Foreign Direct Investment, Technology Transfer and Firm Performance

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Abstract:

Using a firm-level survey, this study examines the effects of foreign direct investment and foreign technology on local Chinese firms. The empirical results suggest that knowledge inflow carried out mainly through direct foreign investment is an important conduit in promoting Chinese firms' export. Moreover, foreign knowledge is likely to increase local firms' total employment and production, especially in the short-run. In addition, local non-affiliate firms can benefit through business dealings with those firms directly associated with foreign businesses. The study also explores the possible contributing factors related to foreign technology transfer, such as domestic competition and employees education level.

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I. Introduction

What is the role of foreign direct investment (FDI) in developing countries? How does FDI affect local companies in their efforts to grow and to become global? These have become important questions in recent years. On one hand, more developing countries are pursuing economic policies open to trade and foreign investment. On the other hand, developing countries have become important players in the world economy, as producers, as consumers, as investors and as destinations for cross-border investment.

Numerous empirical studies have demonstrated a positive correlation between the "openness" of an economy and its economic growth among developing countries (e.g. Syrquin and Chenery 1989, Borensztein, De Gregoria & Lee 1995, and Wei 1993). Edwards (1993) and Harrison (1996) provide reviews of the early studies. By the "openness" of an economy, we refer to a business and regulatory environment that are friendly toward trade and foreign investment. It is sometimes measured by the percentages of trade (or foreign direct investment) of a country's gross domestic product (GDP), or overall tariff level. Despite the overall enthusiasm toward the positive impact of openness and trade in recent years, there are only a limited number of studies that analyze the economic mechanism involved in the process. Some suggest that economic openness affects growth by inducing more investment (e.g. Baldwin and Seghezza, 1996). Many others emphasize the role of technological progress associated with more trade and more foreign investment of an economy.

Trade can promote technology progress in developing countries. For example, more trade induces more R&D spending in domestic firms so that they can be more competitive in the market place. In addition, firms in developing countries can acquire new technologies embodied in new machines and new products they purchased from foreign sources. Similarly, foreign direct

investment can facilitate technology progress in developing countries. In fact, foreign direct investment carried out by multinational corporations (MNCs) is believed to be one of the most important vehicles for the international diffusion of technology.

There are two reasons why FDI is very important for developing countries to acquire new technologies. First, MNCs are more advanced in technology. A substantial portion of the world's total research and development is carried out within the large MNCs. Therefore; MNCs often possess the much-needed new and advanced technologies. Second, through direct involvement of foreign businesses, MNCs' domestic affiliates and other domestic producers can acquire new technology more directly and more effectively.

The benefits from FDI are not limited to new technology. Other direct benefits include the productivity increases in MNCs' local affiliates, new management skills brought in by the MNCs, and a potential market expansion brought about through foreign investors. Foreign investment can also increase the productivity in the host economy indirectly through its influence on both the industrial structure of the host economy and the conduct and performance of domestically owned firms. This is accomplished through increased competition in local economy, more investment in capital and human capital, training of labor and management, training of local suppliers of intermediate products, and transfer of knowledge (e.g. Blomstrom and Persson 1983, Frischtak and Newfarmer 1992, Blomstrom 1991).

As a result of foreign investment and foreign knowledge inflow, local affiliates of MNCs can achieve productivity increase and therefore higher growth. At the same time, the firms can also realize more export as they become more and more competitive. Empirical studies suggest that the presence of MNCs in developing countries and the associated investment have important

impacts on the export of their local affiliates and not-affiliates in the host economy (e.g. Aitken, Hanson, and Harrison 1997, Lipsey 1995, and Naujoks and Schmidt 1995).

Although these studies indicate that foreign direct investment have a positive impact on the growth and export by local firms, they usually don't explicitly examine the effect of knowledge inflows that are often associated with foreign investment. As FDI can benefit domestic producers in various ways, such as providing new technology and new potential market network, the distinction is important. In this study, we take a different approach by using micro-level firm survey data to investigate the role of foreign investment and foreign technology inflow separately. In particular, we are interested in the impact of foreign investment and technology transfer on local firms' export activities. We also investigate the effects of FDI and technology transfer on firms' other activities, such as employment and production. Furthermore, we also seek to identify factors that might contribute to foreign knowledge inflow.

The empirical results are consistent with the hypothesis that foreign direct investment indeed contributes to local firms' exports and growth through technology transfer. The results also indicate that the effects of foreign direct investment are carried out through both direct technology transfer and indirect knowledge diffusion. That means both MNCs' local affiliates and other domestic firms benefit. Through analyzing contributing factors to foreign knowledge, we find that domestic competition is an important element in promoting technology transfer.

Section II briefly describes the data set used in the empirical analysis and provides some background information regarding the cities included in the study. Section III presents the analytical framework for the empirical study. Section IV presents and discusses the estimation results. Section V concludes.

II. Background and Data Description

The data used in the analysis are based on a survey conducted by the World Bank in early 1993 in eight cities in China.[1] Six of these cities are located in two coastal provinces in Southeast China, Guangdong and Fujian.[2] The remaining two cities are located in the inland province of Sichuan. In each of the eight cities, fifty to sixty firms are randomly chosen and a total of about 500 firms are included in the survey.[3]

Table 1 is a summary of basic economic indices for the eight cities. It is obvious that the cities are quite different in their population, total industrial output, ownership composition, industry composition, and the intensity of foreign involvement. For example, some of the cities are much larger and more dominated by the state sector than the other cities. These are either provincial capitals, such as Guangzhou, Fuzhou and Chengdu, or a city of heavy industry base, such as Chongqing. In contrast, the other four cities are relatively small and have less presence of a state sector. In these small cities, industrial output is more concentrated on consumer goods such as food, textiles, and electronics. Between the coastal and the inland cities, there are considerable differences in terms of foreign involvement in local industry. In the two inland cities, firms with foreign participation account for less than 1% of all the firms and less than 2% of total industrial output. For the coastal cities, the numbers are 10% and 20%. In the two SEZs, foreign participation is even higher. More than 1/3 of the industrial establishment and more than half of industrial output in Shenzhen and Xiamen are from firms with foreign involvement.

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[1] These are Chengdu (CD) and Chongqing (CQ) in Sichuan Province of Western inland, Guangzhou (GZ), Shenzhen (SZ), and Dongguan (DG) in Guangdong Province on Southeast coast, and Fuzhou (FZ), Xiamen (XM) and Quanzhou (QZ) in Fujian Province on Southern coast.

[2] Two of the coastal cities, Shenzhen and Xiamen, were chosen as Special Economic Zones (SEZs) in the early 1980s. The other two SEZs are Zhuhai and Shantou.

[3] The firms in the sample are randomly chosen within each type of ownership category, namely the state-owned enterprises, the collectively owned enterprises and others.

Three factors are important to the contrast between the coastal and inland cities. First, the difference reflects the gradual and uneven nature of China's economic reform. These two provinces are among the first to have a more open and more flexible economic environment, they also enjoy a geographic proximity to the fast growing Southeast economies. For example, in the early 1980s when China's economic reform began, 4 coastal cities[4], including two cities in our sample (Shenzhen and Xiamen), were chosen as China's Special Economic Zones (SEZs). They are given various policy privileges including some autonomy to create a more open and market oriented business environment. In 1984, the government opened another 14 coastal cities as a step to deepen the reform process. On the contrary, inland cities are given lower preference in their reform process.

Second, the two southeast coastal provinces enjoy various location advantages. The region has better infrastructure endowment, including a relatively well-developed road system and multiple seaports. The region's sound transportation facilities plus its close proximity to Southeast Asian economies[5] have given the firms in the region easier access to both domestic and international markets. They also contribute to the region's competitiveness in attracting foreign investment.

Third, the two coastal provinces enjoy close ties with overseas Chinese[6]. The majority of overseas Chinese in many Southeast Asian countries and elsewhere, as well as Chinese in Hong Kong, are either emigrants from the two provinces or descendants of those who emigrated from

[4] In 1980, four Special Economic Zones were set up, including Shenzhen, Zhuhai and Shantao in Guangdong Province, and Xiamen in Fujian Province. In 1987, Hainan Island in Guangdong Province was given provincial status and became the fifth special economic zone. Within SEZs, foreign investment as well as various forms of foreign joint ventures are encouraged through measures on tax abatement, relaxation of foreign exchange controls and material imports quotas, etc.

[5] Guangdong Province is adjacent to Hong Kong and Macao. Fujian Province lies just across the Taiwan Straits from neighboring Taiwan itself.

the two provinces. During the economic reform, oversea Chinese, together with business people from Taiwan, have played a crucial role in bringing investment into mainland China. Until recently, direct investments from outside the border have in fact concentrated in China's southeast coastal region.[7]

The differences between the coastal and inland cities give us a unique opportunity to examine the role of foreign involvement and foreign technology in facilitating economic development. To empirically study the effect of foreign involvement and foreign knowledge on local Chinese firms, we use a data set obtained from firm survey. Next, we will compare the industry and ownership composition between the survey data the macro data obtained for each of the 8 cities. This is to give us an indication as to how far we can generalize out result.

The survey includes a total of about 500 firms. They account for about 3% of all the industrial establishments and 14% of total manufacturing output for the eight cities together. That suggests to us that an average firm in the sample is larger than an average firm in the relevant cities. Table 2 compares the ownership composition between sample firms and all firms in the cities. Among the three types of ownership forms[8], collective firms account for the most in the number of establishment and state enterprises account for the most industrial outputs. This is true for most of the cities in our sample as well as for the sum of the eight cities. Among the sample firms, the proportion of collective firms is generally smaller than that for the cities and the proportions of state enterprises and other firms are generally larger than those for the cities.

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[6] By using the term "overseas Chinese", we mean ethnic Chinese living outside mainland China and Taiwan.

[7] In 1992, investment from Hong Kong, Macao and Taiwan amounted to approximately 80% of total investment from outside the mainland in 1992. In the same year, 13% of total FDI landed in Fujian province, 33% in Guangdong province, and only less than 1% in Sichuan province.

[8] Business establishment are categorized into three groups, state-owned enterprises, collectively owned enterprises and other. Other forms of ownership include private firms, foreign owned businesses and various types of joint-venture establishments.

Similar comparison is made regarding the firms' industry composition based on output value. The results are summarized in Table 3.

To numerically assess the sample's similarity in ownership and industrial composition with those of the cities, we calculate three correlation coefficients, two based on the shares of firms in different ownership categories and one based on the shares of firms in different industries. The results are summarized in Table 4. The correlations for ownership composition based on total output are 0.71 for the pooled data and 0.96 for the total of the eight cities (0.41 and 0.95 when calculations are based on the number of firms in each category). For the industry composition, the correlation coefficients between the sample and the cities are 0.62 for the pooled and 0.70 for the total. We also obtained the same correlation coefficients for the individual cities and the results show substantial variations across cities.

Overall, the ownership and industry composition of the sample firms reflect the overall structure for the cities fairly. Therefore, our analysis reflects the overall situation for the cities involved relatively well. However, we should take precautions when we apply our results to more general circumstances. In the next section, we study the effect of foreign direct investment on local Chinese firms'. In particular, we examine the role of foreign technology.

III. Empirical Study on the Effects of FDI and Knowledge Inflow

Many theoretical and empirical studies suggest that foreign investment, especially foreign technology associated with foreign investment, carries positive effects to both local affiliates as well as to local businesses in general. In this section, we will empirically investigate the effects of foreign investment and foreign knowledge on local Chinese firms' activities. The analysis concentrates on three aspects of a firm's activity: export, employment and production growth, and training provided to domestic suppliers. The primary hypothesis is whether foreign investment

and knowledge inflow each and together have significantly positive impact on a firm's performance in the above three areas. The general model can be represented as following:

$$Y_i = \alpha + \beta TECH_i + \gamma FDI_i + \zeta X_i + \varepsilon_i \qquad (1)$$

$$H_0 : \gamma = 0 \text{ and/or } \zeta = 0$$
$$H_1 : \gamma > 0 \text{ and/or } \zeta > 0$$

In this equation, Y_i is one of performance variables for the sample firms such as export amount or output growth. $TECH_i$ is a binary variable indicating whether a firm has obtained substantial foreign knowledge inflow. FDI_i is the share of the firm's foreign ownership. Finally X_i is a vector that contains a firm's basic characteristics such as geographic location, industry, and number of years in business, etc. The variables included in the following estimations will be specified in the subsequent sections.

In the first set of analyses, we examine the effect of foreign investment and foreign knowledge on a firm's export activities. There are three closely related questions we want to address. First, whether foreign investment and foreign knowledge increase the probability that a firm exports? Second, whether foreign investment and foreign knowledge increase the total amount of export? And third, whether foreign investment and foreign knowledge increase the share of total output being exported.

After investigating the relationship between the firms' foreign participation and their export activities, we study the firms' employment and production to see whether foreign involvement helps domestic to expand. And finally, we explore the possible spillover effect, focusing on one particular aspect. That is whether a firm is more likely to provide training to its local domestic suppliers as a result of foreign knowledge inflow.

Before getting into the specific empirical models, we will first introduce some of the key variables used in the study. The definitions of all the variables relevant to this paper are listed in the appendix.

Performance variables:

EXPT_D is a binary variable takes the value of 1 if a firm exports (in 1991) and 0 otherwise.

LEXPT91 is the natural log of a firm's total export amount in 1991 (log (export91+1)).

PCEXPT91 is the percentage of a firm's output being exported in 1991.

GEMPL is the growth rate of a firm's total employment from 1988 to 1991.

GPRODN is the growth rate of a firm's total production from 1988 to 1991 calculated using output based on constant price.

GPRODR is the growth rate of a firm's total production from 1988 to 1991 calculated using output based on current price.

TRAINING is a binary variable takes the values of 1 if a firm provided training to its domestic input suppliers in 1990 and 0 otherwise.

Foreign participation and foreign knowledge variables:

FRN is the share of foreign ownership in a firm in 1991.

FJV is a binary variable takes the value of 1 if a firm has a foreign joint venture partner in 1991 and 0 otherwise.

TECH is a binary variable takes the values of 1 if the firm has in the past experienced substantial foreign knowledge inflow, and 0 otherwise.

IMPORT is the percentage of the firm's machinery that is imported.

CONTACT is a binary variable takes the value of 1 if the firm' typical high-level manager in the firm having business lunches with foreign buyers and suppliers or foreign machinery suppliers in 1991, 0 otherwise.

Variables indicating a firm's characteristics:

SOE is the share of state ownership in a firm in 1991.

PVT is the share of private ownership in a firm in 1991.

LEMPL is the log of the firm's total number of employees in 1991.

LPROD91N is the log of the firm's production in 1991 in constant value.

EDU is the weighted average years of education of a firm's employees.

LSPEC is the number (in log) of a firm's full time special employees (including quality control, computer aided design, and training in the firm).

AGE is the number of years a firm has been in operation.

OLD is a binary variable takes the value of 1 if the firm started operation before 1980 and 0 otherwise.

COMPETITION is an index for the intensity of domestic competition, firm perceived by a firm's top manager. It is represented by the absolute value of the firm's perceived price electricity, ranging from 0 to 3.

3.1. General descriptions of the sample

In this section, we will examine the general statistics for some of the key variables. Table 5 presents the mean values of these variables broken down by cities. It shows that a substantial portion of the firms has either direct or indirect association with foreign businesses. For example, about one third of the firms have foreign ownership. The average share of foreign ownership in these firms is over 60%, which suggests deep involvement of foreign owners. In addition, about 30 percent of the firms have foreign joint venture partners.[9] Assets holding and forming a joint venture are not the only forms of foreign involvement in domestic economy. Firms sometimes form close relations with their input suppliers, output buyers, and machine providers. These informal associations can also serve as a source of now technology. Data show that in at least 30 percent of the firms, the top managers have had business lunches with their foreign associates.[10]

Associated with various forms of foreign involvement, 45% of the firms have reported substantial foreign knowledge inflow in the past. There is another measure that can also indicate a firm exposure to new technologies, machine import. Machine import is important for domestic firms since many believed that information regarding new technologies in designing, production and so on could be embodied in the advanced machines. Table 5 shows that imported machines are present in more than two fifth of the sample firms. In those firms, imported machines account for more than 60 percent of total machinery on average.

[9] In most cases, a firm's foreign owner is also its joint venture partner. There are, however, foreign venture partners that do not own any portion of the firm's assets. For example, some joint ventures are set up for import material processing. Joint ventures could also exist in the form of joint-management, etc.

[10] The survey also asked whether a firm's top managers had business dinner with foreign business associates.

Table 5 also summarizes some of the firms' performance variables such as export. Among all the sample firms, more than half exported in 1991. In these firms nearly 60% of their output are sold to foreign market on average.

Aside from the overall mean values for the key variables, Table 5 also shows the variation among the cities in terms of their association with foreign businesses and their export performance. In the two inland cities, Chengdu and Chongqing, only very few firms have foreign ownership or have a foreign joint venture partner. Seemingly related to the sparse association with foreign businesses in the two inland cities, few firms reported having experience foreign knowledge inflow or imported machinery. The differences in the firms' access to foreign businesses and foreign knowledge does seem to be reflected in firms' export activities. In the two inland cities, few firms export. Among the exporting firms, those located in the small coastal cities (such as Shenzhen, Dongguan, and Quanzhou) sell more, as a percentage to total sales, to the world market. For total amount of export, however, there are no large variations among firms in different locations.

The above observation suggests that foreign ownership, technology diffusion and the Chinese firms' export seem to be closely related. Other factors may also be attributive to the difference in the firms export activities. For example, firms in the two inland cities, as well as firms in Guangzhou and Fuzhou, the other two provincial capitals are on average older. To study the relations among the firms foreign association, knowledge inflow, export, and other characteristics, we first calculated the correlation coefficients among the key variables. The results in Table 6 indicate that positive and significant correlations do exist among the three key variables: the share of foreign ownership, technology transfer, and export. Furthermore, technology transfer is also positively associated with the size of the firm, the average education

level of employees, a firm's perceived competition intensity, and a firm's informal contact with foreign businesses. In the empirical analysis that follows, we attempt to empirically analyze the relations among these different activities carried out by the Chinese firms.

3.2. Likelihood that a Firm Exports

Analyzing the correlation coefficients can provide us with very useful information regarding the possible relations among variables for the firms' various activities. To further analyze the impact of the firms' association with foreign firms and foreign knowledge inflow on the firms' performance, we use multivariate regressions. Multivariable analysis will enable us to concentrate on the key variables while controlling other relevant variable such as the firms' basic characteristics.

First, we study the factors possibly associated with the probability that a firm exports. The question involved is whether foreign investment and the associated foreign knowledge inflow increase the likelihood that a firm exports in the future. The dependent variable is a dummy variable denoted by EXPT_D. It takes the value of 1 when a firm exports in 1991 and 0 otherwise. There are four independent variables that we are most interested in. Three out of the four are binary variables. TECH takes the value of 1 when a firm reported having received foreign knowledge inflow that started before 1990, and zero if the firm does not receive foreign knowledge. FJV takes the value of 1 when the firm had formed a foreign joint venture with a foreign partner before 1990 and 0 if the firm has not formed joint venture partnership with a foreign firm. FRN is the share of foreign ownership in a firm. It represents the intensity of foreign involvement in a firm. Finally, CONTACT is another binary variable indicating the firm's informal association with foreign businesses. Noted that there is no information regarding the

time when foreign ownership began. Therefore, we would not be able to tell which one of the two, foreign ownership and export, precede the other from the estimated coefficient.

The equation also has variables on the firms' characteristics such as total number of employees, share of various ownership, industry and location. Finally, we include a variable EXPT0 representing a firm's initial export status. Two alternative indices are used. One is a binary variable, EXPT0_D, and the other is a continuous variable, LEXPT0. EXPT0_D is calculated as the following. If a firm has experienced technology transfer, it indicates whether this firm exports at the time when technology transfer began. If a firm does not report technology inflow from foreign sources, it indicates whether this firm exports in 1980 (the first year reported in the survey) or the beginning of the firm's operation (if the firms was established after 1980). Specifically, if TECH is 1 for a firm and the year technology transfer started is T, then EXPT0_D takes the value of 1 if the firm exports in year T and 0 if the firm does not export in year T. When TECH is 0 for a firm, EXPT0_D takes the value of 1 if the firm exports in 1980 (or first year of operation if later than 1980) and 0 otherwise. LEXPT0 is obtained in the same way, except it is a natural log value of the total export and thus a continuous variable[11].

Since the dependent variable is a binary variable, a logistic specification is used to estimate the equation. A logistic regression assumes an S-shape curve and has the following functional form, $y_i = 1/(1+\exp(-\mathbf{X}_i\beta+\varepsilon_i))$. In other word, the X's are linearly related to the logit transformation of the y's, where $logit(y_i) = \ln(y_i/(1-y_i))$. Thus, the empirical model we estimate is the following:

$$\text{logit}(expt91_i) = \alpha + \beta_1 TECH_i + \beta_2 FJV_i + \beta_3 FRN_i + \beta_4 CONTACT_i + \gamma Z_i + \varepsilon_i$$

[11] LEXPT0 is calculated as ln (export0+1) in order to retain the firms with zero initial export in the sample.

Here Z is vector of variables of firms' characteristics including $LEMPL$, $IMPORT$, SOE, PVT, FRN, $COND$, $EXPT0$, as well as CITY and INDUSTRY. The estimation results are summarized in Table 7. The result in column A does not include EXPT0, a variable for the firm's initial export condition. The results in columns B and C are obtained using the two indicators for the firm's initial export condition, LEXPT0 and EXPTO_D. For column C, we calculate the two marginal effects for each key variables, one at the sample mean and the other the average over all sample points.

For the logistic model, the marginal effect is defined as the following:

$$\text{marginal effect} = \frac{\partial E[y \mid \mathbf{X}]}{\partial \mathbf{X}} = \Lambda(\beta^T X)[1 - \Lambda(\beta^T X)]\beta$$
$$\text{where } \Lambda(\beta^T X) = \frac{1}{1 + \exp(-\beta^T \mathbf{X})} \qquad (2)$$

Now we will examine the estimation results. If we don't control for the initial export condition, as shown in the first column in Table 7, the estimation shows that knowledge inflow from foreign sources is positively and significantly correlated with the probability that a firm will export in the subsequent years. There is an appealing explanation to this finding. That is, assuming the same initial conditions among Chinese firms, foreign knowledge will significantly increase the probability of the recipients to export in the subsequent years. However, another scenario could also generate outcome consistent with the above positive results. Let's assume that when a domestic firm wants to export, it needs to acquire certain technology or knowledge to achieve that goal. Under this assumption, we will observe that technology transfer precede export. When interpreting the estimation results, we would not be able to exclude the second scenario. Nevertheless, what we can conclude that foreign knowledge inflows tend to precede the firm's export activity, either as a cause or possibly a necessary step.

The estimation results also show that the share of foreign ownership has a positive partial correlation but the coefficient is only marginally significant. When two firms both received foreign knowledge, the one with higher foreign ownership is more likely to export, other things being equal. This result suggests that joint equity with foreign businesses benefit local affiliates not only in newer technology, but other export related benefits as well. One of such benefits might be an easier access to a market network. On the other hand, forming a joint venture with foreigners does not provide more export related assistance in addition to TECH and FRN. Finally, the results show that having informal contact with foreign firms is positively associated with the likelihood that a firm exports. This finding is consistent with the assumption that local firms benefit from informal contact with foreign businesses.

We now take a look at the coefficients on firms' basic characteristic variables. First of all, the size of a firm's total employment is positively associated with higher probability that a firm exports. Secondly, the coefficient on CONTD is negative and marginally significant. That suggests firms having regular informal meeting with other domestic firms (buyers, suppliers and so on) tend to be less export oriented. Finally, the coefficients on some of the other basic variables such as SOE, PVT and OLD are not significantly different from 0.

Including firms' initial export status significantly improves the model's overall estimation (Column B and Column C). A firm's initial export condition has a high prediction power as to whether the firm will export in 1991. The estimated coefficients on other variables mostly remain the same sign. If we compare column C with column A, the coefficient for TECH and LEMPL remain positive and significant but the magnitude decreases from 1.15 to 0.94 and from 0.90 to 0.71, respectively. The coefficient for FRN increases slightly and the coefficient for CONTACT remains positive but lost statistical significance.

The marginal effects can provide us with an intuitive interpretation for the magnitude of the coefficients. At the sample mean, having foreign knowledge inflow (TECH=1) corresponds to a 23.4% higher probability that the firm will export. Also, one percentage higher in foreign ownership will increase the probability that the firm will export in 1991 by 0.4%. If we use the average of all sample firms for calculation, the above marginal effects are about 11.3% and 0.2% respectively. As mentioned above, initial export condition has a higher prediction power on a firm's future export. At the sample mean, initial export status will increase the likelihood that the firm exports in 1991 by 74%. If calculated as the average of all sample points, the marginal effect of initial export status is about 36%.

There is not any significant difference between older firms and newer firms in their export. The likelihood that a firm exports in 1991 is similar for firms started before the economic reform to those started after the reform in 1978, other factors being equal. This is somewhat surprising. We would naturally expect newer firms to be more export-oriented than older firms; given that there have been dramatic changes in the economic system. There are three explanations that might be relevant to the finding. First, old firms and new firms differ greatly in many of their characteristics, such as foreign ownership. When these other variables are included in the estimation, there may not be any additional effect for the variable OLD. Second, older firms may have other advantages that are not accounted for. For example, Old firms have accumulated more human capital. The last explanation is related to the role of government in China. Although firms have gained much autonomy in management decision making during the reform, government agencies at various level still play an important role in firms' exporting activities. Consequently, old state firms may possess advantages over private firms for their longer and closer relations with government agencies.

The size of the firm is significantly associated with the firm's probability to export in the future. On average, a one-percent increase in a firm's employment in 1988 increase is associated with nearly 9% higher probability that a firm export in 1991. At the sample mean point, the number is approximately 18%. This suggests that larger firms have the advantage in penetrating foreign market because they have more resources.

3.3. Total Amount of a Firm's Export

The results in the previous section indicate that foreign knowledge inflow significantly increases the probability that a firm will export in the subsequent years. In addition, foreign ownership is also associated with higher likelihood that a firm exports. In the following two sections, we will explore further the extent of the positive effect that technology transfer has on the export of local Chinese firms. In this section, we will examine how the total amount of a firm's export is affected by foreign technology inflow. In the next section, we will analyze how the share of a firm's export in total output is affected.

The variable we will examine in this section is the natural log of a firm's total export value in 1991. We first estimate the model using an ordinary linear specification (OLS). However, there is a problem in applying the log specification to a censored data. Firms that do not export will be dropped from the sample when taking the log of the total export. If we assume that when the desired level of export based on the characteristics of a firm is zero or negative, the observed level of export is zero, then dropping these firms may generate biased estimates. Unfortunately, it is not feasible to apply the Tobit specification while maintaining the log linear structure, as the logarithm of zero is undefined. To overcome this problem, we use a modified Tobit model (or threshold Tobit model) introduced by Eaton and Tamura (1996). This method has

been applied in the context of estimating trade volume and foreign direct investment (e.g. Rauch 1999, Wei 1998).

The modified Tobit specification is defined as following:

$$\begin{aligned} \ln(EXPT91_i + A) &= \mathbf{X}_i\beta + \mu_i \quad \text{if } \mathbf{X}_i\beta + \mu_i > \ln(A) \\ &= \ln(A) \quad \text{if } \mathbf{X}_i\beta + \mu_i \le \ln(A) \end{aligned} \tag{3}$$

In the model, A is a threshold parameter to be estimated from the model, μ_i is a normally distributed i.i.d variable with mean zero and variance σ^2. In this specification, when $\mathbf{X}_i\beta + \mu_i$ exceeds a threshold value, $\ln(A)$, there will be a positive export; when $\mathbf{X}_i\beta + \mu_i$ is below the threshold value, the realized level of a firm's export is zero.

The independent variables include the same variables as in equation (2), such as TECH, FRN, FJV, CONTACT, and EXPT0_D. The model also includes variables of the firms' basic characteristics such as LEMPL, SOE, PVT, CITY and INDUSTRY. In addition, we include the share of imported. The reason is many believe that new and advanced technologies are embodied in the imported machines. The threshold model is estimated using the maximum likelihood method. The results for both the OLS and the modified Tobit model are listed in Table 8. [12]

A total of 164 firms are included in the OLS estimation and 307 in the Tobit model. For most of the variables, the coefficients from the two models have the same sign. The ones obtained from OLS are generally not significantly statistically. In the subsequent discussions, we will focus on the results obtained from the Tobit estimation. The coefficient on TECH is 0.77 and significant at 10% level. That suggests that the desired level of export in 1991 is at least 77% higher for a firm that experienced foreign knowledge inflow before 1990 compared to one with no foreign

knowledge inflow, other things being equal. The coefficient for IMPORT[13] is also positive but only marginally significant (at 13% level). This indicates that more imported machines is associated with higher export from a firm, consistent with the embodied technology assumption.

Foreign ownership is positively related to desired level of a firm's export. A one-percentage point increase in a firm's foreign ownership can result in a 2% increase in total export. Informal contact with foreign businesses is also associated with higher level of desired export. However, FJV is not significantly related with the desired level of a firm's export. These results are all consistent with those obtained in the previous section.

Like in the results for EXPT_D, a firm's initial export condition is a strong predictor for its export in 1991. In addition, a firm's total employment is positively associated with its desired level of export. These again are consistent with the earlier results. One different result is that the coefficient on PVT, the share of private ownership, is positively and significant. The coefficient is 4 times higher than that of foreign ownership. Assuming that private firms are more market oriented and have less government involvement, this result indicates that firms operating under more market orientation are more motivated in extending their sale outward.

To test the robustness of the model, we estimated the equation with alternative dependent variables. One such alternative is the natural log of a firm's export 4 years after foreign technology inflow began.[14] The results are consistent with the earlier outcome listed in Table 8. They show that foreign knowledge inflow is associated with higher desired level of a firm's

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[12] The OLS estimation only includes firms with positive export. The TOBIT estimation includes all firms. In obtaining the TOBIT estimation, we first estimate an OLS using ln(EXPT+1). The resulting coefficients are then used as the initial values for the Tobit estimation.

[13] IMPORT, the share of imported machines in the firm is initially included in the previous equations on EXPT_D. But it is later dropped since it has not significant effect. Dropping it does not affect the over model fitting.

[14] Natural logs of a firms export 1, 2 and 3 years after foreign technology inflow started are also used as alternative dependent variables to test the model. The results are not included in this paper.

future export, for example three or four years after the knowledge inflow began. However, foreign technology does not seem to significantly increase a firm's export immediately.

The results from this section are consistent with those from the previous section. Foreign technology inflow tends to precede the firm's export. Technology transfer is also associated with higher level of a firm's future export. In addition, the results show that there may be a lag between technology inflow and higher export, suggesting that it takes time for the domestic firms to absorb and adapt the new technology before they can increase their export.

3.4. The Share of Export in Total Output

The empirical analysis so far suggests that firms that have received foreign knowledge during the 1980s not only are more likely to export in 1991, they export more in total amount as well. In this section, we further study the impact of foreign participation by examining the share of a firm's export in its total output. We believe that examining the share of export in firm's total sale is important. Suppose that a firm is associated with foreign businesses such as equity involvement and as a result receives technology transfer; based on the results from above, the firm will be likely to start exporting and export more. There are two alternative ways to achieve this outcome. On one hand, the firm could divert part of its domestic sale to the world market. On the other hand, the firm could also increase its production and increase its export at the same time. In the first case, the share of export in total output will increase dramatically while in the second case it need not. Both outcomes are good for the domestic market if we are more concerned with export but the second case is more desirable because it is associated with economic expansion for the domestic firms.

The variable concerned in this section is the share of a firm's export in its total sale in 1991 (PCEXPT). Since the value of the dependent variable is censored on both 0 and 100 percent,

we use its logit transformation for estimation.[15] About 240 firms are included in the regression. More than half of the firms do not export while about 10 percent of the firms export 100 percent of their output.

The results in Table 9 indicate that the share of export in total output is not significantly higher for firms that have experienced foreign knowledge inflow during the 1980s. However, the share of imported machines in the firm does a positive and significant association with higher export share. The marginal effect on IMPORT calculated with the formula in section 3.1 shows that a 1-percentage increase in IMPORT corresponds to up to more than 1 percent higher export share in a firm's total output.

In addition, the intensity of foreign participation does not seem to be association with the export share of a firm's export. The coefficients on FRN, the share of foreign ownership, and FJV, foreign joint venture indicator, are insignificant. Once again, a firm's initial export status and total employment are important predictors for a firm's export share in 1991. Finally, there is evidence that old firms, firms started operation before 1980, tend to have smaller export share. The coefficient is not significant.

The results from the three sections indicate that foreign knowledge inflow brings positive effects on local firms' export activity. It seems that the results for EXPT_D are much stronger than those for LNEXPT and PCEXPT. Part of the reason is that there may be more measurement error in the latter. This is plausible, especially for using survey data. It is probably easier to answer a yes or no question such as whether the firm exports in a certain year than try to produce a precise amount or percentage. Nonetheless, the analysis does provide some support that foreign

[15] Logit (PCEXPT)=Ln [PCEXPT/(1-PCEXPT)]. In the transformation, 0 and 1 are replaced with 1E(-15) and 1-1E(-15). In addition, both one-sided and two-sided Tobit estimation are also used and the results are similar.

knowledge has positive effect on Chinese firm's export. Firms that have received foreign knowledge during the 1980s are more likely to export and to export more. More importantly, this is likely to be the result of expanded production rather than from diverting sales from domestic to international markets. In the next two sections, we will examine the effect of knowledge inflow on the growth of a firm in terms of both employment and production.

3.5. Employment, Output and Their Growth

In the previous three sections, we study the effect of foreign knowledge on firm's export. In this section, we examine the association between foreign knowledge inflow and the firm's employment, production including their growth. First, we examine the effect of foreign knowledge inflow on a firm's employment and its growth rate. Then we look at the firms' production and its growth.

When studying the firms' employment, three dependent variables are used but the basic models are the same. LEMPL88 and LEMPL91 are the logs of total numbers of employees in 1988 and in 1991 respectively. GEMPL is the growth rate of total employment from 1988 to 1991. Since we use 1988-1991 to calculate growth rate, the analysis includes only firms that either have not experienced foreign knowledge inflow or have received foreign knowledge beginning before 1988. The following are the basic models.

$$lempl88_I = \alpha + \beta_1 TECH_I + \beta_2 FJV_I + \gamma X_I + \varepsilon_I \quad (4)$$

$$lempl91_I = \alpha + \beta_1 TECH_I + \beta_2 FJV_I + \gamma X_I + \varepsilon_I \quad (5)$$

$$gempl_I = \alpha + \beta_1 TECH_I + \beta_2 FJV_I + \gamma X_I + \varepsilon_I \quad (6)$$

In these three equations, X includes EXPT0, SOE, PVT, FRN, IMPORT, as well as CITY and INDUSTRY. For equation (6), LEMPL88 is also included control for the effect of initial firm size. The results are summarized in Table 10, Panel A.

From the first two columns, we find that the results for LEMPL88 and LEMPL91 are essentially the same. TECH is positively associated with a firm's future employment level. The significance level is only marginal (15%). Furthermore, foreign ownership and foreign joint venture partnership are also associated with higher future employment. In addition, firms with large state ownership tend to have more employees, other things being equal.

For the regression on employment growth, we obtain two estimates. In the first estimation, TECH enters the model alone and in the second specification, an interaction term between TECH and a time variable, TECHYR is added. It is defined as the product of TECH and the number of years from the first year of foreign knowledge inflow to 1988. The goal is to capture the possible decreasing effect of TECH on employment growth over time. The results in the third show that, when TECH enters the equation alone, the coefficient is positive but insignificant. But when the interaction term is included, the overall model fitting improves significantly. The coefficient for TECH is positive and that for TECHYR is negative. Both are significant. These suggest that foreign technology inflow significantly increase the growth rate of a firm's total employment. However, the effect seems to decrease over time. For example, foreign knowledge inflow started in 1987 corresponds to about 14% higher employment growth between 1988 and 1991. However, the effect amounts to only 5% for the knowledge inflow started in 1985 and 0 for those started before 1985. [16]

Next, we analyze the effect of foreign knowledge on the firms' production. We re-estimated the models (4)-(6) using the level and growth of a firm's total output as dependent variables. Output and growth rate evaluated based on constant prices and current prices are both

[16] About one third of the firms (67 out of 203) included in the regression received foreign knowledge inflow, in about half of these firms (36 firms) the event occurred in and before 1985.

used in the equation, including LPROD88N, LPROD91N, GPRODN, LPROD88R, LPROD91R, and GPRODR.[17] The first three variables are a firm's production (in 1988 and 1991, natural log) and growth rate between 1988 and 1991 evaluated on constant prices. The last three are defined similarly but evaluated on current prices. The estimation results are in Panel B and Panel C of Table 10.

The estimation results are not as clear as those obtained for employment. When we examine the estimation result regarding future output level, TECH seems to be associated with higher future production only when output value is based on constant prices. In addition, foreign joint venture partnership is not related a firm's future production. For the results regarding the growth rate of production, results similar to that for employment growth are obtained when current prices are used for evaluation. That means, when TECH enters the model along, not significant coefficient is obtained. When interaction term TECHYR is included, the model generates positive coefficient for TECH and negative coefficient for TECHYR. Both are significant. No such results are obtained when output is valued on constant prices. In addition, foreign ownership and forming a foreign joint venture partnership before 1988 seem to be positively and significantly associated with the output growth between 1988 and 1991.

The analysis in the section indicate that foreign knowledge inflow not only have a positive impact in facilitating local firms' export, it also seems to have positive effects on a firm's future employment and output growth. These effects, however, decrease over time and may only be present within the short run. We might think of it as a short-term effect rather than a long run

[17] In this section, we use growth rate calculated through current-valued as well as current valued production. The reason is that during the 1988-1990 period, the base year for constant price was changed from 1980 price (for 1988 and 1989) to 1990 price (for 1990 and 1991) and there is no conversion for the two. In this case, both measures are somewhat flawed. We included all industry dummies, assuming that the inflation is the same for all firm in one industry and try to explain the difference from the industry mean.

growth rate increase. In addition, firms also seem to draw addition benefits from foreign ownership and forming a foreign joint venture with foreign businesses to gain employment and output growth.

3.6. Training of Domestic Suppliers

In the previous sections, we analyzed the possible benefits a Chinese firm may accumulate through direct equation partnership with foreign businesses and foreign knowledge inflow. As we discussed earlier, in addition to the benefits received by their direct recipients, foreign technology inflow may generate spillover effect to other domestic firms as well. The assumption is that when a Chinese firm is involved with foreign firms and has obtained foreign knowledge, other local firms may benefit from the above process through business relations with the firm. In this section, we analyze one aspect of such spillover effects. The basic question is whether a firm is more likely to provide training to its domestic suppliers when it has received foreign knowledge inflow. At the same time, we also look at the relation between foreign ownership and providing training to domestic suppliers. The dependent is a binary variable valued at 1 when a firm does provide training to its domestic supplier and 0 otherwise. Once again, a logistic specification has to be used for the estimation.

$$\text{logit}(TRAINING_i) = \alpha + \beta_1 TECH_i + \beta_2 FRN_i + \beta_3 FJV_i + \gamma \mathbf{X}_i + \varepsilon_I \qquad (6)$$

In this equation, $\mathbf{X}_i$ include the EXPT_D, LPEOUT, LEMPL, AGE, SOE, PVT, LSPEC, EDU, as well as CITY and INDUSTRY. All the firms included in the regression have at least one domestic supplier. The estimation results presented in the first three column of Table 11 provide supporting evidence to our assumption. Firms that have received foreign knowledge inflow are more likely to provide training to their domestic suppliers. The average marginal effect (third column) suggests that firms with foreign knowledge inflow are 10% more likely to provide

training to their domestic suppliers). That means foreign knowledge inflow benefit not only its direct recipient but other related domestic firms as well. The result is consistent with the assumption that foreign knowledge has spillover effect to domestic economy. We offer one explanation to the positive correlation between receiving foreign knowledge inflow and providing training to domestic supplies, though there could be different reasons. We believe that while a firm received foreign technology, it is likely to raise its product standard and thus require input of higher quality. One solution is to import material from abroad. However, if import is too costly or prohibited (restricted) by government regulations, an alternative solution is to train domestic suppliers so higher quality input could be acquired locally.

The results also show that a firm's output per employee in natural log, LPEOUT, is positively associated with the likelihood that it provides training to its domestic suppliers. This finding probably reflects the fact that relatively high capital-intensive firms require higher input quality and thus more likely to train their domestic suppliers. The average marginal effect for LPEOUT is 0.05. That means a 1% increase in per employee output corresponds to 5% higher probability that a firm provides training to its domestic input supplier.

From the estimation results, we find that foreign ownership and having a foreign joint-venture partner are not associated with how likely a firm provides training to its domestic suppliers. It is not too surprising that high foreign ownership does not indicate more training to domestic suppliers, as the effect is probably reflected through TECH. To further examine the effect of foreign ownership on the probability a firm provides training, we replace the variable FRN with five foreign ownership variables, each corresponding to a difference source. Four countries/regions, the United State, Hong Kong and Macao, Taiwan, and Japan, can be identified in our sample and the rest are categorized as other. The five variables are denoted as FRN_US,

FRN_HKMACAU, FRN_TW, FRN_JP, and FRN_OTHER. We estimate this new model and present the results on the columns 4 to 6 of Table 11. It is shown that foreign ownership from the United States is associated with a significantly higher probability that the local affiliates provide training to their domestic suppliers. A 1 percentage higher ownership by a US company corrects to 0.3% higher probability of providing training. However, foreign ownership in general does not seem to have a significant relation to the firm's likelihood of providing training to its domestic suppliers, unless there is technology transfer involved.

In this section we have find support to the assumption that foreign knowledge inflow has positive spillover effect. However, the evidence is somewhat weak. It is possible that there are measurement errors in the dependent variable. For example, the definition of "formal and informal training" may differ from person to another[18].

In the above six sections, we have examined the effects derived from foreign involvement in Chinese firms from various aspects. In particular, we focus on the role of technology transfer from foreign sources to their local subsidiaries. Several important outcomes arise from this analysis. Foreign knowledge inflow is important to promote domestic firms in engaging in export activities. Specifically, firms that received foreign technology not only are more likely to export, but export a larger amount as well. More importantly, it is likely that firms achieve this outcome through production expansion rather than market redistribution between domestic and international market. Further studies on the firm's employment and production confirm that that firms will employ more people and produce more following the inflow of foreign knowledge. The growth rates of employment and production increase for firms that receive foreign knowledge, at

least within a short period of time. In addition to the direct positive effect related to foreign knowledge, we also find evidence supporting the spillover assumption on technology transfer. Domestic firms can benefit from foreign participation even when they are not directly associated with foreign businesses. We find that firms that have experienced foreign knowledge inflow themselves are more likely to provide training to their domestic input suppliers. Similar results are found for firm with higher foreign ownership originated from the United State.

IV. Study on the Factors Associated with Technology Transfer

Analysis in Part III has shown that foreign knowledge inflow has positive impact on local recipients and other related domestic firms in general. A relevant question is, what are the important elements that are associated with foreign knowledge inflow. The objective of the following study is to empirically identify the contributing factors related to foreign knowledge inflow.

[18] The corresponding question to obtaining the dependent variable is the following: "In the past year (1991), did you provide any training to your domestic input suppliers, either formal or informal training in your factor or in the supplier's premises?"

4.1. Factors Associated with Foreign Knowledge Inflow.

It is commonly accepted that technology is the driving force for economic growth and development. As developing countries only have limited accumulation of human and capital resources crucial for technology advances, technologies originating from external sources become very important for economic development. Theoretical models and empirical studies have generated some predictions regarding the factors affecting foreign technology influx to domestic firms. First, various forms of associations with foreign businesses such as equity participation, forming joint-venture partnership, associations with foreign buyers and suppliers, can often lead to knowledge inflow from foreign sources. Second, competition in the domestic market can give firms pressure to acquire new technology. Third, more human capital accumulation enables a local firm to absorb, adept and apply new technologies in development and production and therefore accelerate technology transfer.

We define an empirical model to test the assumption that the above factors are of importance for foreign knowledge inflow. The dependent variable is TECH, whether a firm received foreign knowledge inflow. The dependent variables include foreign ownership, competition intensity, and the level of weighted average education, as well as other firm characteristics. As the dependent variable is a binary variable, a logistic specification is used for estimation. The dependent variable can be viewed as the probability that a firm experiences foreign knowledge inflow.

$$\begin{aligned}\text{logit}(TECH_i) = \alpha + \beta_1 FRN_i + \beta_2 FJV_i + \beta_3 CONTACT \\ + \beta_3 COMPITITION_i + \beta_5 EDU_i + \gamma \mathbf{X}_i + \varepsilon_i\end{aligned} \tag{7}$$

$\mathbf{X}_i$ includes the LEMPL, SOE, PVT, CONTD, LR&D, LSPEC, as well as CITY and INDUSTRY. The results are summarized in Table 12. We first discuss the results in relation to

the three predictions. The results show that foreign investment and foreign joint venture partnership are closely associated with the likelihood that a firm has foreign knowledge infusion. Having informal meetings with foreign buyers, input and machine suppliers are also associated with higher probability that technology inflow occurred. This is not surprising. It is widely believed that association with foreign businesses is the most important source of foreign knowledge. In addition, the results indicate that a firm's perceived competition intensity might also important for promoting foreign knowledge. The coefficient on COMPETETITION is positive but only marginally significant (15% level). Furthermore, the results also show the index for human capital EDU, the weighted average years of education for the employees, is positively associated with foreign knowledge inflow.

Some may argue that foreign investment originating from different resources can result in different effects. For example, investments from industrial countries are more likely to bring in new technology while those from developing countries are less so. To examine whether there are differences in the effect of investment from difference sources, we again replace FRN with variables representing foreign ownership from different sources[19]. By introducing the new variables in the place of FRN, the model estimation is improved only marginally. The coefficients on foreign ownership from Japan and the United States is almost twice as large as on foreign ownership from Hong Kong, Macao, and Taiwan, but statistically, they are not different from each other. Therefore, the data provide week evidence that investments from industrial countries may be more likely to bring in new technology.

[19] FRN is first replaced with FRN_US, FRN_JP, FRN_HKMACAO, FRN_TW and FRN_OTHER. We also combine FRN_US with FRN_JP, and FRN_HKMACAO with FRN_TW and re-estimate the model.

As mentioned above, a firm's perceived level of competition intensity is positively associated with the likelihood of receiving foreign knowledge inflow. The coefficient, however, is only significant at a 15% level. This is consistent with the theory that states that more competition compels the firm to seek new technology and increase productivity. We can also find support for the argument by looking at the correlation between private ownership and knowledge inflow. Unlike state-owned enterprises and most collectively owned enterprises that traditionally have been under government protection and subsidy, private firms in China are believed to operate in a much more market driven environment. A positive coefficient on PVT provides additional support to the prediction that more competition may pressure domestic firms to acquire new technology. The estimation results show that higher private ownership is positively associated with higher probability that a firm experienced knowledge inflow and the coefficient is significant.

There are several additional points worth mentioning. We notice that larger firms are more likely to obtain foreign knowledge. Furthermore, the number of a firm's specialized employees is associated with the likelihood that a firm experience technology transfer. Finally, geographic location is also related to how likely a firm obtains foreign technology, even after taking into account such factors as ownership differences[20]. Specifically, we find that firms from Shenzhen, China's foremost Special Economic Zone are significantly more likely to receive foreign knowledge while firms from the only two inland cities in the survey, Chengdu and Chongqing, are significantly less likely to do so.

[20] Coefficient estimates are not reported.

4.2. Does Export Induce Foreign Knowledge Inflow?

It is apparent from our study in the previous section that the three variables, foreign ownership, foreign technology transfer, and export are closely related. What we are more interested in is which event leads to the other events. We have shown in Part III that foreign knowledge inflow tends to promote future export of Chinese firms. In this section, we will do an exercise to examine whether export will precede knowledge inflow from foreign sources. The rationale here is that export is very different from selling domestically. Higher product quality is required for export. Exporters also face more competition than firms that only sell to a domestic market and thus find it desirable to obtain more and better technology from abroad. On the other hand, export may also serve as a signal for higher productivity and better management and thus attract foreign investment and foreign knowledge.

To test the above prediction, we have defined a simple logit model. The dependent variable is whether a firm receives foreign knowledge inflow after year T (TECH_T). A firm's export condition at year T (EXPT_DT) is included as an independent variable. We use the logistic specification to estimate the model.

$$\text{logit}(TECH\_T_i) = \alpha + \beta EXPT\_DM_i + \gamma \mathbf{X}_i + \varepsilon_i \qquad (8)$$

Xi includes LEMPL_T, AGE, SOE, PVT, FRN, FJV, COMPETITION, OLD, as well as CITY and INDUSTRY. The results are summarized in Table 13. Three estimations are obtained corresponding to the dependent variable evaluated at three separate times: TECH_80, TECH_84 and TECH_86. There are indications that firms that export in year T have a higher chance of obtaining foreign knowledge in subsequent years. The coefficients, however, are generally insignificant. Thus, we find no strong proof that export will induce knowledge inflow from abroad from this exercise.

V. Conclusions

The purpose of this empirical study is two-folded. On one hand, we examine the positive effect on local Chinese firms derived from business associations with foreign firms. The analysis focuses on the role of foreign knowledge inflow. On the other hand, we try to identify contributing factors that are associated with foreign technology transfer from which policy implications may be drawn.

For the first part of the empirical analysis, the results suggest that there is significant positive impact on local firms following foreign knowledge inflow. The benefits are reflected in different aspects of a firm's performance. Foreign technology transfer increases the probability that a firm will export in the subsequent years. It also tends to increase the amount of total export. In addition, the higher export following foreign knowledge inflow is likely resulted from higher production rather than diverting domestic sale to export. Consistent to this finding, foreign knowledge transfer is followed higher employment and more production. However, the increases seem to be in the short-run and decreasing pace. Or it might be more of a one time level change than a long run growth rate change. Finally, the benefits from technology transfer may go beyond its immediate recipient. We find that firms that have received foreign knowledge inflow are more likely to provide training to their domestic suppliers. This is an evidence of spillover effect of technology transfer.

For the second task, we have identified some factors associated with foreign knowledge inflow. The finding is consistent with theoretical predictions. Foreign ownership, which is believed to be the mean for international technology diffusion, and foreign joint venture partnership are strongly related to foreign knowledge. In addition, a firm's perceived competition intensity is also positively related to foreign knowledge inflow. Furthermore, the overall

education level of a firm's employees is positively correlated with the likelihood that the firm receives foreign knowledge. Finally, we also investigate whether export precedes the inflow of foreign knowledge for the firms. Empirical analysis fail to show evidence that exporting firms are more likely to be the destination for foreign knowledge inflow.

We have learned that foreign knowledge inflows generate various positive consequences to local economy and foreign participation is an important mechanism for technology transfer. In addition, domestic competition and employee's education is also correlated with the probability that knowledge inflow occurs. From these findings, we can draw the following implications. It is important to maintain an open and business-friendly environment to attract foreign businesses. It is also important to encourage domestic competition. Finally, the government can encourage cooperation between domestic firms and firms with foreign involvement to maximize the economic benefit from foreign participation.

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Appendix: Definitions of variables used in the empirical analysis.

EXPORT

EXPT_D:	1 if the firm export in 1991 and 0 otherwise.
EXPT0_D:	1 if the firm export at the time when foreign technology transfer began and 0 otherwise.
EXPT88_D:	1 if the firm export in 1988 and 0 otherwise.
PCEXPT91:	the percentage of a firm's output being exported in 1991.
LEXPT91:	the log of firm export amount in 1991 (=log(export91+1).
LEXPT0:	the log of firm export at the time when foreign technology transfer began (=log(export0+1)).
LEXPT88	the log of firm export in 1988 (=log(export88+1).

FIRM SIZE:

LEMPL	log of the firm's total number of employees in 1991.
LEMPL0	log of the firm's total number of employees at the time when foreign technology transfer began.
LEMPL88	log of the firm's total number of employees in 1988.
LEMPL91	log of the firm's total number of employees in 1991.
LPROD88N	log of the firm's production in 1988 in constant value.
LPROD88R	log of the firm's production in 1988 in current value.
LPROD91N	log of the firm's production in 1991 in constant value.
LPROD91R	log of the firm's production in 1991 in current value.

FIRM GROWTH:

GEMPL	Total employment growth from 1988 to 1991.
GPRODN	Total growth rate of total production from 1988 to 1991 in constant value.
GPRODR	Total growth rate of total production from 1988 to 1991 in current value.

HUMAN CAPITAL:

LR&D	log of the number of employees in research and development in 1991.
LSPEC	the log of the number of full time employees in quality control, computer aided design, and training.
EDU	the weighted average years of education employees have.

OWNERSHIP:

SOE	the share of state ownership in 1991.
PVT	the share of private ownership in 1991.
FRN	the share of foreign ownership in 1991.
HKMACAU	the share of foreign ownership from Hong Kong and Macau in 1991.
TAIWAN	the share of foreign ownership from Taiwan in 1991.
US	the share of foreign ownership from the United States in 1991.
JP	the share of foreign ownership from Japan in 1991.
OTHER	the share of foreign ownership from sources other than the four regions specified above.
FJV	1 if a firm has a foreign joint venture partner in 1991 and 0 otherwise.

TECHNOLOGY TRANSFER:

TECH	1 if the firm has in the past experienced substantial foreign knowledge inflow, and 0 otherwise.
IMPORT	the percentage of the firm's machinery that is imported.

INFORMAL CONTACT:

CONTACT	1 if the firm 'typical high-level manager in the firm having business lunches with foreign buyers and suppliers or foreign machinery suppliers in 1991, 0 otherwise.
CONTD	1 if the firm's high-level manager in the firm having business lunches with domestic buyers and suppliers or competitors in 1991, and 0 otherwise.

OTHER

CITY	eight dummy variables for each of the eight cities in the survey.
INDUSTRY	ten dummies variables for each two digit manufacturing industry.
AGE	the age of the firm.
OLD	1 if the firm started operation before 1980 and 0 otherwise.
COMPETITION	the intensity of domestic competition the firm perceived. It is represented by the absolute value of the firm's perceived price electricity, ranging from 0 to 3.

Table 1: Selected economic characteristics for the cities in the survey.

			Inland		Coast					
		Total	CD	CQ	GZ	SZ	DG	FZ	XM	QZ
Population										
Total[a]	million	9.5	1.78	2.31	3.00	0.57	0.33	0.91	0.41	0.20
Industrial establishment										
Total number[a,b]	k	15.35	2.26	2.68	3.36	3.17	1.25	1.36	0.89	0.38
State-owned[a,b,d]	%	21.37	22.56	18.83	26.15	27.86	6.35	18.94	19.49	21.17
Collectively owned[a,b,d]	%	63.81	75.24	79.70	60.56	34.32	79.80	65.47	35.86	62.77
Other[a,b,d]	%	14.83	2.21	1.47	13.30	37.81	13.85	15.59	44.65	16.06
-w/foreign involvement[a,b,d]	%	13.19	0.68	0.62	11.15	36.61	12.94	14.02	39.23	15.57
Industrial output										
Total[c]	bil. RMB	180.8	20.94	27.57	58.39	37.10	11.18	12.03	11.89	1.70
State owned-1991[b,d]	%	55.81	80.84	81.69	63.90	22.66	16.68	48.13	35.21	43.11
Collectively owned[b,d]	%	14.45	17.08	17.50	12.84	3.80	46.67	16.39	6.90	24.38
Other[b,d]	%	29.74	2.08	0.80	23.26	73.54	36.65	35.47	57.89	32.52
-w/foreign involvement[d]	%	26.45	1.97	0.33	19.51	72.85	26.52	30.55	54.09	20.48
Manufacturing output[a,b,c,d]										
Total[a,b,c,d]	bil. RMB	128.52	16.62	20.99	42.32	22.57	6.13	9.45	9.12	1.31
food[a,b,c,d]	%	11.16	9.67	7.86	13.01	7.49	11.65	9.76	21.48	22.58
textile[a,b,c,d]	%	11.17	8.28	7.32	10.57	15.21	17.55	12.31	9.70	31.61
lumber[a,b,c,d]	%	1.41	1.32	0.60	1.79	1.46	3.02	1.37	0.46	1.59
paper[a,b,c,d]	%	3.63	4.08	2.52	3.57	3.63	4.81	4.56	3.78	4.76
chemical[a,b,c,d]	%	18.26	13.05	15.41	26.10	10.17	15.78	19.61	18.91	13.41
glass[a,b,c,d]	%	2.65	2.20	2.97	2.37	2.23	6.41	2.22	2.63	4.77
iron and steel[a,b,c,d]	%	7.78	21.87	14.25	5.86	1.55	0.41	4.09	1.54	0.00
non-electric machinery[a,b,c,d]	%	29.39	31.90	46.20	32.31	17.41	21.72	20.12	19.32	12.83
electronics[a,b,c,d]	%	11.88	6.86	2.37	2.38	37.73	10.59	18.21	18.55	3.18
other[a,b,c,d]	%	2.67	0.77	0.50	2.05	3.13	8.05	7.76	3.63	5.26

Note: a--excluding suburban areas; b--township level and above; c--in current price; d--for 1991.

Source: Statistics Year book of China's Cities 1992, 1993-1994

Table 2: A comparison of ownership structure between the cities

CITY	OWNERSHIP	City total		Sample firms		share in city total	
		%output	%number	%output	%number	output	# firms
CD	state	80.8%	22.56%	50.4%	47.3%	28.94%	2.43%
	collective	17.1%	75.24%	14.3%	38.2%		
	other	2.1%	2.21%	35.3%	14.5%		
CQ	state	81.7%	18.83%	86.7%	45.3%	6.67%	1.98%
	collective	17.5%	79.70%	5.8%	35.8%		
	other	0.8%	1.47%	7.5%	18.9%		
GZ	state	63.9%	26.15%	71.4%	33.3%	7.22%	4.80%
	collective	12.8%	60.56%	11.7%	33.3%		
	other	23.3%	13.30%	16.9%	33.3%		
SZ	state	22.7%	27.86%	44.0%	33.3%	4.42%	6.74%
	collective	3.8%	34.32%	12.4%	41.7%		
	other	73.5%	37.81%	43.6%	25.0%		
DG	state	16.7%	6.35%	25.9%	16.7%	22.24%	1.79%
	collective	46.7%	79.80%	12.5%	50.0%		
	other	36.7%	13.85%	61.6%	33.3%		
FZ	state	48.1%	18.94%	51.3%	33.3%	18.18%	1.89%
	collective	16.4%	65.47%	15.9%	31.7%		
	other	35.5%	15.59%	32.7%	35.0%		
XM	state	35.2%	19.49%	38.1%	41.7%	44.59%	15.79%
	collective	6.9%	35.86%	12.6%	16.7%		
	other	57.9%	44.65%	49.3%	41.7%		
QZ	state	43.1%	21.17%	17.4%	16.7%	51.93%	4.41%
	collective	24.4%	62.77%	21.1%	41.7%		
	other	32.5%	16.06%	61.5%	41.7%		
Total	state	55.8%	21.37%	50.63%	33.12%	14.08%	3.05%
	collective	14.4%	63.81%	12.99%	36.11%		
	other	29.7%	14.83%	36.38%	30.77%		

Table 3: A comparison of industrial composition between the cities

		share in total output value									
Location		food	textile	lumb	paper	chemicals	non-metal	metal	machine	electronics	other
CD	Sample	15.1%	0.5%	1.8%	1.2%	1.2%	0.2%	0.4%	31.6%	10.6%	37.4%
	City	9.7%	8.3%	1.3%	4.1%	13.0%	2.2%	21.9%	31.9%	6.9%	0.8%
CQ	Sample	0.5%	5.4%	0.0%	0.6%	4.2%	5.2%	0.1%	36.0%	9.1%	12.5%
	City	7.9%	7.3%	0.6%	2.5%	15.4%	3.0%	14.2%	46.2%	2.4%	0.5%
GZ	Sample	5.5%	2.7%	0.0%	0.9%	18.2%	1.8%	0.0%	49.2%	7.8%	4.6%
	City	13.0%	10.6%	1.8%	3.6%	26.1%	2.4%	5.9%	32.3%	2.4%	2.1%
SZ	Sample	0.0%	8.7%	0.0%	0.8%	4.4%	0.7%	0.0%	7.1%	34.7%	15.3%
	City	7.5%	15.2%	1.5%	3.6%	10.2%	2.2%	1.5%	17.4%	37.7%	3.1%
DG	Sample	5.1%	36.9%	0.0%	2.1%	2.4%	1.8%	0.8%	3.2%	14.5%	33.3%
	City	11.7%	17.6%	3.0%	4.8%	15.8%	6.4%	0.4%	21.7%	10.6%	8.1%
FZ	Sample	4.6%	11.1%	0.2%	0.7%	38.9%	4.8%	0.3%	19.5%	3.7%	16.2%
	City	9.8%	12.3%	1.4%	4.6%	19.6%	2.2%	4.1%	20.1%	18.2%	7.8%
XM	Sample	27.3%	6.5%	5.5%	0.0%	14.9%	3.0%	9.9%	0.0%	29.7%	3.2%
	City	21.5%	9.7%	0.5%	3.8%	18.9%	2.6%	1.5%	19.3%	18.6%	3.6%
QZ	Sample	2.0%	37.3%	1.2%	1.7%	2.6%	13.2%	0.0%	9.7%	0.8%	16.2%
	City	22.6%	31.6%	1.6%	4.8%	13.4%	4.8%	0.0%	12.8%	3.2%	5.3%
total	Sample	12.1%	8.8%	1.8%	0.9%	11.8%	2.8%	2.4%	24.4%	16.1%	18.8%
	City	11.2%	11.2%	1.4%	3.6%	18.3%	2.6%	7.8%	29.4%	11.9%	2.7%

Table 4: Correlations between industrial composition and ownership structure in the sample cities

location	industry composition	ownership composition	
	% in total output	% in total output	% in # of firms
CD	0.233	0.699	0.501
CQ	0.799	0.977	0.368
GZ	0.872	0.993	---
SZ	0.851	0.703	-0.346
DG	0.303	-0.078	0.909
FZ	0.303	0.989	-0.895
XM	0.624	0.988	-0.171
QZ	0.651	-0.150	0.411
Total	0.697	0.959	0.946
Pooled	0.617	0.711	0.409

Industry: food, textile, lumb, paper, chemicals, non-metal, metal, non-electric machines, electronics, and others

Ownership: state owned, collectively owned, and other.

Table 5: Mean values for the key variables in the sample cities

variables	Total	INLAND		COAST						# firms
		CHENGDU[b]	CHONGQING	GUANGZHOU[b]	SHENZHEN[a]	DONGGUAN	FUZHOU[b]	XIAMEN[a]	QUANZHOU	
TECH	0.45	0.25	0.16	0.63	0.85	0.37	0.49	0.61	0.22	416
Foreign ownership										
FRN_D	0.32	0.15	0.17	0.33	0.37	0.33	0.35	0.42	0.43	468
%FRN (for FRN>0)	60.78	90.63	43.56	54.50	44.64	56.75	72.67	69.56	61.12	151
Foreign joint-venture										
FJV_D	0.30	0.18	0.19	0.32	0.60	0.27	0.18	0.33	0.33	468
IMPORT										
IMPORT_D	0.69	0.60	0.42	0.69	0.89	0.74	0.66	0.84	0.68	452
%IMPORT(for import>0)	62.26	37.24	40.18	54.05	81.27	80.00	63.95	62.62	58.05	314
CONTACT	0.29	0.25	0.25	0.45	0.35	0.23	0.28	0.30	0.18	468
Export										
EXPT_D	0.56	0.25	0.28	0.56	0.88	0.77	0.58	0.60	0.52	464
LEXPT(for EXPT>0)	8.29	7.94	8.50	8.50	7.72	8.11	8.85	8.74	8.24	242
%EXPT(for EXPT>0)	58.43	20.14	41.20	45.79	72.43	81.00	56.41	39.26	63.90	261
TRAINING	0.22	0.20	0.09	0.93	0.10	0.01	0.10	0.13	0.10	467
LEMPL	5.52	6.03	5.68	5.47	4.89	5.52	5.72	5.60	5.30	468
LPROD	9.12	9.94	9.04	9.30	8.50	8.72	9.30	9.75	8.26	436
SOE										
SOE_D	0.49	0.49	0.58	0.58	0.57	0.22	0.48	0.63	0.35	468
%SOE (for %SOE>0)	82.86	99.07	90.42	81.00	74.26	87.38	83.07	82.53	65.33	228
PVT										
PVT_D	0.02	0.00	0.00	0.00	0.02	0.00	0.03	0.05	0.07	468
%PVT (for %PVT>0)	35.00	--	--	--	30.00	--	30.00	46.67	30.00	10
AGE	16.66	24.11	23.83	19.87	7.15	8.15	20.02	16.37	15.35	467
OLD	0.40	0.69	0.65	0.45	0.03	0.08	0.55	0.38	0.42	467
COMPETITION	1.06	0.91	1.23	1.13	1.39	0.89	0.89	1.03	1.01	468
LSPEC	2.57	3.52	2.74	2.67	2.06	1.84	2.53	2.85	2.44	468
EDU	2.52	2.73	2.59	2.56	2.55	2.28	2.59	2.59	2.32	468

Table 6: Correlations between key variables in the sample

	EDU	COMPETITION	CONTACT	IMPORT	TECH	EXPT_D	FJV	FRN	PVT	SOE	LPROD
LEMPL	-0.0067	-0.093	0.1749	-0.0741	0.1222	0.1748	-0.0998	-0.1014	-0.0813	0.2978	0.6775
	468	468	468	452	416	464	468	468	468	468	436
	P= .885	P= .044	P= .000	P= .116	P= .013	P= .000	P= .031	P= .028	P= .079	P= .000	P= .000
LPROD	0.271	-0.0401	0.2629	0.0027	0.2694	0.1372	0.0838	0.1031	-0.0711	0.3336	
	436	436	436	421	388	433	436	436	436	436	
	P= .000	P= .403	P= .000	P= .956	P= .000	P= .004	P= .080	P= .031	P= .138	P= .000	
SOE	0.2555	0.0125	0.1055	-0.221	0.0569	-0.0629	-0.1074	-0.3084	-0.0976		
	468	468	468	452	416	464	468	468	468		
	P= .000	P= .788	P= .022	P= .000	P= .247	P= .176	P= .020	P= .000	P= .035		
PVT	0.0355	-0.0028	-0.0343	0.0631	-0.0385	-0.0206	-0.0546	-0.046			
	468	468	468	452	416	464	468	468			
	P= .444	P= .952	P= .459	P= .181	P= .433	P= .657	P= .238	P= .321			
FRN	0.1403	-0.0106	0.0535	0.4098	0.4158	0.2671	0.5005				
	468	468	468	452	416	464	468				
	P= .002	P= .819	P= .248	P= .000	P= .000	P= .000	P= .000				
FJV	0.1123	0.059	0.0619	0.3551	0.4806	0.2557					
	468	468	468	452	416	464					
	P= .015	P= .203	P= .181	P= .000	P= .000	P= .000					
EXPT_D	-0.0452	0.0735	0.1632	0.4324	0.4422						
	464	464	464	448	412						
	P= .331	P= .114	P= .000	P= .000	P= .000						
TECH	0.2074	0.0857	0.241	0.4469							
	416	416	416	401							
	P= .000	P= .081	P= .000	P= .000							
IMPORT	0.0735	0.0515	0.1589								
	452	452	452								
	P= .118	P= .275	P= .001								
CONTACT	0.1567	0.0823									
	468	468									
	P= .001	P= .075									
COMPETITION	0.0006										
	468										
	P= .990										

Table 7: Logistic regression for effects of technology transfer on whether a firm exports
Dependent Variable: EXPT_D

	A		B		C		Marginal effect	
	coefficient	S.E.	coefficient	S.E.	coefficient	S.E.	@ mean	ave.
TECH	1.150***	0.410	0.884**	0.459	0.938**	0.456	0.234	0.113
FRN	0.015*	0.009	0.017**	0.009	0.017*	0.009	0.004	0.002
FJV	0.178	0.567	0.428	0.613	0.422	0.608	0.105	0.051
CONTACT	0.706*	0.386	0.552	0.432	0.509	0.431	0.127	0.061
EXPT0_D					2.968***	0.580	0.739	0.356
LEXPT0			0.459***	0.093				
LEMPL	0.900***	0.202	0.707***	0.218	0.712***	0.217	0.177	0.085
SOE	-0.002	0.004	-0.001	0.005	0.000	0.005	0.000	0.000
PVT	0.693	1.321	0.867	2.034	0.851	2.017	0.212	0.102
OLD	0.017	0.473	0.234	0.525	0.153	0.514	0.038	0.018
CONTD	-0.784*	0.423	-0.341	0.483	-0.313	0.483	-0.078	-0.038
C	-4.076	1.222	-4.055	1.346	-4.096	1.350		
CITY included	Y		Y		Y			
INDUSTRY included	Y		Y		Y			
-2 Log Likelihood	264.12		223.742		224.848			
chi-square	154.54		40.38		39.28			
DF	24		25		25			
significance	0.000		0.001		0.001			
# of firms	302							
-2 initial log likelihood	418.66							

Note: 1. includes firms that either have TECH and FJV between 1980 and 1990, or have neither
2. ***, **, *, and # denote the significance of 1%, 5%, 10% and 15% respectively.

Table 8: Tobit regression for the effect of technology transfer on the amount of a firm's export
Dependent Variable: Log of export in 1991

	OLS			TOBIT		
Variable	Coefficient	t-statistic	P-value	Coefficient	t-statistic	P-value
TECH	0.496	1.20	[.234]	0.767	1.67	[.096]
IMPORT	0.006	1.20	[.231]	0.008	1.52	[.130]
FRN	0.008	1.24	[.217]	0.020	3.27	[.001]
FJV	-0.090	-0.22	[.829]	0.406	0.91	[.361]
EXPT0D	0.967	2.91	[.004]	2.850	8.98	[.000]
CONTACT	-0.297	-0.84	[.401]	0.768	2.00	[.045]
LEMPL	0.978	5.65	[.000]	1.194	6.84	[.000]
SOE	0.004	0.90	[.368]	0.006	1.25	[.212]
PVT	0.051	1.32	[.188]	0.100	1.87	[.062]
CONTD	-0.482	-1.15	[.252]	-0.890	-2.22	[.027]
C	1.455	1.16	[.249]	-2.040	-1.75	[.080]
AI				186.53	5.34	[.000]
SIGI				2.93		
R-squared	0.36					
Log likelihood	-326.7			-1745.1		
# of obs	164			307		

Table 9: Regression on the share of export
Dependent variable: LN[PCEXPT/(1-PCEXPT)]

	Model1			Model2			Model3		
	B	t-stat	P-value	B	t-stat	P-value	B	t-stat	P-value
C	-38.092	-5.519	[.000]	-37.739	-5.372	[.000]	-41.647	-6.086	[.000]
SOE	0.009	0.356	[.722]	0.006	0.210	[.834]	0.017	0.675	[.501]
PVT	0.152	0.349	[.728]	0.248	0.562	[.575]	0.107	0.247	[.805]
FRN	-0.002	-0.034	[.973]	-0.012	-0.228	[.820]	0.017	0.308	[.758]
FJV	0.579	0.181	[.856]	0.727	0.224	[.823]	0.838	0.264	[.792]
OLD	-3.982	-1.236	[.218]	-4.183	-1.278	[.203]	-3.409	-1.061	[.290]
LNEMPL	4.285	2.403	[.017]	4.171	2.303	[.022]	4.338	2.446	[.015]
EXPT0D	14.275	5.327	[.000]						
LNEXPT0				1.693	4.577	[.000]			
PCEXPT0							0.219	5.576	[.000]
LNEMPL0	-1.063	-0.600	[.549]	-0.850	-0.472	[.637]	-0.526	-0.302	[.763]
TECH	2.294	0.786	[.433]	1.752	0.584	[.560]	2.860	0.990	[.323]
IMPORT	14.558	4.192	[.000]	15.693	4.463	[.000]	13.332	3.834	[.000]
COMPETITION	1.510	1.328	[.186]	1.519	1.311	[.191]	1.454	1.285	[.200]
R2	0.562			0.548			0.567		
Adjusted R2	0.511			0.495			0.516		
F-stat	10.85			10.25			11.07		
DF	25								
# of obs	237								

Note: 1--includes firms where either TECH=1 and experienced inflow between 1980 and 1990, or FJV=1 and started between 1980 and 1990, or TECH=0 and FJV=0.
2--in the transformation, 0 and 1 are replaced with 1E(-15) and 1-1E(-15), respectively.

Table 10: The effect of technology transfer on a firm's employment, production and growth

	B	S.E.	B	S.E.	B	S.E.	B	S.E.
	LEMPL88		LEMPL91		GRMPL			
TECH	0.137#	0.114	0.191#	0.129	3.091	6.673	18.442**	9.444
TECHYR							-4.395**	1.935
IMPORT	0.000	0.001	0.000	0.002	0.039	0.079	0.017	0.079
FRN	0.005*	0.003	0.007**	0.003	0.149	0.156	0.105	0.156
FJV	0.420**	0.209	0.392*	0.237	8.956	11.368	10.744	11.27
EXPT0_D	-0.015	0.117	-0.027	0.132	-2.126	6.587	-1.202	6.525
LEMPL0	0.719***	0.039	0.687***	0.044				
LEMPL88					-2.780	2.576	-2.468	2.551
SOE	0.003***	0.001	0.003***	0.001	0.014	0.060	0.012	0.059
C	1.591	0.236	1.792	0.267	21.949	15.415	20.318	15.256
R square	0.799		0.742		0.263		0.284	
Adjusted R2	0.772		0.708		0.173		0.192	
F_stat	30.323		21.949		2.919		10.995	
DF	22		22		22		23	
significance	0.000		0.000		0.000		<1%	
# of firms	191		191		203			
	LPROD88N		LPROD91N		GPRODN			
TECH	0.574**	0.243	0.435#	0.282	-409.78	448.54	-36.73	631.88
TECHYR							-100.929	120.296
IMPORT	0.000	0.003	0.002	0.003	3.797	5.677	3.115	5.740
FRN	0.024***	0.007	0.026***	0.008	28.312**	11.950	27.025**	12.060
FJV	-0.293	0.493	0.370	0.529	907.95	829.54	952.89	832.09
EXPT0_D	-0.164	0.249	-0.205	0.287	-794.43*	427.55	-780.510	428.29
LEMPL0	0.818***	0.085	0.648***	0.092				
LEMPL88					1219.370	243.07	1224.2***	243.38
LPROC88N					-1037.03***	164.23	-1032.3***	164.49
SOE	0.002	0.002	0.006**	0.003	4.975	4.156	4.727	4.171
C	3.908	0.502	5.749	0.570	2508.93	1087.31	2453.18	1090.41
R square	0.634		0.518		0.278		0.281	
Adjusted R2	0.578		0.450		0.167		0.165	
F_stat	11.393		7.621		2.507		0.701	
DF	22		22		23		24	
significance	0.000		0.000		0.0005		>10%	
# of firms	168		179		174			
	LPROD88R		LPROD91R		GPRODR			
TECH	0.288	0.237	0.314	0.278	131.71	114.49	358.42**	164.91
TECHYR							-60.418*	31.682
IMPORT	0.003	0.003	0.001	0.003		-0.731	-1.220	1.517
FRN	0.017***	0.006	0.021***	0.007	0.877	2.692	0.018	2.706
FJV	0.705	0.496	1.227**	0.538	834.72***	210.65	869.05***	209.60
EXPT0_D	-0.242	0.245	-0.094	0.285	-7.467	113.37	3.033	112.52
LEMPL0	0.732***	0.082	0.693***	0.094				
LEMPL88					19.384	66.478	20.832	65.906
LPROC88R					-116.53**	46.18	-112.54**	45.83
SOE		0.002	0.006***	0.002	1.351	1.082	1.214	1.075
C	4.668	0.482	5.661	0.566	2508.9	1053.5	1021.0	293.3
R square	0.654		0.538		0.247		0.265	
Adjusted R2	0.601		0.472		0.132		0.147	
F_stat	12.280		8.143		2.141		10.218	
DF	22		22		23		1	
significance	0.000		0.000		0.004		<1%	
# of firms	166		178		174			

Note: 1. includes firms where either TECH=1 and experienced inflow between 1980 and 1990, or FJV=1 and started between 1980 and 1990, or TECH=0 and FJV=0.

2. include firms that has more than 10 employees in 1988

3. ***, **, *, and # denote the significance of 1%, 5%, 10% and 15% respectively.

Table 11: Logistic regression on the indirect impact of technology transfer
Dependent Variable: TRAINING

	Model3.7		Model3.8		Model3.9		Average Marginal effect	
	B	S.E.	B	S.E.	B	S.E.	model3.7	model3.8
TECH	1.165**	0.7826	1.109**	0.5154	1.209**	0.5127	0.1012	0.0945
FRN								
US	]		0.036*	0.0217	0.038*	0.0224	]	0.0031
HKMACAU	]		]		0.0075	0.0107	]	]
TAIWAN	}-0.0001	0.0085	}-0.003	0.0088	-0.1778	0.9402	}-0.0000	}-0.0003
JAPAN	]		]		-0.1611	1.0812	]	]
OTHER	]		]		0.0046	0.0133	]	]
FIV	-0.127	0.583	-0.065	0.592	-0.447	0.653	-0.011	-0.006
EXPT_D	-0.1525	0.7826	-0.1732	0.7895	-0.2567	0.7858	-0.0133	-0.0148
LPEOUT	0.605***	0.2231	0.710***	0.2337	0.725***	0.2412	0.0526	0.0605
AGE	-0.0083	0.0198	-0.0068	0.0200	-0.0143	0.0204	-0.0007	-0.0006
SOE	0.0018	0.0058	0.0017	0.0059	0.0021	0.0059	0.0002	0.0001
PVT	-0.0168	0.0559	-0.0119	0.0547	-0.0231	0.0657	-0.0015	-0.0010
LSPEC	0.261#	0.1700	0.251#	0.1702	0.258#	0.1774	0.0227	0.0214
EDU	-0.186	0.427	-0.117	0.435	-0.040	0.436	-0.016	-0.010
C	-5.102	1.642	-5.761	1.722	-5.925	1.739		
CITY included	Y		Y		Y			
INDUSTRY included	N		N		N			
Log Likelihood	176.14		172.80		164.08			
Chi-squared	157.91		3.34		8.72			
DF	17		1		3			
significance	0		<10%		<5%			
-2 Initial log likelihood	334.05							
# of firms	302							

Note: Including firms with at least one domestic suppliers, either having techtrans/fjv at or before 1990, or no techtrns/fjv

Table 12: Logistic regression on the factors associated with technology transfer
Dependent Variable: TECH

	Model3.10		Model3.11		Model3.12		Model3.13	
	B	S.E.	B	S.E.	B	S.E.	B	S.E.
LEMPL	0.8823***	0.2252	0.9123***	0.2289	0.9300***	0.2310	0.9359***	0.2323
FRN								
HKMACAU	]		]		}0.481***	0.0098	0.0471***	0.0104
TAIWAN	]		}0.0490***	0.0099	}		0.0543***	0.0203
US	}0.0425***	0.0080	]		}0.885***	0.0270	0.0924**	0.0480
JAPAN	]		]		}		0.0869***	0.0319
OTHER	]		0.0320***	0.0111	0.335***	0.0112	0.0334***	0.0112
FJV	1.0774**	0.4489	0.9524**	0.4619	0.9424**	0.4611	0.9552**	0.4728
COMPETITION	0.2218	0.1714	0.2451#	0.1720	0.2697#	0.1735	0.2724#	0.1738
EDU	0.7982**	0.3654	0.7775**	0.3683	0.7555**	0.3748	0.7601**	0.3758
CONTACT	0.9027***	0.3695	0.9624***	0.3726	0.9895***	0.3764	0.9825***	0.3766
LEMPL	0.8823***	0.2252	0.9123***	0.2289	0.9300***	0.2310	0.9359***	0.2323
SOE	0.0089**	0.0045	0.0084*	0.0045	0.0082*	0.0046	0.0082*	0.0046
PVT	0.0651**	0.0315	0.0621**	0.0316	0.0660**	0.0321	0.0658**	0.0320
CONTD	-0.2200	0.4335	-0.1808	0.4386	-0.1980	0.4387	-0.1995	0.4388
LR&D	-0.2504	0.1936	-0.2586	0.1934	-0.2590	0.1939	-0.2589	0.1939
LSPEC	0.3372**	0.1626	0.3299**	0.1633	0.3610**	0.1660	0.3594**	0.1659
C	-8.0465	1.7473	-8.0902	1.7566	-8.2276	1.7759	-8.2712	1.7854
CITY significant	Y		Y		Y		Y	
INDUSTRY significant	Y		Y		Y		Y	
-2 Log Likelihood	248.052		246.285		243.732		243.593	
Chi-squared	-248.052		1.767		2.553		0.139	
DF	1		1		1		2	
significance	<1%		>10%		>10%		>25%	

Initial log likelihood	500.221
log likelihood with INDUSTRY (8 DF)	472.736
log likelihood with CITY (7 DF)	421.269
log likelihood with CITY and INDUSTRY (15 DF)	390.488
# of firms	363

Note: ***, **, *, and # denote the significance of 1%, 5%, 10% and 15% respectively.

Table 13: Logistic regression on factors affecting technology transfer
Dependent Variable: TECH_T

	TECH80		TECH84		TECH86	
	B	S.E.	B	S.E.	B	S.E.
EXPT80_D	0.338	0.622				
EXPT84_D			1.046#	0.721		
EXPT86_D					0.638	0.661
LEMPL80	0.773***	0.264				
LEMPL84			0.553*	0.320		
LEMPL86					0.693**	0.316
FRN	0.001	0.025	0.026	0.023	0.025*	0.015
FJV	1.321	0.950	1.462	1.133	1.572*	0.868
COMPETITION	0.035	0.622	0.462#	0.295	0.442*	0.268
OLD	-0.855	1.072	-1.184	0.985	-0.415	0.866
SOE	0.010*	0.006	0.002	0.007	0.001	0.007
PVT			0.057	0.108	0.038	0.089
C	-4.078	1.680	-4.096	1.742	-5.343	1.744
CITY included	Y		Y		Y	
INDUSTRY included	Y		Y		Y	
-2 Log Likelihood	125.56		93.39		111.36	
Chi-squared	72.31		54.77		67.43	
DF	22		23		23	
significance	0.0000		0.0003		0.0000	
-2 initial log likelihood	197.87		148.16		178.79	
# of firms	161		152		177	

Note: ***, **, *, and # denote the significance of 1%, 5%, 10% and 15% respectively.