Do Domestic Firms Benefit from Foreign Direct Investment? Initial Evidence from Chinese Manufacturing[±]

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Abstract

Foreign direct investment (FDI)[1] is believed to bring positive spillovers to domestic firms in the host country. Empirical studies, however, have found conflicting evidence on the effects of FDI. In this study, we use a firm-level industrial census to estimate the relationship between the intensity of foreign presence and performance of domestic firms in China. More specifically, we attempt to answer the following questions. First, are Chinese domestic enterprises affected by the presence of foreign invested firms operating in the same industry which they do business in? Second, are Chinese domestic enterprises affected by the presence of foreign invested firms operating within related industries at the same locality where they conducted their businesses? It is a fact that a substantial portion of FDI in China are originated from neighboring economies, especially from the three most Chinese populated economies Hong Kong, Macao and Taiwan, that are technologically much less advanced than industrial countries. Finally, we examine whether foreign investment firms from these economies affect the Chinese domestic firms differently compared to those from other investing countries. The estimation results offer some support for the existence of positive spillovers. There seems to be stronger evidence that domestic industries benefit from foreign presence in the related industries within the province. Employment shares of foreign affiliates, especially those with investors from advanced countries, are associated with higher productivity. The impact of foreign presence within the industry is rather mixed. Employment shares of firms with investment from greater China area are negatively associated with domestic productivity while those with other foreign investment are positively associated with domestic productivity. It supports the argument that larger technology gap provides large potentials for technology spillover. For investment from greater China area, smaller technology gap present less potential gain. More over, they may be in direct competition with domestic firms and result in shrinking market share for domestic firms.

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[1] In the context of this study, foreign direct investment refers to inward investment originated from outside mainland China. Official Chinese statistics categorize foreign direct investment into two groups, those from Hong Kong, Macao, and Taiwan and those from other countries.

Do Domestic Firms Benefit from Foreign Direct Investment?
Initial Evidence from Chinese Manufacturing

I. Introduction

Attracting foreign direct investment (FDI) has become an important policy element for developing countries to pursue growth and development. There has been less theoretical disagreement on FDI's potential positive impact on hosting country's development. FDI in the manufacturing sector is particularly favored as it is often regarded as an amalgamation of capital, technology, as well as managerial and marketing skills. Most developing countries lack technology capability and FDI can serve to facilitate technology transfer and reduce the technology gap between developing countries and industrial countries. In fact, it is suggested that spillovers or the external effects from FDI are the most significant channels for the dissemination of modern technology (Blomstrom, 1989).

Although little theoretical controversy remains, empirical studies have not been able to generate consistent evidence for significant and positive spillover effects from FDI. While many researchers find that there exist significant positive spillovers from foreign direct investment, some others find no or statistically insignificant spillovers effects. Utilize a firm-level industrial census in China, this paper attempts to provide some evidence to help reconcile the empirical differences between the two groups of studies. Our first intention is to identify and examine different FDI effects due to different modes of technology spillover from foreign affiliates to indigenous Chinese firms. More specifically, we look at the influence of foreign affiliates in both the intra-industry context and the inter-industry level. Our second intention is to identify any dependency between spillover effects and the source country characteristics. We will examine whether FDI from neighboring economies of Hong Kong, Macao and Taiwan creates different impact compared to FDI from other investing countries.

In addition to provide empirical evidence on the existence of FDI spillovers in China, the study of FDI's impact on Chinese manufacturing industries is a very interesting subject by itself. China's economic transformation started more than two decades has been characterized by its active promotion of foreign investment. As a result, China's has attracted large and growing amount of foreign investment inflow. It is been widely believed that inward investment in China has contributed significantly in China's trade expansion as well as it rapid economic growth in recent years. With China's recent accession to the World Trade Organization (WTO), China is expected to become more attractive for foreign investors. A study on the impact of FDI in China not only serve to provide policy implication for the Chinese leadership in its future pursue of sustainable economic development, but generate important implications for other developing countries as well.

The remainder of the thesis proceeds as follows. In Chapter 2, we provide a brief review of the literature on the study of FDI spillovers. We will also develop our theoretical specification in Chapter 2. In Chapter 3, we construct our empirical model and introduce the data. Some descriptions and discussions of variables will also be provided. In Chapter 4, the regression results are presented. We conclude with Chapter 5.

II. Literature Review and Theoretical Framework

In recent decades, it has been widely accepted that foreign direct investment contributes to a host country's economic growth. Generally speaking, FDI may affect the host economies in two ways, namely directly and indirectly. By forming joint-venture or establishing new factories, FDI directly affect an economy by increased employment, capital inflow, usage of advanced equipment and technology. On the other hand, FDI could also generate indirect impact on local economies through, for example, increased competition, and technology spillover from subsidiaries of multinational corporations to local indigenous firms. In this study, we are interested in the latter, the indirect spillover effect.

Technology spillovers from FDI have been widely discussed in the literature. First of all, it is well established that multinational corporations (MNCs) in general possess more advanced technology. When MNCs decide to penetrate a new market through directly investing in the country, they tend to bring with them more sophisticated technology and superior managerial practice in order to compete with local firms who tend to be more familiar with the consumer preferences and business practices in the local market (Blomstrom, Sjoholm, 1999). It is reasonably to assume that some of the technology and the experience brought in by MNCs will inevitable be diffuse from their affiliates to the local indigenous establishments of the host economy. Secondly, economic relations with MNCs provide learning opportunities for the domestic firms and thus reduce their innovation and imitation costs which will in tern speed up the improvement in total factor productivity (Helpman, 1999). Thirdly, workers and managers employed and trained by the MNCs may later either move to the local firms or establish businesses of their own. In both cases, the pool of 'the knowledge of getting things done' in domestic industries is expanded. Technology spillovers just discussed work mainly among firms within industries and will be referred as intra-industry spillovers. Spillovers may also work through the backward and forward linkages between suppliers and supporters. MNCs, through their local affiliates, may provide technical assistance to local suppliers or prospective suppliers. Similarly, we will refer to these spillover effects as inter-industry spillover. Finally, MNCs' entry into the domestic market will intensify competition and force local firms to improve efficiency and to adopt new technologies (Kokko, 1996). Technology advances due to increased competition may be both intra- and inter-industries.

There have been an increasing number of empirical studies which focus on the spillover effects of FDI on host country economies. The results, however, have been mixed. Some studies find evidence supporting the theoretical prediction on the existence of spillover effect from FDI. Examples include earlier studies by Caves (1974) on Australian manufacturing, Globerman (1979) on Canadian manufacturing, and Blomstrom and Persson (1983) on Mexican manufacturing industries. Three recent studies on Indonesia manufacturing industry (Blomstrom and Sjoholm, 1999; Sjoholm 1999; Takii 2001) all find supporting evidence of spillover effects from FDI. In contrast, a number of studies did not find significant spillover effects on domestic productivity from FDI. In some studies, domestic productivity is found to be even negatively associated with the intensity of foreign presence. Examples include studies by Kokko and Tansini (1996) on Uruguayan manufacturing sector, Aslanoglu (2000) on Turkey manufacturing, Haddad and Harrison (1993) on Morocco manufacturing industries, and Aitken and Harrison (1999) on Venezuela industries.

The empirical studies we briefly discussed may also be categorized based on the level of aggregation. Some studies utilize data collected at the factory/firm level. Others examine the FDI spillover effects on the more aggregate level using industry data. Moreover, we may also group the studies into cross-sectional studies where information are collected at one point of time and panel studies where firm/industry specifics are gather over a period of time. In various cases, though, conflicting results are obtained. What can we conclude from these studies and why is there so much variation in the outcome of empirical studies of different countries on spillover effects? From our brief overview, it seems that earlier studies on FDI spillover effect in relatively more advanced countries tend to find stronger empirical evidence. Aside from the fact that different methods are used to conduct empirical estimation, the large variation in empirical results suggest that significant spillover may only be present conditional on some other unspecified factors. One important candidate for such factors is the technology gap between domestic firms and MNCs or their local affiliates.

To shed lights on this empirical puzzlement, we conduct the study to examine spillover effects of FDI on domestic Chinese industries. There are several advantages in studying FDI spillover effect in Chinese industries. First of all, since China opened up more than two decades ago, China has attracted large amount of foreign direct investment, especially since early 1990s. Foreign investment in China not only represents a substantial portion of industries, it is in fact often sited as the most important factor for Chinese the economic success during the transition. Moreover, China has a much diversified industrial structure. There is also a large variation in the intensity of foreign presence across industries. This provides us with confidence in conducting empirical analysis on the impact of FDI on domestic economic performance. More importantly, China received large amount of FDI from both the western industrial countries as well as the newly industrialized economies in the regions. We could reasonably assume that FDI from western industrial countries carries much more advanced technologies than those from neighboring economies. To separately investigate the FDI impact from the two types of sources may help to address the empirical question why spillover effect only presents in some of the cases.

There have been several studies examine the spillover effects of FDI on Chinese industries. The findings of these studies tend to support the theoretical prediction that FDI generate positive spillovers to domestic industries. A study by Zhu and Lu (1998), for example, suggests that higher FDI intensity leads to higher productivity of domestic industries. To our knowledge, however, there has not been any study examine separately the FDI spillover effects based on the sources of the investment.

In the current study, we follow the others in estimating the impact of foreign presence on Chinese domestic productivity. Based on the existing literature, we hypothesize that higher productivity is associated with the higher intensity of FDI presence in the domestic industry. We could use the following to represent this simple relation.

$$Y_i = f(FS_i, \mathbf{X}_i)$$

Where Y measures the productivity of domestic industries, FS measures the intensities of foreign presence in the industries, and **X** denotes the other factors that would have significant impact on the productivity of domestic industries.

Studies suggest that technology spillovers from FDI may be influenced by the technology gap between the domestic and foreign companies. There are, however, different theoretical predictions. On one hand, large technology gap may indicate large potential gains from FDI presence. Domestic industries could thus benefit greatly from the "catch-up" effect. On the other hand, large technology gap may indicate low technology capacity in domestic industries and may result in limited benefits from FDI presence. In another word, it might be easier to gain knowledge of and to benefit from technologies only modestly more advanced and more applicable. Because of the theoretical ambiguity, we will not be able to assume a prior in terms of the direction of technology gap on the spillover effect. Given that China is still a developing country and lags far behind in most technology areas, we will assume that investment from western industrial countries carries technologies much more advanced than Chinese industries compared to investment from the newly industrialized economies. We thus have our first hypothesis.

Hypothesis 1: Spillover effect is different for FDI from industrialized countries from that from newly industrialized economies.

In our study, we are able to identify FDI into two sources. The first include investment from Hong Kong, Macao and Taiwan. Two of the three economies, Hong Kong and Taiwan, are among the newly industrialized economies in Asian. Macao is another economy that has achieved similar substantial economic development in recent decades. We assume that FDI from these economies mostly resembles that of economies of moderate technology advancement. In additional to technology applicability, investment from Hong Kong, Macao and Taiwan may also present additional benefit due to the proximity in culture, language, and historical heritage between the investing economies and mainland China. The second group of investors include those form all other countries, mostly western industrial countries.[2] In the study, we will treat the two groups of foreign investment as imperfect representations of investment from newly industrialized economies and from advanced countries.

As discussed earlier, FDI from industrialized countries may present larger potential spillover benefits since they generally carries technologies much more advanced than those of the host economies. However it is also possible that FDI from Hong Kong, Macao and Taiwan generates higher spillovers because its technology is more applicable for the domestic industries due to the investors' similarity with local firms in technology advancement. In addition, we will need to keep in mind that some additional factors may also be at play when we discuss the impact of the two groups of investment, such as culture, history, shared languages.

In this study, we also attempt to separately identify and estimate the FDI spillovers through different means, namely the intra-industry and inter-industry spillovers. By intra-industry spillovers, we mean the impact of foreign presence[3] in an industry on the productivity of domestic firms in the same industry. In addition, we assume there is also spillover effect across industries. That is to say, domestic industries benefit from foreign presence in the related industries, through, for example, buyer-seller

[2] Two of the newly industrialized economies in Asia, Korea and Singapore, are also included in this group. However, they only account for a smaller portion in the total.

[3] The share of foreign invested enterprises in terms of employment at a 4-digit industry level is used to measure the intensity of foreign presence in an industry.

linkages. We also assume that FDI spillover effects across industries are the strongest when foreign companies or their local affiliates are located near by. We use the foreign presence within a broadly defined industry[4] within a certain geographic location to represent the potential benefit of inter-industry spillover effect.[5] We now have the second hypothesis.

Hypothesis 2: Domestic firms benefit from both inter-industry spillovers and intra-industry spillovers of FDI.

We expect that foreign subsidiaries and domestic firms within a narrowly defined industry (such as a 4-digit industry) produce the same or very similar goods. While domestic firms could potentially gain from foreign technology in the industry, they may also suffer in terms of demand for their goods, skilled labor, and scarce input, due to much intensified competition. In contrast, productions of foreign subsidiaries and domestic firms in a broadly defined sector may overlap only marginally. Thus foreign presence may present more potential benefits to their suppliers and customers in China than competitors.

To summarize the above, we define four modes of technology spillovers: intra-industry and inter-industry spillovers for investment from advanced economies, and intra-industry and inter-industry spillovers for investment from Hong Kong, Macao and Taiwan. We could now state our model in a bit more detail as follows:

$$Y_{ij} = f(FSintra\_GCA_i, FSinter\_GCA_{ij}, FSintra\_FIE_i, FSinter\_FIE_{ij}, \mathbf{X}_{ij})$$

where Y_{ij} is the domestic productivity of industry i province j, $FSintra\_GCA_i$ is the employment share of firms with investment from Hong Kong, Macao and Taiwan, or Greater China Area (GCA) in industry i, $FSintra\_FIE_i$ is the employment share of firms with foreign investment from sources other than Hong Kong, Macao and Taiwan. $FSinter\_GCA_{ij}$ and $FSinter\_FIE_{ij}$ is the employment share of firms with investment from the two different sources within a broader defined sector which industry i belongs to in province j. X_{ij} represent other factors affecting productivity or productivity growth.

III. Empirical Model and Data

1. Model specification

We use a simple model as discussed in the previous section to estimate FDI spillover effect in Chinese manufacturing sector for the year 1995. The dependent variable is the productivity level of an industry in a province[6]. As discussed in the previous section, we attempt to identify and examine technology spillovers of four different modes: intra-industry and inter-industry spillovers from investment from Greater China Area, and intra-industry and inter-industry spillovers from investment originated from industrial countries. In additional to the four variables measuring each of the four, we will also include some other factors that are believed to affect industry productivity. Each of these factors will be introduced and discussed in the following.

[4] The share of foreign invested enterprises at a 2-digit industry level is used to estimate the inter-industry spillover effects.
[5] The assumption is that inter-industry is the strongest among similar industries. This may not be true for some cases. For example, automobile industry and steal industry have strong buyer-seller linkage but they belong to different 2-digit industries.
[6] The firms are situated in 30 provinces. There are close to 600 4-digit industries.

Industrial Concentration

The level of concentration in an industry may affect its productivity. It is believed that firms in higher concentrated industries have certain market power and are in more advantageous position in price setting. As a result, they tend to have higher productivities (e.g. Blomstrom and Persson, 1983). We therefore assume that higher concentration tend to be associated with higher productivity.

Scale economy

Economy of scale is also an important factor affecting an industry's productivity. When there exist increasing returns to scale, industry tend to enjoy higher productivity as more sophisticated machinery and greater division of labor are often involved.

Government Policies

Government policies have great impact on domestic industries in China. For example, firms operating in special economic zones enjoy much economic freedom in conducting businesses and forming business linkages with foreign firms. On the other hand, they also face more intense competition in the marketplace. China's economic transition has been one with gradual opening up and sequential policy measures. Industries in different locations will thus be exposed to foreign technology and foreign competition with very different intensity. Some of the differences may not be fully accounted for by the difference in foreign presence. Regions opened earlier tend to have higher productivity level.

Labor quality and R&D expenditure

We also include proxies for labor quality and R&D expenditure of an industry. Both reflect the technology capacity of domestic industries in adopting new technologies. R&D may also measure the extent of an external economy in an industry. It could also be an indirect proxy for an industry's intent of external economy. We assume that higher labor quality and higher R&D expenditure are associated with higher productivity.

Share of state-owned enterprises (SOE)

State-owned enterprises in China account for a substantial portion of total industrial employment and state investment. Reforming and restructuring SOEs is one of the few remaining issues in China's transition to a socialist market economy. It is widely believed that SOEs are less productive than firms of other ownership structures. As a result, we assume that industries with higher proportions of SOEs are expected to exhibit lower productivity.

These factors are added to our empirical specification.

$$\begin{aligned} Y_{ij} = {} & \beta_0 + \beta_1 FSintra\_GCA_i + \beta_2 FSinter\_GCA_{ij} \\ & + \beta_3 FSintra\_FIE_i + \beta_4 FSinter\_FIE_{ij} \\ & + \beta_5 HER_i + \beta_6 SCALE_i + \beta_7 LQ_i + \boldsymbol{\beta}_9 \mathbf{OPEN}_j \\ & + \boldsymbol{\beta}_{10} \mathbf{X}_{ij} + e_{ij} \end{aligned}$$

HER_i is the Herfindahl Index that measures an industry's concentration level. SCALE is a measure of the

importance of scale economy in any industry. LQ and RD measure the labor quality and R&D expenditure of an industry, OPEN is a set of dummy variables indicating the openness of a location due to policy differences. X includes the other potential factors, such as firms' average year in business and the share of SOEs in an industry.

2. Data

Industrial census data of 1995[7] at the firm level are used to construct our industry study. The database include close to 500,000 industrial firms. The dataset provides the basic characteristics of the firms, such as industry, location, ownership type. Main information on the firms' business activities are also reported such as employment, the original value of fixed assets and total sale. This background information is used to compute industry level aggregates used in our empirical analysis, such the share of foreign invested businesses in respective industries. There are more than 500 4-digit industries and the firms are located in 30 provinces. We also utilize information in *Third National Industrial Census of the People's Republic of China in 1995* to construct industry specific variables such as labor quality, R&D expenditure.

3. Measurement

In this section, we define and discuss in a more detail the method used to measure the variables used in the analysis. A summary could also be found in Table 1.

Dependent variables

The dependent variable is the level of productivity of an industry at a particular province. We go through two steps to obtain this measure. First, we obtain a proxy of productivity for each firm. We divide all the firms into 28 2-digit industries. Within each industry, we estimate a log-linear regression of a firm's total sale on its employment and the amount of fixed asset. The residual is thus taken as a proximate measure of the firm's productivity level. Second, based on the estimates of firm level productivity, we construct a weighted average productivity of an industry within a province. Only domestic firms are included in the aggregation and the weight is the firm's total sale.

Independent variables

Foreign (Employment) Shares

We first construct the variables on the employment shares of foreign invested firms. Four measures are computed. For measures on intra-industry foreign presence, we calculate, in each of the 4-digit industry, the employment shares of firms with investment from Hong Kong, Macao and Taiwan (FSintra_GCA). A similar measure is calculated for firms with investment from other investing countries (FSinter_FIE). For measures on inter-industry foreign presence, the computation is primarily the same. Employment share of firms with investment from Hong Kong, Macao, and Taiwan in a 2-digit industry in a province is used to measure FSinter_GCA. Employment share of firms with investment from other countries is used to measure FSinter_FIE.

[7] *Chinese Manufacturing Industries Database* is obtained through the All China Marketing Research Co. Ltd.

Average Year of Establishment

A variable is constructed to measure the average year of establishment (DATE). We predict that if firms in an industry at a province consist of mainly news firms, they should have be posited to adopt new technologies as opposed to those with many older firms.

SOE Share

Under China's traditional socialist central-planning, state-owned enterprises operate as government production workshops. Economic reforms have greatly transformed Chinese SOEs but they are still suffer from factors redundant labor and out-dated machinery. Industries with higher portion of SOEs tend to perform worse on average. Employment share of SOEs in each of the 4-digit industries in a province is calculated (SOE).

Industrial Concentration

We use the Herfindahl index (HER) to measure the concentration level of the 4-digit industries. It is computed as the sum of the squares of each firm's share in an industry's total sales. We expect the level of industrial concentration to be positively correlated with industry productivity level.

Economy of Scale

We use the average scale of firms in an industry as a proxy for the importance of economy of scale in that industry. We assume that the firm with the largest total sales in the industry has achieved economy of scale. Then we calculate each firm's relative scale by dividing its sales by that largest firm's sales in the industry. Average scale of all the domestic firms in the industry is used to measure economy of scale (SCALE).

Labor Quality

We use the percentage of white-collar workers to proximate labor quality. We include engineers and managerial staff as white-collar workers. We should point out that information on total employment and the number of engineers and managerial staffs are only available at the 3-digit industry level (LQ).[8] We expect labor quality of an industry is positively related to its productivity.

R&D Expenditure

We used the ratio of R&D expenditure in total industrial output to measure the importance of research and development in an industry (RD). Similar to measures on labor quality, data on R&D expenditure is available at the 3-digit industry level and they include only R&D expenditure of large and medium size firms.

Government Policy

We construct four dummy (OPEN_X, OPEN_Y, OPEN_Z, and OPEN_D) variables to measure

[8] From *The Third National Industrial Census of the People's Republic of China in 1995*. There are 168 3-digit manufacturing industries in the report. Two alternative measures on labor quality are also constructed. One is percentage of employees with tertiary education total employment. The other is the average salary of each industry. The rational is that more productive workers normally receive higher pay. Both measures are also available at 3-digit industry level.

the impact of government policy on productivity of industries at a province. OPEN_X takes the value of 1 for the provinces most open to foreign investment and trade. OPEN_Y and OPEN_Z take the value of 1 for provinces whose level of openness ranks the second, and the third. And OPEN_D takes the value of 1 for the least open provinces. We rank the provinces in terms of their openness based on the policy index constructed in Demurger, Sachs, Woo, Bao and Chang (2002). The original index takes four different values, 3, 2, 1, and 0. We calculated an average index for each province for the years 1992 to 1994. The result consists of 4 different values: 3 (most open), 2, 1.7 and 1 (least open). Four dummy variables are thus created with OPEN_X for the most open provinces and OPEN_D the least open provinces (See Figure 1).

4. Descriptive statistics

Table 2 summarizes the descriptive statistics of the main variables. On average, foreign invested firms accounted for about 8% (FSinter_GCA+FSinter_FIE=0.08) of industrial employment. They are rather equally divided into the two types of investment, those from Hong Kong, Macao, and Taiwan, and those from the rest of the world. On average, about 18% of employees are engineers and managerial staff (LQ=0.18) and state owned enterprises account for about 40% of total industrial employment (SOE=0.41)[9]. If we look at the degree of openness, we see that about half of the provinces are in the second group.

Table 3 presents the correlation coefficients among the variables. In Table 3, intra-industry FDI from Hong Kong, Macao and Taiwan is negatively correlated with domestic productivity. It suggests that FDI from Hong Kong, Macao and Taiwan tends to exist in the domestic industries with lower domestic productivity. However, when geographic location is taken into consideration, that is, when we look at inter-industry FDI from the same sources as above, we find that such FDI is positively correlated with domestic productivity. It suggests that there is more FDI from Hong Kong, Macao and Taiwan in the higher-developed regions. We also find that both intra-industry and inter-industry FDI from the other sources, mainly from the western countries, have positive correlation with domestic productivity. It suggests that disregarding the other factors' effects, FDI mainly from the industrialized countries tends to be present at industries and geographic regions with higher domestic productivity.

We find the correlation between the presence of FDI from different sources to be positive and high. The correlation between $FSintra\_GCA_i$ and $FSintra\_FIE_i$ is as high as 0.55 in Table 3. Thus we could find that when a 4-digit industry has a lot of foreign investment from Hong Kong, Macao and Taiwan, it generally has a lot of FIEs from the other places as well. We also find such a high and positive correlation between inter-industry FDI from these two sources, which suggests that some geographic factors have attraction on both sources of FDI.

Table 3 suggests that domestic productivity is positively correlated with the degree of openness to the foreign country, labor quality, R&D expenditure, level of industry concentration, economic scale, average year of establishment, and is negatively correlated with the share of SOE. The directions of these relations are reasonable. R&D expenditure has positive correlation with labor quality. It is a reasonable

[9] As the mean values are simple averages, not weighted averages, they may be different from the overall industrial average.

relation, as labor quality and R&D expenditure are both indicators of technology level of an industry.

OPEN_X has positive and high correlation with the presence of inter-industry FDI or FDI growth. It suggests that there exist more FDI in the most opened provinces. Moreover, FDI tends to exist in industries with higher level of concentration, suggested by the positive correlation between the Herfindahl index and the two kinds of intra-industry FDI. Besides, the correlation between HER_i and $FSintra\_FIE_i$ is much larger than that between HER_i and $FSintra\_GCA_i$. It might suggest that, compared with FDI from GCA, FDI mainly from industrialized countries has larger scale and market share, and contributes more to an industry's level of concentration.

It may seem strange that the correlation between R&D expenditure and all the measures for FDI presence is negative. Normally we would expect that foreign firms spend more on research and development since they have higher technology level. But it seems that in China an industry with higher FDI presence will have comparatively lower R&D expenditure. Moreover, It is interesting that the share of SOE is positively correlated with R&D expenditure in an industry. The above correlation may suggest that most of the R&D expenditure is made by SOEs rather than FIEs in China. If it is true for the Chinese experience, and if the reward of SOE's R&D expenditure is particularly low, it would be possible that we could not find positive relationship between R&D expenditure and productivity, which is contrary to the normal expectation. $DATE_i$ is positively correlated with the proxies for FDI share, and negatively correlated with the proxies for SOE share. It suggests that foreign firms are generally newer, while SOEs usually have older ages. This is a reasonable finding, as most FIEs entered the China market only in the past 20 years.

IV. Regression results

Regression results are presented in Table 4. As mentioned before, although we have more than 500 4-digit industries and 30 provinces, our valid number of observations is reduced substantially due to the following. First, some 4-digit industries do not exist in all provinces. This reduces our sample size by the greatest amount and more than half combinations of 4-digit industry and province are discarded for this reason. Second, some observations are discarded when zero appears as a denominator or is taken log. Third, some observations do not have all the variables available and thus are discarded from the sample. For example, the 513 4-digit industries are categorized into 163 3-digit industries, only 160 of which have data on R&D expenditure. Fourth, to avoid the influence of outliers, we exclude the 4-digit industries with no FDI, and we also discard the firms that were established before 1900. Hence, are left with 10601 observations in the regression respectively. The R-squares of the OLS estimations shows that the models can explain 37% of total variations in domestic productivity.

1. Spillovers of FDI

In the regression, coefficient for $FSintra\_GCA_i$ is negative and highly significant. It suggests that FIEs from Hong Kong, Macao and Taiwan tend to exist in the 4 digit industries with lower domestic productivity, and such an investment has a negative effect on productivity growth of domestic firms in the same 4-digit industry. As we discussed earlier, foreign investment from Hong Kong, Macao and Taiwan do not have high technology level themselves and have entered the low technological sectors, such as

garments and leather products. They do not have much technology spillovers on domestic firms, and rather, they impose competition upon the domestic firms who produce the same goods with theirs, in other words, domestic firms in the same 4-digit industry.

Coefficient for $FSintra\_FIE_i$ is positive and highly significant. It appears that FDI from the other sources, mainly from industrialized countries has significantly positive spillovers on domestic productivity within the same industry. The results suggest that FDI from the other sources, mainly from industrialized countries tend to exist in the 4 digit industries with higher domestic productivity.

The estimated coefficients for $FSinter\_GCA_{ij}$ and $FSinter\_FIE_{ij}$ are both positive and significant. It suggests that when a 2-digit industry in a province has more FDI, regardless of the source, domestic firms tend to tend to have higher productivity.

Overall, we find that domestic productivity is positively correlated with inter-industry FDI from both sources and intra-industry FDI mainly from industrialized countries..

2. Other variables

Scale is highly significant and is positively correlated with productivity of the same year, negatively correlated with the productivity growth of the following years, as expected. Although the relation between its growth and productivity growth is insignificant, the result of the other two regressions supports the economy of scale and is consistent with the expectation that large firms generally grow less quickly.

Coefficient for SOE_{ij} is negative and highly significant which is consistent with our expectation. The Chinese SOEs are less efficient than firms of the other ownership types, so domestic industries and regions with higher share of SOE have lower productivity as well as also lower rate of productivity growth, and a smaller or even negative growth of SOE share is associated with a larger productivity growth.

The average year of establishment has a significantly positive effect on productivity. This result support our expectation that newer firms tend to have higher productivity and grow faster, since it is easier for such firms to adopt up-to-date equipment as well as advanced management skills..

The coefficient for labor quality is positive, highly significant. Alternative proxies for labor quality yield similar result. This finding strongly supports the argument that industries with higher labor quality generally have higher level of productivity.

Coefficients for OPEN_X, OPEN_Y and OPEN_Z are all positive and highly significant. It shows that, compared to the least opened provinces, provinces opened earlier or deeper have significantly higher productivity. It is consistent with our expectation that the open-door policy contributes to China's economic growth. The result shows that the open-door policy could enhance domestic productivity, and the earliest opened places have the largest benefit in terms of productivity.

R&D expenditure is negatively correlated with domestic productivity, and highly significant. This is somewhat surprising, since it would be more reasonable to expect a positive correlation between R&D

expenditure and productivity. One possible explanation is that RD_i is an imperfect proxy for R&D expenditure. RD_i measures the level of R&D expenditure of all firms in a 3-digit industry, including foreign firms. Unfortunately, we are not able to separate out the R&D expenditure for domestic firms. Another possible reason is that most of R&D expenditure is made by SOE, as suggested by the positive correlation between RD_i and SOE_{ij}, as well as the negative correlation between RD_i and the proxies for FDI presence in Table 3. The negative coefficient for RD_i might be the result of the low return to R&D in SOEs. The large magnitude of RD_i does not suggest that RD_i has a particular large impact on productivity, since the value of RD_i is small, as Table 1 shows.

Coefficient for HER_i is positively correlated with domestic productivity and significant at the 10 percent level. It should be noted that the level of industry concentration measures the entire 4-digit industry, including foreign firms. The above result provides weak support to the argument that domestic industry tends to have higher productivity if the industry's concentration level is higher. The positive correlation between the level of industry concentration and productivity could be explained by the argument that an industry with a higher level of concentration could have advantages in setting the market price, thus could have higher productivity.

V. Concluding remarks

This study investigates FDI spillovers on the Chinese manufacturing sector. Access to a firm level data enables us to separately estimate FDI spillover effect according to its sources and modes of impact. We are therefore able to study the FDI spillovers with two innovations. First, we separate the inward FDI to China into two groups, one from Greater China Area and that from the rest. By making this division, we could possibly examine the impact of technology gap on FDI spillovers. Second, attempt to identify FDI spillovers through its mode of transmission. We categorized various spillovers into intra-industry and inter-industry.

Estimation results provide empirical support for FDI spillovers. Average productivity of an industry is positively correlated with foreign presence within the industry (indication of intra-industry spillover) for investment from advanced countries. There is consistent with hypothesis that domestic industry tend to benefit from foreign businesses with more advanced technologies. On the other hand, higher presence of businesses with connections with Hong Kong, Macao, and Taiwan does not seem to be associated with higher productivity of domestic firms. It is possible that, as the technology gap is rather small, there is little potential productivity gain for domestic firms. It is also possible that increasing number of firms with investment from Greater China Area, being closer in technology advancement, in fact post greater competition and drive down the performance of local firms.

Moreover, the study also suggests that technology spillover also work across industries. The two measures on inter-industry foreign presents are both positively correlated with higher productivity of domestic firms. This suggests that domestic firms benefit significantly from the intensified foreign presence in the industries that closely related to their own in the region. These benefits may include technology transfer through buyer-seller relations, higher competition intensity for market as well as for talents, better development supplier and marketing network, etc.

Our study suffers from certain caveats. For example, since our study depends on a cross-section data, we may suffer from causality problem. It is possible that the positive correction we observed between foreign presence and domestic productivity is the results of preference of foreign investors. That is to say, foreign investment tends to be concentrated in industries with higher productivity. A panel study would be able to resolve the problem. At present, we are not able to conduct such analysis due to data availability problem.

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Table 1. Description of major variables

Dependent variable:	
Y_{ij}	Productivity of 4-digit industry i within province j
Independent variables:	
$FS\_intra\_GCA_i$	Employment share of FDI from Hong Kong, Macao and Taiwan in the 4-digit industry i
$FS\_intra\_FIE_i$	Employment share of FDI from all the other sources in the 4-digit industry i
$FS\_inter\_GCA_{ij}$	Employment share of FDI from Hong Kong, Macao and Taiwan in the 2-digit industry i in province j
$FS\_inter\_FIE_{ij}$	Employment share of FDI from all the other sources in the 2-digit industry i in province j
HER_i	Herfindahl index of the 4-digit industry i $HER_i = \sum (SALE_m / SALE_i)^2$, firm m belongs to industry i
$SCALE_i$	Divide each firm's sales by the largest firm sales in the 4-digit industry i to obtain each firm's relative scale, then take their simple average to obtain the industry average scale
LQ_i	Ratio of white-collar workers in 3-digit industry i in 1995
RD_i	R&D expenditure of 3-digit industry i divided the industry total sales in 1995
SOE_{ij}	Employment share of SOE in the 4-digit industry i in province j

Table 2. Descriptive statistics for the variables

	Mean	Median	Maximum	Minimum	Std. Dev.	# of obs.
Y	1.70	1.70	6.67	-4.54	0.91	10601
FS_intra_GCA	0.06	0.03	0.41	0.00	0.06	10601
FS_intra_FIE	0.05	0.03	0.78	0.00	0.06	10601
FS_inter_GCA	0.04	0.02	0.63	0.00	0.08	10601
FS_inter_FIE	0.04	0.02	0.73	0.00	0.05	10601
OPEN_X	0.13	0	1	0	0.34	10601
OPEN_Y	0.48	0	1	0	0.50	10601
OPEN_Z	0.12	0	1	0	0.32	10601
LQ	0.18	0.18	0.34	0.10	0.04	10601
RD	0.00*	0.00*	0.01	0.00	0.00*	10601
HER	0.04	0.02	0.84	0.00	0.07	10601
SCALE	0.03	0.02	0.28	0.00	0.04	10601
DATE	1981	1982	1995	1906	9	10601
SOE	0.41	0.36	1.00	0.00	0.34	10601

* The value is not zero, but a number smaller than 0.005.

Table 3. Simple correlation coefficients for the variables

FS_intra_GCA	-0.10	1.00										
FS_intra_FIE	0.01	0.55	1.00									
FS_inter_GCA	0.09	0.20	0.15	1.00								
FS_inter_FIE	0.07	0.21	0.18	0.47	1.00							
OPEN_X	0.16	0.01	0.01	0.57	0.32	1.00						
OPEN_Y	0.01	0.00	0.01	-0.10	0.11	-0.37	1.00					
OPEN_Z	0.04	0.00	0.01	-0.13	-0.15	-0.14	-0.35	1.00				
LQ	0.20	-0.11	-0.03	-0.07	-0.03	0.01	0.00	0.00	1.00			
RD	0.03	-0.19	-0.16	-0.09	-0.10	0.00	-0.00	-0.00	0.51	1.00		
HER	0.12	0.04	0.26	0.03	0.03	-0.01	0.02	0.02	0.12	-0.03	1.00	
SCALE	0.16	-0.13	-0.13	-0.02	-0.04	-0.01	0.02	0.03	0.04	0.08	0.12	1.00
SOE	-0.09	-0.20	-0.18	-0.14	-0.11	-0.01	-0.05	-0.02	0.11	0.07	-0.04	0.04
	Y	FS_intra_GCA	FS_intra_OTH	FS_inter_GCA	FS_inter_OTH	OPEN_X	OPEN_Y	OPEN_Z	LQ	RD	HER	SCALE

Table 4. Regression Results:

Dependent variable: logged domestic productivity in 1995

Independent variables	Coefficient
FS_intra_GCA	-1.09 (-6.83)***
FS_intra_FIE	0.75 (4.56)***
FS_inter_GCA	0.27 (2.04)**
FS_inter_FIE	1.26 (6.72)***
OPEN_X	0.51 (16.44)***
OPEN_Y	0.17 (9.59)***
OPEN_Z	0.28 (11.28)***
LQ	3.55 (9.61)***
RD	-160.58 (-6.34)***
HER	0.20 (1.81)*
SCALE	1.52 (7.00)***
SOE	-0.34 (-13.95)***
DATE	0.01 (14.52)***
C	-25.56 (-13.65)***
Number of observations	10601
R-square	0.37
Adjusted R-square	0.37

Note: 2-digit industry dummies are included; t-statistics in parenthesis; ***Significant at the 1 percent level; **Significant at 5 percent level; *Significant at 10 percent level.