International Technology Diffusion via Goods Trade: Theory and Evidence from China*

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Abstract

This paper develops a multi-product firm model of international trade with the endogenous decisions on export and import to study technology diffusion via goods trade. In our model, a firm's productivity in a product is a combination of its general ability which applies to all the goods the firm produces and product expertise which applies only to a particular good. Within each firm, the decisions of export and import are based on product expertise. Technology diffuses via goods trade, therefore a firm can improve its productivity by reverse-engineering the imported advanced foreign products. We use Chinese trade data to empirically analyze our theory. The results show that a firm will import the product in the category where it already has higher expertise, which is consistent with the theoretical prediction. We find that a firm's productivity in a category gets improved when it imports in the same category, but only product expertise gets accumulated, not the firm ability.

Keywords: International Technology Diffusion; Multi-product Firm; Reverse Engineering; Productivity; Product Expertise
JEL classification: F12, F14, O33

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1 Introduction

Technology plays a crucial role in determining productivity which in turn can explain the variation in economic outcomes across firms and countries. A better understanding of technology diffusion to developing countries via international trade could provide the answer to whether the poor countries can catch up with the rich ones. Empirical evidence on this issue is not conclusive. The effects vary with countries, economic development, and the content of trade. Recently, researchers find that some multi-product firms export and import the products in a narrowly-defined category in transaction-level trade data. [1] This phenomenon hints that the technology may diffuse to developing countries via their reverse-engineering the imported goods. However, there is few studies analyzing this possibility and its impacts.

This paper develops a multi-product firm model of export and import decisions with heterogeneities at the firm and product level and analyzes the pattern aforementioned and its impacts. A firm can produce multiple products in different categories and its productivity in a product has two components: one is the general ability that applies to all the products the firm produces and the other is the product expertise that applies to a particular product of the firm. Firms have access to different export modes in each category: non-exporter, common exporter, and reverse engineering exporter (r-exporter). Common exporters only export their products but don't import the products in the same category, while r-exporters import and export products in the same category. We call an r-exporter's import in the product category where it export simultaneously as product import, in order to distinguish from input import that the imports are directly used as intermediate inputs in the production. The r-exporters have to pay the fixed costs related to the imports, but they derive productivity growth if they learn from the foreign products by reverse-engineering the imports. Therefore the r-exporters can produce the product in the same category as the imported good at lower marginal costs than if they don't import in the category. The trade-off implies that the firms will self-sort into different export types according to their expertise given their ability. Specifically, a firm will import and export in the product categories of his higher expertise, export in the product categories of his medium expertise and sell in the product categories of his lowest expertise only in the domestic market. Moreover, the model predicts the sorting pattern across firms: the productivity of r-exporters is higher than that of common exporters and

[1] For example, Damijan et al. (2013) and Damijan et al. (2014) document that 70% Slovenia firms engage in exports and imports in the same product category simultaneously. They call this type of trade as pass-on trade (POT), which they argue is a subset of carry-along trade (CAT) found by Bernard et al. (2012).

the productivity of non-exporters is lowest among all firms.

This paper tests the firm- and product-level predictions of the model using the product-level trade data collected by China Custom and firm production data collected by National Bureau of Statistics of China during 2000-2006. We distinguish between r-exporters and POT traders who just pass their imports on to exports.[2] We find that, during this period, around 15% of Chinese exporters were r-exporters in the industries where China was less likely to have comparative advantage in international trade. Some firms even imported in the product category where they wrote their best records of export sales. Then our econometric analysis confirms the sorting pattern predicted by the model. More productive firms are more likely to be r-exporters and a firm will import the product of his better expertise with greater probability. In order to learn about whether and how the export performance of r-exporters in a product category improves when a firm imports in the same category simultaneously, this paper examines the correlations between a firm's export performance (export prices and export market coverage) and its product import status. The results demonstrate that the r-exporters export at lower prices in the product category when they import in the same category simultaneously and also deliver their products in that category to more countries. POT traders also sell their products in a category to more countries but at higher prices when they import in the same category simultaneously. The evidence on the export performance could also rise as a result of other factors such as import competition and intermediate input import. China's accession to the WTO in 2001 facilitates these activities. To address these concerns, this paper includes import competition and intermediate input import in our empirical model. The conclusions are robust to these additional controls.

Reverse-engineering is as important an economic activity as innovation. The stories about Chinese firms' reverse-engineering activities kept hitting the headlines these years. For example, mass media reported how BYD, one of China's fastest-growing car makers, developed its car models by dismantling the newest cars built by the leading manufacturers around the world including Benz and Toyota. Meanwhile, these reports admit that BYD has obtained some expertise in car making by merging other car companies, "Wang (CEO of BYD) decided to move into autos in 2002, and the following January his company bought a 77 percent stake in Shaanxi's Qinchuan Auto Co." The reports also point out that "BYD's excellent quality

[2] Firm i engages in POT in product j in year t if $m_{ijt} > 0$ or $m_{ij,t-1} > 0, x_{ijt} > 0, x_{ij,t-1} = 0$. x and m stand for export and import respectively. In our paper, we modify this definition and identify POT trader as: firm i is a POT trader in product j in year t if $m_{ijt} > 0, x_{ijt} > 0, m_{ijs} > 0$, here s is the period when firm-product pair ij appears in the dataset for the first time. Firm i is an r-exporter of product j in year t if $m_{ijt} > 0, x_{ijt} > 0, x_{ij,s<t} > 0, m_{ijs} = 0$, here s is the period when firm-product pair ij appears in the dataset for the first time.

imitation cars are tied to the fact that the company has accumulated experience in strict product control from its earlier practices in batteries and the IT sector." [3] There are some controversies over the distortion effects of reverse-engineering on the incentives of potential innovators. However, empirical investigation finds no evidence that tighter intellectual property right protection which reduces the reverse-engineering and imitation increases the R&D spending or innovative output. (Sakakibara and Branstetter 2001; Bessen and Hunt 2004) Theoretical studies further demonstrate the possibilities where reverse-engineering is beneficial for the original inventor and the long-run economic growth. (Mukoyama 2003; Bessen and Maskin 2009; Borota 2012)

Our paper is related to the literature on the international technology diffusion (Henry et al. 2009; Veeramani 2009; Keller and Yeaple 2009; Connolly 2003) and the connection between imports and exports (Kasahara and Lapham 2013; Feng et al. 2012; Fan et al. 2015). Our paper is also related to the work of Damijan et al. (2013) and Damijan et al. (2014) who document firm-product level bilateral trade and call this "Pass-on-Trade" (POT). They also investigate possible explanations for POT and find evidence on the importance of firms' multinational networks and demand complementarities between firms' own and POT products. (Damijan et al. 2013) Moreover, they find that POT has less favorable effects on firms' long-run performance than regular trade. (Damijan et al. 2014)

The main contribution of this paper to the existing literature is to reveal the importance of a firm's product expertise in its decisions of import in the technology-intensive industries in a developing country. Our paper differs from the previous studies in the trade pattern investigated. Damijan et al. (2013) and Damijan et al. (2014) define POT product as the product that a firm imports currently but doesn't export in previous period. In this paper, by checking the history of a firm's exports, we define r-exporter as a firm who simultaneously imports and exports a product that the firm exports previously. Our theory predicts that for a firm who wants to learn from the imported products it will import in the product category where it has higher expertise. This prediction finds strong support in the empirical evidence. We also find that the firm-level productivity of the r-exporters is significantly higher than that of the common exporters. However, we don't find reverse engineering exporting (r-exporting) causes extra productivity growth at firm level. This is consistent with the predictions of our model. Moreover, we find r-exporting does promote the efficiency of r-exporters at product level. In particular, an r-exporter exports the product in a category at lower prices and delivers the product to more markets when it imports in the same category than when it

[3] "How Manufacturing's Mockingbird Sings", by staff reporters Liang Dongmei, Yang Binbin, Fu Yanyan and Wang Duan at caixin.com, Feb 10, 2010.

doesn't import.

The rest of the paper is organized as follows. Section 2 presents the theoretical model with the testable predictions. Section 3 introduces the data used in the empirical analysis. Section 4 presents the results for firm- and product-level self sorting and Section 5 provides additional evidence on the effects of the product import on the intensive and extensive of export. Section 6 concludes.

2 Model

The model is built on the theoretical framework in Bernard et al. (2011), where a standard multi-product firm can export with or without product import. Firms that import products have to pay the sunk costs related to imports but have lower marginal costs by assimilating the technology or knowledge embodied in the imported products.

2.1 Demand

There are N countries in the world. The representative consumer derives his utility from consuming the products in M categories. The utility function takes the form:

$$U_s = \prod_{j=1}^{M} C_j^{\alpha_j}, \qquad \sum_{j=1}^{M} \alpha_j = 1 \tag{1}$$

where the subscript s is the country index. C_j is the composite goods of category j and it aggregates all the products (varieties) in category j according to a CES function:

$$C_j = \left[\int_0^1 c_{ij}^{\rho} di \right]^{\frac{1}{\rho}} \tag{2}$$

where c_{ij} is the variety in category j produced by firm i. Solving the consumer's maximization problem, country s's demand for firm i's product in category j can be derived:

$$c_{ijs} = \frac{Y_{sj} p_{ijs}^{-\sigma}}{P_{sj}^{1-\sigma}} \tag{3}$$

where $\sigma = \frac{1}{1-\rho} > 1$, Y_{sj} is the country s's expenditure in category j, p_{ijs} is the price of firm i's the product in category j in country s and $P_{js} = \left[\int_0^1 p_{ijs}^{1-\sigma} di \right]^{\frac{1}{1-\sigma}}$ is the aggregate price index of category j in country s. Firms take all price indices P_{js} as given when making separate decisions in different markets.

2.2 Multi-Product Firm and Sorting Pattern

Now we turn to a firm's decisions of export and import and we drop i, the subscript for firm. Each firm has the potential to produce only one good in category j by combining labor and productivity. A firm's productivity in a product consists of two components: firm-level ability $\phi > 0$ that applies to all the products produced by the firm and drawn from a distribution $g(\phi)$, and product-level expertise $\lambda_j > 0$ that applies to only a good in a particular category j and drawn from a distribution $z(\lambda)$. The distributions of firm-ability and product-expertise are independent of one another and common to all firms, and the product-expertise distribution is independent and identical across products. A firm's productivity in a product, $\theta_j = \phi\lambda_j$ depends on both the firm-ability and product-expertise. The marginal costs of production of the product j is w/θ_j where w is the wage rate and normalized to 1. A firm makes the decisions on the market entry and product introduction separately and a firm's price for product j doesn't affect the demand for his other products. A firm has to incur the fixed costs f_p to produce the product j for the domestic market and solves the following maximization problem:

$$\begin{aligned} \max_{p_{jh}, c_{jh}} \quad & \pi_{jh} = p_{jh}c_{jh} - \frac{c_{jh}}{\theta_j} - f_p \\ s.t. \quad & c_{jh} = \frac{Y_{hj}p_{jh}^{-\sigma}}{P_{hj}^{1-\sigma}} \end{aligned} \tag{4}$$

where the subscript h indicates the domestic market. The optimization problems yields the price for the firm's product in category j in domestic market:

$$p_{jh}^* = \frac{\sigma}{\sigma - 1}\frac{1}{\phi\lambda_j} \tag{5}$$

The optimal profits a firm can make in category j in the home country are given by:

$$\pi_{jh}^* = (\frac{\sigma}{\sigma - 1}\frac{1}{\phi\lambda_j}\frac{1}{P_{hj}})^{1-\sigma}\frac{Y_{hj}}{\sigma} - f_p \tag{6}$$

By setting π_{jh}^*equal to zero, the cutoff expertise for which domestic production is profitable can be derived as $\lambda_h(\phi)$. Only the products where a firm's product expertise is greater than $\lambda_h(\phi)$ will be produced for the domestic market if the firm's general ability is ϕ.

A firm selling to foreign markets has the option of learning from the imported foreign product. A firm can import a foreign variety in a product category, reverse-engineer it and produce its own variety in the same product category with the technology it learns from the imported variety. We call this type of import as product import, in order to distinguish from input import where the imports are directly used as intermediate inputs in the production. The optimal export mode is determined by solving the problem:

$$\max_{\mathit{1}\{Import\}} \quad \mathit{1}\{Import\}\pi^r_{jd} + (1 - \mathit{1}\{Import\})\pi^e_{jd} \tag{7}$$

where $\mathit{1}\{Import\}$ takes one if the firm chooses to export with learning from the imported foreign variety (r-export) and zero if the firm chooses to export without learning by importing (common export); π^r_{jd} and π^e_{jd} are the profits for firm i to export its variety in category j to foreign country d in the two modes and, respectively, given by:

$$\begin{aligned} \max_{p^r_{jd}, c_{jd}} \quad & \pi^r_{jd} = p^r_{jd}c_{jd} - \frac{\tau c_{jd}}{\gamma\theta_j} - f_r \\ s.t. \quad & c_{jd} = \frac{Y_{dj}(p^r_{jd})^{-\sigma}}{P^{1-\sigma}_{dj}} \end{aligned} \tag{8}$$

$$\begin{aligned} \max_{p^e_{jd}, c_{jd}} \quad & \pi^e_{jd} = p^e_{jd}c_{jd} - \frac{\tau c_{jd}}{\theta_j} - f_e \\ s.t. \quad & c_{jd} = \frac{Y_{dj}(p^e_{jd})^{-\sigma}}{P^{1-\sigma}_{dj}} \end{aligned} \tag{9}$$

where the superscripts e and r denote r-export and common export respectively; f_r and f_e are the sunk costs of two different export modes. The firm can assimilate the technology or knowledge embodied in the imported goods in category j and raise its productivity in producing goods in the same category to $\gamma\theta_j$ where $\gamma > 1$. Importing the product requires extra sunk costs, therefore the sunk costs related to r-export are higher than the those related to common export, i.e. $f_r > f_e$. Both types of export are subject to the iceberg costs: $\tau > 1$ units of products must be delivered for one unit of product arriving in the destination. We call the firm an r-exporter in category j if it r-exports products in category j and the firm a common exporter in category j if it only exports but doesn't import products in category j. The optimal prices for the firm's product in category j in foreign market d are given by :

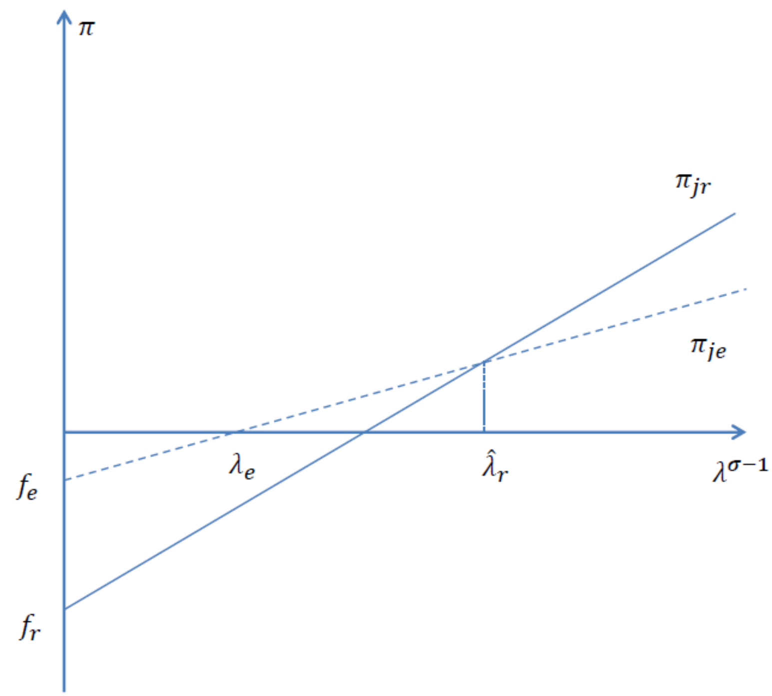
$$p^*_{jd} = \begin{cases} p^{r*}_{jd} = \frac{\sigma}{\sigma-1}\frac{\tau}{\gamma\phi\lambda_j}, & \text{if choosing r-export;} \\ p^{e*}_{jd} = \frac{\sigma}{\sigma-1}\frac{\tau}{\phi\lambda_j}, & \text{if choosing common export.} \end{cases} \tag{10}$$

Because $\gamma{>}1$, $p^{r*}_{jh} < p^{e*}_{jh}$, i.e. a firm will sell in the foreign markets at lower prices if it imports and learns from foreign variety than if it doesn't.

Within each firm, the ability ϕ is fixed. The profits the firm can make in category j in foreign market d are given:

$$\pi^*_{jd} = \begin{cases} \pi^{e*}_{jd} = (\frac{\sigma}{\sigma-1}\frac{\tau}{\phi\lambda_j}\frac{1}{P_d})^{1-\sigma}\frac{Y_{dj}}{\sigma} - f_e, & \text{if choosing common export;} \\ \pi^{r*}_{jd} = (\frac{\sigma}{\sigma-1}\frac{\tau}{\gamma\phi\lambda_j}\frac{1}{P_d})^{1-\sigma}\frac{Y_{dj}}{\sigma} - f_r, & \text{if choosing r-export.} \end{cases} \tag{11}$$

Figure 1: Profit Curves and Product Sorting in Foreign Market



By setting π_{jd}^{e*} equal to zero, the cutoff expertise for which common export is profitable can be derived as $\lambda_e(\phi)$. Furthermore, by setting π_{jd}^{e*} equal to π_{jd}^{r*}, the cutoff expertise for which the firm with the ability ϕ can make more profits by importing product can be derived as $\hat{\lambda}_r(\phi)$. $\hat{\lambda}_r(\phi)$ could be smaller than $\lambda_e(\phi)$. Here we assume that f_r is sufficiently greater than f_e such that $\hat{\lambda}_r(\phi) > \lambda_e(\phi)$. We also assume that f_e is sufficiently greater than f_h such that $\lambda_e(\phi) > \lambda_h(\phi)$. A firm will choose to be an r-exporter if $\pi_{jd}^{r*} \geq \pi_{jd}^{e*}$ and to be a common exporter if $\pi_{jd}^{e*} > \pi_{jd}^{r*}$. Figure 1 illustrates the product sorting pattern in foreign market. A firm will be a common exporter in its products of the expertise between λ_e and $\hat{\lambda}_r$. The firm will be an r-exporter in its products of the expertise above $\hat{\lambda}_r$. Some products (of expertise between $\lambda_h(\phi)$ and $\lambda_e(\phi)$) are sold only in the domestic market. Proposition 1 summarizes the product sorting pattern.

Proposition 1. *(Product Sorting Within Firm) Within the firm, a firm will sell the variety in the product category where its expertise is lower only in the domestic market; sell the variety in the product variety where it has medium expertise in the domestic and foreign markets; and import the foreign variety in the product category where its expertise is higher* *and sell its own variety in the same product category in both the domestic and export markets.*

We assume that reverse-engineering foreign variety accumulates a firm's product expertise and has no impacts on its ability, the expected productivities of non-traders, common exporters and import-exporters can be derived following the procedure in Bernard et al. (2011):

$$\begin{aligned}
\tilde{\theta}(\phi) &= \frac{\phi^{\sigma-1}}{Z(\lambda_e(\phi)) - Z(\lambda_h(\phi))} \int_{\lambda_h(\phi)}^{\lambda_e(\phi)} \lambda^{\sigma-1} z(\lambda) d\lambda \\
\tilde{\theta}_e(\phi) &= \frac{\phi^{\sigma-1}}{Z(\hat{\lambda_r}(\phi)) - Z(\lambda_h(\phi))} \int_{\lambda_h(\phi)}^{\hat{\lambda_r}(\phi)} \lambda^{\sigma-1} z(\lambda) d\lambda \\
\tilde{\theta}_r(\phi) &= \frac{\phi^{\sigma-1}}{1 - Z(\lambda_h(\phi))} \left[\int_{\lambda_h(\phi)}^{\hat{\lambda_r}(\phi)} \lambda^{\sigma-1} z(\lambda) d\lambda + \int_{\hat{\lambda_r}(\phi)}^{\infty} (\gamma\lambda)^{\sigma-1} z(\lambda) d\lambda \right]
\end{aligned} \tag{12}$$

If we assume that learning-from-importing raises a firm's ability instead[4], the aggregate productivity for an r-exporter is:

$$\tilde{\theta}_r(\phi) = \frac{(\gamma\phi)^{\sigma-1}}{1 - Z(\lambda_h(\phi))} \int_{\lambda_h(\phi)}^{\infty} \lambda^{\sigma-1} z(\lambda) d\lambda \tag{13}$$

In either case, we can obtain that $\tilde{\theta}_r > \tilde{\theta}_e > \tilde{\theta}$. The traders have higher productivity mainly because they have better draw of expertise. Besides, the r-exporters derive productivity growth from importing the product. Proposition 2 summarizes the productivity sorting pattern.

Proposition 2. *(Productivity Sorting Across Firms) The productivity of r-exporters is higher than that of common exporters. The productivity of non-traders is lowest among all the firms.*

Propositions 1 and 2 are tested using the data from China in the following sections.

3 Data

The current paper utilizes two data sources. One is the transaction-level data collected by General Administration of Customs of P.R.C. from 2000 to 2006. Each of the records in the data contains the information about the firm's identification, the trade flow, the transaction type, the HS code, the trade quantity, the trade value and the trade partner country. We define product category with the 8-digit HS code reported in the dataset. The first 6 digits

[4]This assumption is rejected by the empirical result where we don't find such spillover effects

of HS code are provided by World Customs Organization and are the same across countries. The last two digits of HS code are left for each country's adjustment. Classification of goods at 8-digit HS code level is very detailed. For example, the 8-digit HS code 85299042 represents "non special purpose image taking module", which is described with details: "non special purpose image taking module has optical lens, CMOS/CCD image sensor and primary signal processing circuit (for example, A/D converter), but doesn't have digital signal processing circuit".

The transaction type relates to the regulation of the trade. Only the transactions of "Ordinary Trade" type are included in our analysis and we exclude processing trade. The imported product will not be categorized by "Ordinary Trade" if they are returned items. The import of the samples by the firms who produce according to the buyer's samples will not be categorized as "Ordinary Trade", either. By further checking the history of a firm's exports, we can confirm that the r-exporters are not conducting pass-on trade[5] (Damijan et al. (2013), Damijan et al. (2014)), in other words, we focus on the pattern that a firm simultaneously imports and exports in the same product category where it only exports previously.[6] With these restrictions, the firms in the sample import a foreign variety in a product category and export its own variety in the same product category.

The other data we employ is the firm-level survey data collected by China Statistic Bureau during the same period. The survey covers all the state-owned manufacture firms and the non-state-owned manufacture firms with annual sales above 5 million Chinese dollars (about 0.8 million U.S. dollars). The survey records the firm's identification information, capital, employees, total sales, total wages and other production data that are extracted from balance sheets and financial statement. The two data set are matched by firm's identification information, including firm name, firm address, phone number, post code and the contact person.

In the construction of the sample, we first pick up the firms with 2-digit Chinese Industry Code 34-41. These industries covers the electrical instruments, mechanical equipments, vehicles, and communication equipments. These industries are of high-technology and capital-intensive and China doesn't have comparative advantage in these industries. The distance of Chinese firm's technology in these industries to the world frontier is greater, thus the technology diffusion may be more significant in these industries. Then we match the firms year

[5]Pass-on trade(POT) refers to trade pattern that firms simultaneously export and import the same products which they import previously.

[6]More precisely, firm i engage in the trade of interest in product j if $x_{ijt} > 0$, $m_{ijt} > 0$, and $m_{ijs} = 0$, here s is the period that firm-product pair ij appears for the first time in the custom data.

by year using the identification information and build a balanced panel sample containing 7085 firms in each year from 2000 to 2006. We identify the trade status of the sampled firms according to their export and import value in the custom data. We consider only the export and import in the industries with the 2-digit code from 85 to 90 which correspond to the electrical instruments, mechanical equipments, vehicles, and communication equipments.[7]

We are interested in the firms who import in the category where they themselves can produce and export a vareity. However, we don't have the data on the production data on firm-product level. Therefore we use the export and import data to look for the firms of interest. Simply defining the firms who import and export in the same category in the same period as r-exporters doesn't work out because a firm may be a POT trader who passes its imports on to exports according to Damijan et al. (2013) and Damijan et al. (2014). Hence, by examining a firm's historical status of export and import in the data, we define POT trader and r-exporter as follows:

$$\begin{aligned} POT\ Trader_{ijt} &= 1 \quad if \quad x_{ijt} > 0, m_{ijt} > 0, m_{ijs} > 0 \\ R\text{-}Exporter_{ijt} &= 1 \quad if \quad x_{ijt} > 0, m_{ijt} > 0, m_{ijs} = 0 \end{aligned} \tag{14}$$

where s is the period when firm-product pair ij appears in the dataset for the first time[8]. Examples of POT traders and r-exporters are given in the top and bottom panels in Table 1 respectively. Before 2006 when the firm identified by Panel Id in the top panel exported in 8-digit HS category 85115090 (a kind of generator), it started its trading with importing in this category in 2001, so this firm is treated as a POT trader in this category in 2006. The case in the bottom panel is more subtle. The firm in that panel stopped trading in the 8-digit HS category 87119000 (a kind of motorcycle) in 2003, but it exported and imported in the same category in 2004. We track the firm's history of trade in this category to 2000 when it started trading in this category and find that it started trading with exporting. This firm is categorized as r-exporter in this category in 2004 and as common exporter in this category in other years. Our definition will treat the firm in the bottom panel as r-exporter in 2005 if it exported in that year, while the firm will be a POT trader according to Damijan's definition. If a firm doesn't import in the category where it exports in the same period, we define it as common exporter in that category. Table 2 summarizes the different types of exporters. R-exporters are quite rare, only 15% of exporters are of this type. About one

[7] A new version of HS code came in 2002. Four 6-digit HS categories in 2-digit HS industry 85 in old version are recoded to industry 84 in the new version, we dropped these categories. Some 6-digit HS categories in old version are divided into different categories in the new version, we drop these categories, too. The dropped 6-digit categories account for about 4% of all 6-digit categories in industries 85-90.

[8] Damjian's definition on POT is $POTer_{ijt} = 1$ if $x_{ijt} > 0$, $m_{ijt} > 0$ or $m_{ij,t-1} > 0$

forth of the exporters engage in POT trade, this ratio, however, is still much lower than that documented by Damijan et al. (2013) who find 70% of exporting firms actually engage in POT in Slovenian data. Around 40% of r-exporters also engage in POT in different product categories. One may guess that an r-exporter doesn't need to import in large volume because reverse-engineering requires only a small number of samples of the product. For example, in the bottom panel in Figure 1, the export value of the r-exporter is 800 times greater than its import value in 2004. This is further confirmed in the data. We find that the median value of the ratios of the export value of an r-exporter to its import value in the same period is 37, while the median ratio for POT traders is only 0.42.

Firm ownership structure also has some effects on firm's POT trade and r-export. According to the firm type reported in the firm survey data, we divide firms into foreign firms that are either foreignly-owned or joint ventures, HKT firms that are owned by the capital from Hongkong, Macau or Taiwan, state firms that are state- or collective-owned, and private firms. Foreign firms and joint venture may have better access to foreign products, and they may also have better expertise than domestic firms. In the data, we find 59.7% of firm-product pairs defined as r-export are carried by foreign firms. HKT firms account for 22.8% of r-export firm-product pairs. Private firms have stronger incentive to learn from imported product than the state firms and they conduct 12.5% of r-export cases. State firms only account for 4.5% of r-export cases. We also find that foreign firms dominate POT trade: 81.1% of POT trade cases are carried by them.

Table 3 summarizes the transition probability of a firm's trade status. It's worthy to point out that nearly half of the exporters are also importers. A firm may simultaneously engage in POT trade and r-export in differen products, we consider the firms who engage in only one of POT trade and r-export when calculating the probability. The status is generally persistent. For example, less than 4% of non-exporters in the current period start trading next period. Current common exporters will continue exporting with probability 70%. 70% of POT traders and 50% of r-exporters stick to the trade mode but they may change their import varieties. The persistence in the trade status may imply the possibility of sunk costs for trade.

Table 4 replicates the well-known heterogeneity across the firm cohorts defined by the trade status in the trade literature. We consider the firms who engage in only one of POT trade and r-export when calculating their characteristics. The comparisons of the non-exporters and the common exporters show that the common exporters are a little more productive than the non-exporters in terms of both value added per worker and total factor productivity although they have almost two times greater scale in terms of sales, employment and fixed assets. This suggests that some unobserved heterogeneity besides the productivity may play an important part in a firm's export decision. Proceeding to the comparisons including other types of traders, we find that the POT traders are much more productive than other firms and they have the largest scale in terms of every measure in the table. The r-exporters are more productive than non-exporters and common-exporters, this may imply that the costs related to importing are much more substantial than exporting, so the firms have to be sufficiently productive to overcome the barrier of importing. The pattern in this table is consistent with Proposition 2 except we don't have a position for POT traders in our theory.

Tables 5 and 6 report the import probability of the export variety by the export quantity ranking and over years. Only the firms exporting at least 10 products are considered. The export quantity ranking is defined within each firm and it reflects a firm's expertise in a product category. The higher expertise a firm has in a product category, the more the firm exports in that category. The import probability is the percentage of the firms who import in their k^{th} product category. For example, 4% of the firms with at least 10 export varieties in 2000 imported in their product categories where they exported the most in the same year. One trend stands out from Table 5: roughly speaking, an r-exporter imports in the product category where it has higher export records with greater probability. The sorting pattern in this table is supportive of Proposition 1. We don't find similar pattern for POT traders in Table 6. The import probability is kind of stable over the popularity, if not decreasing.

Figure 2 displays the countries from which POT traders and r-exporters import the product. About two-third of the firms import from OECD countries. We use Figure 3 to compare the surviving years of firm-product pair in export market by trade type. As an example, the firm-product pairs in the top and bottom panels in Figure 1 survived 1 and 5 years in export market respectively. We drop the observations in 2000. We find that around one half of the firm-product pairs of POT trade survived for only 1 year in export markets and less than 10% of them survived the whole period; while almost all the firm-product pairs of im-export survived for multiple years in export markets and one third of them kept exporting for 6 years.

4 Empirical Evidence: Sorting Pattern

This paper examines the sorting pattern across firms by estimating an ordered probit model:

$$Status_{it} = \begin{cases} 0, & if \quad \alpha_0 + \alpha_1 Prod_{it} + \alpha_2 Prod_{it}^2 + X\beta + \epsilon_{it} < c_0; \\ 1, & if \quad c_0 \leq \alpha_0 + \alpha_1 Prod_{it} + \alpha_2 Prod_{it}^2 + X\beta + \epsilon_{it} < c_1; \\ 2, & if \quad \alpha_0 + \alpha_1 Prod_{it} + \alpha_2 Prod_{it}^2 + X\beta + \epsilon_{it} \geq c_1. \end{cases} \tag{15}$$

where $Status_{it}$ is the foreign market participation status of firm i in year t. $Status$ takes 0 if the firm doesn't export to the foreign market, 1 if the firm only exports to foreign market, 2 if the firm exports and imports in the same product category; c_0 and c_1 are the thresholds for common exporter and r-export respectively. We drop POT traders from the sample. X is a vector of control variables and $Prod_{it}$ is the firm's productivity in year t. The squared productivity is included for the marginal effects of the productivity on the status may decrease.

This model is estimated by maximizing the log likelihood function. The contribution of each observation to the likelihood function is:

$$\begin{aligned} p_{it} = \sum_{k=0}^{2} I_k(Status_{it})[&\Phi(c_k - \alpha_0 - \alpha_1 Prod_{it} - \alpha_2 Prod_{it}^2 - X\beta) \\ &- \Phi(c_{k-1} - \alpha_0 - \alpha_1 Prod_{it} - \alpha_2 Prod_{it}^2 - X\beta)] \end{aligned} \tag{16}$$

where $I_k(Status_{it})$ takes a value of 1 if $Status_{it} = k$ and 0 otherwise. $\Phi(\cdot)$ is the standard normal cumulative distribution function. c_{-1} is defined as $-\infty$ and c_2 as ∞. c_1 is assumed to be greater than c_0 in order to guarantee positive probabilities. The log likelihood is given by:

$$lnL = \sum_i \sum_t ln(p_{it}) \tag{17}$$

Tables 7 reports the results from the estimation. We use two alternatives to capture a firm's productivity. The one is TFP that is estimated with Olley-Pakes method (Olley and Pakes, 1996)[9] and the other one is added value per employee. Capital is used to control for the firm scale. Firms may learn from their previous trade participation, so the lagged status is included to control for the learning-by-doing effects and the observations in the beginning year are dropped. We report the results from the specification without the quadratic productivity terms in the first two columns and results from the specification including the

[9]We use the package provided by Yasar et al.(2008).

quadratic productivity terms in the last two columns. The coefficients on the productivity in all the columns are positive and significant, which suggests that the more productive firms are more likely to be a trader while the less productive firms are more likely to serve only the domestic market. The coefficients on productivity in the first two columns are positive and close to the absolute value of the coefficients on the quadratic productivity terms in the last two columns, which implies that our observations are located on the increasing (left) part of the quadratic function. Meanwhile, the negative and significant coefficients on the quadratic productivity terms reminds us that the marginal effects decrease with the productivity. The threshold for r-exporters (c_1) is higher than that for common exporters (c_0), which confirms that r-export is more difficult than common export. We also employ another specification that includes POT traders. POT traders are given the order between common exporters and r-exporters. The results reported in Table 8 confirms again the role of productivity in determining the trade mode. Moreover, the thresholds confirms that r-export is the most difficult trade mode. This is in sharp contrast to Table 4 where POT traders have the highest value added and largest scale.

We present another set of results from regressing the productivity on the status dummies in Table 9. The lagged status is included to control the learning effects from previous participation in trade. In all the columns, the non-exporters are used as the reference. In column (1), we find that the TFP of both r-exporters and common exporters are higher than non-exporters and we reject the hypothesis that the coefficient on $IEer_{it}$ is equal to that on $common\ exporter_{it}$, i.e. the TFP of r-exporters is higher than that of common exporters. However, this difference disappears after we take firm-fixed effects into account and employ within estimation in column (2), i.e. we regress a firm's productivity deviation from its historical average productivity on its trade status and controls. None of the coefficients on the trade status dummies is significantly positive in column (2), therefore the deviation of a firm's productivity from its historical average is not correlated to the trade participation. In the first two columns, we treat the firm who simultaneously engages in POT and r-export as an r-exporter. We treat this type of firms as POT traders and control firm-fixed effects in column (3). Again, we fail to find any significant coefficients. In summary, we find that the r-exporters are more productive than common exporters and non-exporters, but the abnormal positive deviation of a firm's TFP from its average TFP is not caused by trade participation.

The model also predicts that a firm will import the product of his better expertise. This cannot be directly tested in our data because we cannot observe firm-product level production information. So we turn to examine the product sorting pattern by estimating the logit model:

$$I(IEer_{ijt}) = Expertise_{ijt}\beta + X\delta + \varepsilon_{ijt} \tag{18}$$

where $IEer_{ijt}$ (r-exporter) is defined in Equation 14. We cannot measure the expertise from the production data at firm-product level due to data availability. We resort to the export data and measure expertise in the following way:

$$Expertise_{ijt} = ln\left(\frac{EQ_{ijt}}{\min_k(EQ_{ikt})}\right) \tag{19}$$

where EQ_{ijt} is the export quantity of product j by firm i in year t. The intuition behind this measure is that a firm will export the product of his higher expertise in the larger quantity[10]. This definition will underassess the expertise of single-product exporters (that is zero), so we also estimate this model using the subsample of multi-product exporters. The vector of control variables X includes the firm characteristics such as sales revenue, wage per worker, firm age, and capital intensity. The import tariff is also included.

The results reported in Table 10 are supportive of Proposition 1. The coefficient on $Expertise_{ijt}$ in column (1) is positive and statistically significant, so the product of a firm's higher expertise is more likely to be imported. We also find that the lower tariff raises the probability of import as the negative coefficient on $Tariff_{jt}$ shows. In order to address the concern on the omitted variables, we control firm characteristics including sales, firm age, capital intensity and wage in column (2). The coefficient on $Expertise_{ijt}$ is reduced after firm characteristics are controlled, but it's still positive and significant. Firms who export multi products may be more experienced in the international trade so they may know better about their expertise. So we reestimate the model using the subsample of the firms who export at least 10 kinds of products and the results are reported in Columns (3). Using the subsample of multi-product exporters can also correct the problem of under-measuring the product expertise. We find that the coefficient on $Expertise_{ijt}$ is almost two times greater in column (3) than in other columns and significant. However, we find that the effects of import tariff are not significant.

The above results show that import decision is negatively correlated with import tariff, but sometimes not significantly. Because import tariff reflects both the import competition (import competition rises as the tariff reduces) and part of variable costs related to import, it's hard to tell what is behind the negative coefficients on tariff. We try to disentangle these two by adding import value of a product j in the province where firm i is located , which is

[10] In the multi-product firm theory, the ratio of demands for firm i's products j and k is a function of the ratio of firm i's expertise on the products: $\frac{c_{ij}}{c_{ik}} = (\frac{\lambda_j}{\lambda_k})^{\sigma}$.

$import_{jpt}$, to measure the import competition in column (4) in Table 10. The import value of a product in a province is aggregated at 8-digit HS code level. The inclusion of import competition doesn't violate the conclusion that a firm will import the product of his better expertise and the magnitude of the effects is very close to that in columns (1) and (2). The coefficient on $ln(import_{jpt})$ in column (4) shows that the import competition does encourage a firm to import the same product. The coefficient on the tariff is not significant, so we conclude that the higher import tariff does't have significant effects on a firm's decision of import if a firm wants to learn from imported products.

5 Additional Evidence

The above empirical evidence confirms the predicted sorting pattern of the model at the firm and firm-product level. The evidence shows that engaging in either POT or r-export doesn't contribute to firm-level productivity growth, similar to the conclusion of Damijan et al. (2014) who show that POT has less favorable effects on productivity growth. So we turn our eyes to the export performance at firm-product level and try to find the evidence on the export promotion effects of either POT or r-export. Empirically, this is done by estimating the equation:

$$EXP_{ijt} = \delta_1 IEer_{ijt} + \delta_2 POTer_{ijt} + \beta X_{ijt} + \varepsilon_{ijt} \tag{20}$$

Here, EXP is the export performance indicator, which is either the export price p_{ijdt} or the country coverage n_{ijt}. The construction of these indicators will be explained in the following subsections where the indicators are used. X is a vector of firm-level control variables and dummies. $IEer_{ijt}$ (r-exporter) and POT_{ijt} (POT trader) are defined in Equation 14. We estimate this equation with fixed-effect model and obtain within-estimator.

5.1 Export Prices and Market Coverage

The r-exporters raise their productivity to $\gamma\theta_j$ by learning from the imports compared to the common exporters, which suggests the negative correlation between the export price change and the import status at firm-product level. The export prices can be calculated from the data. However, the prices may vary with the product quality as well as the productivity, so, following Khandelwal et al. (2013), we use the estimated quality to adjust the prices. Specifically, we estimate the quality of the product j exported to destination d by firm i in year t as the residual of the regression[11]:

$$ln(q_{ijdt}) + \sigma ln(p^u_{ijdt}) = \phi_j + \phi_d + \phi_t + \phi_{dt} + \epsilon_{ijdt} \tag{21}$$

where q_{ijdt} is the export quantity and p^u_{ijdt} is unadjusted export price. The quality-adjusted prices are $p_{ijdt} = ln(p^u_{ijdt}) - \hat{\epsilon}_{ijdt}/(\sigma - 1)$. Then, we examine the correlation between the import status and quality-adjusted export prices by estimating the following equations:

$$p_{ijdt} = \delta_1 IEer_{ijt} + \delta_2 POTer_{ijt} + \beta X_{ijt} + \sigma_{ijd} + \varepsilon_{ijdt} \tag{22}$$

where X is a vector of control variables. We estimate this equation with firm-product-market fixed effects σ_{ijd}.

R-exporters raise their productivity to $\gamma\theta_j$ by assimilating the technology embodied in the imports and the higher productivity enables them to deliver the product to more countries. We examine the relationship between the trade extensive margin and importing by estimating the following equations:

$$ln(n_{ijt}) = \delta_1 IEer_{ijt} + \delta_2 POTer_{ijt} + \beta X_{ijt} + \sigma_{ij} + \varepsilon_{ijt} \tag{23}$$

where n_{ijt} is the number of the countries to which firm i export its variety in product category j. We estimate this equation with firm-product fixed effects σ_{ij}.

5.2 Results

The benchmark results from estimating Equations 22 and 23 are reported in Table 11. We employ the within estimation. The coefficients on $IEer_{ijt}$ in the first two columns shows the r-exporters export their varieties in a product category at lower price when they import in the same category than when they don't import. The POT traders also export their varieties in a product category to more foreign markets when they import in the same category, but the effects are smaller than the effects for r-exporters; meanwhile, the POT traders don't lower their export prices when they import in the same product category; to the contrary, they raise their export prices. The results in the first two columns suffer from the lack of time-varying control variables. So, in columns (3) and (4), we add firm and firm-product level controls including firm-product expertise, sales, wage, capital intensity, and firm age.

[11]Suppose the utility function is $U = \left(\int_{\phi\in\Omega}(\lambda(\phi)q(\phi))^{\frac{\sigma-1}{\sigma}}d\phi\right)^{\frac{\sigma}{\sigma-1}}$, where $\lambda(\phi)$ is the quality of product ϕ, the demand can be derived as: $q_{ijdt} = \lambda^{\sigma-1}_{ijdt}p^{-\sigma}_{ijdt}P^{\sigma-1}_{dt}Y_{dt}$, so the demand is higher for the product of higher quality when other factors are controlled. Taking logarithm on the both sides of the demand gives the regression function.

The coefficients on $IEer_{ijt}$ in the last two columns change a little but are still significant and have the same signs as in the first two columns. Both the coefficients on $POTer_{ijt}$ in the last two columns are not significant. This suggests that when the POT traders utilize their multinational marketing network to deliver their in-house produced and outsourced products, they cannot reduce the export prices for their outsourced products because that will incur losses.

Some people may be interested in the source effects that importing from countries closer to the technology frontier may have more important effects than from countries distant from the frontier. We consider this problem by dividing the source countries into OECD countries and non-OECD countries and interacting firm's trade status with their source country group. The results are reported in Table 12. In the first two columns reports the benchmark results. Now, we find that importing from the OECD countries significantly reduces the export prices for r-exporters while importing from non-OECD countries does't have such effects. Importing from both OECD and OECD countries helps an r-exporter expand its coverage over export destinations. POT traders also benefit from importing (sourcing) foreign products. In columns (3) and (4), we add the firm and firm-product level controls. We find that the effects for r-exporters are still significant. However, POT traders raises the export prices when they import from OECD countries and the effects are significant at 10% level, and POT traders deliver their outsourced products to more countries if they import from non-OECD countries.

The product-level evidences presented above demonstrate the strong relationship between a firm's export performance in a product category and its importing in the same category. However, the relationship could arise because of other factors, especially in the context of this paper that China experienced the import tariff deduction after the accession to the WTO. The import competition due to the tariff deduction could force the firm to adopt new technology. Economists have discussed many mechanisms on the import competition and firm performance (Amiti and Konings (2007), Amiti and Khandelwal (2013), Verhoogen (2008), Bustos (2011), and Liu (2010),). To address this concern, this paper adds the import competition terms to the equations of both the export prices and the coverage over export markets. The results are reported in the last two columns in Table 12. We use the import value of product j in province p where firm i is located in period t to capture the import competition. We consider the the export prices first. The coefficient on $ln(import_{jpt})$ is negative and significant in column (5), suggesting that firms who face stiffer competition export at lower prices. The impacts of competition on a firm's export market coverage is less important as the coefficient on $ln(import_{jpt})$ is not significant in column (6). The inclusion of import competition doesn't alter the signs of the coefficients on $Import_{ijt}$.

The export performance could also improve due to the advanced intermediate input import. To examine the influences of the input import, we include several input import indicators in Equations 22 and 23. we choose three popular input import indicators: the share of imported input in the total input, the variety scope of the imported input, and the imported input value. All of these indicators may capture some technology diffusion effect via intermediate input import. The results are reported in Tables 13. The first three columns report the effects on export prices and the last three columns report the effects on country coverage. We don't find any significant effects of input import on either export prices or country coverage if imported input value or imported input variety is used. When we use imported input share to measure the input import, we find statistically significant effects on both export prices and country coverage, however, it's not economically significant. Controlling the input import doesn't alter the conclusion on the source effects above. According to our results, importing from OECD countries is a more effective strategy to promote export than from non-OECD countries for r-exporters and POT traders are excellent middlemen who purchase the products from somewhere and sell elsewhere.

So far, the empirical evidence has confirmed that a firm may learn from the imports and improve its own efficiency in producing the same products. Some people may be interested in whether there are any spillover effects that importing in one product category will improve a firm's efficiencies in the production in its all product categories. We consider this problem in Table 14. In this table we consider only the firm-product pairs with positive export and zero import. We redefine r-export and POT trader at firm level as follows: a firm is r-exporter if it engages in r-export in any of its product and similar for POT traders. We also distinguish between OECD and non-OECD countries. The results are reported in Table 14. We don't find any significant effects on either export price or country coverage for either r-exporters or POT traders.

Finally, one may be concerned that our results are not robust because we consider the trade of only the firms who appear during the whole period from 2000 to 2006. Some firms may quit from not only the export market but also the domestic market. Next step considers the trade of all the firms and reports the results in Table 15. The effects for r-exporters are still significant and of the similar magnitude to estimates in the balanced panel sample of firms. We also find some statistically significant effects for POT traders.

6 Conclusion

This paper finds a significant relationship between import and export performance improvement at the firm-product level. The paper first confirms that a firm's expertise on its product is crucial for its trade decisions. A firm will import the product of its better expertise. Then this paper provides the empirical evidence on the relationship between the product import and export performance. For the r-exporters derive the productivity gains by assimilating the technology embodied in the imports, they improve their efficiencies in producing the same product. Therefore they reduce their costs of production and charge less for their exports than if they behave as common exporter. Also, their exports cover more markets than common exporters.

These results support that the firms in developing countries can improve their efficiencies in producing a specific product by importing the same product from other countries. Hence this paper has some implications for a country's development. In this paper, we choose the technology- and capital-intensive industries where China doesn't have comparative advantages in international trade. We show that, in these industries, a firm can learn from the imported final products and improve the same products it produces in-house and learning from the final products is much more effective than importing the intermediate inputs.

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7 Tables and Figures

Table 1: Examples of different bilateral traders

(a) POT traders

Panel Id	HS	Year	Export Value	Import Value
2000 27328	85115090	2001	0	27615
2000 27328	85115090	2002	0	1330
2000 27328	85115090	2003	0	280
2000 27328	85115090	2004	0	13670
2000 27328	85115090	2005	0	31009
2000 27328	85115090	2006	151	85706

(b) R-exporters

Panel Id	HS	Year	Export Value	Import Value
2000 24897	87119000	2000	286800	0
2000 24897	87119000	2001	3558	0
2000 24897	87119000	2002	163607	0
2000 24897	87119000	2004	649973	738
2000 24897	87119000	2005	9100	0

Table 2: Firm Types

Year	2000	2001	2002	2003	2004	2005	2006
Total Exporter	845	968	1019	1137	1230	1268	1325
R-Exporter(IEer)	0	67	130	171	195	185	190
POT trader(POTer)	245	237	278	308	337	349	341
Common Exporter	600	693	673	724	781	812	880
Non Exporter	6240	6117	6066	65948	5855	5817	5760
Total Firms	7085	7085	7085	7085	7085	7085	7085

[1] $IEer_{ijt} = 1$ if $x_{ijt} > 0$, $m_{ijt} > 0$, $m_{ij,s<t} = 0$ and 0 otherwise and s is the period when firm-product pair ij appears in the dataset for the first time. So there is no r-exporter in 2000, which is the beginning period. A firm can be both r-exporter and POT trader if it engages in these two types of trade in different product categories.

Table 3: Probability of Transition of Trade Status

t\t+1	Non-Exporter	Common-Exporter	POTer	R-Exporter
Non-Exporter	0.961	0.030	0.008	0.001
Common-Exporter	0.166	0.709	0.052	0.073
POTer	0.111	0.168	0.701	0.019
R-Exporter	0.060	0.400	0.040	0.500

A firm may simultaneously engage in POT in one product category and r-export in another category. In calculating the transition probability, we consider only the firms who engage in one of POT and r-export.

Table 4: Firm Characteristics

Statistic: Mean

Indicators	Sales	Employment	Fixed Assets	Productivity 1	Productivity 2
Non-Exporters	105800	362	30639	82	0.655
Common Exporters	194416	608	63823	83	0.688
R-Exporters	254754	693	70245	102	0.727
POT traders	987622	987	200817	235	0.784

[1] Productivity 1: added value per worker. Productivity 2: Total Factor productivity. A firm may simultaneously engage in POT in one product category and r-export in another category. When calculating the mean of the variables, we consider only the firms who engage in one of POT and r-export.

Table 5: Export Quantity Ranking and R-Export Probability

Export Quantity Ranking	2001	2002	2003	2004	2005	2006
1	0.04	0.06	0.08	0.09	0.08	0.08
2	0.02	0.07	0.07	0.07	0.07	0.06
3	0.04	0.03	0.05	0.05	0.03	0.04
4	0.02	0.03	0.03	0.05	0.04	0.04
5	0.02	0.01	0.02	0.04	0.04	0.04
6	0.02	0.07	0.06	0.02	0.04	0.02
7	0.05	0.05	0.02	0.02	0.03	0.02
8	0.00	0.04	0.03	0.04	0.02	0.03
9	0.03	0.04	0.03	0.05	0.03	0.05
10+	0.01	0.02	0.02	0.03	0.02	0.03

This table is constructed by using the subsample of firms exporting at least in 10 products categories.

Table 6: Export Quantity Ranking and POT Probability

Export Quantity Ranking	2000	2001	2002	2003	2004	2005	2006
1	0.22	0.17	0.18	0.19	0.18	0.19	0.17
2	0.21	0.17	0.17	0.19	0.20	0.18	0.17
3	0.16	0.16	0.20	0.17	0.20	0.21	0.17
4	0.21	0.16	0.20	0.19	0.19	0.17	0.18
5	0.21	0.17	0.22	0.19	0.23	0.25	0.19
6	0.19	0.17	0.18	0.22	0.22	0.24	0.23
7	0.14	0.15	0.22	0.21	0.25	0.22	0.29
8	0.17	0.29	0.21	0.27	0.25	0.23	0.24
9	0.18	0.24	0.29	0.30	0.20	0.30	0.21
10+	0.18	0.10	0.23	0.26	0.32	0.32	0.30

This table is constructed by using the subsample of firms exporting at least in 10 products categories.

Figure 2: Source Countries

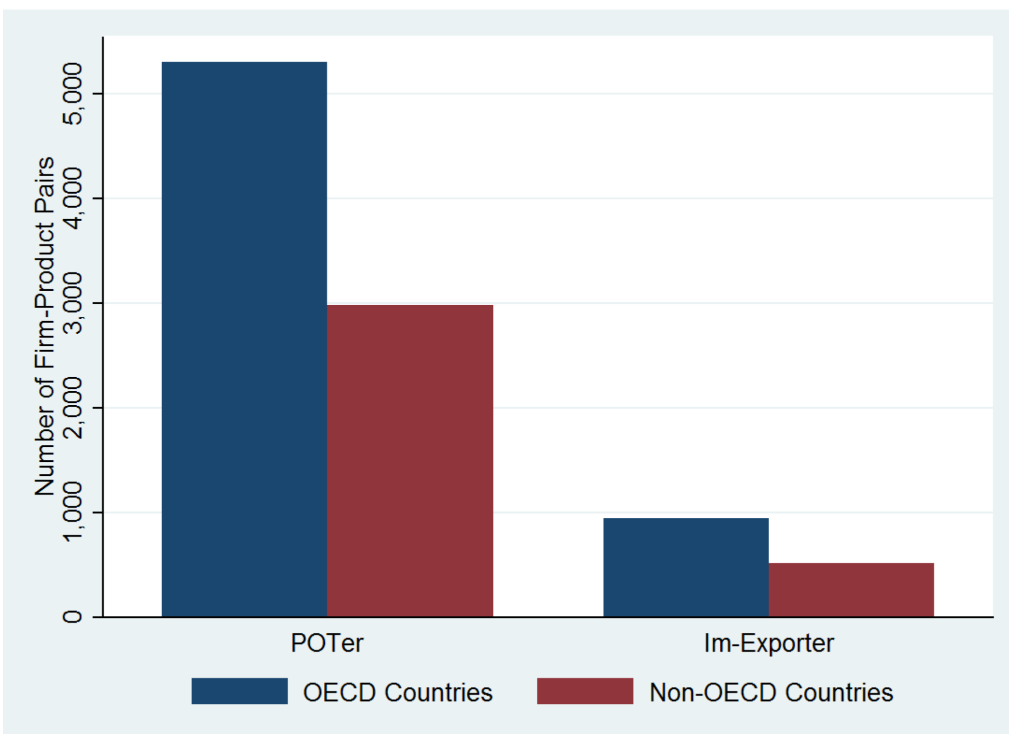

Figure 3: Surviving Years of Firm-product Pair in Export Market by Trade Type

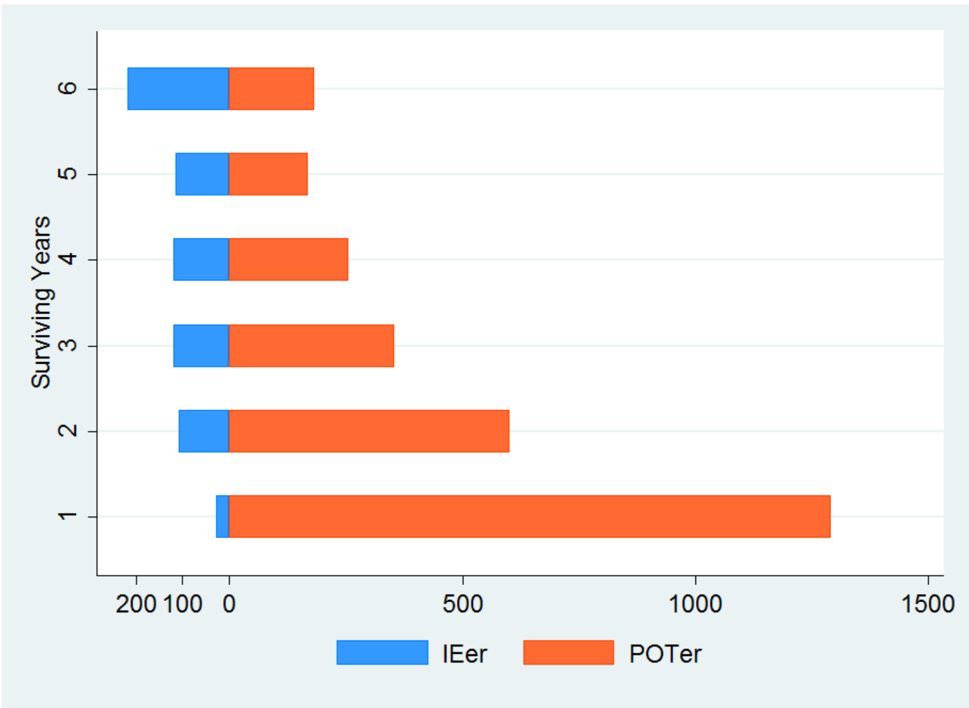

Table 7: Firm Self Sorting Pattern

	(1)	(2)	(3)	(4)
Variables	$Status_{it}$	$Status_{it}$	$Status_{it}$	$Status_{it}$
$ln\frac{value\ added}{employment}$	0.021**		0.272***	
	(2.261)		(5.541)	
TFP		0.071***		0.344***
		(3.469)		(4.561)
$\left(ln\frac{value\ added}{employment}\right)^2$			-0.033***	
			(-5.241)	
TFP^2				-0.119***
				(-3.167)
$ln(capital)$	0.087***	0.090***	0.091***	0.090***
	(13.323)	(13.869)	(13.536)	(13.925)
Year	Yes	Yes	Yes	Yes
Lagged Status	Yes	Yes	Yes	Yes
Cutoffs				
c_0	2.714***	2.701***	3.188***	2.812***
	(38.614)	(40.533)	(27.059)	(38.572)
c_1	5.024***	5.006***	5.502***	5.120***
	(62.776)	(65.433)	(43.513)	(62.624)
N	38943	39670	38943	39670
pseudo R^2	0.498	0.498	0.499	0.499

t statistics in parentheses. Significance level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, $Status = 0$ for non-exporters, 1 for common exporters, 2 for r-exporters.

Table 8: Firm Self Sorting Pattern: Continued

Variables	(1) $Status_{it}$	(2) $Status_{it}$	(3) $Status_{it}$	(4) $Status_{it}$
$ln\frac{value\ added}{employment}$	0.184***		0.171***	
	(5.395)		(4.721)	
$\left(ln\frac{value\ added}{employment}\right)^2$	-0.014***		-0.012***	
	(-3.458)		(-2.768)	
TFP		0.380***		0.381***
		(6.065)		(5.856)
TFP^2		-0.080***		-0.080***
		(-2.990)		(-2.878)
$ln(capital)$	0.118***	0.126***	0.115***	0.124***
	(19.713)	(21.627)	(17.713)	(19.400)
Year	Yes	Yes	Yes	Yes
Lagged Status	Yes	Yes	Yes	Yes
Cutoffs				
c_0	3.237***	3.031***	3.171***	2.990***
	(35.118)	(46.233)	(32.573)	(42.353)
c_1	4.549***	4.340***	4.443***	4.260***
	(47.497)	(62.306)	(44.038)	(57.160)
c_2	5.371***	5.159***	5.572***	5.382***
	(52.606)	(66.169)	(49.941)	(61.711)
N	41198	41960	41198	41960
pseudo R^2	0.433	0.433	0.415	0.415

t statistics in parentheses. Significance level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, $Status = 0$ for non-exporters, 1 for common exporters, 2 for POT traders, 3 for r-exporters. If a firm simultaneously engages in POT and r-export, we treat it as an r-exporter in the first two columns and as POT trader in the last two columns.

Table 9: Productivity Sorting

	(1)	(2)	(3)
	TFP_{it}	TFP_{it}	TFP_{it}
$IEer_{it}$	0.054***	-0.008	-0.016
	(4.291)	(-0.457)	(-0.759)
$POTer_{it}$	0.098***	-0.016	-0.011
	(8.160)	(-0.981)	(-0.715)
$common\ exporter_{it}$	0.016**	-0.010	-0.010
	(2.347)	(-1.003)	(-1.072)
$Capital_{it}$	-0.008***	-0.024***	-0.024***
	(-4.207)	(-6.656)	(-6.659)
Year Dummy	Yes	Yes	Yes
Firm-Fixed Effects	No	Yes	Yes
N	41960	41960	41960
R^2	0.027	0.037	0.037

t statistics in parentheses. Significance level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. $IEer_{it} = 1$ if firm i engage in r-export in any category; $POTer_{it} = 1$ if firm i engages in POT in any category. $common\ exporter_{it} = 1$ if firm i doesn't import any products in the category where it export a good. The reference group is non-exporters. IF a firm simultaneously engages in POT and r-export, we treat it as r-exporter in the first two columns and as POT trader in the last column.

Table 10: Firm-Product Expertise, Import Tariff, and Product Import

	(1)	(2)	(3)	(4)
	$IEer_{ijt}$	$IEer_{ijt}$	$IEer_{ijt}$	$IEer_{ijt}$
$Expertise_{ijt}$	0.064***	0.062***	0.133***	0.061***
	(4.694)	(4.550)	(5.749)	(2.729)
$Tariff_{jt}$	-0.029**	-0.029**	-0.019	0.012
	(-2.435)	(-2.478)	(-0.833)	(0.440)
$ln(sales_{it})$		0.017	0.082	0.003
		(0.468)	(1.202)	(0.022)
$ln(wage_{it})$		0.086	-0.057	0.190
		(0.925)	(-0.354)	(1.203)
$ln(\frac{capital_{it}}{employees_{it}})$		0.389	0.408	-0.899*
		(1.604)	(0.785)	(-1.892)
$ln(age_{it})$		-0.087	-0.057	0.003
		(-0.945)	(-0.331)	(0.019)
$ln(import_{jpt})$				0.258***
				(6.868)
Year Dummy	Yes	Yes	Yes	Yes
HS4 Dummy	Yes	Yes	Yes	Yes
N	23493	23390	7228	2973
pseudo R^2	0.046	0.048	0.068	0.270

z statistics in parentheses. Significance level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered by firm. Only firms that export at least 10 products are used in the estimation in column (3). Column (4) uses fixed-effect logit model and others use logit model. $import_{jpt}$: Import value of category j in province p in year t. $IEer_{ijt} = 1$ if $x_{ijt} > 0$, $m_{ijt} > 0$, and $m_{ijs} = 0$, here s is the period when firm-product pair ij appears in the dataset for the first time.

Table 11: Export Performance and Product Import

	(1)	(2)	(3)	(4)
	p_{ijdt}	$ln(n_{ijt})$	p_{ijdt}	$ln(n_{ijt})$
$IEer_{ijt}$	-0.019***	0.155***	-0.014*	0.127***
	(-2.758)	(6.600)	(-1.730)	(5.807)
$POTer_{ijt}$	0.007	0.069***	0.021	0.021
	(0.521)	(2.608)	(1.591)	(0.787)
$Expertise_{ijt}$			-0.012***	0.067***
			(-11.252)	(19.508)
$ln(sales_{it})$			-0.049***	0.138***
			(-6.066)	(6.469)
$ln(wage_{it})$			0.011*	-0.003
			(1.894)	(-0.199)
$ln(\frac{capital_{it}}{employees_{it}})$			0.030*	0.001
			(1.647)	(0.022)
$ln(age_{it})$			0.013	0.016
			(1.383)	(0.603)
Year	Yes	Yes	Yes	Yes
N	95729	29425	92023	27589
R^2 within	0.093	0.065	0.122	0.175

[1] t statistics in parentheses. Significance level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All columns use fixed-effect model.

[2] $IEer_{ijt} = 1$ if $x_{ijt} > 0$, $m_{ijt} > 0$, $m_{ij,s<t} = 0$ and 0 otherwise; $POTer_{ijt} = 1$ if $x_{ijt} > 0$, $m_{ijt} > 0$, $m_{ijs} > 0$ and 0 otherwise. Here s is the period when firm-product pair ij appears in the dataset for the first time.

Table 12: Export Performance and Product Import, By Source Country

	(1)	(2)	(3)	(4)	(5)	(6)
	p_{ijdt}	$ln(n_{ijt})$	p_{ijdt}	$ln(n_{ijt})$	p_{ijdt}	$ln(n_{ijt})$
$IEer_{ijt}$, importing from OECD Countries	-0.021***	0.134***	-0.019**	0.118***	-0.018**	0.118***
	(-3.000)	(4.907)	(-2.519)	(4.657)	(-2.278)	(4.644)
$IEer_{ijt}$, importing from Non-OECD Countries	-0.010	0.122***	-0.004	0.088***	-0.004	0.088***
	(-1.025)	(3.969)	(-0.370)	(2.894)	(-0.340)	(2.887)
$POTer_{ijt}$, importing from OECD Countries	0.006	0.060**	0.019*	0.026	0.019*	0.026
	(0.494)	(2.170)	(1.719)	(0.921)	(1.778)	(0.907)
$POTer_{ijt}$, importing from Non-OECD Countries	-0.019**	0.096***	-0.011	0.061**	-0.011	0.061**
	(-1.994)	(3.768)	(-1.091)	(2.356)	(-1.015)	(2.348)
$ln(import_{jpt})$					-0.002*	0.001
					(-1.935)	(0.392)
Controls	No	No	Yes	Yes	Yes	Yes
N	95729	29425	92008	27576	92008	27576
R^2 within	0.093	0.066	0.123	0.176	0.123	0.176

[1] t statistics in parentheses. Significance level: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered by firm. All use fixed-effects estimation. Control variables include Firm sales, average wage, capital intensity, firm age, firm-product expertise and year-fixed effects.

[2] $IEer_{ijt} = 1$ if $x_{ijt} > 0$, $m_{ijt} > 0$, $m_{ijs} = 0$ and 0 otherwise; $POTer_{ijt} = 1$ if $x_{ijt} > 0$, $m_{ijt} > 0$, $m_{ijs} > 0$ and 0 otherwise. Here s is the period when firm-product pair ij appears in the dataset for the first time.

Table 13: Input import and Export Performance

	(1)	(2)	(3)	(4)	(5)	(6)
	p_{ijdt}	p_{ijdt}	p_{ijdt}	$ln(n_{ijt})$	$ln(n_{ijt})$	$ln(n_{ijt})$
$IEer_{ijt}$, importing from OECD Countries	-0.018**	-0.019**	-0.019**	0.117***	0.120***	0.118***
	(-2.387)	(-2.443)	(-2.520)	(4.547)	(4.718)	(4.655)
$IEer_{ijt}$, importing from Non-OECD Countries	-0.003	-0.004	-0.004	0.086***	0.090***	0.088***
	(-0.262)	(-0.376)	(-0.372)	(2.841)	(2.933)	(2.896)
$POTer_{ijt}$, importing from OECD Countries	0.020*	0.019*	0.019*	0.025	0.028	0.027
	(1.873)	(1.746)	(1.736)	(0.864)	(0.968)	(0.947)
$POTer_{ijt}$, importing from Non-OECD Countries	-0.011	-0.011	-0.011	0.061**	0.062**	0.061**
	(-1.043)	(-1.093)	(-1.092)	(2.328)	(2.395)	(2.357)
$ln(imported\ input\ value_{it})$	-0.001			0.002		
	(-0.697)			(0.484)		
$ln(imported\ input\ variety_{it})$		-0.000			-0.004	
		(-0.002)			(-0.421)	
$ln(imported\ input\ share_{it})$			0.000***			0.000***
			(7.442)			(4.272)
N	92023	92023	92005	27589	27589	27580
R^2 within	0.123	0.123	0.123	0.176	0.176	0.175

[1] t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. *imported input share*$_{it}$: $\frac{Import\ value_{it}}{Total\ Input_{it}}$. All use fixed-effects estimation. Firm sales, average wage, capital intensity, firm age, firm-product expertise and year-fixed effects are controlled.

[2] $IEer_{ijt} = 1$ if $x_{ijt} > 0$, $m_{ijt} > 0$, $m_{ijs} = 0$ and 0 otherwise; $POTer_{ijt} = 1$ if $x_{ijt} > 0$, $m_{ijt} > 0$, $m_{ijs} > 0$ and 0 otherwise. Here s is the period when firm-product pair ij appears in the dataset for the first time.

Table 14: Export Performance and Product Import: Spillover Effects

	(1)	(2)
	p_{ijdt}	$ln(n_{ijt})$
$IEer_{it}$ Import from OECD Countries	-0.009	-0.022
	(-0.920)	(-0.832)
$IEer_{it}$ Import from Non-OECD Countries	-0.004	-0.022
	(-0.391)	(-0.794)
$POTer_{it}$ Import from OECD Countries	0.013	-0.041
	(1.474)	(-1.382)
$POTer_{it}$ Import from Non-OECD Countries	0.006	-0.000
	(0.570)	(-0.004)
N	68758	21208
R^2 within	0.144	0.167

[1] t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All use fixed-effects estimation. Firm sales, average wage, capital intensity, firm age, firm-product expertise and year-fixed effects are controlled.

[2] Observation restriction: $x_{ijt} > 0$, $m_{jit} = 0$.

[3] $IEer_{it} = 1$ if firm i engages in im-export in any product; $POTer_{it} = 1$ if firm i engages in POT in any product.

Table 15: Export Performance and Product Import: Full data

	(1)	(2)
	p_{ijdt}	$ln(n_{ijt})$
$IEer_{ijt}$ Import from OECD Countries	-0.017***	0.095***
	(-3.780)	(6.387)
$IEer_{ijt}$ Import from Non-OECD Countries	-0.007	0.101***
	(-1.388)	(5.218)
$POTer_{ijt}$ Import from OECD Countries	-0.003	0.026*
	(-0.661)	(1.726)
$POTer_{ijt}$ Import from Non-OECD Countries	-0.012**	0.052***
	(-2.323)	(3.424)
N	449830	122880
R^2 within	0.108	0.172

[1] t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All use fixed-effects estimation. Firm sales, average wage, capital intensity, firm age, and year-fixed effects are controlled.

[2] $IEer_{ijt} = 1$ if $x_{ijt} > 0$, $m_{ijt} > 0$, $m_{ijs} = 0$ and 0 otherwise; $POTer_{ijt} = 1$ if $x_{ijt} > 0$, $m_{ijt} > 0$, $m_{ijs} > 0$ and 0 otherwise. Here s is the period when firm-product pair ij appears in the dataset for the first time.