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Processing-trade-cum-FDI, Firm Heterogeneity and Exports of Indigenous Firms: Firm-level Evidence from Technology-intensive Industries in China

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Abstract

Using firm-level panel data from China, this paper examines the impact of processing trade-cum-foreign direct investment on the export performances of indigenous firms in technology-intensive industries. It finds that although a few industries have experienced rapid growth over the sample period, so far the indigenous Chinese firms have not built up their global competitiveness in the high-technology sector in general. Although processing-trade-cum-FDI has generated significant information spillovers on the export performance of indigenous firms, the technological competitiveness it enjoys has crowded the indigenous firms out off the international markets. In industries where processing trade is pervasive, the threshold productivity requirement for export market entry becomes low and firm heterogeneity in productivity turns to be a less significant factor in their export market participation.

JEL code: F10, F23, F14

I. Introduction

Fragmentation and segmentation of production on the global scale has been one of the major trends driven by the multinational enterprises (MNEs). Encouragement of processing trade, especially the encouragement of foreign direct investment (FDI) engaging in export-oriented processing activities in export processing zones (EPZs) has become a policy tool widely utilized by developing countries in order to enter the global production network. One of the main objectives of this policy is to allow the indigenous firms to learn from partners in the global value chain and build up international competitiveness, especially in the technology-intensive industries which are regarded as more dynamic and of strategic importance. However, empirical evidence about the effectiveness of this policy is scarce.

So far, this literature has concerned itself exclusively on standard FDI. The evidence indicates, in general, positive export spillovers; while some find no or negative impact (eg., Aitken et al., 1997; Kokko et al., 2001; Greenaway et al., 2004; Kneller and Pisu, 2007; Buck, et al., 2007). However, little is known about the effects of export-oriented processing trade-cum-FDI (PT-cum-FDI), which is widely observed in developing countries. This is an important area given the fact that many developing countries have used EPZs to attract FDI and expect these FDI to provide an entry point and learning opportunity for local firms to upgrade their technological capabilities and international competitiveness. In the case of China, exports on account of processing trade accounted for about 85 to 90 percent of its total exports in the high-technology industries[1] (Ma and Assche, 2010). Is processing-trade-cum-FDI an effective channel for the development of global competitiveness of the indigenous firms? Has FDI helped indigenous firms gain international competitiveness in the technology-intensive industries in developing countries? In industries where processing – trade is pervasive, is firm heterogeneity in productivity still an important determinant of export market entry and is exporting still an effective mechanism for intra-industry resources relocation and hence industry-level productivity growth? Research in this area is limited.

Using firm level panel data from China, this paper examines these research questions in China's high-technology industries where processing trade is pervasive. The technology-intensive industries in China have great involvement with processing trade-cum-FDI, and therefore, provide a good case for this study. The paper contributes to the literature by

[1] Refers to industries with high R&D expenditure to sales ratio.

providing a systematic research on the impact of processing-trade-cum-FDI on the export competitiveness of local firms. Second, it tests whether the firm heterogeneity, export-market participation and aggregate productivity growth mechanism remain valid under the processing trade regime. Finally, unlike most of the existing literature, this paper constructs the FDI knowledge pools at a more disaggregate level.

The rest of the paper is organised as follows. Section 2 reviews the literature and presents a theoretical framework for the research. Section 3 briefly reviews the background of processing trade and exports of high-technology products in China. Section 4 discusses the methodology and data. Section 5 presents the estimated results, and finally, Section 6 concludes.

II. Theory and the literature

Knowledge spillovers from FDI occur when multinationals find it difficult to protect a leakage of firm-specific assets, such as superior production techniques, know-how or management practices, to the local firms (Caves, 1996). Therefore, FDI may contribute to the global competitiveness of the local firms in two ways. One is the so-called export spillovers referring to the externalities from FDI that affect the export market participation of domestic firms. This may take place through demonstration effects and information spillovers, especially those related to marketing skills and customer information (Rosenbloom, 1990; Aitken et al. 1997). The other is technology spillovers which could strengthen the core competitiveness of the local firms. Such spillovers could take place within an industry or region facilitated through demonstration effect and labour movement. There may also be vertical spillovers within the supply chain when MNEs provide better intermediate materials for their producer customers or when they transfer knowledge to their suppliers or customers for better quality final products.

Export spillovers may include information externalities, which can effectively lower the sunk costs associated with export market entry (Aitken et al., 1997). Exporting involves sunk cost (Bernar and Jensen, 2004 and Melitz, 2003). This includes the establishment of distribution and logistics channels, product compliance and regulations, market research to acquire information about consumer preferences and market structure in foreign countries. Export spillovers may occur if there is a transfer of knowledge from foreign to local firms about foreign markets. This could lower sunk costs so that the ***marginal*** firm finds it profitable to start exporting. It may also allow existing exporters to find more overseas customers. Moreover, because of information asymmetries, the costs of export market entry are perceived by some domestic firms to be too high. This would discourage export market participation (Greenaway and Kneller, 2004). Co-location may then improve the information about foreign tastes and markets (Aitken et al., 1997). To note, Greenaway and Kneller's study focuses on industrialised countries. Their argument is based on the assumption that the domestic firms are already technically capable of competing in the international market.

Moreover, the Trade Development Path theory suggests a transition of indigenous firms in developing countries from targets of inward FDI to exporters. FDI are expected to help a host country to create assets (comparative advantage) in certain areas from stage 3, and "determinants of exports become less related to the comparative advantages of their natural resource endowments and more to those of their created assets" (Dunning et al. 2001). One possible way that FDI may help host countries to create assets is the transfer or spillovers of technology to domestic firms in the same industry or up- or down- the supply chain. Firms may benefit from higher quality intermediate inputs produced by FIEs suppliers. Kneller and Pisu (2007) find positive vertical spillovers using firm-level data from the UK.

On the other hand, FDI may also generate a strong, negative competition effect on the exports of local firms. There may be a significant depression effect on the productivity of local firms (Hu and Jefferson, 1997). Moreover, while information externalities might be geographically concentrated, the effects of competition are less likely to be so (Kneller and Pisu, 2007). They can affect other firms in the same industry in other regions.

Empirical literature on export spillovers from foreign firms is in relatively smaller supply. Using firm level data from Mexico, Aitken et al (1997) find the probability of exporting by domestic firms is increases with the concentration of exports of foreign firms operating in the same industry and region. Kokko et al (1997) also find that foreign firms positively affect of probability of exporting of domestic firms using firm level data from Uruguay. However, using the sum of the total FDI in the region to measure foreign presence, Sjoholm (1999) find no significant inter-industry effects of FDI (unweighted) on exports of domestic firms in Indonesia. Similarly, Barrrios et al. (2003) find no evidence of an effect from MNEs on the export share in Spain. Moreover, Ruane and Sutherland (2005) find negative export spillover effects in Ireland probably due to the use of Ireland as an export platform to the rest of the EU. They argue that export spillovers are unlikely in this case because competition with domestic firms in local product markets is limited. In the context of China, Buckley et al (2007) suggest FDI from HKT are more likely to transfer marketing skills to the local firms based on evidence from industry level data. Buck et al. (2007) test the mechanisms underpinning Dunning's Trade Development Path hypothesis (Dunning, et al., 2001) using firm level panel data of Chinese firms in nine SIC two-digit industries for the period 1998-2001. They use the share of foreign in total employment, output, exports and R&D investment as the measure of FDI spillovers, and find evidence in support of such spillovers in all of these foreign share variables. These studies provide useful insights, but none of them explored whether there is any difference between normal FDI and processing-trade-cum-FDI. The industry and regional pool of FDI presence is constructed at aggregate SIC 2-digit and province level. The selection bias arises from firms' export decision has not been appropriately corrected.

Processing-trade-cum-FDI and export market participation of domestic firms

Processing export activities in these industries include 'processing or assembly with imported materials' and 'processing or assembly with supplied materials'. The later type of processing is also called contract manufacturing. In this case, the processing firms process duty free materials and components supplied by foreign firms and export finished products. The processing firms do not assume ownership of the imported components and are paid a fee for the assembly or processing activity. The foreign firms control both the supply of the materials as well as the entire international marketing of the processed goods. In the case of processing or assembly with imported materials, the processing firms import, free of customs duty, parts and components that are used to produce finished goods, and these firms then export these goods to international markets. Hence, backward linkages from these processing trade activities to local firms may be limited because the utilization of local materials and intermediate inputs is limited. In addition, forward linkages of such processing trade are also limited because the processing firms are often paid a low processing fee, and tariffs and taxes are usually exempted for export processing activities. For example, as Koopman et al (2009) find in processing exports from China, there was only 18% of Chinese content while that for ordinary trade was as high as 89%.

As discussed earlier, export entry involves sunk costs, fixed export market entry costs that do not vary with export volume. Roberts and Tybout (1997) show that firms in differentiated product industries face significant fixed costs associated with the entry into export markets: a firms must find and inform foreign buyers about its product and learn about the foreign markets. It must research the foreign regulatory environment and adapt its product to ensure that it confirms to foreign standards including testing, packaging and labelling requirements. An exporting firm must also set up new distribution networks in the foreign country and conform to all the shipping rules specified by the foreign customs agency. By engaging in unskilled or semi-skilled labour intensive processing trade, which foreign customers provide material and spare parts, and the product design and processing routine, which often encompasses most of high value-added knowledge-intensive components, and the foreign customers are also responsible for the sales of the outputs of the assembly/processing activity. Therefore, such sunk costs are much lower than those face ordinary trade.

As regards the possible technological spillovers, because the activity that is undertaken in processing trade in many developing countries such as China is actually low-technology and are unskilled or semi-skilled labour-intensive, so there is little scope for transfer of technology. The core technologies are controlled by the MNEs and are embedded in the imported spare parts or the imported production lines. With regard to possible vertical spillovers of technology, processing-type activities mainly import spare parts from abroad and export the assembled outputs to the international markets, either as final product or intermediary inputs. According to the processing trade policy and practice, the outputs of the assembly activities shall not be sold to other domestic firms. Moreover, given the strong supplier-buyer relationship in the integrated global network and the fact that many MNEs have internalised the production process, key components and spare parts are less likely to be sold to competing indigenous Chinese firms. As a result, vertical technology spillovers through provision of high quality intermediate inputs to the local firms are also limited.

Finally, as a two-edged sword, FDI spillovers may have negative competition effect on the local firms (eg., Hu and Jefferson, 1997). Processing type FDI has combined advanced technology (often embedded in the imported spare parts), financial resources, marketing channels and skills with cheap labour, they will be more competitive than indigenous firms in the international market. MNEs in these sectors have the advantages in (a) access to the right intermediate inputs (which are often genuinely high-technology) and (b) access to markets for the output, sold to wholesalers or retailers for consumers or to firms for use as intermediate inputs. In other words, MNEs are integrated into and often dominate the global value chains (important parts of which are within MNEs themselves) while the indigenous firms are not. Therefore, MNEs engaged in processing-trade activities will enjoy a clear competitive advantage over the indigenous firms in the international markets and will have a significant negative competition effect on indigenous firms which may crowd them out of the export market. The above discussion has led to the following hypothesis:

H1: Processing-trade-cum-FDI is likely to have a positive information spillovers effect on the export performance of indigenous firm.

H2: Technology spillovers from processing-trade-cum-FDI are likely to be limited. Its effect on the export performance of indigenous firms will be insignificant or even negative.

Firm heterogeneities and export market participation

The recent theoretical development on exports in industries with firm heterogeneity suggests that exposure to trade will induce *only* the more productive firms to enter the export markets (while some less productive firms continue to produce only for the domestic market) and will simultaneously force the least productive firms to exit. The opening of new export markets exclusively benefits the more efficient firms, as entry into these markets is costly and can only be afforded by the more efficient firms who earn higher profits. Therefore it is an endogenous selection of heterogeneous firms. Firms within an industry are then partitioned by their export status at the cutoff productivity level. This partitioning of firms by export status will occur if and only if the trade costs relative to the overhead production cost are above a threshold level. A large enough fixed export cost will induce partitioning even when there are no variable trade costs. When there are no fixed (sunk) export costs, no level of variable costs for trade can induce this partitioning (Melitz, 2003).

In the case of engagement of processing trade, the sunk costs for export is sufficiently low because the costs associated with collection of information in foreign markets, identify potential customer, marketing and advertisement are not needed as the foreign company that offered the processing trade contract has already all this in hand and will deal with this themselves. Therefore, a firm’s decision of export market entry is less dependent on its relative productivity than it will be in ordinary trade mode. The effect of export information spillovers on domestic firm's export decision will not only benefit those firms marginal to the normal export cutoff productivity level as suggested by the literature, but also less productive firms whose productivity and flexibility meets the basic requirement of the foreign contractor but not high enough to afford independent foreign market exploration. Therefore we have the following:

H3: In industries where processing-trade is pervasive, firm heterogeneity in productivity will play a less important role in their export market participation than that suggested by the standard trade theory. Export market participation can be made not only by the more productive firms, but also those less productive firms.

III. FDI and exports in the technology-intensive industries in China

After embarking upon economic reforms in 1978, the Chinese economy has been gradually opened up to foreign trade and investment. As a measure to join the global division of labour and integrate into the global production network, the government encouraged export-oriented FDI which mainly engages in processing and assembling spare parts and components for the export markets. In 1988, the Chinese government introduced the coastal regions development strategy and the two-ends outside policy, which encourage processing trade in order to exploit China's comparative advantage in abundant cheap labour. Export-oriented FDI was encouraged by fiscal and financial incentives, e.g., tax holidays and tax-rebates for exports. As a result, exports under the export-processing (EP) regime grew much faster than that under the ordinary-trade (OT) regime due to the involvement of FDI, the preferential government policy and the lower transaction costs of the EP regime. The average annual growth rate of processing-exports was as high as 18 percent in the 1990s, while that for ordinary-exports was only 10 percent (Fu, 2004). Exports on account of processing-trade have become the major component of China's exports.

Since 1996, exports generated from processing trade have accounted for more than 50 percent of China's total exports (MOFTEC, 2000). In 1998 and 1999, the share of exports on account of processing trade reached its historical peak, accounting for 57% of China's total exports (Fu, 2004). This figure is much higher in the high-technology sector. Since 1996, the share of high-tech exports on account of processing trade has reached 85%. In 2004, the share has increased to as high as 90% (Ma and Van Assche, 2010). To note, while the share of processing exports have declined in the medium-high, medium low and low-technology industry since its peak time in late 1990s, there is no evidence of decline, but in fact slight increase, in the high-technology industry (Figure 1). In the electronic computer and other computer periphery equipment industries, the shares of processing exports were both as high as 99% in 2002. In many other industries such as office equipment, telecommunication equipment and electronic element and device industries, the share of processing exports in total industry exports were all above 90% in 2002 (Koopman, et al., 2008)

Most of FIEs in China are engaged in processing-type export activity. For example, in 1999 exports on account of processing trade accounted for 85% of FIEs' total exports (Fu, 2004). This share could be even higher in the technology-intensive sector. As a result, exports of high-technology products from China have increased rapidly. In 2008, high-technology exports from China accounted for 13.1% of the world's total exports of high-technology products, ranking as the second largest high-tech exporter in the world following the US which account for slightly higher proportion at 15.4%. This share is much higher than other traditional exporters of high-technology products such as Japan (4.7%), Korea (3.4%), and the individual EU countries. It is also much higher than other that of the other emerging economies such as Mexico (1.9%) and Russia (0.17%) (Figure 2).

IV. Methodology

This study examines the effect of externalities from PT-cum-FDI on the export market participation of domestic firms. Two problems arise with the modelling of export performance. First, because of the sunk costs of exports, some firms decide not to enter the export market although some of them do. So there is a number of firms have not made any exports at all, and hence have no export sales. Therefore, there is a selection effect based on the decision to export or not. This problem involves estimating a Heckman selection model for panel data controlling for sample selection bias (Hsiao, 2003; Kneller and Pisu, 2007). Second, the value of the dependent variable is censored at zero. Normal ordinary least squares estimator may produce biased estimates since the dependent variable is not normally distributed and hence imposing inappropriate restrictions on the residuals. Therefore, a Tobit model should be employed for the estimation.

Therefore the Type II Tobit model (selection in censored data) is used for estimation. It is a two-stage model incorporates two equations. The first equation of the model explains the propensity to export. Those firms that reported having positive export sales are defined as exporters. The second equation explains the export sales of a firm (if it exports). The empirical model is therefore:

(1) Decision equation (Probit model)

$$z^*_{it} = w_{it}\gamma + v_{it} \qquad (1)$$

and $z_{it} = 1$ if $z^*_{it} > 0$,

$z_{it} = 0$ if $z^*_{it} \le 0$.

(2) Export performance equation (Tobit model)

$$e^*_{it} = \beta\ x_{it} + \sigma\lambda_i + \mu_{it} \qquad (2)$$

and $e_{it} = e*_{it}$ if $z_{it} = 1$

$e_{it} = 0$ if $z_{it} = 0$

$\mu_{it} = \alpha_i + \varepsilon_{it}$

$v_{it} = \alpha'_i + \varepsilon'_{it}$

t = 1, …, T and i = 1, …, N

and

$\varepsilon_{it} = \rho_1\varepsilon_{it-1} + \tau_{it}$

$\varepsilon'_{it} = \rho_2\varepsilon'_{it-1} + \tau'_{it}$

$\tau_{it} \sim N(0,\sigma^2_\tau), \tau'_{it} \sim N(0,\sigma^2_{\tau'})$

where e is logarithm of total exports[2], z is a dummy variable for export or not, w and x are vectors of explanatory variables for export decision and export performance equations, σ is the standard deviation, and λ is the inverse Mills ratio. The components α_i and α_i' are unobserved individual specific random disturbance which is constant over time, and ε_{it} are idiosyncratic errors which vary across time and individuals. Hence the model allows unobserved heterogeneity, first order state dependence, and serial correlation in the error

[2] Firms whose exports value is zero are given a zero value after taking logarithm. This does not affect the data distribution because the minimum positive value of exports is greater than 1.

components. Admittedly this approach has a drawback lies in the difficulty in establishing a distribution of individual specific effects.

When a firm decides not to export (*z*=0), the observed exports value *e* is zero. The significance of the presence of the selection effects is indicated by the Rho statistics, which reflects the correlation between the error terms of the two equations (μ and υ). If there are significant selection effects, the Heckman selection model is preferred. Otherwise, we utilize the standard Tobit model.

Following the literature (eg. Aitken, et al., 1997; Kneller and Pisu, 2007; and Buck et al., 2007), the explanatory variables consist of firm size (*fs*), capital intensity measured by capital-labour ratio (*kl*), labour productivity (*yl*), innovation measured by percentage of sales on account of new products (*rd*), and wage rate (*wage*) which reflects labour skills on one hand and labour costs on the other. Moreover, I also control for some industry-level characteristics that may influence a firm's export market entry. These include competition (*comp*) in the industry measured by the Hirschman concentration index[3], innovation intensity in the industry (rd^i) measured by % of new sales in the industry and the industry average export-sales ratio (exp^i) which measures the export-orientation of the industry. These variables also control for the possibility that foreign firms choose to locate in more technology-advanced or export-intensive industries.

Since the vectors of covariates, x_i and w_i may be the same, there is a possible problem of identification if this is the case. To note, however, the identification depends on the model and normality assumption about the two error terms which, in most cases, are too weak (Johnston and DiNardo, 1997). Following Kneller and Pisu (2007), I include a lagged export variable in both export equations. This is theoretically consistent with the models of exports (Melitz, 2003; Bernard et al., 2003) and helps to reduce the identification problem. Details of the definition of the variables are described in Table 1.

[3] The degree of concentration can be obtained by calculating the Hirschman concentration index (H_x) as follows: $H_X = \sqrt{\sum (X_i / X_t)^2}$, where X_i is the output of firm i, and X_t is the total outputs during the same period.

The estimation of the export performance equation involves an estimation of a Heckman sample selection model with panel data. The Generalized Linear Latent and Mixed Models (GLLAMMs) developed by Skrondal and Rabe-Hesketh (2004) is employed for the estimation of the export performance equation. Moreover, there is possible endogeneity between exports and productivity, with more efficient firms choose to enter the export market (Bernard and Jensen, 2004). Therefore, instrumental variables approach should be used for the estimation. Hence, the instruments used include (i) the lagged dependent and endogenous variables; (2) all the rest exogenous variables in the model; and (3) the share of state ownership are used as instruments for the estimation. Given the drawbacks in governance of state ownership in the Chinese firms, it can reasonably argue that a firm will be less productive if it has more proportion of assets owned by the state. The appropriateness of the instrumental variable candidates is also carefully tested using the Sargan test for overidentifying restrictions and examine the validity of the instruments based on the null hypothesis that the instrumental variables are uncorrelated to the residuals. Reassuringly, it is found that the instruments are appropriate.

V. Data and measurement

This paper uses a firm-level panel dataset of the Chinese technology-intensive industries over the 2000-2007 eight years period. The data were drawn from the *Annual Report of Industrial Enterprise Statistics* compiled by the National Bureau of Statistics of China, covering all state-owned firms and other types of firms with annual turnover of over five million Renminbi ($0.7 million). It includes information about firm ownership structure, industry affiliation, geographic location, year of establishment, employment, gross output, value added, fixed assets, exports, percentage of sales on account of new products and wage rates.[4] The data include firms of both domestic and foreign ownership. Domestic-owned firms include firms that are: (i) state-owned, (ii) collectively-owned, (iii) privately-owned, and (iv) shareholding companies. Foreign firms are defined as firms with 25% or more foreign equity investment according to the Joint Venture Law of the People's Republic of China. Foreign-owned firms are further divided into firms with investments from Hong Kong, Taiwan and Macao (HKTM firms) and firms with investments from other foreign sources (FIEs). The study focuses on the high-technology industries which have a high technology intensity (measured by R&D to sales ratio). Following Eurostat (2004), firms in industries for the

[4] Nominal values are deflated using consumer price indices obtained from the China Statistical Yearbook, various years.

manufacture of medical and pharmaceutical products (SIC 27), electronic products and communication equipment (SIC 40) and instrument, stationery and office equipment (SIC41) are included in the sample. These include 52 industries at the SIC 4-digit level[5].

I use an unbalanced panel allowing for firm entry and exit to capture the industrial dynamics over the sample period. Data cleaning has been carried out to exclude the outliers and unreasonable data entries. The final data set consists of 108,930 observations from 53,981 firms, including 70,587 observations of domestic firms and 38,343 observations of foreign firms. Table 2 presents the firm demographics in the three technology-intensive industries in the sample. Overall, 63% of the firms are domestic firms, and 21% are wholly foreign owned subsidiaries, 15% are joint ventures. The share of foreign firms however varies across three industries. In the electronics industry, foreign firms accounted for almost 50% of the total number of firms, and most of them (32%) are wholly-foreign-owned subsidiaries. The share of foreign firms is the lowest in the pharmaceutical industry. Only 18% of the firms are foreign owned, and most of them (14%) are joint ventures. In the instruments industries, the proportion of foreign invested firms is 32%.

Measurement

Export performance of the firms can be measured by the value of exports or the export-sales ratio. Most of the literature uses the latter with a few exceptions (eg., Sjoholm. 1999). There are some differences between the two measurements. While the total value of exports reflects the overall export performance and a firm's competitiveness in the export markets, export to sales ratio reflects more the export market orientation of a firm. Given the main concern of this paper is the international competitiveness of domestic firms, I use the value of exports for the measurement of export performance.

Externalities from PT-dum-FDI (*fdi)* are proxied using a vector of FDI externality variables that represent spillovers from FDI from different sources and through different channels. FDI spillovers are often measured in two alternative ways in the literature. One is the value of foreign capital, output, employment, exports or R&D investment, etc. in an industry or region (eg., Sjoholm. 1999; Girma et al, 2009); another is the share of foreign presence in these aspects (Aitken, et al., 1997; Buck et al., 2007). While the share measurement gives more

[5] Industry classification changed from GB1994 to GB2002 since 2003. So all the SIC codes are recoded for years before 2003 (00, 01, 02) at the SIC 4–digit level.

emphasis on foreign penetration intensity, the value measurement represents more the scale of the foreign knowledge pool that may generate externalities. Export information spillovers are normally measured by the value of exports in foreign firms or the share of foreign exports in total exports in the same industry or region (eg. Aitken, et al., 1997; Sjoholm. 1999; Kneller and Pisu, 2007). Technology spillovers from FDI are often measured by the total value of R&D capital in FIEs or the share of foreign R&D capital in total R&D capital in the same industry or region (eg. Buck, et al., 2007; Fu & Gong, 2008). Admittedly R&D investment is only one of the major inputs for innovation and knowledge creation. Sales from new products hence offer an alternative measure of innovation from output perspective. Therefore, following the measurement used in the literature and the paper's emphasis on the scale of knowledge externalities from FDI, the total value of exports and sales from new products in the same industry are used as measures of foreign export information and technology spillovers.

Most of the existing literature constructs FDI knowledge pool at SIC 2- or 3-digit level for industry classification and provincial level for geographic region division. Different from these existing constructs, in this paper the FDI knowledge pool is constructed at a more disaggregate level: SIC 4-digit level for industry classification and broad-city level, which include a city and its surrounding rural area[6], for regional classification. Therefore, the FDI export spillovers variable is constructed as total exports of foreign-owned firms in each of the SIC four-digit industries in each of the 439 broad cities. Similarly, the FDI technology spillovers variable is measured as the total sales of new products in foreign-owned firms in each of the four-digit industries in each of the broad-city area. The advantage of such disaggregation is that first, technologies, especially in the technology-intensive industries, are specialised and industry-specific. Secondly, knowledge spillovers are geographically localized (Jaffe, et al, 1993; Austreche and Feldman, 1996). Knowledge and information may flow more easily among agents located within the same area because of social bonds that foster reciprocal trust and frequent face-to-face contacts (Breschi and Lissoni (2001). Therefore, there are geographic boundaries to information flows or knowledge spillovers among the firms in an industry. Acs (2002) found that the range 50-75 miles provides a 'consolidated' measure for the geographical extent of knowledge spillovers in the US case. Funk and Niebuhr (2000) find that in Europe the intensity of spillovers declines by more than

[6] This is identified using the telephone area codes.

90% over a range of 120 kilometres, and the spillovers decrease rather quickly with 30 kilometres turns out to be the half-distance. Many provinces in China are larger than the size of most of the countries in Europe. Aggregation at the provincial level is hence too wide for effective knowledge spillover in normal sense.

Here we distinguish FDI from Hong Kong, Macao and Taiwan (HKTM) and from other foreign sources. FDI from these sources consist more than half of the inward FDI into China. The diasporas share a similar set of cultural traits and its businesses are characterised by intra-ethnic, national and transnational networks. Because of the historical entrepot position that Hong Kong and Macao have played in China's exports, and the shift of production activities to from HKTM mainland China for cheaper labour and land costs, firms invested by HKTM investors are more likely to use China as an export platform and assembly workshop and re-export their final products. This type of FDI is found to have generated spillovers in terms of marketing skills and knowledge (Buckley, et al., 2002) and contributed positively to the export intensity of local firms (Buck et al., 2007). Table 1 reports the summary statistics of the variables used in the test.

VI. Results

Table 3 reports the main export and innovation performance indicators of the domestic and foreign firms in the technology-intensive industries over the sample period. Comparing the foreign to the indigenous firms, in all the industries, foreign firms have much higher proportion of firms participated in export activities, they also have much higher export-to-sales ratio, and much higher value of exports per firm. In the Electronics and Instruments industries (SIC 40 and 41), FIE export participation and export intensity are around three times as high as that in the indigenous firms. In the pharmaceutical industry, foreign export participation is also about two times as high as that in the indigenous firms. All this indicates export participation is much wider and deeper in the foreign than in the indigenous frms. Comparing across the industries, the electronics industry has the highest share of exporters among the foreign firms. About 75% of the foreign firms in this industry engaged in export activity, which is 3 times as high as that in the indigenous firms at 27%. The average export-sales ratio in this industry is 54%, which is about 5 times as high as that in the indigenous firms on average. Looking at changes over time, the propensity of export participation pattern among foreign and indigenous firms have not changed much over the 2000-2007 period

(Figure 3). As regards of technology and innovation measured by percentage of new sales, the difference between foreign and indigenous firms is much smaller. In some industries, eg., the electronics and the instruments industries, this ratio is even higher in the indigenous than in the foreign firms. HKTM Chinese invested firms have the lowest new sales ratio which is around a third of that in the indigenous firms in the electronics and instruments industries.

Focusing on export volume, the electronics industry (SIC40) on average accounted for 87% of China's total exports of high-technology products. This proportion has increased slightly but steadily over the years from 82% in 2000 to 88% in 2007. The instruments industry (SIC 41) counted for 9% of China's total high-technology exports, while the pharmaceutical industry accounted for only 4%. On average, 89% of China's total exports of high-technology products are produced by foreign firms. This indigenous-foreign division has been relatively stable over the years, although the year 2004 saw the highest foreign contribution at 92% (Table 4).

Disaggregating the industries into 4-digit level, Table 5 shows that the industry for the manufacture of electronic components and their assembly (SIC 4061) has the largest export value, followed by the Computer peripheral equipment manufacturing industry (SIC 4043). All the top 10 export industries fall in the electronics sector (SIC40). In SIC 4061, foreign firms contributed to 88% of China's total exports in this industry. In industry for the manufacture of computer peripheral equipment (SIC 4043) and computer network equipment (SIC 4042), the share of exports from foreign firms is even as high as 96%. The share of exports from foreign invested firms are also as high as 97% in the entire computer manufacturing (SIC 4041) and camera and other photographic equipment manufacturing (SIC 4153) industries. All this evidence suggests that the export of high-technology products from China are in fact exports of MNEs rather than indigenous Chinese firms.

On the other hand, evidence reported in this table also indicates the learning and catch up across industries is heterogeneous. There has been rapid export growth in indigenous firms in a few sectors, such as the manufacture of geological exploration and earthquake instrument, data recording instrument for automobiles, industrial automatic control system, optical devices and integrated circuit devices. In these sectors, the indigenous firms have moved on a catch-up track. However, despite the high growth rate in the indigenous firms in these several industries, probably due to a low starting level, strong foreign dominance in the exports of these industries and in the Chinese high-technology sector is clear.

Table 6 reports the Probit model estimates of the propensity of export market participation in indigenous firms. In order to test the hypothesis on indifference to productivity for firms' export market participation, I divide the whole sample of indigenous firms into four sub-samples according to the quartiles of their labour productivity. Column 1 shows the estimates for the whole sample. The estimated coefficients of the export spillovers variables are positive and significant suggesting positive export information externalities emanating from FDI to the indigenous firms. However, the estimated coefficients of the technology spillovers variables are both negative and is statistically significant at the 5% level for the FIE technology spillovers variable, indicating the strong competition and crowding out effect of the technological capabilities of the foreign firms on the indigenous firms in the international markets. All this evidence supports Hypotheses 1 & 2 that on one hand PT-cum-FDI has offered positive marketing and product information spillovers to local firm for their export market participation; on the other hand, its advantage in innovation and technology which has integrated technology, capital, marketing channel and cheap labour has formed a strong competitive pressure that crowds the local firms out off the international markets.

Columns 2-5 report the estimates of the four sub-samples divided according to firms' productivity level. Firms in all of the four quartile ranges have felt positive export spillovers from FDI coming from different sources in different quartile, all statistically significant at the 1% level. As regards to technology spillovers from FDI on indigenous firms' export participation, they are negative and statistically significant at the 5 or 10% level in all quartiles except the top quartile. For firms in the top quartile range, the estimated coefficients of the foreign technology spillovers variables though bear a negative sign; it is not statistically significant, suggesting the most productive indigenous firms have had a certain degree of competence to resist the negative impact of the foreign invested firms.

The estimated coefficient of the past export status variable is positive and statistically significant at the 1% level in all samples suggesting the importance of past experience of exporting in firms' current export decision. The estimated coefficient of the labour productivity variable is positive and statistically significant in the full sample, but the magnitude of the coefficient is negligible. The relative noticeable influence of the productivity variable appears in the lowest quartile, with an estimated coefficient of 0.0051, suggesting that for the least efficient firms the level of their labour productivity plays an important role in export market participation propensity. But firms' heterogeneity in productivity, which is regarded as an important factor in firms' decision about export market participation, does not appear to be significant or economically important in all the rest quartile ranges. This evidence also suggests that the cut-off point of productivity for export market entry has moved to a fairly low level.

As regards the rest control variables, larger firms appear to be more likely to enter the export market; firms with greater innovation are more likely to export. Labour skills appear to have a positive effect on firms' export propensity, but its significance disappears in the quartile sub-samples. Moreover, firms in industries with greater export-orientation tend to be more likely to export. Firms in industries with more innovation are also more likely to export. In other words, there are spillovers of sectoral specific technology within the sector innovation and production system. However, such sectoral technology spillovers are only significant in the first-quartile sub-sample, i.e., for the most productive firms who possess greater absorptive capacity. Finally, capital-labour ratio and competition index do not appear to have any significant impact on firms' export market participation in these high-technology industries.

Table 7 reports the Probit model estimates for the electronic components manufacture and assembly industry (SIC 4061). This industry is the largest exporting industry in the high-technology sector in China, which is also deeply engaged in processing-trade by the nature of its production activity[7]. Not surprisingly, none of the four FDI spillovers variables are statistically significant for the whole sample and for the four sub-samples except a marginal significance shown by the HKMT investment in the lowest inter-quartile group. Moreover, the estimated coefficient of labour productivity for the whole sample is not statistically significant either and is of negligible size. Looking at the corresponding productivity estimates for the four sub-samples, they are also insignificant for the top two inter-quartile range sub-samples. The estimated coefficient though show a marginal significance in the sub-sample of the least productive firms, the coefficient in the 3rd inter-quartile sub-sample even bears a significant negative sign. Again, all this evidence suggests that in industries where

[7] According to Koopman et al (2008), the share of processing exports in total industry exports was 90% in this sector in 2002.

processing-trade is pervasive, the threshold productivity requirement for export market entry has moved to a low level. The role of firm heterogeneity in productivity in firms' export market participation becomes not as important as that suggested by the new trade theory.

The factors that make a significant impact on firms' export market participation include their past experience in exporting, firm size, capital intensity (which reflects the possession of necessary equipment or production line for the processing activity), and firms' capacity in producing new products. Wage rates, a proxy of labour skills and which is positive and significant in the whole high-technology sector sample, turns to be insignificant in this sub-sample. The estimated coefficient is even significantly negative in the top quartile sub-sample suggesting the low requirement for labour skills and the sensitivity to labour costs in the processing trade activities although their final products belong to the knowledge-intensive category.

Turning to the estimates of export performance measured by the value of exports, Table 8 reports the Heckman selection estimates obtained using GLLAMM that have corrected the selection bias due to each firms' different decision on exporting. The rho-statistics indicates significant selection effect in the full sample and the sub-samples and therefore the GMMALL estimates are preferred. Evidence from this table shows that information spillovers from FDI have a significant impact on the export performance of the local firms. However, the impact of technological spillovers from FDI on the export performance of local firms is negative and insignificant in general except in the upper-middle inter-quartile sub-sample, where the estimated coefficient of the non-HKMT FDI technology spillovers variable is marginally significant.

Factors that significantly affect how much a domestic firm will export include a firm's past experience in exporting, firm size, and export-orientation of the whole industry. These effects are robust across a wide spectrum of firms with different levels of productivity. Productivity of firms and innovativeness of the industry also show a significant positive impact on the value of exports in local firm in the whole sample. Their effects, however, do vary for difference firm groups. Productivity appears to matter for the bottom and the upper-middle division sub-samples but not the rest suggesting that productivity is of different importance in firms in different competition position. Innovation capacity appears to play a significant role for firms in the first division by productivity, but insignificant for the bottom half. Similarly, innovation in the industry only matters for the top quartile group who enjoy greater absorptive capacity.

Looking at the processing-trade dominated electronic components manufacture and assembly industry (SIC 4061), none of the estimated coefficients of the spillovers variables are statistically significant (Table 9). Labour productivity though shows a very small but significant effect on export value, it only matters for firms at the lowest quartile range. For most firms in the industry, productivity does not mark any significant impact. Comparing this with the results from the whole sample, the significance of productivity reduces further to only matter in the lowest quartile range. This evidence further proves that the productivity cutoff level is low in industries where processing trade is pervasive. Innovation though demonstrates a significant and positive impact in the whole sample, none of the corresponding coefficients in the sub-samples is statistically significant. Wage rate and capital intensity does not show any significant effect, nor does domestic market competition. The factors that matter in this industry for export performance are previous export experience and firm size.

VII. Robustness check

Tables 10 and 11 report estimated results using different estimation methods and different industry sub-sample as robustness check. The estimated results using instrumental variables controlling for the endogeneity between exports and productivity are reported in Part A of Table 10. For both the export decision and export performance equations, the sign and significance of the coefficients of all the four spillover variables are consistent with that in Tables 6, 7, 8 and 9: significant positive information spillovers but insignificant or negative technology spillovers in the whole sample; but not significant for any types of spillovers in the industry SIC4061 subsample. To note, productivity loses its significance after controlling for the possible endogeneity between it and exports. The estimated coefficients of the rest control variables are also consistent with the earlier results. Estimation results of the standard Tobit approach without controlling for either the selection bias or the endogeneity are also reported in Part B of Table 10 for comparison. The estimated results of the four spillover variables remain consistent with the selection model estimates and the instrumental variable estimates, thus suggesting the robustness of the results. The estimated coefficients of most of the control variables also agree with this. However, that of the productivity variable turns out to be significant, which is likely due to the fact that the selection bias and endogeneity bias are not corrected in this approach.

Table 11 reports the estimated results of the export decision and performance equations using different industry samples. Two sub-samples are used for the estimation. First is a subsample of all the technology-intensive industries where the processing exports share exceeds 80% according to the estimates reported in Koopman et al (2008). This subsample involves about 7000 firms with 16789 observations over the sample period. The second is the electronic computer and computer periphery equipments industries (SIC 4041 and 4043), which reported a processing exports share at 99% in 2002 according to Koopman et al (2008) and which are arguably more technology intensive than the electronic components industry (SIC 4061). The estimated results of three of spillovers variables are again insignificant for both subsamples. The only difference appears in the export spillovers from FDI invested by HKMT Chinese. The estimated coefficients remain positive but turn to be significant in both samples, suggesting export information spillovers from these Chinese diasporas-invested firms have benefited export activities of indigenous Chinese firms. This result is consistent with the findings from Buckley et al (2002) that HKMT Chinese-invested firms have transferred marketing skills and knowledge to domestic firms.

VIII. Conclusions

This paper examines the impact of processing-trade-cum-FDI on the international competitiveness of indigenous firms in the presence of firm heterogeneity. It finds that about 90% of the technology-intensive exports from China are in fact exports of MNEs rather than that of Chinese firms. After 30 years of the "exchange market for technology" strategy, although there has been some fast export growth in a few of the industries, in general, the indigenous Chinese firms have not built up their international competitiveness. Most of them heavily rely on the domestic market.

In industries where processing trade is pervasive, FDI engaged in assembly-based export activity have offered significant positive information spillovers to local firms with regard to their export activities. Such spillovers have offered domestic firms not only foreign market intelligence but also marketing skills which will contribute to the long term capabilities building of the domestic firms. However, their externalities on local firms in terms of technological knowledge are limited. This is true even if such trade activities are taking place in a technology-intensive industry. The greater the engagement of unskilled labour-intensive processing trade activities in an industry, the smaller are the technological externalities from such FDI. The competitive advantage enjoyed by the MNEs by combining technological, financial and marketing capital with cheap labour have crowded out local firms from the export markets since processing-trade-cum-FDI has integrated all the advantages offered by international technology and marketing network of the MNEs and cheap labour offered by the developing countries.

Findings from this paper also suggest that export sunk costs are low for processing trade. The threshold productivity requirement for export market entry is therefore fairly low in such an environment. In other words, firm heterogeneity in productivity hence plays a less important role in their export market participation than the standard trade theory suggests. Not only can the more productive firms enter the foreign markets but also can those less productive firms because the foreign contractor will be responsible for the sales in addition to providing the materials and components. Therefore, resources are not necessarily reallocated to the most productive firms in the processing-trade regime.

Evidence from the current research has important policy implications. Establishment of export process zones and encouragement of process-trade-cum-FDI has been used by many developing countries as a major policy tool to attract FDI, enable technological learning and promote technological progress and leapfrogging by indigenous firms. Evidence from this research suggests that this is not an effective policy for indigenous technological learning and capabilities building. At least, the learning opportunity is limited and the speed is slow. In the case of the technology-intensive industries in China, although there is some catching up taking place in a few industries, none of them are substantial enough to raise the Chinese firms to the international frontier on a great scale. With increasing sophistication of technology and modulisation of production, the opportunities of learning and catching-up through labour-intensive processing-trade based production activities have become much smaller than what the Japanese and Korean firms had in the 1960s and 70s. Alternative policy tools which provide real commitment for technology transfer and opportunities for indigenous technological learning need to be developed.

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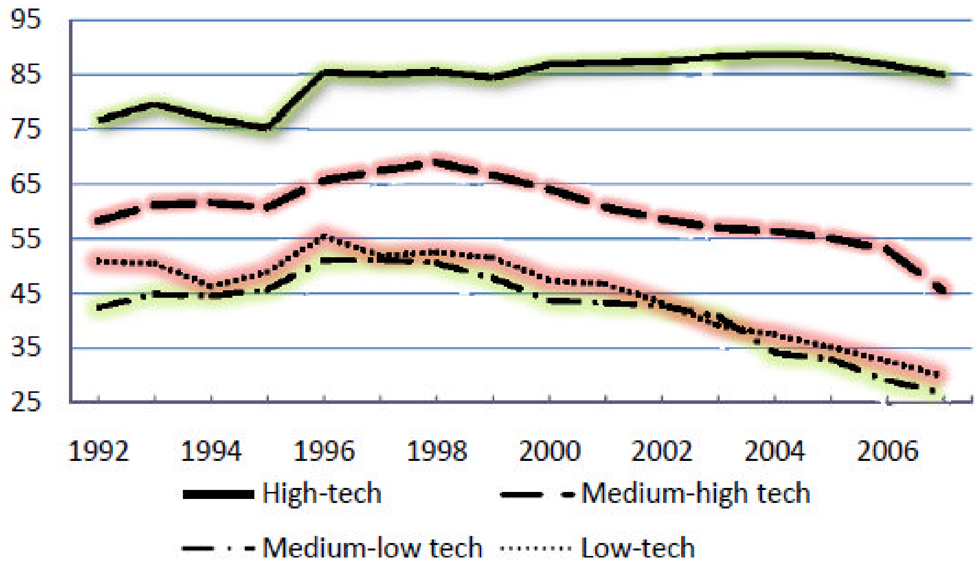
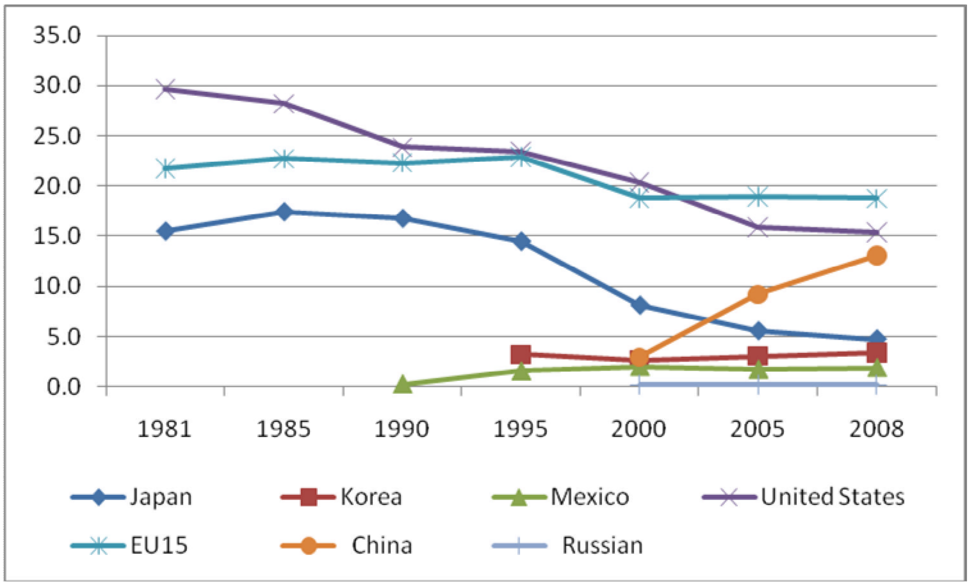
Figure 1: Share of processing exports in China's total exports, by technology level (%)



Note: The share of processing exports in total industry exports were 99.1%, 99.2% in the electronic computer and other computer periphery equipment industries in 2002. This share was 93.4%, 91.2%, 90.6%, 89.7%, 83.0%, 68.6% in culture and office equipment, telecommunication equipment, electronic element and device, printing, reproduction of recording media, instruments meters and other measuring equipment industries, and 16.9% in pharmaceutical products industry in 2002.
Source: Ma and Van Assche (2010) and Koopman, et al. (2008)

Figure 2. Export market share in R&D intensive industries



Note: Five R&D intensive industries are: Aerospace, Electronics, Instruments, Office machine and Pharmaceutical. The figure is a simple average of the share of the five industries.
Source: OECD STAN.

Figure 3. Percentage of exporters: foreign vs domestic firms, 2000-07

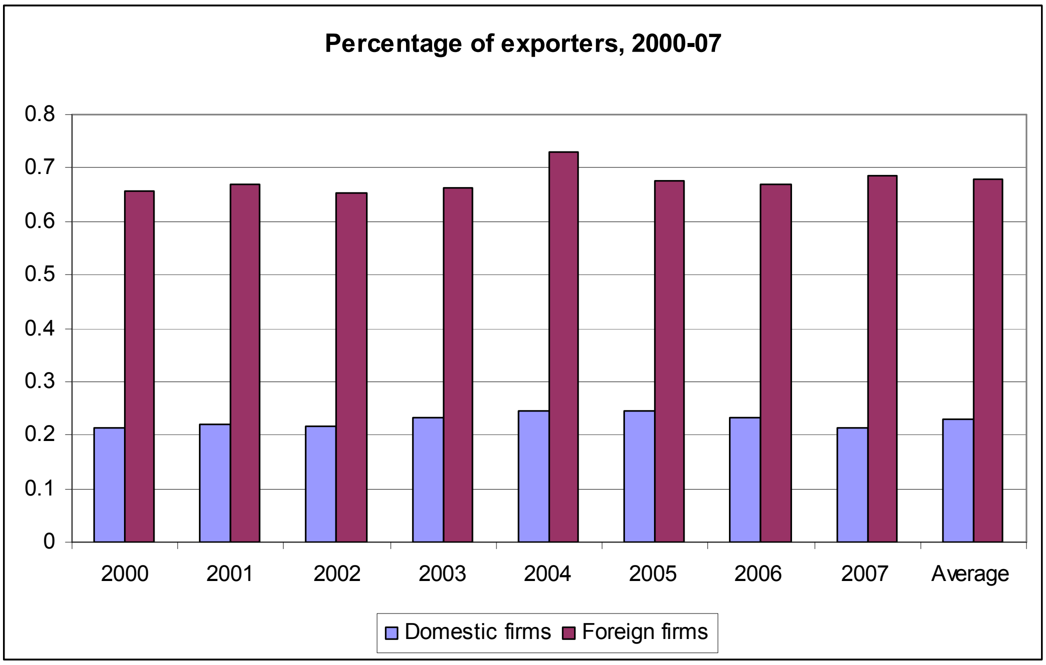


TABLE 1. Summary statistics of the variables

Variable	Definition	Obs	Mean	Std.	Min	Max
expd	Export dummy, equals 1 for exporters	108930	0.3877	0.4872	0	1
exp3	Ln (export value)	108930	3.7480	4.8657	0	18.0558
newsl	% of sales of new products in total sales	92087	0.0902	0.2574	0	23.3465
wage	Ln (wage rate)	108726	2.5978	0.6873	-5.0304	10.1765
size	Ln (no of employees)	108930	4.9750	1.0866	0	11.1832
comp	Hirschman concentration index	108930	0.5011	0.2942	4.66E-05	1
kl	Capital to labour ratio	108930	84.2505	241.6479	0	53920
yl	Labour productivity	108930	287.1808	294.9331	15.5729	1806.8640
horehmtx2	Export spillovers of HKTM investment	108930	5.4535	6.2241	0	17.1706
horefiex2	Export spillovers of foreign investment	108930	6.4833	6.4463	0	18.7003
horehmti2	Technology spillovers of HKTM investment	108930	2.2676	4.4757	0	16.4316
horefiei2	Technology spillovers of foreign investment	108930	2.9694	5.1508	0	16.4696
indexp1	Export-sales ratio of the industry	108930	0.3183	0.2522	0	0.9899
indRD1	% of new sales of the industry	108930	7.4566	9.3228	0	41.6360

Table 2. Distribution of number of observations

	Part A			
		Industry SIC		
Foreign	27	40	41	Total
Domestic	27,570	28,131	14,886	70,587
Foreign	5,507	25,907	6,929	38,343
Total	33,077	54,038	21,815	108,930
	Part B			
		Industry SIC		
	27	40	41	Total
Domestic	0.82	0.51	0.68	0.63
HKTMJV	0.06	0.09	0.05	0.07
HKTM-Wholly owned	0.02	0.15	0.09	0.10
FIEJV	0.08	0.08	0.09	0.08
FIE-Wholly owned	0.03	0.17	0.09	0.11
Total	1.00	1.00	1.00	1.00

Table 3. Export and innovation indicators of domestic and foreign firms

	Domestic				Foreign			
sic	Export-sales ratio	Ln(exports)	Export dummy	% of new sales	Export-sales ratio	Ln(exports)	Export dummy	% of new sales
27	5.41	1.47	0.17	0.08	16.41	3.30	0.36	0.09
40	11.62	2.46	0.27	0.12	53.53	7.73	0.75	0.07
41	12.74	2.26	0.26	0.12	48.61	6.70	0.69	0.06
Total	9.42	2.03	0.23	0.10	47.21	6.91	0.68	0.07
Of all the foreign firms								
	None-HKTM				HKTM			
sic	Export-sales ratio	Ln(exports)	Export dummy	% of new sales	Export-sales ratio	Ln(exports)	Export dummy	% of new sales
27	18.87	3.75	0.41	0.09	11.39	2.37	0.26	0.08
40	52.35	7.87	0.75	0.08	53.78	7.46	0.73	0.06
41	41.98	6.38	0.65	0.08	54.60	6.83	0.70	0.05
Total	44.87	6.92	0.68	0.08	48.07	6.67	0.66	0.06

Table 4 Industry distribution of China's high-technology exports: 2000-07

	Industry (SIC)				
year	27	40	41	local	foreign
	Medical & Pharmaceutical	Electronic & telecommunications	Instruments and meters		
2000	6%	82%	12%	13%	87%
2001	6%	83%	12%	12%	88%
2002	5%	83%	12%	11%	89%
2003	5%	83%	12%	11%	89%
2004	2%	89%	8%	8%	92%
2005	4%	88%	8%	11%	89%
2006	4%	88%	9%	14%	86%
2007	4%	88%	8%	13%	87%
Total	4%	87%	9%	11%	89%

Table 5 Export performance of foreign and domestic firms: detailed industry breakdown at SIC 4-digit level, 2007

		Export growth rate: domestic-foreign (2000-07)	foreign sum/domestic sum	Indigenous firms as % of total exports	Foreign firms as % of total	No of Observations	Exports total
4061	Manufacture of electronic components and their assembly	-0.8	7.3	12%	88%	18,655	184200000
4043	Manufacture of computer peripheral equipment	2.0	22.0	4%	96%	3,838	174607367
4071	Manufacture of household video equipment	4.1	5.9	15%	85%	2,082	90100000
4053	Manufacture of integrated circuit devices	21.1	14.2	7%	93%	1,790	82647074
4062	Manufacture of the printed circuit board	1.6	11.1	8%	92%	3,320	78492232
4059	Manufacture of optical devices and other electronic devices	58.7	4.6	18%	82%	2,638	75100000
4014	Manufacture of mobile communication and terminal equipment	15.5	16.8	6%	94%	1,280	72570516
4041	Manufacture of the entire computer	6.3	30.1	3%	97%	891	68606735
4072	Manufacture of household audio equipment	0.4	6.7	13%	87%	2,982	51390928
4052	Manufacture of semiconductor discrete devices	-1.6	13.0	7%	93%	2,081	31552535
2710	Manufacture of chemical medicines	-4.7	0.6	64%	36%	5,953	19497381
4090	Manufacture of other electronic equipment	1.8	4.5	18%	82%	3,681	17595206
4051	Manufacture of vacuum electronic devices	20.0	3.2	24%	76%	821	13665721
4153	Manufacture of camerae and other photographic equipment	-2.9	29.3	3%	97%	735	12202932
4013	Manufacture of communication terminal equipment	-1.0	7.1	12%	88%	1,313	11014903
4011	Manufacture of communication transmitting equipment	4.4	7.7	12%	88%	1,412	10266942
4042	Manufacture of computer network equipment	-20.9	24.6	4%	96%	823	9083310
4154	Manufacture of photocopying and offset printing equipment	6.1	16.4	6%	94%	504	9082617
4111	Manufacture of the industrial automatic control system	241.8	1.3	43%	57%	3,683	8664155
2760	Manufacture of biological and biochemical products	6.1	0.8	57%	43%	2,905	8583769
4130	Manufacture of watches and chronometers	-31.9	2.4	30%	70%	1,860	8557311
4119	Manufacture of auxiliary instrument and other general instrument	12.4	2.8	26%	74%	1,881	7901288
4141	Manufacture of optical instrument	2.0	2.6	28%	72%	1,704	7427148
4039	Application of television equipment and other auxiliary television equipment		17.0	6%	94%	278	6771724
4142	Manufacture of glasses	-0.2	1.8	35%	65%	2,121	6445711
4032	Manufacture of the equipment for receiving TV programs	49.5	2.4	30%	70%	1,272	6346321

4019	Manufacture of other communication equipment	3.3	2.6	28%	72%	2,287	5027869
2720	Manufacture of chemical medicine preparations	-0.8	0.9	54%	46%	7,261	4851587
4155	Manufacture of calculators and currency-specialized equipment	-1.1	6.6	13%	87%	502	4161395
2740	Manufacture of proprietary Chinese medicines	7.2	0.5	69%	31%	8,972	4090698
4012	Manufacture of communication exchanging equipment	-1.7	3.7	21%	79%	1,798	4074843
2770	Manufacture of sanitary materials and medical products	-0.3	1.7	37%	63%	2,579	3974803
4112	Manufacture of electrical instrument	-0.4	3.9	20%	80%	1,989	3124973
4114	Manufacture of experimental analysis instrument	44.8	14.4	6%	94%	1,030	3101904
4128	Manufacture of electric measuring instrument	-3.5	7.3	12%	88%	792	2964135
4113	Manufacture of drawing, calculating and measuring instrument	-7.2	2.2	32%	68%	872	2669492
4159	Manufacture of other stationery and office equipment	-5.6	3.5	22%	78%	357	2650723
4122	Manufacture of data recording instrument for automobiles and others	360.0	3.3	23%	77%	590	2472229
4020	Manufacture of radar and auxiliary equipment	51.8	0.0	98%	2%	325	2322478
4152	Manufacture of slide projectors and other projection equipment	-87.3	19.2	5%	95%	113	2247417
2750	Manufacture of veterinary medicines	5.8	0.8	54%	46%	2,275	1705634
2730	Manufacture of Chinese medicine tablets	0.0	0.5	67%	33%	3,065	1513133
4190	Manufacture and repair of other instrument	5.5	1.0	51%	49%	791	988706
4121	Manufacture of environmental monitoring instrument	-70.5	10.7	9%	91%	352	915169
4129	Manufacture of other specialized instrument	2.1	1.1	48%	52%	621	707993
4123	Manufacture of navigating, meteorological and oceanographic instrument	-207.8	1.3	44%	56%	292	524232
4115	Manufacture of testing instrument	-41.9	0.5	68%	32%	429	480197
4125	Manufacture of geological exploration and earthquake instrument	1788.4	8.7	10%	90%	234	350586
4031	Manufacture of the equipment for producing and transmitting TV programs		0.1	95%	5%	274	165134
4151	Manufacture of filming equipment		0.7	59%	41%	68	159050
4126	Manufacture of teaching instrument	-21.0	0.8	56%	44%	412	106298
4124	Manufacture of agricultural, forestry, livestock breeding and fishery instrument		0.0	96%	4%	22	43246
Total		0.0	6.8	13%	87%	108,805	1128000000

Table 6. Probit model estimates of export decision in the high-technology industry (whole sample)

	Whole sample	1st quartile	2nd quartile	3rd quartile	4th quartile
	(1)	(2)	(3)	(4)	(5)
rhorehmtx2	0.0101***	0.0183***	0.00109	0.0138***	0.006
	0.002	0.005	0.005	0.005	0.006
rhorefiex2	0.0118***	0.005	0.0155***	0.00958**	0.0182***
	0.002	0.005	0.005	0.005	0.006
rhorehmti2	-0.004	-0.006	0.002	-0.0128**	-0.002
	0.003	0.005	0.005	0.005	0.006
rhorefiei2	-0.00557**	-0.001	-0.00862*	-0.004	-0.00996*
	0.003	0.005	0.005	0.005	0.006
expdlag	2.457***	2.445***	2.459***	2.452***	2.473***
	0.020	0.040	0.038	0.038	0.048
size	0.220***	0.203***	0.216***	0.226***	0.295***
	0.010	0.019	0.019	0.020	0.026
kl	0.000	0.000	0.000	0.000	-0.0007**
	0.000	0.000	0.000	0.000	0.000
yl	9.83e-05***	0.000	0.000690*	0.001	0.00511***
	0.000	0.000	0.000	0.001	0.001
newsl	0.255***	0.493***	0.362***	0.285***	0.105**
	0.028	0.063	0.066	0.079	0.047
wage	0.0332**	-0.012	-0.017	0.011	0.027
	0.016	0.030	0.033	0.038	0.040
comp	-0.002	-0.042	-0.046	-0.004	0.096
	0.032	0.064	0.062	0.061	0.068
indexp1	0.541***	0.463***	0.635***	0.524***	0.507***
	0.048	0.102	0.095	0.094	0.096
indRD1	0.00277***	0.00695***	0.003	-0.003	0.000
	0.001	0.002	0.002	0.002	0.002
Constant	-2.983***	-2.714***	-2.986***	-2.950***	-3.780***
	0.070	0.134	0.163	0.181	0.199
Observations	42,460	10,634	11,050	10,811	9,965
ll	-10681	-2621	-2821	-2848	-2316
chi2	18366	4360	4700	4870	2752

Notes: Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 7. Probit model estimates of export decision in electronics components industry (SIC4061)

	Whole sample	1st quartile	2nd quartile	3rd quartile	4th quartile
	(1)	(2)	(3)	(4)	(5)
rhorehmtx2	0.008	0.012	0.017	0.012	0.000
	0.007	0.017	0.016	0.012	0.012
rhorefiex2	-0.007	-0.025	0.005	-0.007	-0.006
	0.007	0.016	0.016	0.013	0.013
rhorehmti2	0.008	0.019	0.004	0.008	0.0222*
	0.006	0.016	0.014	0.011	0.012
rhorefiei2	0.006	0.007	0.017	0.011	-0.010
	0.006	0.015	0.014	0.010	0.011
expdlag	2.447***	2.506***	2.718***	2.461***	2.465***
	0.050	0.141	0.219	0.088	0.094
size	0.263***	0.236***	0.273***	0.288***	0.337***
	0.027	0.066	0.070	0.051	0.058
kl	0.000744**	0.00101**	0.00223***	0.000	0.000
	0.000	0.000	0.001	0.001	0.001
yl	0.000	0.000	-0.001	-0.00370**	0.00363*
	0.000	0.000	0.001	0.002	0.002
newsl	0.545***	0.404	0.576**	0.691***	0.608**
	0.117	0.250	0.261	0.224	0.270
wage	0.000	-0.209*	0.011	-0.003	0.140
	0.0536	0.115	0.136	0.114	0.117
comp	0.0193	-0.141	0.0361	-0.0521	0.171
	0.082	0.221	0.194	0.145	0.155
indexp1	-0.0284	1.018	-0.55	-0.0446	-0.128
	0.197	0.828	0.544	0.377	0.304
indRD1	-0.0176*	-0.0073	-0.036	-0.0136	-0.0203
	0.0098	0.0254	0.0227	0.0173	0.0193
Constant	-2.753***	-2.597***	-2.840***	-2.262***	-3.733***
	0.202	0.578	0.67	0.453	0.437
Observations	5,522	873	1,358	1,735	1,556
ll	-1602	-228.2	-376.4	-519.8	-453.2
chi2	2746	388.1	157.2	862.9	789.7

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 8. Spillovers from FDI and export value of local firms: GLLAMM estimates for selection model

	Whole	1st quartile	2nd quartile	3rd quartile	4th quartile
	Coef.	Coef.	Coef.	Coef.	Coef.
rhorehmtx2	0.0277***	0.049***	0.013	0.026**	0.025*
	0.0071	0.017	0.014	0.013	0.013
rhorefiex2	0.0249***	0.012	0.032**	0.025**	0.033**
	0.0069	0.016	0.013	0.012	0.013
rhorehmti2	-0.0071	-0.013	0.004	-0.019	-0.008
	0.008	0.018	0.015	0.014	0.014
rhorefiei2	-0.0187**	-0.009	-0.026*	-0.017	-0.02
	0.0073	0.017	0.014	0.013	0.013
rexp3lag	0.650***	0.726***	0.657***	0.589***	0.543***
	0.0099	0.018	0.015	0.016	0.017
size	0.478***	0.476***	0.507***	0.528***	0.577***
	0.0306	0.065	0.056	0.056	0.061
kl	-0.0003	0.000	0.000	-0.001	-0.002**
	0.0002	0.000	0.000	0.001	0.001
yl	0.0008***	0.000	0.003***	0.002	0.012***
	0.0001	0.000	0.001	0.002	0.002
newsl	0.426***	0.925***	0.501**	0.211	0.103
	0.0885	0.212	0.195	0.216	0.159
wage	0.00467	-0.191*	-0.113	-0.073	-0.02
	0.0498	0.105	0.103	0.106	0.103
comp	-0.00091	-0.008	-0.073	0.035	0.053
	0.0931	0.223	0.184	0.161	0.161
indexp1	1.080***	1.104***	1.209***	1.150***	0.800***
	0.139	0.35	0.278	0.249	0.229
indRD1	0.00548*	0.013**	0.003	-0.007	0
	0.003	0.006	0.006	0.006	0.006
_cons	-2.638***	-2.091***	-2.906***	-2.685***	-3.749***
	0.221	0.475	0.494	0.497	0.464
rho	0.896**	0.914***	0.902***	0.896**	0.898**
Wald chi2	6884	2116.98	2362	2026.9	1547.87
likelihood	-10225	-2622.32	-2695.05	-2736.29	-2059.32
N	42027	10526	11004	10764	9733

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 9. Spillovers from FDI and export value of local firms in industry SIC4061: GLLAMM estimates for selection model

	Whole sample	1st quartile	2nd quartile	3rd quartile	4th quartile
	(1)	(2)	(3)	(4)	(5)
rhorehmtx2	0.017	0.0348	0.0123	0.00845	0.0177
	0.0161	0.0521	0.0368	0.0272	0.0252
rhorefiex2	0.0116	-0.0251	0.0139	0.0178	0.0157
	0.0168	0.0518	0.0373	0.0277	0.0273
rhorehmti2	0.0207	0.0398	0.018	0.0012	0.029
	0.0146	0.0476	0.0337	0.0234	0.0231
rhorefiei2	-0.00687	0.0166	0.00294	-0.00553	-0.03
	0.0138	0.046	0.0312	0.0221	0.0213
rexp3lag	0.564***	0.683***	0.625***	0.520***	0.473***
	0.0216	0.0552	0.0434	0.0303	0.0309
size	0.563***	0.570***	0.564***	0.585***	0.692***
	0.0697	0.196	0.141	0.114	0.125
kl	0.00060	0.00148	0.00069	-0.0006	-0.00134
	0.0007	0.0013	0.0011	0.0018	0.0023
yl	0.0009***	0.0003	0.0002	-0.0027	0.0130***
	0.0003	0.0007	0.0029	0.0039	0.0044
newsl	0.617**	0.624	0.592	0.667	0.408
	0.259	0.718	0.553	0.439	0.467
wage	0.0146	-0.398	-0.0877	0.0515	0.0136
	0.134	0.352	0.332	0.258	0.236
comp	0.0412	-0.0783	-0.0373	0.0060	0.176
	0.192	0.687	0.454	0.293	0.282
indexp1	0.158	0.944	-1.196	0.107	0.0141
	0.452	2.514	1.246	0.749	0.533
indRD1	-0.014	0.0137	-0.0289	-0.0091	-0.0082
	0.0228	0.0784	0.0534	0.0347	0.0342
Constant	-2.534***	-1.778	-1.487	-1.916*	-4.031***
	0.526	1.842	1.426	1.024	0.932
Observations	5,482	868	1,358	1,733	1,523
Log likelihood	-1755	-260.7	-417.3	-573	-481.2
chi2	1237	229.6	313.2	478.6	376.1
Rho	0.0836**	0.1256**	0.0461**	0.2375**	0.3107**

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 10. Robustness check using different estimation methods

	Part A: IV				Part B: Standard Tobit	
	Probit		Selection model (gllamm)			
	Whole sample	SIC4061	Whole sample	SIC4061	Whole sample	SIC4061
rhorehmtx2	0.0097***	0.008	0.0259***	0.016	0.0277***	0.0170*
	0.002	0.007	0.007	0.016	0.004	0.010
rhorefiex2	0.0117***	-0.005	0.0232***	0.012	0.0249***	0.012
	0.002	0.007	0.007	0.017	0.004	0.010
rhorehmti2	-0.004	0.010	-0.008	0.020	-0.007	0.0207**
	0.003	0.006	0.008	0.015	0.005	0.009
rhorefiei2	-0.0057**	0.005	-0.0189**	-0.008	-0.0187***	-0.007
	0.003	0.006	0.007	0.014	0.004	0.008
yl	0.000	-0.0010*	0.0016***	0.001	0.0008**	0.0009***
	0.000	0.001	0.000	0.001	0.000	0.000
expdlag	2.456***	2.467***				
	0.0198	0.0505				
rexp3lag			0.650***	0.562***	0.650***	0.564***
			0.010	0.022	0.006	0.013
size	0.225***	0.163***	0.593***	0.625***	0.478***	0.563***
	0.017	0.059	0.052	0.141	0.019	0.043
kl	0.000	0.0010***	-0.0004*	0.001	-0.0003**	0.001
	0.000	0.000	0.000	0.001	0.000	0.000
newsl	0.253***	0.584***	0.417***	0.650**	0.426***	0.617***
	0.028	0.118	0.090	0.263	0.054	0.158
wage	0.028	0.096	-0.067	0.002	0.005	0.015
	0.023	0.077	0.070	0.189	0.030	0.082
comp	-0.003	0.004	0.004	0.042	-0.001	0.041
	0.032	0.083	0.094	0.194	0.057	0.117
indexp1	0.532***	-0.005	1.027***	0.186	1.080***	0.158
	0.048	0.200	0.140	0.456	0.085	0.276
indRD1	0.0028***	-0.0188*	0.0071**	-0.016	0.0055***	-0.014
	0.001	0.010	0.003	0.023	0.002	0.014
Constant	-2.997***	-2.267***	-3.238***	-2.923***	-2.638***	-2.534***
	0.0965	0.317	0.297	0.779	0.135	0.321
Observations	42,027	5,482	42,027	5,482	42,027	5,482
Loglikelihood	-10602	-1582	-10247	-1759	-27411	-4705
Chi2	18253	2730	6769	1212	18456	3317
rho			0.006*	0.087*		

Notes: Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 11. Robustness check using different industry sample, IV estimates

	All industries with more than 80% processing trade		Computer industry	
	Probit	gllamm	Probit	gllamm
	expd	rexp3	expd	rexp3
rhorehmtx2	0.0082**	0.0247**	0.161***	0.875***
	0.003	0.010	0.044	0.124
rhorefiex2	0.003	0.013	0.000	0.000
	0.003	0.010	0.000	0.001
rhorehmti2	0.005	0.006	-0.001	0.001
	0.003	0.010	0.000	0.001
rhorefiei2	0.000	-0.012	0.177	0.026
	0.003	0.010	0.132	0.360
yl	0.000	0.0012*	0.153	-0.069
	0.000	0.001	0.204	0.538
expdlag	2.406***		2.181***	
	0.029		0.074	
rexp3lag		0.619***		0.494***
		0.014		0.034
size	0.223***	0.656***	0.075	-0.003
	0.026	0.075	0.073	0.194
kl	0.0003**	0.000	-0.032	-0.010
	0.000	0.000	0.119	0.290
newsl	0.171***	0.294***	-0.0298***	-0.0383*
	0.035	0.113	0.008	0.023
wage	0.038	-0.024	0.010	0.019
	0.036	0.106	0.008	0.022
comp	-0.022	-0.065	0.0236***	0.0416*
	0.047	0.135	0.008	0.022
indexp1	0.314***	0.718***	0.004	-0.007
	0.071	0.207	0.007	0.018
indRD1	-0.003	-0.004	-0.010	-0.007
	0.003	0.008	0.007	0.018
Constant	-2.764***	-3.406***	-2.029***	-3.604***
	0.142	0.425	0.295	0.826
Observations	16,789	16,789	2,526	2,266
Log likelihood	-4810	-5040	-839.6	-1315
Chi2	7920	3303	1250	787.8
rho		0.0843**		0.0349**

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1