\left(SUBSIDY_{rjt}, COMPETITION_{rj0}\right) \quad (3.21)$$

Since subsidies vary over time, we have a time-varying change in the correlation between initial levels of competition and the patterns of interventions. We then explore whether higher correlations between subsidies and competition, as measured by Ω_{rt} , were associated with better performance. Total factor productivity is computed using four methods: AW et al 2001 (AW), OLS, OLS with fixed effects, and Olley & Pakes 1996 (OP). The firm-level estimation equation is as follows

$$\ln TFP_{ijrt} = \alpha_0 + \alpha_1\Omega_{rt} + \alpha_2 SUBSIDY_{ijt-1} + \alpha_3 X_{ijrt} + \alpha_i + \alpha_t + \epsilon_{ijt} \quad (3.22)$$

TFP_{ijrt} is the total factor productivity for firm i in industry j located in city r in year t . $SUBSIDY_{ijt-1}$ is the level of subsidy for firm i in sector j and region r in year t − 1. X_{ijrt} includes firm level controls such as the share of the firms' total equity owned by the state, etc. α_i is firm fixed effects and α_t represents year dummies.

To check the impact of targeting on industry level performance, which takes into account both within-firm changes in behavior as well as reallocation across firms, we also compute aggregate industry productivity measures for each city every year and estimate the following equation

$$ln\, TFP_{jrt} = \alpha_0 + \alpha_1\Omega_{rt} + \alpha_2 SUBSIDY_{jt-1} + \alpha_3 X_{jrt} + \alpha_i + \alpha_t + \epsilon_{ijt} \quad (3.23)$$

In a given city and year the aggregate industry productivity measure $lnTFP_{ijrt}$ is a weighted average of the firm's individual un-weighted productivities $lnTFP_{ijrt}$ with an individual firm's weight s_{it} corresponding to its output's share in total industry output in a particular year and city:

$$lnTFP_{jrt} = \sum_i s_{it} lnTFP_{ijrt} \quad (3.24)$$

In the industry-level equation, X_{ijrt} includes industry-city level controls, η_j and h_r are industry fixed effects and region dummies, respectively, and d_t includes year dummies.

The coefficient on the subsidy term captures the own firm or own industry effect of the policy on total factor productivity. The coefficient on the correlation coefficient between subsidies and competition indicates the beneficial effect of targeting, at the city level, when such targeting via subsidies is higher in competitive industries, as measured by the initial degree of competition at the beginning of the sample period.

Table 3.7 presents results for estimation equation (9). Columns (1) to (3) show firm-level estimation results using OLS, OLS with firm fixed effects, and OLS when TFP is calculated using the Olley-Pakes approach. All specifications include year and firm fixed effects. These results show that while the individual effects of subsidies at the firm level is associated with a negative impact on TFP, a positive correlation coefficient between the pattern of subsidization and competition is associated with a positive and significant impact on firm productivity. The coefficient estimate in column (3), .072, indicates that if the correlation between subsidies and competition at the city level was perfect (100 percent), then productivity would be 7.2 percent higher. Based on the sample means, a one standard deviation increase in the city-industry correlation would increase TFP by 0.6 percentage points for firms in that city and industry.

Table 3.8 separates the sample by the dispersion of subsidies, using the *Herf_subsidy* variable defined earlier. The impact of subsidies in the second quartile (when subsidies are more dispersed) is reported in the top panel of Table 3.8 and the impact in the fourth quartile (when subsidies are more concentrated) is reported in the bottom panel. In the top panel, the coefficient on the correlation between subsidies and competition is positive, significant, and twice the size of the coefficient in Table 3.7. The coefficient estimate, at 0.145 in the third column, indicates that perfect correlation between subsidies given and competition levels would increase productivity by 14.5 percentage points. The coefficient on subsidies alone, while still negative, is barely significant at conventional levels. The net impact of a one standard deviation increase in subsidies and the correlation variable would lead to a net increase in productivity of 1.2 percentage points. In contrast, the bottom panel of Table 3.8 shows no significant positive effects of the correlation measure. The results in Table 3.8 indicate that when subsidies are not sufficiently disbursed across firms, then subsidies do not positively affect productivity even when subsidies are higher in more competitive sectors. These results confirm the earlier results in Tables 3.2 and 3.3 suggesting that both competition and focus are necessary to promote industrial performance.

Tables 3.9 and 3.10 repeat the specifications reported in Tables 3.7 and 3.8 but estimate (10) instead, where the firm-level measure of the log of total factor productivity is replaced with the share-weighted industry-level measure as defined above. The results are comparable at the industry level to those at the firm-level, indicating that the benefits of industrial policy when there is competition and focus survive at the aggregate level.

Another approach to addressing the endogeneity of subsidies is to redo the analysis using an instrument of industrial policy which does not vary across firms. One such instrument is tariffs, which protect all firms in a particular sector. Consequently, we redid the estimation, but replaced subsidies with tariffs and replaced the correlation between initial competition and subsidies with the correlation between initial competition and current period tariffs. At the city level, the correlation between that city's degree of competition at the beginning of the sample period and current period tariffs should be strictly exogenous, as the level of competition is predetermined and tariffs are set at the national, not the city, level. Our new correlation measure is now defined as:

$$\Omega_{rt} = Corr(TARIFF_{jt}, COMPETITION_{rj0}) \quad (3.25)$$

The results are reported in Tables 3.11 and 3.12. In Table 3.11, the coefficient on the correlation measure defined in (3.25) is positive and statistically significant across all specifications. The coefficient, which ranges from .0722 to .0833, indicates that a perfect

(100 percent) correlation between higher tariff levels in sector j and time t and the degree of competition in region r, sector j and the initial year would lead to an increase in productivity of 7 to 8 percentage points. However, the independent effect of tariffs on productivity is negative and significant, as indicated by the coefficient on *lnTariff_lag*. Evaluated using a one standard deviation increase in both variables from Table 3.1, the net impact of an increase in tariffs is likely to be negative. In Table 3.12, we repeat the analysis using industry-level variables, which takes into account not only within firm changes in productivity but productivity gains or losses from reallocating market shares across firms. The results are qualitatively similar, but the negative impact of tariffs on productivity are stronger and larger in magnitude. Unless the targeting of tariffs is significantly stronger, with a higher correlation between the degree of competition in a sector and sectoral tariff levels, the negative impact of tariffs (possibly due to their anti-competitive effect) is likely to predominate. This is in contrast to subsidies, which the results indicate do have a net positive effect when we take into account the positive impact of targeting more competitive sectors.

Future extensions will further explore alternative ways to address the potential endogeneity of firms targeted for industrial policy. In particular, we have recently purchased a dataset on roads in China over time and across provinces to use as a potential instrument for our measures of competition.

3.4 Conclusion

In this paper we have argued that sectoral state aids tend to foster productivity, productivity growth, and product innovation to a larger extent when it targets more competitive sectors and when it is not concentrated on one or a small number of firms in the sector. A main implication from our analysis is that the debate on industrial policy should no longer be for or against having such a policy. As it turns out, sectoral policies are being implemented in one form or another by a large number of countries worldwide, starting with China. Rather, the issue should be on how to design and govern sectoral policies in order to make them more competition-friendly and therefore more growth-enhancing. While our analysis suggests that proper selection criteria together with good guidelines for governing sectoral support, can make a significant difference in terms of growth and innovation performance, yet the issue remains of how to minimize the scope for influence activities by sectoral interests when a sectoral state aid policy is to be implemented. One answer is that the less concentrated and more competition-compatible the allocation of state aid to a sector, the less firms in that sector will lobby for that aid as they will anticipate lower profits from it. In other words, political economy considerations should reinforce the interaction between competition and the efficiency of sectoral state aid. A comprehensive analysis of the optimal governance of sectoral policies still awaits further research.

References

[1] Aghion, Philippe, Bloom, Nick, Blundell, Richard, Griggith, Rachel and Howitt, Peter. (2005) PeterCompetition and Innovation: An Inverted-U Relationship. Quarterly Journal of Economics, Vol. 120(2): 701-728.

[2] Beck, Thorsten, Demirgu¨¸c-Kunt, Asli and Levine, Ross. (2000) A New Database on Financial Development and Structure. World Bank Economic Review, Vol. 14: 597-605, (November 2010 update).

[3] Brander, James A. (1995) Strategic Trade Policy. NBER Working Papers 5020.

[4] Brander, James A. and Spencer, Barbara J. (1985) Export Subsidies and International Market Share Rivalry. Journal of International Economics, Vol. 18(1-2): 83-100.

[5] Greenwald, Bruce and Stiglitz, Joseph E. (2006) Helping Infant Economies Grow: Foundations of Trade Policies for Developing Countries. The American Economic Review, Vol. 96(2): 141-146.

[6] Griliches, Zvi and Mairesse, Jacques. (1995) Production Functions: The Search for Identification. NBER Working Paper No. 5067.

[7] Harrison, Ann (1994) An Empirical Test of the Infant Industry Argument: Comment. The American Economic Review, Vol. 84(4): 1090-1095.

[8] Harrison, Ann and Rodriguez-Clare, Andres. (2009) Trade, Foreign In- vestment, and Industrial Policy for Developing Countries. NBER Working Papers 15261.

[9] Hausmann, Ricardo and Dani Rodrik. (2003) Economic development as self-discovery. Journal of Development Economics, Vol. 72(2): 603-633.

[10] Krueger, Anne O. and Tuncer, Baran. (1982) An Empirical Test of the Infant Industry Argument. The American Economic Review, Vol. 72(5): 1142-52.

[11] Nunn, Nathan and Daniel Trefler. (2010) The Structure of Tariffs and Long-Term Growth. The American Economic Journal: Macroeconomics, Vol. 2(4): 158-94.

[12] Olley, Steven and Ariel Pakes. (1996) The Dynamics of productivity in the Telecommunications Equipment Industry. Econometrica, Vol. 64: 1263-1297.

[13] Rodrik, Dani (1999) Making Openness Work: The New Global Economy and the Developing Countries. Barnes and Noble, Washington DC.

Appendix: Theory

Appendix 3.1 Social Optimum

In this first part of the Appendix we assume full Bertrand competition within sectors, and then compare the laissez-faire choice between diversity and focus with the choice that maximizes social welfare, not just innovation intensity and growth.

Suppose that a social planner could impose targeting on a single technology, i.e., force the two firms to focus on that same technology. The benefit of society from targeting on technology A is to provide a larger cost decrease from production and also a lower price for consumers. Hence targeting is necessarily socially beneficial as far as technology A is concerned. However, as far as technology B is concerned, targeting on technology A is harmful: on the one hand, consumers have the same surplus with or without the presence of one of the big firms since anyway they consume $x^B = E/c_f$ at price c_f; on the other hand, the good is provided at a higher marginal cost (net of the cost of innovation) than under diversity.

On technology B, consumers have the same total surplus of $\log(E/c_f) - E$ but the good is provided at cost $c_f E/c_f = E$ while the cost of provision under diversity, denoted by $C_B^D(\delta)$, is obviously the revenue of the firm, E, minus its profit, $\pi_B{}^D(\delta)$. Hence targeting leads a loss of $\pi_B{}^D(\delta)$ on technology B.

On technology A, consumers gain a surplus of $\log(E/c) - \log(E/c_f) = \log(c_f) - \log(c)$, which is a direct effect of increased product market competition. Moreover there is also a change in the total cost of production. Indeed, with diversity the cost of production, denoted by $C_A{}^D(\delta)$, is $E - \pi_A{}^D(\delta)$, while with focus the total cost is revenue E minus twice the expected profit of each firm, that is, $E - 2\pi^F(\delta)$. Hence targeting yields a gain of $\log(c_f) - \log(c) + 2\pi^F(\delta) - \pi_A{}^D(\delta)$.

Consequently, targeting is socially beneficial when:

$$\log(c_f) - \log(c) \geqslant \pi_A{}^D(\delta) + \pi_A{}^D(\delta) - 2\pi^F(\delta)$$

Let us denote $\Delta(\delta) \equiv \Pi_A^D(\delta) + \Pi_B^D(\delta) - 2\Pi^F(\delta)$. From the previous section, we know that $\Delta(\delta^L) > 0$: firm 2 is indifferent between diversity and targeting but firm 1 strictly prefers diversity to targeting. Under diversity and focus, the price to consumers on island B is equal to c but with focus there is a higher probability that firms have lower costs and because total welfare is decreasing in price, it is the case that the above condition holds at δ^L.

We show now that $\Delta(\delta)$ is a decreasing function of δ implying the existence of a cutoff $\delta^S < \delta^L$ such that social welfare is greater under focus if and only if $\geq \delta_S$.

Indeed, letting $g_+ \equiv \frac{\gamma+\delta-1}{\gamma+\delta}$ and $g_- \equiv \frac{\gamma-\delta-1}{\gamma-\delta}$. Direct differentiation yields

$$\Delta'(\delta) \propto \frac{2}{(\gamma+\delta)^2} g_+ \left[\left(\frac{c}{c_f}\right)^2 - 2\right] - \frac{2}{(\gamma-\delta)^2} g_- \left(\frac{c}{c_f}\right)^2$$

which is negative since $c < c_f$.

Note that we can have $\delta^S > 0$ only if targeting is not socially beneficial at $\delta = 0$, that is when:

$$\log(c_f) - \log(c) < 2\frac{c_f - c}{c_f}E + \frac{1}{2}\left(\frac{\gamma - 1}{\gamma}\right)^2\left(\left(\frac{c}{c_f}\right)^2 - 1\right)E^2 = \frac{c_f - c}{c_f}E\left\{2 - \frac{1}{2}\frac{c_f + c}{c_f}\left(\frac{\gamma - 1}{\gamma}\right)^2 E\right\}.$$

By the intermediate value theorem, there exists $\tilde{c} \in (c, c_f)$ such that $\log(c_f) - \log(c) = (c_f - c)/\tilde{c}$. Let $g \equiv \frac{(\gamma-1)}{\gamma}$ be the cost improvement when $\delta = 0$. The condition becomes:

$$\frac{1}{2}\frac{c_f + c}{c_f}g^2E^2 - 2E + \frac{c_f}{\tilde{c}} < 0.$$

The discriminant of the quadratic is $1 - (c_f + c)g^2/(2\tilde{c}) < 0$. Therefore, if $g^2 > \tilde{c}/(c_f + c)$ there is no real root, and $\delta^S = 0$. However if $g^2 < \tilde{c}/(c_f + c)$, there exist two roots for the quadratic equation.[33]

For instance, if $\gamma = 1$, there is no cost improvement ($g = 0$) and the condition is that $E \in [0, 2c_f/(c_f + c)]$; if $g^2 = \tilde{c}/(c_f + c)$, the condition cannot be satisfied for any value of E. We summarize our findings in the following proposition.

Proposition 2

1. There exists $\delta^S < \delta^L$ such that targeting is socially optimal if, and only if, δ is greater than δ^S.

2. Letting $g = \frac{\gamma-1}{\gamma}$, $\delta^s = 0$ when $g^2 \geq \frac{1}{2}\frac{\tilde{c}}{c_f+c}$.

3. When $g^2 < \frac{\tilde{c}}{c_f+c}$, there exist E_0, E_1 with $E_0 < E_1$ such that $\delta^S > 0$ only if the market size $E \in [E_0, E_1]$; for $E < E_0$, or $E > E_1$, $\delta^s = 0$.

These results are quite intuitive. First, ceteris paribus, for small values of δ, targeting has a low social benefit (in terms of higher competition and innovation) relative to the cost reduction on technology B achieved thanks to diversity. There may however be room for a targeting policy for higher δ's: the desire to relax price competition by choosing diversity leads the big firms not to focus enough.

Second, with perfect information, (innovation-reducing) diversity is welfare-decreasing if γ, and thus the potential cost decrease from innovation, is high enough. In this case, laissez-faire conflicts with social optimal for all values of δ less than δ^L, and we can 'safely' go for targeting: it is either welfare-increasing (for $\delta < \delta^L$) or irrelevant (for $\delta \geqslant \delta^L$).

[33] The rootes are $E_0 = 2c_f\frac{1-\sqrt{1-\frac{c_f+c}{2\tilde{c}}g^2}}{c_f+c}$, $E_1 = 2c_f\frac{1-\sqrt{1+\frac{c_f+c}{2\tilde{c}}g^2}}{c_f+c}$

Third, for smaller values of γ, there exists an intermediate region for market size E, where diversity may be socially optimal for some values of δ. If market size (E) is large, targeting is desirable.

Appendix 3.2 Imperfect Information

Our assumption of perfect information is obviously extreme. Below we consider two possibilities. One where the firms know the technology on which the cost reduction possibilities are greater but the planner does not. The other case is where neither the firms nor the planner know the identity of the technology with the greater cost reduction. It turns out that the first case is equivalent to the case of perfect information if the planner can use mechanisms. For the second case, the laissez-faire outcome looks very different from the one under perfect information since it is now for high values of δ that diversity emerges. The possibility of conflict between the firms and the planner are still present and there is value for a targeting policy.

Appendix 3.2.1 Only the planner has imperfect information

If the planner has imperfect information about the identity of the technology leading to higher cost reduction but the firms (or at least one of them) have perfect information, as long as δ is known by the planner, the perfect information outcome can be replicated.

For $\delta \geqslant \delta^S$, letting the firm diversify is socially optimal and the planner will not intervene. When $\delta < \delta^S$, the planner would like to impose targeting on the better technology, but it does not know which one it is. However, conditional on being obliged to focus, firms 1 and 2 prefer to do it on the better technology, so that a planner can simply impose targeting to firms 1, 2 and let them locate subject to this constraint.

If in addition the planner does not have information about the value of δ, since the parties have correlated information revelation mechanisms can be used to extract this information from the parties. The design of the optimal mechanism is beyond the scope of this paper however.

Appendix 3.2.2 All parties have imperfect information

When neither the firms nor the planner have information about which technology leads to the higher cost reduction under innovation, there may be a coordination failure both under laissez-faire and under intervention.

We consider the case where firms locate without knowing whether the market they have chosen allows for a cost reduction of $\gamma + \delta$ or $\gamma - \delta$ but, upon being called to innovate, they learn which cost reduction can be generated. This interpretation facilitates comparison with the perfect-information case.

Assume first diversity. Then total industry profit is the same as before since firms make the same decisions when they are chosen to innovate.

Under focus, since at the time technology is chosen firms do not know which is the better one, focus yields with probability 1/2 the level of profit $\pi^F(\delta)$ and with probability 1/2 the same level of profit but with $\gamma + \delta$ replaced by $\gamma - \delta$, that is, $(\pi^F(\delta) + \pi^F(-\delta))/2$.

By revealed preferences in the perfect information case, we have $\pi^D(\delta) > \pi^F(\delta)$ since a firm under diversity could have chosen to set the same price and use the same innovation intensity as under focus. A similar argument shows that $\pi^D(-\delta) > \pi^F(-\delta)$, therefore:

$$(\pi^D(\delta) + \pi^D(-\delta))/2 > (\pi^F(\delta) + \pi^F(-\delta))/2$$

and firms prefer to diversity rather than to focus for any value of δ.

Proposition A1 Under imperfect information, the laissez-faire outcome is for firms to diversify for any value of δ and γ.

Let us now turn to intervention. Diversity brings the same social value as under perfect information. With targeting on the good technology, the social benefit is the same as under perfect information; but the social benefit is much lower than under perfect information with targeting on the bad technology. When there is focus, the total cost is in fact $(2E - \pi^F(\delta) - \pi^F(-\delta))/2$ and therefore targeting is socially optimal when:

$$\log(c_f) - \log(c) \geqslant \pi^D(\delta) + \pi^D(-\delta) - (\pi^F(\delta) + \pi^F(-\delta)).$$

The RHS is the difference in industry profit between diversity and focus, which is positive by Proposition A1. Using the expressions for the profit functions, we have:

$$\pi^D(\delta) + \pi^D(-\delta) - \left(\pi^F(\delta) + \pi^F(-\delta)\right) = \frac{1}{4}\left[\left(\frac{\gamma+\delta-1}{\gamma+\delta}\right)^2 + \left(\frac{\gamma-\delta-1}{\gamma-\delta}\right)^2\right]\left(\left(\frac{c}{c_f}\right)^2 - 1\right)E^2 + 2\frac{c_f - c}{c_f}E.$$

We know from the derivations in section 3.2.4 that the term in brackets is decreasing in δ; since $c < c_f$, the coefficient of E^2 is negative and therefore the expression is increasing in δ. This is in sharp contrast with the perfect information case since the difference in industry profit between diversity and focus was decreasing in δ. In the perfect information case, focusing on the "good" technology led to a decreasing opportunity cost since as δ increases the value of being located on the "bad" technology sector decreases. With imperfect information though, focusing makes it as likely to be on competition in the "good" or in the "bad" sector; since conditional on being on one sector firms prefer not to face competition as δ increases, firms value more diversity.

A necessary condition for targeting to be socially optimal is that $\log(c_f) - \log(c)$ be greater than the minimum difference in profits, which arises at $\delta = 0$, which is the case where both technologies yield the same cost reduction in the case of innovation. Using the same reasoning as in the perfect information case for deriving condition (13), if $\tilde{c}$ solves $\log(c_f) - \log(c) = (c_f - c)/\tilde{c}$ the necessary condition can be written when $\delta = 0$ as (recall that $g \equiv (\gamma - 1)/\gamma$):

$$\frac{c_f - c}{c_f} g^2 E^2 - 2E + \frac{c_f}{\tilde{c}} > 0$$

which is (obviously) the same condition as under perfect information. Therefore when g^2 is larger than $\tilde{c}/(c_f + c)$, targeting is optimal when $\delta = 0$ and when g^2 is smaller than this value, targeting is optimal when E is smaller than the root E_0 or is larger than the root E_1.

If focus is optimal at $\delta = 0$, by continuity there exists $\delta^* > 0$ such that focus is socially optimal for all δ less than δ^*.

Proposition A2 *1. If* $g^2 > \frac{\tilde{c}}{c_f+c}$, *there exists* $\delta^* > 0$ *such that targeting is socially optimal for all* $\delta < \delta^*$.

2. If $g^2 < \frac{\tilde{c}}{c_f+c}$, *and* $E < E_0$ *or* $E > E_1$, *there exists* $\delta^{**} > 0$ *such that targeting is socially optimal for all* $\delta < \delta^{**}$.

3. If $g^2 < \frac{\tilde{c}}{c_f+c}$, *and* $E \in [E_0, E_1]$ *targeting is not an optimal policy for all values of* δ.

Because targeting under imperfect information yields a smaller surplus than under perfect information while diversity brings the same benefit, it must be the case that focus is less often socially optimal, and therefore δ^* is strictly smaller than the cutoff δS in Proposition 2.

Finally, one can show that $\delta^* > \delta^{**}$, so that, as in the perfect information case, the range of δ's for which targeting is socially optimal, is bigger when the growth rate g is high than when it is low. To prove that claim, it suffices to note that if:

$$\Delta\Pi = \pi^D(\delta) + \pi^D(-\delta) - (\pi^F(\delta) + \pi^F(-\delta)),$$

we have:

$$\frac{\partial \Delta\Pi}{\partial \delta} > 0; \frac{\partial \Delta\Pi}{\partial \gamma} < 0.$$

To see this, note that:

$$\Delta\Pi \approx -\left[\left(\frac{\gamma+\delta-1}{\gamma+\delta}\right)^2 + \left(\frac{\gamma-\delta-1}{\gamma-\delta}\right)^2\right] \equiv -F(\delta,\gamma),$$

where:

$$\frac{\partial F}{\partial \delta} = \frac{1}{(\gamma+\delta)^2} - \frac{1}{(\gamma+\delta)^3} - \frac{1}{(\gamma-\delta)^2} + \frac{1}{(\gamma+\delta)^3} < 0$$

and:

$$\frac{\partial F}{\partial \gamma} = \left(1 - \frac{1}{\gamma+\delta}\right)\frac{1}{(\gamma+\delta)^2} + \left(1 - \frac{1}{\gamma-\delta}\right)\frac{1}{(\gamma-\delta)^2} > 0.$$

Appendix 3.3 Growth and dynamic welfare under focus versus diversity

Consider a dynamic extension of the model where the social planner seeks to maximize intertemporal utility

$$U = \sum_{t=1}^{\infty}(1+r)^{-t}[\log x_t^A + log x_t^B] \, ,$$

although private consumers and entrepreneurs live for one period only. More- over, assume that, due to knowledge spillovers, after one period all firms multiply their initial productivity by the same $\tilde{\gamma} \in \{\gamma+\delta, \gamma-\delta\}$ as the innovative firm. Then a social planner who wants to maximize intertemporal utility, will take into account not only the static welfare analyzed above, but also the average growth rates respectively under diversity and under focus.

The growth rates of utility under diversity and focus are respectively given by:

$$G^D = \left[\frac{1}{2}\left(1-\frac{1}{\gamma+\delta}\right)\log(\gamma+\delta) + \frac{1}{2}\left(1-\frac{1}{\gamma-\delta}\right)\log(\gamma-\delta)\right]\frac{c}{c_f}E$$

and

$$G^F = \left(1-\frac{1}{\gamma+\delta}\right)\log(\gamma+\delta)\, E.$$

We clearly have

$$G^F > G^D,$$

as a results of two effects that play in the same direction: (i) focus increases the expected size of innovation (always equal to log(γ + δ) under focus, but sometimes equal to log(γ − δ) under diversity); (ii) focus increases the expected frequency of innovation both because innovation under focus induces bigger cost reduction under focus (under diversity cost is sometimes reduced by factor (γ − δ)) and because under focus there is more incentive to innovate in order to escape competition (term $\frac{c}{c_f}$ in the expression for G^D). This immediately establishes:

Proposition A3 There exists a cut-off value $\delta^S(r) < \delta^S$, increasing in r, such that focus maximizes dynamic welfare whenever $\delta > \delta^S(r)$.

Tables

Table 3.1 Summary Statistics

	Levels			Growth Rates		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
TFP	1,522,730	1.764	0.359	1,072,148	0.055	0.306
Stateshare	1,522,730	0.087	0.269	1,072,148	-0.007	0.144
Horizontal	1,522,730	0.256	0.142	1,072,148	0.004	0.045
Backward	1,522,730	0.078	0.046	1,072,148	0.002	0.015
Forward	1,522,730	0.104	0.174	1,072,148	0.004	0.066
Ratio_subsidy	1,522,730	0.003	0.019	1,072,148	0.000	0.020
Competition _lerner	1,522,730	0.975	0.019	1,072,148	-0.005	0.009
Interaction	1,522,730	0.003	0.019	1,072,148	0.000	0.019
lnTariff	1,522,730	2.418	0.505	1,072,148	-0.063	0.180
lnfwTariff	1,520,636	1.025	1.435	1,070,512	-0.017	0.525
lnbwTariff	1,522,730	1.262	0.505	1,072,148	-0.029	0.206
Competition _Herf_Subsidy	1,522,730	69.001	80.512	1,072,148	3.726	38.721
Subsidy_lag	1,072,148	0.003	0.019	742,902	0.000	0.019
Competition _lerner_lag	1,072,148	0.978	0.018	742,902	-0.004	0.008
Interaction_lag	1,072,148	0.003	0.019	742,902	0.000	0.019
lnTariff_lag	1,072,148	2.446	0.507	742,902	-0.079	0.188
lnbwTariff_lag	1,072,148	1.262	0.507	742,902	-0.075	0.175
lnfwTariff_lag	1,070,533	1.008	1.471	741,689	-0.342	1.635
Cor_tariff_lerner	1,522,730	0.022	0.141	1,072,148	0.016	0.039
Cor_subsidy_lerner	1,522,730	0.141	0.083	1,072,148	-0.013	0.057
Ratio_newproduct	1,323,089	0.034	0.150	891,800	0.001	0.128

Notes: Interation = Ratio_subsidy*Competition_lerner and Interaction_lag = Subsidy_lag * competition_lerner_lag.

Table 3.2

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent: lnTFP (based on Olley-Pakes regression)					
Stateshare	-0.00150	-0.00144	-0.00159	-0.00152	-0.00185	-0.00179
	(0.00337)	(0.00331)	(0.00337)	(0.00331)	(0.00329)	(0.00326)
Horizontal	0.322***	0.335***	0.323***	0.335***	0.178*	0.198*
	(0.0756)	(0.0793)	(0.0755)	(0.0793)	(0.0947)	(0.101)
Ratio_subsidy	-0.185***	-0.188***	-8.201***	-6.752***	-8.067***	-6.798***
	(0.0279)	(0.0276)	(1.769)	(1.404)	(1.748)	(1.392)
Competition		0.512		0.482		0.427
_lerner		(0.533)		(0.535)		(0.535)
Interaction			8.212***	6.724***	8.074***	6.773***
_lerner			(1.818)	(1.441)	(1.796)	(1.429)
Backward					0.779***	0.762***
					(0.278)	(0.273)
Forward					0.112	0.0995
					(0.0991)	(0.0990)
LnTariff	-0.0382**	-0.0348**	-0.0380**	-0.0348**	-0.0335	-0.0321
	(0.0162)	(0.0166)	(0.0162)	(0.0166)	(0.0214)	(0.0213)
LnbwTariff	-0.00764	-0.00672	-0.00770	-0.00682	-0.0223	-0.0213
	(0.0174)	(0.0172)	(0.0174)	(0.0172)	(0.0194)	(0.0189)
LnfwTariff	-0.00373	-0.00422	-0.00379	-0.00424	-0.00418	-0.00406
	(0.00260)	(0.00278)	(0.00260)	(0.00278)	(0.00544)	(0.00537)
Constant	1.726***	1.213**	1.725***	1.242**	1.699***	1.274**
	(0.0315)	(0.534)	(0.0314)	(0.535)	(0.0412)	(0.533)
Observations	1,072,034	1,072,034	1,072,034	1,072,034	1,072,034	1,072,034
R-squared	0.172	0.172	0.172	0.173	0.173	0.173

Notes: Robust clustered standard errors are shown in the parenthesis. Firm fixed effect and time effect are included in each specification.

Table 3.3

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent: lnTFP (based on Olley and Pakes regression)					
	The second quartile: more dispersion in subsidies					
Ratio_subsidy	-0.197*	-0.193**	-16.25***	-12.00***	-16.49***	-11.96***
	(0.0962)	(0.0937)	(4.884)	(4.037)	(4.813)	(4.031)
Competition_lerner		1.818		1.763		2.001
		(1.286)		(1.285)		(1.308)
Interaction_lerner			16.63***	12.24***	16.88***	12.19***
			(5.096)	(4.186)	(5.023)	(4.178)
	The fourth quartile: least dispersion in subsidies (most concentrated)					
Ratio_subsidy	-0.227***	-0.228***	-9.352**	-6.169**	-9.148**	-6.338**
	(0.0625)	(0.0627)	(3.615)	(2.854)	(3.710)	(2.860)
Competition_lerner		1.179		1.153		1.029
		(0.981)		(0.982)		(1.042)
Interaction_lerner			9.320**	6.069**	9.107**	6.238**
			(3.628)	(2.883)	(3.727)	(2.888)
Horizontal	Yes	Yes	Yes	Yes	Yes	Yes
Forward & Backward	No	No	No	No	Yes	Yes
Tariffs	Yes	Yes	Yes	Yes	Yes	Yes

Table 3.4

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent: lnTFP (based on Olley-Pakes regression)					
Stateshare	-0.00150	-0.00106	-0.00144	-0.00106	-0.00171	-0.00133
	(0.00337)	(0.00322)	(0.00331)	(0.00322)	(0.00326)	(0.00317)
Horizontal	0.322***	0.343***	0.335***	0.343***	0.198*	0.212**
	(0.0756)	(0.0785)	(0.0793)	(0.0785)	(0.101)	(0.0975)
Ratio_subsidy	-0.185***	-0.200***	-0.188***	-0.200***	-0.187***	-0.199***
	(0.0279)	(0.0320)	(0.0276)	(0.0320)	(0.0277)	(0.0318)
Competition_lerner		0.448	0.512	0.448	0.457	0.399
		(0.542)	(0.533)	(0.542)	(0.534)	(0.543)
Competition_HerfSubsidy		0.000177***		0.000177***		0.000170**
		(6.24e-05)		(6.24e-05)		(6.49e-05)
Backward					0.762***	0.738***
					(0.273)	(0.274)
Forward					0.0992	0.0931
					(0.0990)	(0.101)
lnTariff	-0.0382**	-0.0360**	-0.0348**	-0.0360**	-0.0322	-0.0338*
	(0.0162)	(0.0155)	(0.0166)	(0.0155)	(0.0213)	(0.0202)
lnbwTariff	-0.00764	-0.00578	-0.00672	-0.00578	-0.0212	-0.0199
	(0.0174)	(0.0166)	(0.0172)	(0.0166)	(0.0189)	(0.0186)
lnfwTariff	-0.00373	-0.00556**	-0.00422	-0.00556**	-0.00402	-0.00517
	(0.00260)	(0.00276)	(0.00278)	(0.00276)	(0.00537)	(0.00541)
Constant	1.726***	1.311**	1.213**	1.311**	1.245**	1.337**
	(0.0315)	(0.539)	(0.534)	(0.539)	(0.532)	(0.537)
Observations	1,072,034	1,072,034	1,072,034	1,072,034	1,072,034	1,072,034
R-squared	0.172	0.173	0.172	0.173	0.173	0.174

Table 3.5

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent: Ratio_newproduct					
Stateshare	-0.0007	-0.0007	-0.0007	-0.0007	-0.0007	-0.0006
	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0019)
Hhorizontal	0.0266***	0.0289***	0.0266***	0.0289***	0.0321***	0.0364***
	(0.0071)	(0.0070)	(0.0071)	(0.0070)	(0.0088)	(0.0090)
Ratio_subsidy	-0.000985	-0.00135	-0.00214	0.236	-0.00860	0.241
	(0.0137)	(0.0139)	(0.543)	(0.526)	(0.543)	(0.526)
Competition_lerner		0.0830**		0.0841**		0.0890**
		(0.0359)		(0.0355)		(0.0358)
Interaction_lerner			0.00118	-0.243	0.00780	-0.248
			(0.559)	(0.541)	(0.559)	(0.541)
Backward					-0.0221	-0.0257
					(0.0272)	(0.0275)
Forward					-0.00564	-0.00807
					(0.00732)	(0.00744)
lnTariff	-0.0016	-0.0011	-0.0016	-0.0011	-0.0021	-0.0017
	(0.0026)	(0.0027)	(0.0026)	(0.0027)	(0.00301)	(0.0031)
lnbwTariff	-0.0045**	-0.0043**	-0.0045**	-0.0043**	-0.0041*	-0.0039*
	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0022)	(0.0022)
lnfwTariff	-0.0003	-0.0004	-0.0003	-0.0004	-0.0002	-0.0002
	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0009)	(0.0009)
Constant	0.0375***	-0.0451	0.0375***	-0.0462	0.0389***	-0.0490
	(0.0053)	(0.0367)	(0.0054)	(0.0363)	(0.0061)	(0.0362)
Observations	925,388	925,388	925,388	925,388	925,388	925,388
R-squared	0.003	0.003	0.003	0.003	0.003	0.003

Table 3.6

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent: Ratio_newproduct					
	The second quartile					
Ratio_subsidy	0.00397	0.0036	-1.503*	-1.689**	-1.508*	-1.679**
	(0.0390)	(0.0388)	(0.821)	(0.755)	(0.816)	(0.755)
Competition_lerner		-0.0724		-0.0798		-0.0777
		(0.0789)		(0.0780)		(0.0720)
Interaction_lerner			1.562*	1.755**	1.568*	1.744**
			(0.841)	(0.780)	(0.837)	(0.780)
	The fourth quartile					
Ratio_subsidy	0.00185	0.00092	-1.324	-1.029	-1.332	-1.022
	(0.0351)	(0.0352)	(1.475)	(1.442)	(1.468)	(1.432)
Competition_lerner		0.117*		0.114*		0.122*
		(0.0662)		(0.0657)		(0.0622)
Interaction_lerner			1.359	1.057	1.368	1.049
			(1.503)	(1.470)	(1.495)	(1.460)
Horizontal	Yes	Yes	Yes	Yes	Yes	Yes
Forward & Backward	No	No	No	No	Yes	Yes
Tariffs	Yes	Yes	Yes	Yes	Yes	Yes

Table 3.7 Effect of Correlation (subsidy and lerner index) on Firm-level productivity

	Dependent: Firm-level TFP		
	TFP_ols	TFP_olsFE	TFP_OP
Cor_subsidy_lerner	0.0325	0.0791***	0.0720***
	(0.0204)	(0.0193)	(0.0193)
Stateshare	-0.00265	-0.00178	-0.00347
	(0.00386)	(0.00365)	(0.00366)
Horizontal	0.201**	0.187*	0.189*
	(0.0939)	(0.0978)	(0.0969)
Backward	0.744***	0.735***	0.733***
	(0.269)	(0.272)	(0.270)
Forward	0.0900	0.104	0.103
	(0.101)	(0.0986)	(0.0984)
Subsidy_lag (at firm level)	-0.0374	-0.0666**	-0.0656**
	(0.0252)	(0.0257)	(0.0263)
Lerner_lag	0.00756	-0.139	-0.129
	(0.105)	(0.109)	(0.108)
lnTariff	-0.0390*	-0.0369*	-0.0366*
	(0.0224)	(0.0215)	(0.0219)
lnbwTariff	-0.0205	-0.0153	-0.0164
	(0.0197)	(0.0189)	(0.0190)
lnfwTariff	-0.00273	-0.00278	-0.00287
	(0.00531)	(0.00511)	(0.00511)
Constant	0.973***	1.932***	1.729***
	(0.111)	(0.113)	(0.113)
Firm FEs	yes	yes	yes
Year dummies	yes	yes	yes
Observations	727,460	727,460	727,460
R-squared	0.136	0.179	0.167

Table 3.8 Effect of Correlation (subsidy and lerner index) on Firm-level productivity
Second Quartile and Fourth Quartile

	(1)	(2)	(3)
VARIABLES	TFP_ols	TFP_olsFE	TFP_OP
	Second Quartile		
Correlation (subsidy & lerner)	0.114***	0.150***	0.145***
	(0.0407)	(0.0413)	(0.0411)
Subsidy_lag	-0.0910*	-0.118*	-0.127*
	(0.0519)	(0.0624)	(0.0633)
Competition_lerner_lag	-0.0333	-0.179*	-0.169*
	(0.0818)	(0.0913)	(0.0910)
	Fourth Quartile		
Correlation (subsidy & lerner)	0.0104	0.0713	0.0636
	(0.0468)	(0.0450)	(0.0456)
Subsidy_lag	0.0721	0.0435	0.0465
	(0.0692)	(0.0740)	(0.0743)
Competition_lerner_lag	-0.0357	-0.124	-0.124
	(0.143)	(0.149)	(0.148)
horizontal	Yes	Yes	Yes
Backward	Yes	Yes	Yes
Forward	Yes	Yes	Yes
lnTariff	Yes	Yes	Yes
lnbwTariff	Yes	Yes	Yes
lnfwTariff	Yes	Yes	Yes

Table 3.9 Effect of Correlation (subsidy and lerner index) on Aggregate Firm Productivity

	Dependent: City-Industry Aggregate TFP		
	OLS	OLS with FEs	OP
cor_subsidy_lerner	0.0348*	0.0796***	0.0689***
	(0.0178)	(0.0192)	(0.0186)
stateshare_aggre	0.00506**	0.0288***	0.0201***
	(0.00243)	(0.00530)	(0.00422)
horizontal	-0.0546	-0.0717	-0.0696
	(0.266)	(0.259)	(0.258)
backward	3.953***	3.546***	3.654***
	(0.984)	(0.923)	(0.923)
forward	0.360	0.459	0.434
	(0.487)	(0.419)	(0.432)
subsidy_lag	-0.0620	-0.0640	-0.125
	(0.0894)	(0.123)	(0.113)
lerner_lag	-0.233***	-0.355***	-0.347***
	(0.0798)	(0.0869)	(0.0871)
lnTariff	-0.190***	-0.164***	-0.169***
	(0.0412)	(0.0394)	(0.0392)
lnbwTariff	-0.155**	-0.135*	-0.137*
	(0.0763)	(0.0716)	(0.0718)
lnfwTariff	0.0450***	0.0409***	0.0412***
	(0.0154)	(0.0150)	(0.0147)
Constant	1.353**	2.195***	2.001***
	(0.510)	(0.457)	(0.468)
Industry FEs	Yes	Yes	Yes
City FEs	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes
Observations	76,923	76,923	76,923
R-squared	0.476	0.458	0.467

Table 3.10 Effect of Correlation (subsidy and lerner index) on Aggregate Firm Productivity Second Quartile and Fourth Quartile

Dependent: City-Industry Aggregate TFP			
	(1)	(2)	(3)
	OLS	OLS with FEs	OP
Second Quartile			
Correlation (subsidy & lerner)	0.0399	0.0892**	0.0812**
	(0.0278)	(0.0422)	(0.0384)
Subsidy_lag	-0.146	-0.0816	-0.167*
	(0.0941)	(0.101)	(0.0966)
Competition_lerner_lag	-0.197*	-0.317**	-0.303*
	(0.110)	(0.154)	(0.148)
Fourth Quartile			
Correlation (subsidy &lerner)	-0.00425	0.0425	0.0299
	(0.0375)	(0.0409)	(0.0393)
Subsidy_lag	-0.0182	-0.113	-0.149
	(0.141)	(0.181)	(0.172)
Competition_lerner_lag	-0.303***	-0.348***	-0.353***
	(0.0802)	(0.0900)	(0.0891)
Horizontal	Yes	Yes	Yes
Backward	Yes	Yes	Yes
Forward	Yes	Yes	Yes
lnTariff	Yes	Yes	Yes
lnbwTariff	Yes	Yes	Yes
lnfwTariff	Yes	Yes	Yes

Table 3.11 Effect of Correlation (tariff and lerner index) on Firm Productivity

	Dependent: Firm-level TFP		
	OLS	OLS with FEs	OP
Correlation (tariff&lerner)	0.0833***	0.0722***	0.0745***
	(0.0219)	(0.0203)	(0.0202)
Stateshare	-0.00257	-0.00199	-0.00365
	(0.00385)	(0.00364)	(0.00367)
Horizontal	0.168*	0.159*	0.161*
	(0.0893)	(0.0935)	(0.0926)
Backward	0.688***	0.698***	0.692***
	(0.255)	(0.259)	(0.256)
Forward	0.123	0.134*	0.131*
	(0.0784)	(0.0774)	(0.0772)
Competition_lerner_lag	0.00278	-0.156	-0.144
	(0.110)	(0.113)	(0.113)
lnTariff_lag	-0.0342**	-0.0340**	-0.0337**
	(0.0144)	(0.0139)	(0.0141)
lnbwTariff_lag	-0.0196	-0.0167	-0.0170
	(0.0180)	(0.0172)	(0.0173)
lnfwTariff_lag	-0.00857***	-0.00806***	-0.00806***
	(0.00214)	(0.00209)	(0.00211)
Constant	1.130***	2.131***	1.918***
	(0.109)	(0.112)	(0.112)
Firm FEs	yes	yes	yes
Year Dummies	yes	yes	yes
Observations	728,274	728,274	728,274
R-squared	0.137	0.179	0.167

Table 3.12 Effect of Correlation (tariff and lerner index) on Aggregate Firm Productivity

	Dependent: City-Industry Aggregate TFP		
	OLS	OLS with FEs	OP
Correlation (tariff & lerner)	0.0783***	0.0856***	0.0873***
	(0.0184)	(0.0223)	(0.0217)
Stateshare_aggre	0.00475*	0.0285***	0.0198***
	(0.00243)	(0.00522)	(0.00415)
Horizontal	0.0670	0.0303	0.0355
	(0.260)	(0.252)	(0.251)
Backward	3.894***	3.464***	3.581***
	(1.029)	(0.968)	(0.967)
Forward	0.179	0.304	0.275
	(0.521)	(0.446)	(0.460)
Competition_lerner_lag	-0.210**	-0.339***	-0.329***
	(0.0851)	(0.0889)	(0.0894)
lnTariff_lag	-0.114***	-0.101***	-0.104***
	(0.0271)	(0.0264)	(0.0260)
lnbwTariff_lag	-0.0256	-0.0424*	-0.0367
	(0.0256)	(0.0228)	(0.0231)
lnfwTariff_lag	-0.00177	-0.00190	-0.00242
	(0.00627)	(0.00569)	(0.00577)
Constant	1.511***	2.503***	2.270***
	(0.115)	(0.119)	(0.118)
Industry FEs	yes	yes	yes
City FEs	yes	yse	yse
Year dummies	yes	yse	yse
Observations	76,935	76,935	76,935
R-squared	0.472	0.456	0.465