Foreign Direct Investment and Technology Spillover:
Some Evidence from China

By

Zhiqiang Liu*

National University of Singapore
and
State University of New York at Buffalo

E-mail: eailiuzq@nus.edu.sg

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Abstract: We investigate empirically whether or not foreign direct investment (FDI) generates externalities in the form of technology transfer. Using data on 29 manufacturing industries over the period 1993-98 in Shenzhen Special Economic Zone of China, we find that FDI generates large and significant spillover effects in that it raises both the level and growth rate of productivity of non-recipient firms, and domestic firms are the main beneficiaries. We also find that some domestic firms benefit more than others from the external effects of FDI. The results are robust to a number of alternative model specifications.

Keywords: Foreign direct investment, technology transfer, productivity, China.

JEL: F2, O1, O3.

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1. Introduction

Foreign direct investment (FDI) is an important channel of technology transfer from developed economies to less developed countries (LDCs). The use of new technology by the immediate recipient is only a small part of its benefits. The larger benefit is the diffusion of technology and skills within the host country. The external effect of FDI arises from the fact that technology possesses the characteristics of public goods. Unlike normal private goods, the use of a new technology by one party does not preclude others from using it. Therefore, new technology brought in via FDI benefits more than just the foreign invested firm itself. Local firms may increase their productivity by observing nearby foreign firms or becoming their suppliers or customers, or through labor turnover as domestic employees move from foreign to local firms.

To attract FDI, governments of LDCs have been falling over each other to provide foreign investors with special incentives, such as tax holidays and subsidies for infrastructure. The rationale behind this preferential treatment of FDI stems, in large part, from the belief that FDI generates externalities in the form of technology transfer. In China, for example, depending on sectors, foreign invested firms are exempt from paying income tax for two years from the first profit-making year and allowed a 50 percent tax reduction thereafter for three years. Are these tax holidays and reductions justifiable?

Many academics, too, subscribe to the notion that technology spills over from foreign invested firms to local ones. Findlay (1978) assumes that FDI increases the rate of technical progress in the host country through a 'contagion' effect from the advanced technology and management practices used by foreign invested firms. Walz (1997) argues that FDI contributes to economic growth because the presence of multinational corporations in LDCs causes knowledge spillovers to the domestic R&D sector. Glass and Saggi (1998) assume that product imitation by local firms in a LDC is possible only when a foreign invested firm produces the product within the country. Thus, FDI promotes economic growth because it facilitates technology spillover.

Somewhat surprisingly, the empirical literature on this issue has produced mixed evidence.[1] Rhee and Belot (1989) find that the entry of several foreign firms is responsible for the creation and growth of domestically owned textile industries in Mauritius and Bangladesh. However, Germidis (1977) examines a sample of 65 multinational subsidiaries in 12 developing countries and finds almost no evidence of technology transfer to local firms. In a recent study of Venezuelan firms, Aitken and Harrison (1999) conclude that FDI negatively affects the productivity of local firms.

There is a large body of literature on FDI in China. Most studies have focused on the role of FDI in promoting trade and economic growth. Considerable attentions have also been devoted to understanding the determinants of FDI across regions in China.[2] But

[1] Foreign investment has been criticized on the grounds that it inhibits the development of an entrepreneurial class, crowds out local efforts, and imparts few if any benefits on the LDCs. See arguments in Grossman (1984).

[2] See, e.g., Cheng and Kwan (2000).

there has been no systematic empirical study that investigates whether or not FDI generates technology spillovers from foreign invested firms to local firms. This is the focus of the paper.

To examine the external effect of FDI, we first develop a production function based on externality, where FDI is allowed to have an impact on the productivity of its recipient firm as well as other firms. Using data on 29 manufacturing industries over the period 1993-98 in Shenzhen Special Economic Zone of China, we estimate the effects of FDI on the firm's level and rate of productivity growth. The empirical results show that FDI generates large and significant spillover effects in that it raises the productivity (both the level and the rate of growth) of non-recipient firms, and domestic firms are the main beneficiaries. The point estimates of the external effects of FDI suggest that a 1-percent increase in the average level of FDI in manufacturing industry could raise an average firm's rate of productivity growth by as much as 0.5 percentage points. We also find that some domestic firms benefit more than others from the external effects of FDI in the manufacturing industry. The results are robust to a number of alternative specifications, which control for variables usually considered as the important determinants of productivity growth. The results are also robust to alternative measures for FDI and are free of simultaneity bias.

The remainder of the paper is organized as follows. In section 2, we provide a brief overview of FDI in China. In section 3, we set out our econometric models that are based on the production function theory allowing for externality. The data and econometric issues are briefly discussed in section 4. Estimation results are presented and discussed in section 5. The last section contains some concluding remarks.

2. An Overview of Foreign Direct Investment in China

Attracting foreign capital has been an integral part of China's overall economic reform strategy since the initiation of the market-oriented reform in the late 1970s. The Law on Sino-Foreign Equity Joint Ventures, promulgated in July 1979, set the legal framework for foreign direct investment by allowing foreign investors to form equity joint ventures with Chinese partners.[3] Since then, as figure 1 shows, annual FDI inflow has been rising steadily. Over a period of ten years, from 1979 to 1989, China received a total of US$ 15.5 billion FDI, or just under US$ 1.6 billion annually. Following China's paramount leader Deng Xiaoping's much publicized tour to the southern provinces in early 1992 and his call for speeding up economic reform and opening up, annual FDI into China soared, increasing more than 150 percent each over two consecutive years in 1992 and 1993, and reached a record high of US$ 45.5 billion in 1998. Although FDI dropped by 11 percent in 1999 to US$40 billion, partly due to the Asian financial crisis that reduced the investment from Asian countries, China still was number 1 FDI recipient among developing economies and number 2 in the world. By the end of 1999, more than 334,000 foreign invested enterprises, including those set up by the world's top 500 multinational

[3] This joint venture law was revised in 1990. The law on Foreign Wholly Owned Enterprises and the law on Sino-Foreign Contractual Cooperative Enterprises were enacted in 1986 and 1988, respectively. A few regulations and provisions were also put into effect to boost FDI.

corporations, were in operation in China. The total FDI exceeded US$300 billion, coming from more than 170 countries and regions in the world. Hong Kong is by far the biggest FDI contributor, accounting for more than half of the total FDI in China during 1979-1999. Taiwan, the US, Japan, and Singapore are among the top 5 investors; together they account for some 27 percent of the total FDI.

The geographic distribution of FDI in China is uneven. As figure 2 illustrates, about 88 percent of FDI went to the 12 coastal provinces and cities in the east region. Guangdong alone absorbed more than 28 percent of the total. This is not surprising. From the very beginning, China's foreign investment policy was set intentionally to favor the coastal areas. The idea was to take geographical advantage of coastal provinces and their linkages with overseas Chinese business communities. Between 1979 and 1980, China established four Special Economic Zones (SEZs) in two southern provinces: Shenzhen, Zhuhai, Shantou in Guangdong (which is adjacent to Hong Kong and Macao), and Xiamen in Fujian (which is about 120 nautical miles away from Taiwan). In 1984, 14 coastal cities, including Dalian, Tianjin, Qingdao, Shanghai, and Guangzhou, were designated as open cities, where foreign investors are entitled to special treatments previously available only in SEZs. Similar policies were extended to other newly-declared economic open areas, such as the Yangtze River Delta and the Pearl River Delta. By the late 1980s, the coastal open areas were further extended to include Liaodong Peninsula and the Shandong Peninsula as well as the Bohai Rim, and Hainan was made the fifth SEZ in China. The development of Shanghai's Pudong New Area in 1990 further helped boost the FDI inflow to the coastal regions.

The sectoral distribution of FDI is lopsided. In early 1980s, the first wave of FDI concentrated in the tourist industry and in labor-intensive manufactures. Since late 1980s, foreign investors have invested in a wider range of economic sectors partly because of the removal of sectoral restrictions on foreign investment. However, a disproportionate 55 percent of the total accumulated FDI went to the industrial sector. Within the industrial sector, manufacturing has been the biggest winner. In 1998, for example, of the US$ 26.3 billion FDI received by the industrial sector, US$ 25.6 billion or more than 87 percent went to manufactures.

There are three common modes of FDI in China: equity joint ventures, contractual joint ventures, and wholly foreign-owned enterprises. Equity joint ventures have been the dominant form of FDI, accounting for 52 percent of the total FDI at the end of 1998. Contractual joint ventures and wholly foreign-owned enterprises account for 21 and 24 percent, respectively.[4]

The contribution of FDI to the Chinese economy is considerable. According to a national industrial census of China, there were more than 10 million Chinese people working in foreign invested enterprises in 1995. FDI accounts for about 12 percent of total fixed asset investment during the period 1979-1998. Foreign invested enterprises account for 15 percent of gross industrial output and 44 percent of China's exports in

[4] Data come from *Almanac of China's Foreign Economic Relations and Trade*, various years.

1998.[5] As we will show in this paper, a large, but hard-to-measure, part of the contribution made by FDI is the transfer of advanced technology, skills and know-how.

Overall, FDI inflow in China has been remarkable, considering that the legal system that protects private property rights is still limited, the domestic currency is not yet fully convertible, and corruption is widespread. This means that foreign investors have been very optimistic about China's ability to overcome these negative factors. However, whether FDI will regain its growth momentum in the future depends in large part on if and when a more hospitable investment environment is created in China.

3. The Model

We assume that the technology is separable between value-added and intermediate goods and technical change is value-added augmenting. Hence, omitting time subscripts for simplicity, the value-added production function at the firm level takes the form

$$Q_{ij} = AL_{ij}^{\alpha} K_{ij}^{\beta}, \qquad (1)$$

where Q denotes value-added, L and K the services of labor and capital inputs, A exogenous technical factors, α the elasticity of labor, β the elasticity of capital, and the subscripts i and j identify the firm and industry, respectively. We then expand the production function to incorporate externalities by allowing FDI to affect productivity of the firm through two channels. Specifically, we assume that A can be decomposed into three parts:

$$A = BH_{ij}^{\gamma} \overline{H}_j^{\theta}, \qquad (2)$$

where B represents the technical factor that is common for all firms, H_{ij} is the firm-specific technical factor associated with foreign equity participation in firm i of industry j, $\overline{H}_j$ denotes the industry-specific technical factor associated with foreign investment in industry j, γ and θ are the elasticities of H_{ij} and $\overline{H}_j$. Whereas γ measures the impact of FDI on the productivity of its recipient firm, θ captures the impact of FDI on the productivity of non-recipient firms through its external effects, i.e., technology spillovers. Replacing A in equation (1) by equation (2), we obtain the production function based on externality:

$$Q_{ij} = B_{ij} L_{ij}^{\alpha} K_{ij}^{\beta} H_{ij}^{\gamma} \overline{H}_j^{\theta}. \qquad (3)$$

Expressing equation (3) in log form and adding a random error term u_{ij}, we obtain the baseline econometric specification:

$$\ln Q_{ij} = \ln B_{ij} + \alpha \ln L_{ij} + \beta \ln K_{ij} + \gamma \ln H_{ij} + \theta \ln \overline{H}_j + u_{ij}. \qquad (4)$$

[5] See *Statistical Yearbook of China*, 1999.

A positive and statistically significant estimate for θ signifies that the productivity (technology) advantage of foreign firms spills over to other firms.[6]

To examine the impact of FDI on the rate of productivity growth, we will also estimate the following growth rate regression:

$$\Delta \ln Q_{ij} = \alpha \Delta \ln L_{ij} + \beta \Delta \ln K_{ij} + \delta \ln H_{ij} + \varphi \ln \overline{H}_j + \varepsilon_{ij}, \tag{5}$$

where $\Delta \ln X_{ij} = \ln X_{ij}(t) - \ln X_{ij}(t-1)$.[7] Since in this specification the growth in output due to growth of private inputs (labor and capital) is fully accounted for, φ captures the external effects of foreign investment on the firm's rate of growth of total factor productivity.

4. The Data and Econometric Issues

The econometric analyses in this study are based on two data sets on manufacturing industries, both coming from *Shenzhen Statistical and Information Yearbook*. The first data set includes 29 manufacturing industries over the period 1993-98.[8] The second data set is more disaggregated, but covers a shorter period 1993-95. It consists of 29

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[6] To see this more clearly, rearranging equation (4), we find:

$$\ln TFP_{ij} = \ln Q_{ij} - \alpha \ln L_{ij} - \beta \ln K_{ij} = \ln B_{ij} + \gamma \ln H_{ij} + \theta \ln \overline{H}_j + u_{ij}, \tag{4'}$$

where $\theta = \partial TFP_{ij} / \partial \overline{H}_j * \overline{H}_j / TFP_{ij}$. It is worth mentioning that some studies have estimated equation (4') by assuming constant returns to scale over the private inputs (labor and capital) and competitive product and factor markets. Under these assumptions, the total factor productivity measure becomes:

$$\ln TFP_{ij} = \ln Q_{ij} - s_l \ln L_{ij} - s_k \ln K_{ij},$$

where s_l and s_k are, respectively, the factor shares for labor and capital in total product. However, these assumptions may be too restrictive. We avoid making such assumptions by estimating θ from equation (4).

[7] It should be noted that equation (5) is not a first-difference regression derived from equation (4). In this specification, H_{ij} and $\overline{H}_j$ are introduced in level (logarithm) rather than first-difference form so that φ can be interpreted as the effect of technology spillover stemming from FDI on the firm's rate of productivity growth. Note that

$$\Delta \ln TFP_{ij} = \Delta \ln Q_{ij} - \alpha \Delta \ln L_{ij} - \beta \Delta \ln K_{ij} = \delta \ln H_{ij} + \varphi \ln \overline{H}_j + \varepsilon_{ij}$$

and

$$\varphi = \partial \Delta \ln TFP_{ij} / \partial \ln \overline{H}_j.$$

Similar specifications have been widely adopted in growth regression analyses.

[8] The 29 manufacturing industries are: food processing, food manufacturing, beverage manufacturing, tobacco processing, textile, garments and other fiber products, leather (including furs and related products), timber processing, furniture, paper and paper products, printing and record medium, educational and sports goods, petroleum processing, chemical material and products, medical and pharmaceutical products, chemical fiber, rubber products, plastic products, nonmetal mineral products, processing of ferrous metals, processing of nonferrous metals, metal products, ordinary machinery, special purpose equipment, transport equipment, electric equipment and machinery, electronic and telecommunications equipment, instruments, and other manufacturing.

manufacturing industries for six ownership sectors. The six ownership sectors are: [9] 1) state-owned enterprises (SOEs); 2) collective-owned enterprises (COEs); 3) joint-owned enterprises (JOEs); 4) shareholding enterprises (SHEs); 5) foreign invested enterprises (FIEs); 6) enterprises funded by entrepreneurs from Hong Kong, Macao, and Taiwan (HKMT). Unavailability of information on FDI before 1993 and lack of statistics by ownership sector after 1995 have limited the size of the samples.

The data contain information for manufacturing industries on the gross value of output in current and constant (1990) prices, value added in current prices, workforce, original value of fixed assets, net value of fixed assets, working capital, and so on. We obtain the real value-add by deflating the value-added figures at current prices by implicit deflators, which are the ratios of gross output in current and constant prices. Labor is measured by the total number of workers employed rather than man-hours due to lack of data on the latter.

Measuring capital stock is a major challenge in productivity studies, especially in the context of China. We try to follow closely the methods used in the literature, particularly that of Chow (1993). The perpetual inventory method is used to construct the real capital stock series (in 1990 prices). First, we calculate the nominal value of newly added fixed asset in each year, and then deflate the series by a price index of investment in fixed assets, which is a weighted average of separate cost indexes for construction, equipment and others.[10] Second, assuming the initial real capital stock is the deflated net value of fixed assets in 1993, we add the increments to previous year's capital stock to obtain the annual real capital stock.[11]

The size of working capital is quite substantial relative to the net value of fixed assets. It is hardly justifiable to exclude entirely the working capital from the capital

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[9] State-owned enterprises refer to firms where the means of production are owned by the state. Collective-owned enterprises refer to firms where the means of production are owned collectively. Township and village enterprises are included in this category. Joint-owned enterprises are defined as firms jointly invested by enterprises of different types of ownership. Shareholding enterprises refer to firms whose registered capitals are provided by shareholders, and the firms are run based on shareholding principles. Companies organized with limited liabilities constitute the bulk of the group. Foreign invested enterprises refer to firms established by foreigners in China according to relevant economic laws and regulations of the People's Republic of China as equity joint ventures, cooperative joint ventures, and wholly foreign-owned enterprises. Enterprises funded by entrepreneurs from Hong Kong, Macao, and Taiwan are enterprises established by entrepreneurs from Hong Kong, Macao, and Taiwan in mainland China as joint ventures, cooperative joint ventures, and wholly-owned enterprises.

[10] The price index is the national average taken from *China Statistical Yearbook*. Such index is not available for Guangdong province.

[11] It may be problematic to use 1993 as the initial year for capital stock. However, due to lack of suitable information for the period prior to 1993, we have no better alternatives. We checked the sensitivity of the results of the study to the way that capital stock is measure. We tried to apply different depreciation rates (5%, 8%, and 10%) and found that alternative measures for capital stock do not alter the main results of the paper, but they do seem to affect the elasticity estimates for labor and capital inputs. We also conducted labor productivity regressions where capital is excluded as an explanatory variable (see next section). It should be noted that such measurement issue associated with capital is by no means peculiar to the current study. It has been a well-recognized problem in empirical studies using data from China as well as many other countries. Also see footnote 15.

inputs. As it is well known, inventory is one of the four asset classes making up capital input at the firm or industry level.[12] Cash, account receivable, and inventory are the main components of working capital in our samples, and inventories take up the lion's share of working capital. We decide to include working capital as part of the capital input. We first deflate the working capital figures by the ex-factory price index of industrial products,[13] and then add the resulting real values (in 1990 prices) to the real capital stock just described. It should be noted that the main results of the study are not sensitive to such a treatment of the working capital.[14]

The two main variables of interest in this study are H_{ij} and $\overline{H}_j$. In Aitken and Harrison (1999), H_{ij} is defined as the percentage of registered equity capital owned by foreign investors in plant *i* of industry *j*, and $\overline{H}_j$ is defined as foreign equity participation averaged over all plants in industry *j*, weighted by each plant's employment share in the industry. Since we are using industry-level data, we have to make some minor adjustments on the definition for these two variables. Specifically, for the first data set (1993-98), H_{ij} refers to the percentage of registered capital owned by foreign investors in industry *j* and $\overline{H}_j$ is the average share of foreign equity participation across all manufacturing industries, weighted by employment share. As such, $\overline{H}_j$ captures the spillover effects across different manufacturing industries. This is broadly in line with a strand of literature that emphasizes the role of technology spillovers between firms across industries. Jacobs (1969) and Glaeser et al. (1992), for instance, have argued that such cross-fertilization of ideas across industries can help to increase firms' productivity.

For the second data set, which includes 29 manufacturing industries for 6 ownership sectors over the period 1993-95, we define H_{ij} as the percentage of registered capital owned by foreign investors in ownership sector *i* of industry *j*, and $\overline{H}_j$ as the share of foreign equity participation in industry *j* averaged over all ownership sectors, weighted by employment share. Therefore, $\overline{H}_j$ captures the spillover effects across different ownership sectors but within the same manufacturing industry.[15] Moreover, using the ownership variable, we can distinguish domestic firms from foreign invested ones, and hence we are able to get a more accurate assessment of the extent to which technology spills over from foreign invested to domestic firms. Table 1 contains the summary statistics of the key variables used in the empirical estimations.

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[12] The other three are producer's durable equipment, nonresidential structures, and land. See, e.g., Jorgenson (1995), p18-20.
[13] This index comes from *China Statistical Yearbook*, various issues.
[14] However, the treatment of working capital does affect the elasticity estimates for labor and capital inputs. Excluding working capital from the capital measure reduces the elasticity estimate for capital input and, in a few incidences, results in insignificant estimates for capital input.
[15] In theories of regional economic growth, many researchers, such as Arrow (1962) and Romer (1986), stress the role of technology spillovers between firms within the same industry.

There seems to be a mismatch between our model specifications and the data just described. While equations (4) and (5) are designed with the firm as the unit of analysis, the data sets are more aggregated. However, it can be easily shown that the same regression models apply to group means as well.[16] In other words, the parameters in equations (4) and (5) can be estimated using group averages of the variables involved, and their interpretations remain the same as if firm level data were used. An obvious change is that the variance of the error term is inversely related to the number of firms in the group. Thus, to account for such heteroscedastic error structure, weighted regression method must be used. This is what we do in the following estimations. First, we obtain group means by dividing output, labor, and capital by the number of firms in each manufacturing industry and in each ownership sector and manufacturing industry combination, respectively, for the 1993-98 and 1993-95 data sets. Second, we run weighted regressions using the group means. The weight is the square root of the number of firms in the group.[17]

5. Results

A. Spillover and the Level of Productivity

Table 2 reports the results for equation (4), which is our benchmark model. In addition to a random component that varies across industries, we include a time trend, *Time*, to capture average technical change and control for productivity differences across industries by including industry dummies. Note, first, the test statistics presented at the bottom of the table. The row titled HN shows the Hausman statistics for testing the random-effects model against the fixed-effects model. As the χ^2 statistics indicate, Hausman's tests reject the random-effects specification in all but models 5 and 6, at the 10 or higher level of significance. The row titled LR, in turn, contains likelihood ratio tests of the hypothesis that there are no fixed-effects. As the χ^2 statistics are greater than the critical values corresponding to the 1 percent level of significance, the tests favor the fixed-effects specification over the classical regression with no fixed effects. We also performed tests on whether serial correlation is present in the disturbances across periods. With an estimated autocorrelation coefficient of –0.121 (with t-statistic=-1.070) and Durbin-Watson statistics of 2.063, we reject the hypothesis that the error terms are serially correlated. Also note that the elasticity estimates for labor and capital inputs are all statistically significant (with one exception in column 3).[18] In addition, the coefficient estimates of the time trend imply that the manufacturing industry as a whole has experienced positive (exogenous) productivity growth, ranging from 4 to 6 percent per annum.

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[16] See Greene (1997), Chapter 9.

[17] The resulting WLS estimates are unbiased and more efficient than the OLS estimates.

[18] The hypothesis that the underlying production technology is of constant returns to scale cannot be rejected. Imposing the constant returns to scale restriction causes little change to the estimates. Also note that the elasticity estimates for labor and capital are broadly in line with those reported in Chow (1993), who estimated similar production functions for non-agriculture sectors in China.

In column 1, the estimated coefficient on foreign equity participation, H_{ij} (denoted by Fdish hereafter), is negative and statistically insignificant, suggesting that there is no firm-specific productivity gain associated with an increase in foreign equity participation in the recipient firm. In contrast, the estimated coefficient on the average foreign equity participation, $\overline{H}$ (denoted by Mfdish here after), is positive and statistically significant at the 1 percent level. This shows that technology spills over from foreign invested to other firms. The point estimate, 0.304, implies that every 1 percent increase in the share of foreign equity participation in the manufacturing industries will lead to, on average, 0.304 percent output-increase among manufacturing firms. Since we have controlled for the increases in labor and capital inputs, the output increase is entirely due to productivity improvement. This means that all firms benefit from a rise in the general level of FDI regardless who the recipients are. For instance, an increase in the average foreign equity participation in the manufacturing industries due to a rise of FDI in firms in the electric equipment and machinery industry will raise the productivity of firms in the electronic and telecommunications equipment industry. Such a gain in productivity in the latter is attributable to technology spillovers stemming from FDI in the former industry.

To what extent then is the estimated spillover effect driven by the model specification and estimation method used? First, since the Hausman's test rejected the random-effects model at the 10 percent level but failed to do so at the 5 percent level, the case for the fixed-effects specification is not exceptionally strong. We, therefore, rerun the regression model with random-effects specification. As can be seen in column 2, the random-effects estimate for Mfdish is positive and statistically significant at the 1 percent level, similar to the fixed-effects estimate in column 1. Second, we have argued that the error term of equation (4) is heteroscedastic due to data aggregation. However, heteroscedasticity may be present as a part of the structure of the model. If this is the case, the weighted least squares estimates remain inefficient, invalidating any inferences based on them. We report the OLS estimates (from un-weighted fixed-effects model) in column 3 along with the t-statistics that are based on the White-variance-estimator. Again, the technology spillover effect continues to be statistically significant at the 1 percent level. The elasticity estimate for Mfdish becomes larger, rising from 0.304 to 0.514.

The finding that FDI recipients do not benefit from more FDI in terms of productivity gains is surprising. To analyze to what extent this is due to the log transformation used for Fdish and Mfdish, we re-estimate equation (4) using the natural values for these two variables, and the results are presented in column 4. In this specification, it is even more surprising that the coefficient on Fdish is negative and statistically significant. This indicates that FDI may actually lower productivity among its recipient firms. Although this is broadly in line with the findings reported in Aitken and Harrison (1999), who found that foreign equity participation did not always bring productivity gains to recipient firms in Venezuela, the use of linear specifications for Fdish and Mfdish is questionable because the Box-Cox transformation test rejects the linear, not the logarithm, as the optimal form of transformation for these two variables.[19]

[19] The estimated transformation parameter is not statistically different from zero and the log likelihood function is quite flat about $\lambda=0$, indicating log is the optimal form of transformation.

The Box-Cox family of transformations, however, does not include a quadratic as a member. We therefore add the square term of Fdish in column 5 of table 2; that is, instead of a linear form, the relation between the level of foreign equity participation and productivity is now quadratic. The estimated coefficient on the linear term is positive, albeit insignificant, indicating that foreign equity participation yields firm-specific productivity gains. The estimated coefficient on the square term is negative, suggesting that the beneficial effect of FDI peaks around the 27 percent level of foreign equity participation. Taken together, these two estimates imply that the positive impact of FDI on firm-specific productivity attenuates as foreign equity participation rises.

It should be stressed that alternative transformations for Fdish have little impact on the estimated spillover effects stemming from FDI. The estimated coefficients of Mfdish remain positive and statistically significant in columns 4 and 5.[20]

It is conceivable that a substantial period of time may pass between the change in FDI and its final impact on productivity. To allow for such a possibility, we use Fdish and Mfdish lagged by one year in column 6 of table 2. In this specification, the coefficient on Fdish is positive but statistically insignificant, whereas the coefficient on Mfdish remains positive and statistically significant at the 1 percent level. The only noticeable change is that the estimated coefficient on Mfdish is larger than the one reported in column 1.

B. Spillover and the Rate of Productivity Growth

We now turn to the question whether FDI and its spillover effect also influence the *rate* of productivity growth. We begin with the growth regression model as specified in equation (5), and then extend the model to account for factors of potential importance to productivity growth. Table 3 reports the results.

B.1. Basic Specification

Column 1 contains the weighted least square estimates of equation (5). The coefficients on labor and capital inputs are both statistically significant at the 1 percent level, with their signs conforming to theoretical expectations. The effect of FDI on the rate of productivity growth of the recipient firm is negative but statistically insignificant. In contrast, the spillover effect of FDI is shown to have a large and statistically significant impact on the rate of productivity growth. The estimated coefficient of Mfdish, 0.523 (statistically significant at the 1 percent level), implies that a 1 percent increase in the average share of foreign equity participation in the manufacturing

[20] We also implemented a regression where the square of Mfdish was introduced as well, and obtained a positive coefficient on the square term and a negative coefficient on the linear term. This indicates that the spillover effect of FDI intensifies as the average level of foreign equity participation rises. However, such pattern is not well supported by the estimation since the estimated coefficients on both the linear and square terms of Mfdish are statistically insignificant. An obvious reason for this is that adding two square terms raised the inter-correlations among Fdish, Mfdish, and their square terms, hence raising the estimated standard deviations for these variables. The estimates are imprecise.

industries will, through its spillover effect, raise the rate of productivity growth of the firms in the manufacturing industries by about 0.523 percentage points.

We have also tested here (as well as in other specifications where applicable in table 3) the potential significance of industry-specific factors by introducing a set of industry dummies. In this specification (as well as in all other growth regression models), however, these industry dummies neither change any of our key estimates materially nor prove to be statistically significant themselves, as the likelihood ratio tests indicate (at the bottom of table 3).

B.2. Convergence in the Level of Output

An important feature of the neoclassical growth model is convergence; that is, countries starting with low level of income tend to grow at higher rates than economies that begin with high level of income. In the long run, the income levels of these two types of economies converge to the same level. Such a tendency of convergence may also exist among industries. If Mfdish is inversely correlated with initial output level, it may simply pick up the convergence effect. We add the industry-specific initial output value (i.e., the real value-added in 1993, the first year of our sample period) to account for the possible negative relation between growth rate and initial output level. The results in column 2 indicate that, indeed, firms with low output in 1993 tend to grow faster. Of course, this convergence is conditional on the rates of growth in inputs and the level of FDI. Worthy of note is that this has no bearing on the estimated spillover effect of foreign investment, as the coefficient on Mfdish remains positive and statistically significant.

B.3. Market Growth

The size of the market for the firm's products and, more importantly, the rate at which the market expands have a huge effect on the firm's productivity. Small markets may reduce the firm's productivity because they obstruct both internal and external scale of economies. When firm sizes are small relative to efficient size due to limited market demand, the internal economies are lost. When the market is small there will be few suppliers of inputs, and the external economies will be missing. In a survey of cross industry comparisons of productivity, Kravis (1976) found that there was a positive relation between productivity and market size. Some also argued that firms in high-growth industries have stronger incentives to invest in productivity-enhancing activities, such as research and development and building firm-specific organizational capital.[21]

We extend the growth regression model to account for the effect of market growth. The variable used for this purpose is the annual growth rate of the aggregated sales (in real terms) for each manufacturing industry in China.[22] We feel that the aggregate sales growth at the national level best reflects the change in market demand conditions because the firms located in Shenzhen have to compete with firms in other areas of China in nation-wide markets. Although using the sales growth rates of our

[21] See, e.g., Ehrlich *et al*. (1994).
[22] National sales data come from the *Statistical Yearbook of China*.

sample manufacturing industries has no bearing on the results, doing so may cause simultaneity problem, for the rates are likely to be endogenously determined. As can be seen in column 3 of table 3, the coefficient on the sales growth rate is positive and statistically significant, implying that the firms facing expanding markets tend to experience higher rates of productivity growth. However, this does not alter the estimated spillover effect of FDI, as the coefficient on Mfdish remains positive and statistically significant.

B.4. Public Capital

Improvements in manufacturing productivity may be in part attributable to changes in the amount of public capital. If an increase in public capital just happens to coincide with the changes in the average level of FDI in the manufacturing industry as a whole, the external effect of foreign equity participation would have been overstated by the estimates reported so far. To consider this possibility, we extend the growth regression model to account for public capital. Column 4 of table 3 contains the estimation results using the length of public streets and highways in the city of Shenzhen as a measure of public capital. The estimated spillover effect from FDI becomes slightly smaller, but remains statistically significant. Public capital itself is shown to have a positive impact, albeit statistically insignificant, on the rate of productivity growth. We have also used alternative measures to approximate public capital, such as the length of sewer system and the total capacity of telephone exchanges in the city, and obtained comparable results.

B.5. Industry Agglomeration

The effect of industrial agglomeration has been examined extensively in the literature.[23] Central to the agglomeration idea is that firms that operate in the same geographic area can benefit from each other. First, clustering facilitates the technology spillover among firms. Second, more firms operating in a region will create a large enough market for inputs, thus each firm can enjoy lower input costs due to the scale economies of input and utility supply. Third, clustering also help to reduce transportation costs.

Again, if the change in overall FDI coincides with the degree of agglomeration in the industry, the contribution of FDI would be overstated. We extend our growth regression model to account for agglomeration effects. In the empirical literature the agglomeration effect is usually examined in the context of cross regional comparisons and the extent of industry agglomeration is often approximated by the number of firms per unit of geographic area in a region under investigation. Since our sample is from one city (so the size of geographic area is fixed), the degree of agglomeration varies only over time and is fully captured by the number of firms in each year. In addition, we make a distinction between intra- and inter-industry agglomerations. The former is measured by the number of firms in each manufacturing industry, while the latter by the total number of firms in the manufacturing industry as a whole. We first introduce the intra-industry

[23] See, e.g., Wolff (1985) and Krugman (1991).

agglomeration variable into our growth regression and then further extend the regression by adding the inter-industry agglomeration variable as well.

The results reported in columns 5 and 6 of table 3 indicate that indeed there are positive agglomeration effects; that is, both intra- and inter-industry agglomerations tend to raise the rate of productivity of manufacturing firms in the city of Shenzhen. According to the estimates in column 6, the agglomeration effect appears to be stronger across manufacturing industries than across firms within the same manufacturing industry. However, the coefficient on inter-industry agglomeration is not statistically significant. It should be stressed that in these two regressions the estimated coefficients on Mfdish are slightly larger than those reported in the previous columns, and remain positive and statistically significant at the 1 percent level. This indicates that the spillover effect of FDI is over and above agglomeration effects.

In column 7 of table 3, we jointly introduce these four variables -- initial output, national sales growth, public capital, and industry agglomeration -- in the growth regression. In this specification, their coefficients all have expected signs, while industry agglomeration losses its significance. The coefficient on Mfdish hardly changes.[24]

C. Alternative Measures for FDI

Recall that the variable Mfdish is a weighted average of foreign equity share in each manufacturing industry and the weight is the labor share. This is the formula used by Aitka and Harrison (1999). An obvious alternative is to use the capital share as the weight. Still another choice is to assign equal weight to all manufacturing industries independent of the size of their workforce and capital. When we use these weighting schemes to construct Mfdish and rerun the regressions, we obtain essentially the same results as those reported in tables 2-4. The estimated spillover effect of FDI not only remains statistically significant but also becomes larger. When the capital share is used as the weight, the coefficients on Mfdish increase from 0.304 (column 1 of table 2) to 0.402, and from 0.523 (column 1 of table 3) to 0.551. Similarly, when equal weighting scheme is used, the coefficients on Mfdish rise to 0.380 from 0.304 and to 0.549 from 0.523.

Another possible way to capture the spillover effects of FDI is to use the output share of foreign invested enterprises. In principle, the larger the share, the greater the influence of foreign investment would have on domestic-owned firms. When this measure is used in place of Mfdish, its coefficient is positive but insignificant in the specification similar to column 1 of table 2. Its coefficient, however, is positive and statistically significant in the growth rate regressions. It should be noted that these estimates may suffer from simultaneity bias because the construction of the output-share variable involves an endogenous variable – output.

D. Simultaneity Issues

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[24] When the inter-industry agglomeration variable is also added to the model in column 7, its coefficient is negative and insignificant, leaving the rest of the estimates unaffected.

We have so far treated FDI measures as exogenous variables. However, it is arguable that the direction of causality may go from productivity or its growth to the level of foreign equity participation. It is also possible that our dependent variables and FDI measures are simultaneously influenced by certain omitted factors. In these situations, Fdish and Mfdish would be correlated with the industry-specific error term, and hence our estimates would be inconsistent.

We apply instrumental variable techniques to deal with possible simultaneity bias. The key to this approach is to identify instruments that are highly correlated with Fdish and Mfidsh but not with the error term in these regressions. Nonetheless, we have used in the reduced forms the lagged values of Fdish and Mfdish, the total number of firms in each manufacturing industry, the total number of firms in the manufacturing industry as a whole, the annual growth rate of public streets and highways (in kilometers) in the city of Shenzhen, the annual national sales growth rate of manufacturing industries, and other independent variables in the regressions.

Table 4 presents the estimation results. Columns 1 and 2 contain estimates based on our basic specifications, i.e., equations (4) and (5), respectively. The instrumental variable estimation gives qualitatively similar results to those obtained by weighted least squares (WLS) method. The estimated spillover effects of FDI remain positive, albeit somewhat smaller than what the WLS estimates indicate.

Since Mfdish is an average measure over all manufacturing industries, it is less likely to be correlated with the industry-specific error term. Accordingly, we have also conducted the instrumental variable estimation treating Fdish alone as an endogenous variable. The estimates in columns 3 and 4 show that the coefficients on Fdish and Mfdish are very similar to those reported in columns 1 and 2 of the table.

It should be noted that statistical tests do not favor treating Fdish and Mfdish as endogenous variables. According to the Wu-Hausman's test statistics[25] reported at the bottom of Table 4, the hypothesis that Fdish alone or along with Mfdish are exogenously determined cannot be rejected. Therefore, the instrumental variable estimates should be interpreted with caution, and the main results of tables 2 and 3 are free of simultaneity bias.

E. Do Domestic Firms Benefit from FDI?

So far our analyses have shown that FDI has large and robust effects on both the level and growth rate of productivity among our sample manufacturing firms, and technology spillover is the main channel through which FDI boosts productivity among firms, which may or may not be recipients of foreign capital. Since the data used are aggregated across all firms, including domestic and foreign-invested enterprises, by manufacturing industry, we cannot infer with high degree of certainty from the above estimation results that the technology spillover from FDI to domestic firms is significant.

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[25] The Wu-Hausman's test statistic has a *F*-distribution. See Maddala (1992).

One way to address this question is to extend our basic model to include an interaction term Fdish_Mfdish=Fdish*Mfdish. In this specification, a positive and significant coefficient on Mfish would indicate that domestic firms benefit from the presence of FDI in manufacturing industries. Of course, such an inference is valid if domestic firms receive little or no foreign capital, which is the case in our samples. The interaction term, on the other hand, captures the spillover effect of FDI on the productivity of foreign invested firms. In fact this is the specification and interpretation adopted by Aitken and Harrison (1999). However, when we apply our data to such a regression model, the coefficient on the interaction term is not statistically significant and the coefficient on Fdish remains insignificant. The major change occurs in the estimated coefficient on Mfdish, which, in this specification, also becomes statistically insignificant. The primary reason behind the sudden loss of significance of our key variables is multicollinearity. The interaction term raises the inter-correlations among independent variables in the model: the standard errors associated with the estimates for Fdish and Mfdish rose by 6 to 8 times (relative to those when the interaction term is not included) and yet Fdish and Mfdish are jointly significant – typical symptoms of multicollinearity.[26] It is well known that multicollinearity reduces the precision of regression estimates.

A most frequently used remedy is to drop variables suspected of causing the problem from the regression. Fdish is an obvious candidate to be removed from the model for two reasons. First, its coefficient is not significant in the basic regression model (column 1 of table 2). Second, our central concerns here are the signs and significance of the coefficients on Mfidsh and Fdish_Mfdish. Thus these two variables must be included in the regrssion. We modify our basic model: dropping Fdish and adding the interaction term, Fdish_Mfdish. In this specification, the estimated coefficient on Mfdish is 0.401 with a t-statistic of 2.034 (statistically significant at the 5 percent level), indicating that, indeed, domestic firms (with low FDI or low Fdish) have benefited substantially from the presence of FDI in the manufacturing industries. The coefficient on the interaction term is –0.0284 with a t-statistic of –1.184, implying that foreign equity participation does not give recipient firms an advantage in reaping the benefits of foreign investment outside them. When we apply the same estimation strategy to the growth regression (column 1 of table 3), we obtain similar results. Specifically, the coefficient on Mfdish is 0.581 with a t-statistic of 2.952, whereas the coefficient on the interaction term is negative (-0.0245) and statistically insignificant (t-statistic=-1.135). These results contradict those reported by Aitken and Harrison (1999), in which foreign investment is found to lower the productivity of domestic enterprises but raise the productivity of foreign invested firms.[27]

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[26] The null hypothesis that all three variables are jointly insignificant is rejected at the 10 percent level of significance.

[27] Aitken and Harrison (1999) argue that foreign investment lowers domestic firm's productivity by forcing domestic firm to reduce output and hence incur higher average costs. They also argue that positive spillover effects documented in previous empirical studies are in large part attributable to the specifications adopted, which fail to control for industry-specific factors. This criticism, however, does not apply to our study because we have controlled for industry-specific productivity differences by introducing industry dummies in all production function regressions. In growth regressions these dummies, when included, are not statistically significant.

However, removing selected variables may create problems of specification. Even though misspecification is not likely to be a serious issue in our case because the removed variable is insignificant in the first place, it is a worthy effort to explore alternative ways and means of addressing the question raised in the title of this section. To do so, we now turn to the analysis of a more disaggregated data set – the second data set that we have described in section 3. This data set contains 29 manufacturing industries for six ownership sectors over the period 1993-95. The first four sectors consist of domestic firms. They are the state-owned enterprises, collective-owned enterprises, joint-owned domestic enterprises, and shareholding companies. The last two sectors include enterprises set up by investors from Hong Kong, Macao and Taiwan and those set up by other foreign investors. The advantage of this data set is that it allows us to isolate the impact of foreign investment on domestic-owned firms.

Table 5 summarizes the results. The first three columns contain estimates of a modified version of equation (4) using, respectively, the pooled sample, the domestic-owned-firm sample, and foreign-invested-firm sample. The last three columns report estimates of the growth regression, a modified version of equation (5), for the same 3 samples. The modifications are: (a) interaction terms between sector-ownership dummies and Mfdish are introduced as additional independent variables to measure sector-specific spillover-effects of FDI; (b) sector-ownership dummies are added in the output regressions (columns 1-3) to account for heterogeneity across sectors of different ownership.[28]

In columns 1 and 2, since the coefficient on COEs_Mfdish is highly insignificant, FDI does not bring any productivity gain to the collective-owned firms. By contrast, the state-owned firms and joint-owned local firms do get large productivity boosts stemming from the spillover effects of FDI. The coefficients on SOEs_Mfdish and JOEs_Mfdish are statistically significant in both the pooled sample and the sample consisting of only domestic-owned firms. The results suggest that a 1 percent increase in the average share of foreign equity participation in a manufacturing industry leads to as much as 0.5- and 0.6-percentage-point increase in the productivity of state-owned and jointly-owned local enterprises, respectively. Shareholding companies, a type of domestic-owned firms, also benefit from the presence of foreign capital. But the estimated effects do not appear to be statistically significant.

Why have some domestic firms benefited more than others from FDI in the manufacturing industry? One explanation is that they differ substantially in managerial and technical capacities that are crucial to absorbing technological and managerial know-how.[29] In terms of technology, China's state-owned firms have always been in the forefront among domestic firms. They tend to have more technical workers who can

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[28] We have conducted tests on the joint significance of the sector-ownership dummies and/or the industry dummies. The likelihood ratio tests favor the inclusion of these dummies in columns 1-3, while calling for their exclusion in columns 4-6.

[29] For example, Borensztein *et al*. (1998) found that FDI contributes to economic growth only when a sufficient absorptive capability of the advanced technologies is available in the host country.

comprehend and put into use the new technology quickly. Joint-owned domestic enterprises, which are normally established jointly by large state-owned enterprises, also have considerable technical resources to facilitate the adoption of new technology. One possible measure for the firm's capacity to absorb new technology or take advantage of the presence of technology-advanced foreign firms is its research capacity or the quality of its staff. Firms that have a large portion of skilled workers may have greater capacity. However, information on the classification of workers is not available. A less direct but useful indicator is the average wage level. If firms that employ more skilled workers tend to have higher average wages, wage level can serve as a surrogate for the firm's learning capacity. Table 6 contains the average wage for industry and construction enterprises by ownership.[30] The average wages in the state-owned enterprises are much higher than those in collective-owned enterprises. Foreign-invested companies and some domestic firms, such as the joint-owned and shareholding ones, are grouped into a single category.

Capital market imperfection is another factor that limits the firm's capacities to adopt new technology. Imperfect domestic factor market is likely to obstruct the adoption process by increasing the cost of expanding firms, even though the firm has high managerial and technical capacities. This is likely to apply to the collective-owned firms, who, despite being efficient producers, are often shut out of the capital market and shunned by state banks.[31]

In principle, foreign firms (including those invested by investors from Hong Kong, Macao and Taiwan) also have great technical and managerial capacities to absorb new technology. However, the coefficients on HKMT_Mfdish and FIEs_Mfdish in columns 1 and 3 are not statistically significant, implying that non-domestic firms do not benefit from the presence of foreign investment in their industries. One conceivable explanation is that these firms (at least most of them) have already employed the best technology. They would not be able to benefit from more foreign investment that brings technology comparable to what they have already possessed.

Qualitatively, similar results emerged from the growth regressions. There are a few noteworthy points. First, foreign investment now has a positive and significant effect on the rate of productivity growth of the recipient firms. Since this result holds for the domestic-owned-firm sample but not the foreign-firm sample, it is domestic firms who benefit directly from foreign investment. This is at least in part due to the fact that domestic firms normally receive little direct foreign investment and the marginal benefit of such investment is still high in terms of productivity gains. In foreign-invested firms, by comparison, the level of foreign investment is likely to have reached a point where the marginal benefit of foreign equity participation is very low. Second, the estimated coefficients on the interaction terms show that, among domestic-owned firms, joint-owned enterprises benefit the most from the spillover effects of FDI followed by the state-owned firms. However, these estimates are not statistically significant partly because the sample data span only three years.

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[30] Wage data for manufactures by ownership are not available.

[31] In 1999, for example, the non-state sector produces more than 50 percent of total industrial output in China, but accounts for less than 30 percent of the total bank loans.

F. A Supplementary Labor Productivity Analysis

To supplement the results from the production function and growth regressions, we have also estimated a labor productivity model in which labor productivity or its growth rate is regressed against our key explanatory variables, Fdish and Mfdish. In these regressions, we do not include capital-labor ratio as an independent variable because doing so would be tantamount to restating (mathematically) the models analyzed before and the labor productivity analysis would provide no new information. There is another reason as well. Excluding capital from the model provides an additional test on the sensitivity of our main results to the assumptions we made in the construction of capital input variable, which may or may not be measured properly.[32] On theoretical grounds, the exclusion of capital-labor ratio from the labor productivity regression may render the estimation results bias due to the omission of a relevant variable. Therefore, keeping the limitation of labor productivity analysis and the potential bias in mind, we should consider the results reported in table 7 as supplements to the results discussed so far.

The results in table 7 strongly corroborate those derived from our production function and growth regression estimations. In the first three columns of table 7, the log of labor productivity is the dependent variable and the three columns are based on, in turn, the 1993-98 data, the 1993-95 data, and a subset of the 1993-95 data consisting of only domestic-owned firms. Since the 1993-95 data are disaggregated by ownership sector, we are able to estimate the spillover effect of FDI on the labor productivity of firms in different ownership sector. This is accomplished by introducing interaction terms between ownership and Mfdish. In column 1, the coefficient on Mfdish is positive and statistically significant at the 1 percent level. The estimate, 0.407, suggests that a 1-percent increase in the average foreign equity participation in the manufacturing industry would lead to 0.407 percent rise in labor productivity among firms in the industry. Similarly, the estimates reported in columns 2 and 3 show that there is a strong and positive relation between the labor productivity of domestic-owned firms and the average foreign equity participation in the industry. Although all four types of domestic-owned firms benefit from the presence of foreign investment in the industry to which they belong, the gains in terms of labor productivity seem to vary. The labor productivity of shareholding firms are the most responsive to increases in foreign investment followed by, in descending order, that of joint-owned, collective, and state-owned firms.

In columns 4-6, the growth rate of labor productivity is the dependent variable. Again, the estimates associated with Mfdish or its interaction terms with the ownership variables are positive and statistically significant at the 1 or 5 percent level. This implies that the higher the foreign equity participation at the industry level, the higher the growth rate of labor productivity of firms within the industry, especially the domestic-owned ones.

[32] Recall that we have conducted sensitivity checks on this variable earlier.

6. Concluding Remarks

FDI brings a number of potential benefits to the host country. It provides much needed capital to fill the savings gap and creates new employment in LDCs. The transfer of technology, skills and know-how is another major benefit expected from FDI. In this paper, we are concerned with the role of FDI as a channel of technology transfer. Specifically, we focus on technology transfer in the form of externality.

Using data on manufacturing industries in Shenzhen Special Economic Zone over the period 1993-98, we estimated the relation between foreign investment and productivity or the rate of productivity growth. We find an insignificant and, sometimes, negative association between FDI and the productivity (and rate of productivity growth) of its recipient firms. In contrast, we find a significant and positive relation between FDI at the industrial level and productivity (and productivity growth) at the firm level. This suggests that FDI generates externalities in the form of technology transfer. The point estimates of the external effects of FDI on productivity suggest that a 1-percent increase in the average level of FDI in manufacturing industry could raise the firms' rate of productivity growth by as much as 0.5 percentage points. The results are robust to a number of alternative specifications, which control for variables usually considered as important determinants of productivity growth, and to alternative measures for FDI. The results are also corroborated by labor productivity analyses.

We also find that technology spills over predominantly from foreign invested enterprises to domestic firms. However, some domestic firms benefit more than others from the external effects of FDI. Specifically, the productivity of state-owned and joint-owned firms are found to be more responsive than that of other domestic firms to a rise of FDI in the manufacturing industry. The main reasons are that the former firms have greater managerial and technical capacities as well as more financial resources that are crucial to absorbing advanced technology and management know-how.

Our results are based on manufacturing data from Shenzhen Special Economic Zone, where, arguably, the market system is in full play. Although more or less similar economic and policy environment exists in China's coastal provinces and cities, it remains to be proven whether technology spillovers stemming from FDI have also occurred in these areas. This raises an important question for future studies: to what extent can our results be generalized to the whole of China?

As noted earlier, technology transfer is only but one of many benefits that FDI is expected to bring to the host country. Thus the contribution of FDI to the Chinese economy may be far greater than what our estimates suggest. However, the transfer of technology, more than anything else, is probably the most important contribution of FDI, because ultimately, it is technology progress that determines the long-term economic growth of China.

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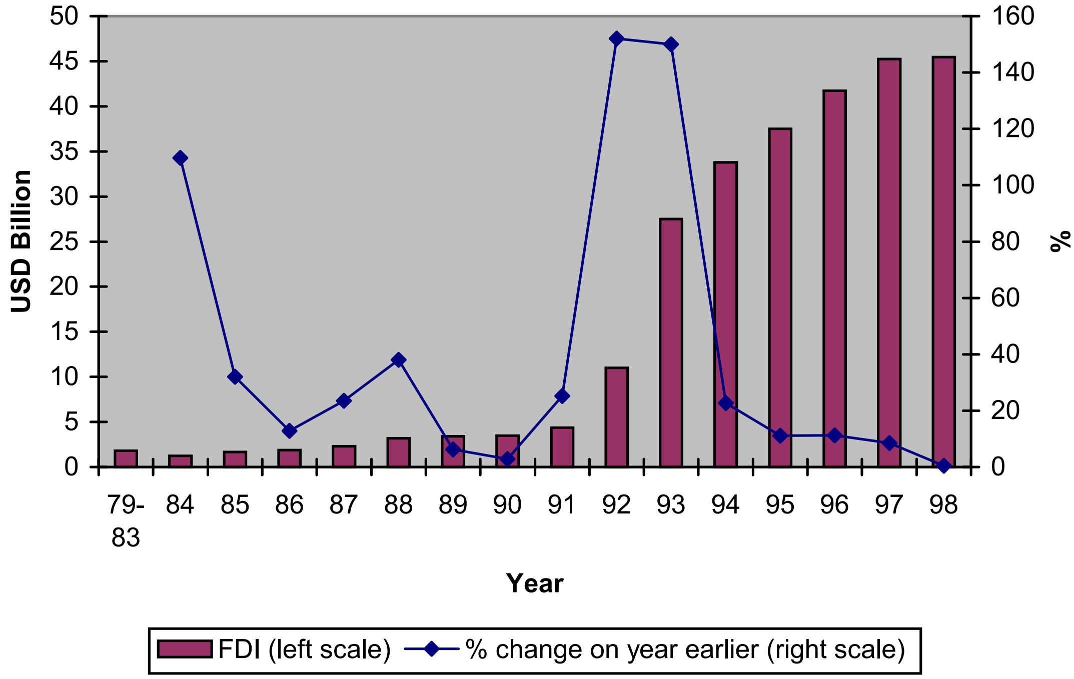
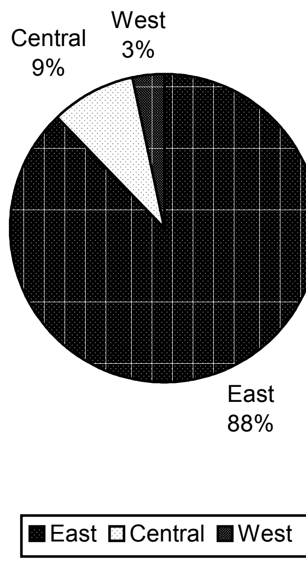
Figure 1: China's FDI Inflow, 1979-98



Source: *Statistical Yearbook of China*, 1999.

Figure 2: Regional Distribution of FDI in China, 1979-1998



Source: *Statistical Yearbook of China*, various years.
East region: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi, and Hainan.
Central region: Shanxi, Neimenggu (inner Mongolia), Anhui, Jiangxi, Henan, Hubei, and Hunan.
West region: Sichuan, Guizhou, Yunnan, Xizang (Tibet), Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.

Table 1: Summary Statistics of Key Variables Used

Variable	Sample: 1993-98	Sample: 1993-95
Fdish (%)	41.83	41.49
Mfidsh (%)	39.10	36.64
Value-added (million yuan)	18.45	13.61
Capital (million yuan)	40.66	32.86
Labor (persons)	279	325
No. of Firms	62.39[a]	12.79[b]
No. of Obs.	174	407

[a] average number of firms in each manufacturing industry;
[b] average number of firms by ownership-sector and manufacturing industry.

Table 2: Production Function Regressions
(29 manufacturing industries, 1993-98)

Variables	(1)	(2)[a]	(3)[b]	(4)[c]	(5)[c]	(6)[d]
Fdish	-0.0984	-0.132*	-0.128	-0.00610**	0.00400	0.0544
	(-1.277)	(-1.886)	(-0.900)	(-2.002)	(0.415)	(0.346)
Mfdish	0.304***	0.313***	0.514*	0.0115***	0.0103***	1.0362***
	(2.455)	(2.692)	(2.147)	(2.955)	(2.532)	(2.749)
$(Fdish)^2$	--	--	--	--	-0.00012	--
					(-1.106)	
Labor	0.526***	0.265***	0.791***	0.511***	0.497***	0.517***
	(3.508)	(2.709)	(3.501)	(3.431)	(3.328)	(2.999)
Capital	0.451***	0.747***	0.142	0.495***	0.527***	0.397***
	(2.799)	(8.355)	(0.659)	(3.056)	(3.206)	(2.055)
Time	0.0621***	0.0423**	0.0475*	0.0539**	0.0600***	-0.0578
	(2.669)	(2.160)	(1.922)	(2.351)	(2.546)	(-1.010)
HN	10.47	10.47	--[e]	9.91	8.15	7.33
	[5]	[5]		[5]	[6]	[5]
LR	129.842	n.a.	109.063	128.416	124.851	124.089
	[28]		[28]	[28]	[28]	[28]
Adjusted- R^2	0.78	0.63	0.75	0.79	0.79	0.79
Sample size	174	174	174	174	174	145

Note: all regressions are weighted by the square root of the number of firms; figures in parentheses are t-statistics. Fdish and Mfdish are in log unless indicated otherwise. * significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

HN: Hausman statistics for testing the random-effects model against the fixed-effects model, the critical values are $\chi^2_{90\%}(5)=9.24$; $\chi^2_{95\%}(5)=11.07$; $\chi^2_{90\%}(6)=10.64$; and $\chi^2_{95\%}(6)=12.59$. Numbers in square brackets are degrees of freedom.

LR: likelihood ratio (Chi-square statistics) tests concerning the hypothesis of no fixed effects, the critical value is $\chi^2_{95\%}(28)=41.34$. Numbers in square brackets are degrees of freedom.

[a] random-effects specification; [b] White-consistent-covariance estimator is used; [c] Fdish and Mfdish are in linear form; [d] Lagged Fdish and Mfdish (in log) are used; [e] the variance matrix for computing the Hausman's statistic is not invertible.

Table 3: Growth Rate Regressions
(29 manufacturing industries, 1993-98)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Fdish	-0.103	-0.120*	-0.105	-0.0926	-0.110	-0.106	-0.128*
	(-1.431)	(-1.659)	(-1.475)	(-1.286)	(-1.541)	(-1.479)	(-1.776)
Mfdish	0.523***	0.537***	0.517***	0.506***	0.539***	0.556***	0.542***
	(3.766)	(3.880)	(3.779)	(3.641)	(3.920)	(3.900)	(3.962)
Output93	--	-0.0812	--	--	--	--	-0.0971*
		(-1.607)					(-1.882)
National sales	--	--	0.805**	--	--	--	0.764*
Growth rate			(2.245)				(1.639)
Public capital	--	--	--	0.156	--	--	0.0175
				(1.353)			(0.129)
Intra-industry	--	--	--	--	0.0675**	0.0662**	0.0389
Agglomeration					(2.023)	(1.971)	(1.087)
Inter-industry	--	--	--	--	--	0.203	--
Agglomeration						(0.469)	
Labor	0.408***	0.363**	0.428***	0.391***	0.410***	0.409***	0.372**
	(2.665)	(2.341)	(2.834)	(2.552)	(2.709)	(2.692)	(2.432)
Capital	0.349**	0.370***	0.352**	0.366***	0.353**	0.368**	0.382***
	(2.372)	(2.520)	(2.427)	(2.486)	(2.426)	(2.464)	(2.634)
Constant	-1.499***	-0.961*	-1.528***	-2.478***	-1.818***	-3.412	-1.178
	(-3.823)	(-1.872)	(-3.952)	(-3.013)	(-4.342)	(-0.996)	(-1.096)
LR	22.246	n.a.	20.984	22.362	18.423	18.252	n.a.
	[28]		[28]	[28]	[28]	[28]	
Adjusted R^2	0.19	0.20	0.21	0.19	0.21	0.20	0.22
Sample size	145	145	145	145	145	145	145

Note: all regressions are weighted by the square root of the number of firms; numbers in parentheses are t-statistics. * significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.
LR: likelihood ratio (Chi-square statistics) tests concerning the hypothesis of no fixed effects, the critical value is $\chi^2_{90\%}(28)$=37.92. Numbers in square brackets are degrees of freedom associated with the Chi-statistics.

Table 4: Two-stage Least Squares Estimates
(29 manufacturing industries, 1993-98)

Variables	(1)[a] Production function	(2)[a] Growth rate regression	(3)[b] Production function	(4)[b] Growth rate regression
Fdish	0.152	-0.0351	-0.0179	-0.0345
	(0.806)	(-0.335)	(-0.059)	(-0.330)
Mfdish	0.208	0.437***	0.381	0.432***
	(0.837)	(2.590)	(1.061)	(2.559)
Labor	0.560***	0.392***	0.562***	0.390***
	(3.098)	(2.575)	(3.273)	(2.563)
Capital	0.370*	0.350***	0.402**	0.351**
	(1.841)	(2.413)	(2.050)	(2.418)
Time	0.136***	--	0.124***	--
	(3.940)		(3.532)	
Constant	--	-1.427***	--	-1.410***
		(-3.610)		(-3.567)
Wu-Hausman Test[c]	0.174 [3.00]	1.354 [3.00]	0.104 [3.84]	0.557 [3.84]
Adjusted R^2	0.77	0.18	0.79	0.18
Sample size	145	145	145	145

Note: all regressions are weighted by the square root of the number of firms; numbers in parentheses are t-statistics. * significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.
[a] Fdish and Mfdish are endogenous variables.
[b] Fdish alone is treated as an endogenous variable.
[c] Wu-Hausman test statistic has a *F*-distribution; numbers in square brackets are critical values at the 5 percent level.

Table 5: Growth Rate Regressions
(29 manufacturing industries by ownership sector, 1993-95)

Variables	Production function regressions			Growth rate regressions		
	(1)	(2)	(3)	(4)	(5)	(6)
	Pooled	Domestic	Foreign	Pooled	Domestic	Foreign
Fdish	0.0400	0.0236	0.0978	0.0994**	0.101*	0.0298
	(1.272)	(0.688)	(0.777)	(1.964)	(1.862)	(0.174)
COEs_Mfdish	-0.195	-0.149	--	-0.0779	-0.0519	--
	(-0.835)	(-0.565)		(-0.665)	(-0.330)	
SOEs_Mfdish	0.307*	0.378*	--	0.00157	0.0214	--
	(1.585)	(1.720)		(0.014)	(0.142)	
JOEs_Mfdish	0.425**	0.462**	--	0.0722	0.0959	--
	(1.959)	(1.915)		(0.616)	(0.609)	
SHEs_Mfdish	0.0755	0.122	--	-0.0808	-0.0453	--
	(0.292)	(0.430)		(-0.663)	(-0.278)	
HKMT_Mfdish	-0.0570	--	-0.165	-0.166	--	-0.207
	(-0.378)		(-0.935)	(-1.409)		(-1.205)
FIEs_Mfdish	0.158	--	-0.0213	-0.0463	--	-0.0891
	(0.719)		(-0.091)	(-0.387)		(-0.513)
Labor	0.493***	0.489***	0.568***	0.485***	0.488***	0.530***
	(8.666)	(7.210)	(3.991)	(7.736)	(6.725)	(3.972)
Capital	0.543***	0.533***	0.456***	0.543***	0.478***	0.623***
	(11.193)	(8.004)	(4.581)	(8.920)	(6.271)	(5.889)
Time	-0.0495	-0.0968*	0.0112	--	--	--
	(-1.250)	(-1.699)	(0.209)			
Constant	--	--	--	0.0850	-0.00327	0.520
				(0.216)	(-0.006)	(0.653)
Industry dummy	Yes	Yes	Yes	No	No	No
Ownership dummy	Yes	Yes	Yes	No	No	No
LR	117.575	75.525	83.802	14.397	19.299	9.176
	[28]	[27]	[27]	[28]	[27]	[27]
Adjusted R^2	0.77	0.75	0.78	0.53	0.53	0.54
Sample size	407	251	156	378	223	155

Note: all regressions are weighted by the square root of the number of firms; numbers in parentheses are t-statistics. * significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.
LR: likelihood ratio (Chi-square statistics) tests concerning the hypothesis of no fixed effects, the critical values are $\chi^2_{90\%}(28)=37.92$ and $\chi^2_{90\%}(27)=36.74$. Numbers in square brackets are degrees of freedom associated with the Chi-statistics.

Table 6: Average Wage of Staff and Workers by Ownership Sector (Yuan/year)

Year	Ownership Sector		
	State-owned	Collective-owned	Others[a]
1993	7,234	5,299	7,296
1994	9,637	6,588	9,358
1995	10,982	6,596	11,328
1996	12,469	8,142	12,347
1997	14,027	9,932	14,546
1998	16,163	10,720	15,971

Source: *Shenzhen Statistical Yearbook*, 1994-1999.

[a] Others include domestic-owned firms, such as joint-owned and shareholding enterprises, and foreign-invested companies (including those founded by entrepreneurs from Hong Kong, Macao and Taiwan).

Table 7: Labor Productivity Regressions
(29 manufacturing industries)

Variables	Productivity level			Productivity growth rate		
	(1)	(2)	(3)	(4)	(5)	(6)
	1993-98 full sample	1993-95 full sample	1993-95 domestic subsample	1993-98 full sample	1993-95 full sample	1993-95 domestic subsample
Fdish	-0.117	0.0326	0.0320	-0.165**	0.113*	0.115*
	(-1.373)	(0.720)	(0.685)	(-1.999)	(1.796)	(1.863)
Mfdish	0.407***	--	--	0.838***	--	--
	(3.017)			(5.421)		
Time	0.0490***	-0.146	-0.0721	--	--	--
	(2.552)	(-2.554)	(-0.925)			
COEs_Mfdish	--	0.715*	0.691**	--	0.322**	0.349**
		(1.802)	(1.941)		(2.208)	(1.970)
SOEs_Mfdish	--	0.408	0.366	--	0.366***	0.393**
		(1.461)	(1.216)		(2.631)	(2.329)
JOEs_Mfdish	--	0.938***	0.856***	--	0.533***	0.561***
		(2.992)	(2.595)		(3.664)	(3.191)
SHEs_Mfdish	--	1.034***	1.126***	--	0.359**	0.386**
		(2.778)	(2.928)		(2.377)	(2.107)
HKMT_Mfdish	--	-0.177	--	--	0.103	--
		(-0.815)			(0.705)	
FIEs_Mfdish	--	-0.505	--	--	0.162	--
		(-1.596)			(1.086)	
Constant	--	--		-2.483***	-1.436***	-1.535***
				(-5.716)	(-2.932)	(-2.552)
Industry dummy	Yes	Yes	Yes	No	No	No
Ownership dummy	--	Yes	Yes	--	No	No
Adjusted R^2	0.92	0.75	0.63	0.18	0.09	0.08
Sample size	174	407	251	145	378	223

Note: all regressions are weighted by the square root of the number of firms; numbers in parentheses are t-statistics. * significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.