Learning by Exporting and Importing: Do What and Where You Trade Matter?

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Abstract

This paper investigates the learning effect of trade by focusing on various types of trades. Aside from trade volume, the trade heterogeneity we consider includes variety, destination, unit price, and trade type. Based on within-firm-product panel data on China's electronics industry, the learning-by-exporting hypothesis is supported when firms trade with developed countries, undertake process trade, and have a higher unit price, but not for firms exporting a greater variety of goods. These heterogeneities in imports also matter to promoting productivity. Moreover, the productivity-enhancing effect of trade varies between domestic and foreign firms, whereby domestic firms benefit more from international trade.

JEL Classification: F1, F14
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1. Introduction

International trade is widely thought to have a positive influence on productivity. Using micro-level data, empirical works have sought to examine the existence of productivity gains benefitting from exports and imports. Competition and exposure to a superior foreign market can speed up technological acquisition and thus lead exporters to promote productivity. This learning-by-exporting hypothesis has been tested in vast studies, yet has shown inconsistent findings (e.g., Wagner, 2012 for a survey). Even if the learning effect of exporting is limited, trade might promote firm productivity through within-firm product reallocation (Eckel and Neary, 2010).[1] Imports, on the other hand, might mediate international knowledge transfers and promote firm productivity (Acharya and Keller, 2011; Lööf and Andersson, 2010). Specifically, trade liberalization enables imported inputs to become cheaper and thus raises productivity via learning, variety, and quality effects (Amiti and Konings, 2007). Lowering output tariffs can also boost firm productivity through the "import competition" effect (Pavcnik, 2002; Topalova and Khandelwal, 2011).

Melitz (2003) initializes an emerging line of theoretical literature dealing with possible reverse causality from productivity to exporting, underpinned by firm heterogeneity. Kasahara and Lapham (2013) further develop an open economy model with heterogeneous final goods producers that simultaneously choose whether to export their output and whether to use imported intermediates. As theoretical models have emphasized the importance of firm heterogeneity on self-selection behaviors regarding exporting and importing, conceptually the reverse causality from trade to productivity can also form in reality - that is, differences in contents of trade may affect firm productivity quite differently. This is because the knowledge embodied in exporting and importing commodities varies significantly, depending on the aforementioned dimensions of trade.

[1] Alternatively, Roberts and Tybout (1997) claim that more productive firms self-select themselves into the export sector, since only they are able to overcome the sunk costs of entering international markets. The self-selection hypothesis thus far has been widely supported empirically (Bernard *et al*., 2012).

Such a concept has been highlighted in Feenstra and Kee (2008) whereby export variety positively matters to a country's productivity, while firm-level studies linking trade heterogeneity to firm productivity are few.

The extant literature relating trade to firm productivity mainly uses either a dummy or value measure of trade (exports and/or imports), but it is unable to unravel the nature of knowledge embodied in trade, potentially resulting in a misleading picture on the productivity gains from trade. Export value contains both intensive and extensive margins, denoting that it consists of quantity, variety, price, and destination. For example, two firms with the same export value of exporting respectively toys and smart phones might experience different learning effects due to competition in international markets. Even if firms are located in the same industry, such as the electronics sector, one is hard to find the same learning effect through exporting telephone and micro-projectors. This situation applies to the effect of learning from imports, but the obvious drawback of the trade value measure motivates our alternative, which we refer to as "trade heterogeneity". Trade heterogeneity symbolizes difference in contents of trade, including destination, variety, trade type, and quality of trade goods measured by unit value. Instead of trade value, using various measures of trade to consider the trade contents can capture more information regarding the learning content and mechanism through trade, enabling us to examine the productivity effect of trade more precisely.

In light of the aforementioned discussion, both exporting and importing may help promote productivity. It inspires another question that then which one is more relevant to promoting firm productivity?[2] Along with the wave of trade liberalization, most emerging countries have adopted the model of export-led economic development successfully applied by the four Asian Tigers in the 1970s. From the perspective of technological development, this export-expansion strategy generally accompanies the goal of import-substitution (Bruton, 1998). For example, after China

[2] Some studies, such as Andersson *et al.* (2008) and Thangavelu and Rajagura (2004), consider both impacts of imports and exports on productivity growth.

joined the WTO in 2001, it became fully integrated into the world trading system and enjoyed a relative advantage in international production fragmentation, especially in the assembly export sector. Emerging but rare studies have tested the learning-by-exporting hypothesis using Chinese firm-level data to support this hypothesis (e.g., Du *et al*., 2012; Yang and Mallick, 2010; Yu and Dai, 2011), while the other possible productivity effect brought about by imports has not yet been examined. Indeed, most Chinese electronics firms engage in final assembly exports in the global vertical integrated supply chain, depending heavily on importing components and intermediate goods. Both technology imports and especially technological imitation are important channels to transfer knowledge, thereby promoting productivity for developing countries. A little imitation is almost always growth-enhancing in a growth model through "step-by-step" innovation (Aghion *et al*., 2001). Since importing intermediates goods and final products mediates knowledge spillover more directly, imports and exports may have qualitatively different impacts on firm productivity.

For most emerging economies, the export-led growth strategy relies heavily on attracting foreign direct investment (FDI) to undertake assembly exports. China has become the main producer of many varieties of information and communication technology (ICT) products in the global market after its accession to WTO in 2001. Its successful development is underpinned by the export-platform FDI of multinational enterprises (MNEs) that is accompanied with intra-firm and intra-industry trading with parent countries. It implies that the productivity effect of trade might vary between domestic firms and Chinese subsidiaries of MNEs. Amiti and Freund (2010) argue that the skill content of China's manufacturing exports remains unchanged once processing trade is excluded, meaning that technological content differs between processing trade and ordinary trade. On the other hand, most foreign-owned enterprises (FOEs) undertake processing trade and have higher productivity, implying that their productivity gain through international trade may differ with that of domestic firms. This is a critical issue not only for China, but also for other developing countries, as the productivity promotion by domestic firms is more relevant to technological upgrading.

We systematically analyze the learning effects on firm productivity due to exports and imports, using detailed firm-level panel data on China's electronics industry matched with Customs Dataset. This paper contributes to the literature in the following three aspects. First, to obtain a clearer picture regarding the productivity effect of trade, this study adopts various measures considering trade heterogeneity rather than trade value to implement empirical estimations. It sheds light on the importance of trade heterogeneity influencing firm productivity. Second, we not only consider the potential productivity-enhancing effects of both exports and imports, but also compare their relative impacts. This comparative analysis lends insightful implications for trade and technological policies for developing countries. As China is widely criticized for its weak protection of intellectual property rights (IPRs), this technological environment should enhance the benefit of learning from imports through imitation. Third and finally, we compare the potential difference in the productivity effect of trade between domestic firms and FOEs in China.

The rest of this paper is organized as follows. Section 2 relates trade heterogeneity to firm productivity and reviews China evidence. Section 3 describes information on the data and several important stylized facts presenting the trade heterogeneity in China's electronics industry. Section 4 contains our estimated productivity equation. Section 5 presents the results of the effect of trade heterogeneity on firm productivity. Robustness checks are also performed in this section. The final section concludes the paper.

2. Trade Heterogeneity, Firm Productivity, and Literature Review

2.1 Trade heterogeneity and firm productivity

The learning-by-exporting hypothesis proposed by Clerides *et al*. (1988) claims that participating in export activity in international markets could help firms acquire technology and knowledge, thereby having a positive effect on promoting firm productivity. Numerous firm-level studies have examined this hypothesis and reached inconclusive results,[3] implying that this productivity gain due to exporting is probably relevant to the characteristics of the exports. Despite no theory linking export heterogeneity to the learning effect on productivity, some empirical witnesses have been highlighted recently. Using detailed Swedish data, Andersson *et al*. (2008) figure out substantial heterogeneity among exporters and importers in terms of destination numbers along with product variety. Crucially, they find productivity premiums increase in the number of markets and the number of products traded, respectively.[4] Silva *et al*. (2012) focus on factors affecting the learning ability of Portugal firms and find that a learning effect among firms exporting to more developed markets helps achieve a certain threshold of export intensity. Silva *et al*. (2013) further present that the greater the diversification of markets and goods, the better the performance, in terms of productivity, that is achieved by internationalized firms. Findings from the above studies suggest that export heterogeneity, in terms of variety and destinations, do matter to disseminate technology and knowledge. However, how export types (ordinary trade vs. process trade) and export quality relate to the effect of learning-by-exporting has not yet been investigated.

Another strand of the literature linking imports and productivity has emerged recently by examining differences in productivity between importers and non-importers as well as their relationships, with different degrees of imports remaining at the center of these studies. Using firm-level data from various countries, most studies note a positive link between importing and productivity, e.g., Muuls and Pisu (2009) for Belgium, Kasahara and Lapham (2013) for Chile, Vogel and Wagner (2010) for Germany, Topalova and Khandelwal (2011) for India, and Andersson *et al*. (2008) for Sweden.

[3] See Wagner (2007, 2012) for a comprehensive survey on the relationship between export and productivity.
[4] Andersson and Lööf (2009) emphasize the role of the temporal dimension and intensity of exports on influencing the scope of learning effects. They claim that the learning effect exists for persistent exporters with high export intensity, but is not present among temporary exporters or persistent exporters with low export intensity.

This spillover effect exists for importing various goods. Capital goods imported from developed economies have higher quality and contain advanced technology. Importing firms can extract the embodied knowledge therein to promote their own productivity (Sjöholm 1999). Specifically, the production mode of original equipment manufacturing (OEM) for international enterprises adopted by developing country firms helps productivity through spilling over the advanced technologies embodied in the imported intermediate goods. This point has been witnessed for Chile (Kasahara and Rodrigue, 2008), for Indonesia (Amiti and Konings, 2007; Blalock and Veloso, 2007), for Spain (Augier *et al*., 2013), and for Sweden (Lööf and Andersson, 2010).

Given there is a positive productivity gain from imports, this effect is related to import heterogeneity. Muuls and Pisu (2009) argue that there is a variety effect and a quality effect caused by imported intermediates, as they have better quality than local intermediates. Silva *et al*. (2013) find that firms exhibit better productivity performance when they are more diversified in markets of imports as well as when they have a higher intensity of imports. Moreover, the origin markets for imports are also important in explaining a firm's performance.

2.2 China literature

There is a vast amount of literature advancing our knowledge about the relationship between international trade and firm productivity in the aforementioned discussion. However, this longstanding issue is rarely analyzed for China, due to the constraint in the availability of micro-level data. Earlier studies concentrate in testing the learning-by-exporting hypothesis and reach a consistent finding of supporting this hypothesis, such as Dai and Yang (2013), Sun and Hong (2010), and Yang and Mallick (2010).

Some studies test the hypothesis of learning-by-exporting by adding additional dimensions. Du *et al*. (2012) focus on comparing the productivity gain from exports between domestic firms and foreign affiliates in China. Robust evidence suggests that domestic firms display significant productivity gains upon export entry, whereas foreign affiliates show no evidential productivity changes. From another viewpoint, Park *et al*. (2010) examine how export demand shocks associated with the Asian financial crisis affected Chinese exporters. They note that export growth leads to increases in firm productivity, thereby supporting the learning-by-exporting hypothesis. Crucially, the productivity impact of export growth is greater when firms export to more developed countries.

As for the productivity effect of imports, only Yu (2015) has explored how reductions in tariffs on imported inputs and final goods affect firm productivity, though that study does not directly test learning-from-importing. The author finds that, unlike previous results, reductions in output tariffs have a greater effect on productivity improvement versus reductions in input tariffs due, in large part, to the fact that processing trade in China enjoys zero tariffs on imported inputs.

In light of the aforementioned literature review, the question of how imports influence firm productivity is less examined in China. There is also no study in the literature relating trade heterogeneity to firm productivity. This inspires the main purpose of this paper to investigate whether trade heterogeneity matters to firm productivity in China.

3. Data, Some Stylized Facts, and Empirical Specification

3.1 Data source

The database used herein is compiled from two data sources: the survey of "scale above" enterprises conducted by the National Bureau of Statistics (NBS) and the Customs data of China. As the firm identification numbers are not the same in the two datasets, we link the two datasets by company name (in Chinese). The Customs data provide information on all Chinese exporters and importers over the period 2000-2006, supplying information on 8-digit HS product code, exporter/importer identity, product unit, quantity, unit value, total value, origin, destination, type of trade, etc. The detailed information enables us to consider trade heterogeneity by constructing various measures of exporting as well as importing activities. The NBS survey covers firms with sales of over RMB 5 million and consists of three parts: basic information such as company name, entry date, industry code, and main products; financial information related to a firm's financial statements; and production information like sales, intermediate goods, and output. The data help us to calculate firm productivity.

This study compiles firm-transaction level panel data for persistent exporters and importers in the China electronics industry during 2002-2007. The data assist our analysis on two levels. First, to examine both hypotheses of learning-by-exporting and learning-from-importing, various measures of trade heterogeneity have to enter the empirical specification in a lagged form. Second, as this paper examines the productivity effect of trade heterogeneity, using firms with persistent international trade enables us to simplify this discussion, despite that it may suffer from the problem of selection bias. The electronics industry we look at contains the two-digit codes of 39, 40, and 41. After cleaning the dataset by deleting observations with unreasonable variables, such as negative values and zeros for sales, capital, wages, and so on, we finally obtain an unbalanced panel dataset containing 15,904 observations for the period 2002-2007.

Ownership also plays an important role in differentiating the learning effect in China (Du *et al*., 2012). Considering this, we classify firms into three ownership types, with the first two groups encompassing domestic firms: (1) SOEs (state-owned enterprises), including state-owned and collectively-owned enterprises; (2) POEs (private-owned enterprises), including shareholding and private enterprises; and (3) FOEs (foreign-owned enterprises), including Hong Kong-owned, Macau-owned, Taiwan-owned, and other foreign-owned enterprises.

3.2 Empirical specification

To examine and compare the productivity-enhancing effects of both learning-by-exporting and learning-from-importing, we relate firm productivity to firm characteristics and two-year lagged trade variables as follows:

$$\begin{aligned}\ln TFP_{it} = \beta_0 + \beta_1 \ln SIZE_{it} + \beta_2 \ln RD_{it} + \beta_3 AGE_{it} + \beta_4 \ln KL_{it} + \beta_5 \ln EXPORT_{i,t-2} \\ + \beta_6 \ln IMPORT_{i,t-2} + OWNERSHIP\alpha + REGION\gamma + u_i + \varepsilon_{it}\end{aligned} \tag{1}$$

The dependent variable is the total factor productivity (TFP) measure calculated by the semi-parametric approach developed in Levinsohn and Petrin (2003). Subscripts i and t denote firm and time, respectively.

Among the explanatory variables, *SIZE* is firm size measured by the number of employee, and it enters the empirical equation in logarithmic form. Large firms enjoy advantages of economies of scale and scope, suggesting that larger firms tend to have higher productivity. However, as the China firm survey contains only "scale above" enterprises, a negative relationship might be present between firm size and productivity in this case (Yang *et al*. 2013). *RD* is a firm's R&D expenditure, serving as the major driver of promoting productivity in the theoretical and empirical literature (Griffith *et al*., 2003). Other firm-specific characteristics we control include firm age (AGE), capital-to-labor ratio, and (lnKL). There is no expected sign for the firm age and capital intensity variables.

EXPORT and *IMPORT* are the two trade variables of concern, denoting exports and imports. Distinguishing this research from existing studies, we adopt several measures of trade heterogeneity to differentiate their potential influences on firm productivity. In the benchmark model of equation (1), we adopt a traditional trade indicator, the logarithm of trade value (ln*EXPORT* and ln*IMPORT*), and it enters the equation in the form of a two-year lag, enabling us to compare with previous findings as well as to compare their relative magnitude. The structure of a time lag in which trade affects firm productivity is complex and is not clear-cut. In the case of China, Du *et al*. (2012) and Yang and Mallick (2010) find the productivity effect of learning-by-exporting to be stronger in the second year after entering the export market. We thus include the two-year lag trade variables first and then implement robustness tests using other various lag variables.

OWNERSHIP contains two ownership dummies, FOEs and POEs, by using SOEs as the reference group. As SOEs are less productive in China (Jefferson *et al*., 2000), we expect a positive coefficient to be associated with these two variables. Finally, as Yang *et al*. (2013) find a non-negligible productivity gain due to the spatial agglomeration of production activity in China, we thus include three region dummies (Beijing, Yangtze River Delta, and Pearl River Delta) by employing other regions as the reference group, following their specification.

As the learning effect of trade on productivity may vary substantially through the trade contents, this study further considers various dimensions of such contents. In the case of what countries a firm trades with, the knowledge embedded in goods exporting to and importing from developed countries is more advanced than that for developing countries. China's major trading partners - East Asian neighbors, the U.S., and European countries - may be the main sources of knowledge spillover from trade. The pooling trade volume of all trade partners biases the estimated effect of trade. We therefore separate trade volume into two parts: trade with advanced economies and trade with developing countries. Equation (1) can be rewritten as follows.

$$\begin{aligned}\ln TFP_{it} = \beta_0 + \beta_1 \ln SIZE_{it} + \beta_2 \ln RD_{it} + \beta_3 AGE_{it} + \beta_4 \ln KL_{it} + \beta_5 \ln EXPORT\_Adv_{i,t-2} \\ + \beta_6 \ln EXPORT\_Dev_{i,t-2} + \beta_7 \ln IMPORT\_Adv_{i,t-2} + \beta_8 \ln IMPORT\_Dev_{i,t-2} \\ + OWNERSHIP\alpha + REGION\gamma + u_i + \varepsilon_{it}\end{aligned} \quad (2)$$

Here, ln*EXPORT_Adv* (ln*EXPORT_Dep*) denotes exports to advanced (developing) countries, and ln*IMPORT_Adv* (ln*IMPORT_Dev*) represents imports from advanced (developing) countries.

Aside from destination, this study also considers the numbers of exporting and importing products (*EX_Variety*, *IM_Variety*), as well as the unit price of exporting and importing (*EX_Price*, *IM_Price*). The empirical literature linking firm heterogeneity and exporting, such as Bernard *et al*. (2012) and Monova and Zhang (2012), finds that more productive firms can export more products, implying the possibility of a reverse causality in which more diversified trade products may mediate knowledge flow and positively contribute to promote firm productivity. A product's unit value can be treated as the proxy for product quality (Bastos and Silva, 2010; Johnson, 2012). Exporting and/or importing goods of high quality mean that the firm will contain more advanced knowledge and technology. If the hypotheses of learning-by-exporting and learning-from-importing hold, then the effect should be related to quality of trade, suggesting a positive coefficient attached to the variables of *EX_Price* and *IM_Price*. Finally, we consider trade types and also separate exports (imports) into processing type (*EX_Process*, *IM_Process*) and ordinary type (*EX_Ordinary*, *IM_Ordinary*). Table 3 summarizes the variable definitions and basic descriptive statistics.

[Insert Table 3 approximately here]

We state that u_i is an individual firm effect that corresponds to permanent, unobserved heterogeneity across firms, but not within a firm over time. Here, v_{it} is a "white noise" error term. The standard estimation method to eliminate the individual effect is to utilize a "within" panel estimator, or a fixed effect (FE) or random effect (RE) technique.

3.3 Export and import heterogeneity in China's electronics industry

Before implementing empirical estimations, we start with depicting the trade heterogeneity across Chinese electronics firms. Figures 1ab and 2ab illustrate substantial heterogeneity among exporting and importing firms, respectively, in terms of product variety and destinations of trading. The figures are akin to those in Andersson *et al*. (2008) on Swedish firm-level export and import data, as well as in Eaton *et al*. (2004) for French firm-level export data.

Figures 1a and 1b present the frequency with which firms are exporting and importing different numbers of products, respectively. As illustrated in the figures, the heterogeneity among trading firms in terms of product variety of their export and import activities is substantial. Despite the number of firms declining as the number of products increases for both exporting and importing, their shapes differ very little. For imports, the firm number-product variety nexus is very smooth, whereas the number of firms declines monotonically with the variety of exporting products. This suggests that given the same product variety of more than two products, the number of importing firms is larger. Figures 1a and 1b present that the elasticities by which the number of firms falls as the number of products increases are respectively -1.764 and -1.960 for exports and imports. They are higher than the case of Sweden, which reaches only -1.4 in the case of both exports and imports (Andresson *et al*., 2008). However, products are distinguished from each other based on a 6-digit HS code in our study rather than an 8-digit code used in Andresson *et al*. (2008).

[Insert Figures 1a and 1b approximately here]

Figures 2a and 2b depict the locus between the frequency of firms and the number of exporting destinations and importing destinations, respectively. We observe that for both exporting and importing, the number of firms declines quite smoothly as the number of destinations increases and they share quite a similar shape. However, most firms import from a limited number of markets, while there are some firms exporting to more destinations. Interestingly, the elasticity by which the number of firms falls as the number of countries increases is about -1.660 for exports and -2.056 for imports, which are similar than that found in Andersson *et al*. (2008) in which the corresponding figures are -1.7 and -2.0 for Sweden, a small open economy. Eaton *et al*. (2004) report an elasticity of -2.5 based on French firm-level export data.

[Insert Figures 2a and 2b approximately here]

We now depict the frequency with which firms are exporting and importing with a different unit value. It is observed from Figures 3a and 3b that both exporting and importing share a similar shape, whereby the number of firms increases as the unit price increases at first and then the number decreases when the unit price is larger than a threshold value. Because the commodities exported and imported are quite diverse, comparing the shape of the firm number – unit price nexus between exports and imports is not our concern. Alternatively, the disparity in unit price within exporting or importing firms sheds light on the difference in quality of trading products and may influence the strength of the learning effect.

[Insert Figures 3a and 3b approximately here]

4. Empirical Results

4.1 Baseline model

Table 4 reports the estimation results with equation (1) as the benchmark model, enabling us to compare the estimated learning effect from trade with that found in previous studies. As ownership and region dummies for individual firms are unchanged (or rarely changing), they will be excluded from the FE model. We thus report various estimations.

[Insert Table 4 approximately here]

Results obtained from various specifications are quite similar, while the estimated coefficients on some variables are sensitive to the consideration of ownership and region dummies. We find a contrasting result on the firm size-productivity nexus. The variable ln*SIZE* is associated with a significantly positive and negative coefficient with and without considering the agglomeration effect. Spatial agglomeration can generate externalities through the advantages of a thick labor market, backward and forward linkages, and information spillover, thereby promoting productivity (Ellison *et al.*, 2010). It is thus hard to judge the firm size-productivity relation.

The coefficient for ln*RD* is significantly positive in all specifications. This finding is not new to the literature, as R&D is well recognized as the main driving force for promoting productivity. Despite the productivity-enhancing effect beign quite small, it remains an encouraging result that confirms the importance of R&D on promoting TFP in China's electronics industry. One has witnessed the considerable increase in R&D expenditure in China during the past decade, suggesting that how to improve R&D productivity remains a central concern. Firm age (*AGE*) is associated with a positive coefficient in all estimations, but is statistically significant in FE models only. Conversely, capital intensity is negatively related with *TFP* in all estimations.

Ownership plays a considerable role at affecting firm performance in terms of productivity.

Estimates on *RE* models show that the coefficients of both ownership dummies are significantly positive, suggesting that SOEs are less productive. This result is consistent with findings in previous studies, such as Jefferson *et al*. (2000) and Yang *et al*. (2013). After replacing ownership dummies by the share of foreign capital (*FOES*), this variable is positive and significant in column (3). It represents that foreign firms are more productive in China, because they have better management skills and technologies.

We now turn to the main focuses of this study: Do firms promote productivity through learning by exporting and/or importing? Various specifications find a consistent result on the estimates of trade variables. The coefficient for the export variable is significantly positive, supporting the hypothesis of learning-by-exporting. This finding is consistent with previous China evidence in Du *et al*. (2012), Park *et al*. (2010), Sun and Hong (2010), and Yang and Mallick (2010). The import variable is also associated with a significant positive coefficient, indicating that firms with more previous imports do experience higher productivity. It thus provides the first firm evidence to support the learning-from-importing hypothesis.

For the estimated magnitudes of export and import variables, two key findings stand out. First, their coefficients are nearly 0.009 in the RE models, implying a 1% increase in exporting (importing) raises firm productivity by 0.009%. The productivity-enhancing effect is larger than that of R&D, highlighting the importance of international trade on promoting productivity for Chinese electronics firms. Second, the productivity-enhancing effect of exports seems to be stronger than that of imports without controlling for regional effects (FE models). One distinct feature of China's electronics industry is the high concentration on assembly exporting, and this operation mode probably leads to a stronger learning effect. Further investigating the content of trading commodities may help clarify their respective influences.

4.2 Trade heterogeneity and learning effect

We next explore how trade heterogeneity impacts the learning effect on promoting productivity.

Table 5 summarizes the estimation results on destinations and product variety, controlling for firm-specific characteristics. Models (1)-(3) present various estimations on destinations, whereas in models (4) and (5) we focus on the influence of product variety on productivity.

[Insert Table 5 approximately here]

The estimates on firm characteristics in Table 5 are fairly similar to those in Table 4. Thus, we focus on discussing the estimates on the trade variables. Given that there is a productivity-enhancing effect of international trade, the estimates overall suggest that where you trade does matter for the learning effects. Either exporting to or importing from advanced economies has a significantly positive impact on productivity, whereas the hypotheses of learning-by-exporting and learning-from-importing are not supported if firms trade with developing or less developed countries. This result is consistent with findings in Silva *et al*. (2012) and can be explained intuitively in that commodity trading with advanced countries exhibits knowledge and technologies that are worth learning for Chinese firms, thereby promoting their productivity.

Given the existence of a positive productivity effect of trade with advanced economies, this learning-by-exporting effect is stronger than that of learning-from importing. As shown in models (2) and (4), the estimated magnitude for the export variable is 0.002, which is about twice as large as the learning effect brought about by imports. It is probably attributed to the production mode of assembly that acquires technologies and knowledge from outsourcing firms. We will examine whether this trade type induces higher productivity later.

The theoretical literature modeling the export behavior of multi-product firms, e.g., Bernard *et al*. (2006) and Arkolakis and Muendler (2010), predicts that more productive firms increase extensive margin (number of products), while there is no reverse effect from export variety to productivity witnessed in our study. As shown in models (6) and (7), the estimated coefficients on ln*EX_Variety* are insignificant, suggesting that a variety of exporting products has no significant influence on promoting productivity. Conversely, ln*IM_Variety* is associated with a positive and significant coefficient, suggesting that an increase in the variety of importing goods shows productivity gains for Chinese importers, due to the variety effect mentioned in Muuls and Pisu (2009).[5] Andersson *et al*. (2008) find productivity premiums increase in the number of products traded for Swedish firms, while our China evidence reaches the same finding for imports rather than for exports. In China's electronics industry, some firms are very productive by focusing on OEM for international enterprises on a few products - for example, Apple's iPhone producer, Foxconn. This could be a possible interpretation leading to the insignificant relation between the variety of exporting products and productivity.

We now shift our focus to trade heterogeneity in terms of trade type and price. Table 6 displays the empirical results. One distinct operation mode in China's electronics industry is assembly operations that engage in production sharing with its East Asian neighbors. As ln*EX_Process* and ln*IM_Process* are highly correlated with a 0.816 correlation coefficient, we conduct various estimations through models (1)-(5). The estimates overall confirm the productivity-enhancing effect brought about by processing trade, as the coefficient on processing trade is significantly positive in models (2) and (4). Indeed, assembly trade has considerably helped the technological upgrading of China's trade (Lemoine and Ünal-Kesenci, 2004), implying that it should also help promote firm productivity as found in our study. The learning channel comes from the variety and quality effects from imported intermediate goods (Muuls and Pisu, 2009). We have to note that processing export is probably the consequence of processing import. That is, electronics firms import intermediate goods and use them to conduct assembly operations and then export those products to the global market. As the value-added of assembly exports is low, it leads to a small lower productivity-enhancing effect versus that of processing imports. Moreover, the learning effect is also present for ordinary exports through the competition effect, but not for ordinary

5 We experience similar results by using either 6-digit or 8-digit HS code products.

imports.

[Insert Table 6 approximately here]

For export and import prices (ln*EX_Price*, ln*IM_Price*), in all specifications we find that they have a positive and significant effect on productivity, indicating firms that export and import products with higher quality obtain a higher productivity premium. Using the unit value of product as the proxy for product quality, Bastos and Silva (2010) find that more productive Portugese firms can export products of high quality. Our results witness the reverse effect that exporting (importing) higher quality products can promote exporters' (importers') productivity, as high quality products contain advanced knowledge and lead to a knowledge spillover effect. The stylized fact indicated in Monava and Zheng (2012) - that more successful exporters use higher quality inputs to produce higher quality goods - provides a good interpretation for our findings.

4.3 Time structure of the learning effect

We can see from the above discussion that trade heterogeneity in terms of various dimensions is relevant to the learning effect of promoting productivity. However, the time structure of the learning effect is the essential debate in this strand of literature. The productivity effect of international trade, if so, arises in different years after entering the export market. We thus specify the lag structure as one year or three years to implement various estimations as shown in Tables 5 and 6. Table 7 summarizes the results of this exercise, accompanied by the estimates on the two-year lag discussed previously.

[Insert Table 7 approximately here]

As shown in column (1), the immediate impacts of exporting and importing, measured by various dimensions, on firm productivity are positive and statistically significant. As time passes, almost all variables have an insignificant coefficient in the third year, except that the coefficient on ln*EXPORT_Adv* remains significantly positive in the third year as shown in column (3). In other words, the learning-by-exporting effect is stronger if firms export to advanced countries, while the magnitude decays sharply starting in the third year. Conversely, the productivity effect of importing from developing countries is positive with a small magnitude in the first year and then becomes insignificant in the second year, and finally turns to become significantly negative in the third year.

Observing the time structure of estimated coefficients on individual trade variables, several key findings are as follows. First, the productivity effect of learning-by-exporting is stronger than that brought about by learning-from-importing in the electronics industry and is mainly contributed by exporting to advanced economies. Second, importing a greater variety of products could lead to a larger productivity-enhancing effect compared with exporting the same variety of products. Third, processing trade is the main channel of international knowledge transfer. Thus, it tends to support the view of Amiti and Freund (2010) that emphasizes the importance of processing trade on facilitating technology upgrading. Finally, the quality of trading commodities indeed matters to the learning effect of international trade. Summarizing the aforementioned findings, processing trade with advanced countries (generally under a higher unit price) is the main channel for facilitating productivity.

4.4 Comparison between domestic and foreign firms

The aforementioned analyses have supported both hypotheses of learning-by-exporting and learning-from-importing and show evidence that trade heterogeneity differentiates the learning effect on promoting productivity considerably through various dimensions. Du *et al.* (2012) argue that the productivity gain from exporting is significant only for domestic firms rather than for foreign affiliates. We further compare the potential differences in the productivity effect of trade heterogeneity between domestic and foreign firms.[6] Table 8 displays the estimates on various dimensions of international trade.

[Insert Table 8 approximately here]

Observing the estimated coefficients on ln*EXPORT* shows that the learning-by-exporting

[6] A firm with foreign equity of more than 10% is classified as being a foreign firm.

hypothesis holds for both domestic and foreign firms, but domestic firms are associated with a large magnitude of productivity gain than their foreign-owned counterparts. This result is little different from findings in Du *et al*. (2012), even though the industries covered in these two studies are diverse. Moreover, the productivity gain from importing occurs for only foreign affiliates, as they mainly import intermediates from their parent firms in advanced countries.

Trade heterogeneity indeed matters to the productivity gain of international trade for both domestic and foreign firms in China. The productivity gain from exports or imports discussed above appears only if firms trade with advanced countries, confirming the viewpoint that where you trade does matter for the learning effect. On the other hand, the number of products is less relevant to meditating knowledge embodied in trading commodities.

Comparing the productivity gain that results from trade types, we find that both processing and ordinary exports show significantly positive impacts for domestic exporters, while neither import types enhance domestic firms' productivity. When the technological level that domestic firms possess is lower, tough competition in international markets will help exporters to benefit from productivity gains through the competition effect. Alternatively, the productivity effect of importing depends on where you import the intermediate goods. Among China's exporters, less successful exporters (domestic firms) use lower quality inputs (Monova and Zhang, 2012), and this can be interpreted as why the productivity effect of processing imports is insignificant for domestic firms. For foreign firms, the influences of trade types on productivity show a diverse pattern in that processing imports rather than processing exports acts a mediating role to promote productivity. Finally, the quality of trading commodities in terms of unit price still has a strong influence on productivity for both domestic firms and foreign affiliates.

The results on domestic and foreign exporters are clearly overall similar and are consistent with those reported in Tables 4-6. The role played by trade types on mediating international knowledge spillover seems to differ considerably between domestic firms and foreign affiliates. Processing exports is the main trade type for China's exporters to assimilate advanced knowledge, while their skill content may remain unchanged once processing trade is excluded (Amit and Freund, 2010). Thus, using in-house R&D to promote indigenous technological capability is a feasible way to sustain productivity growth.

5. Concluding Remarks

International trade is one channel mediating international knowledge flow and is thought to have a productivity-enhancing effect on firm productivity, especially for those firms located in developing countries. There is an emerging preference for shifting the attention from examining the productivity effect of total trade to the detailed contents of such trade. This paper contributes to the existing firm-level literature in three distinct aspects. First, it adds to the rare empirical evidence confirming both hypotheses of learning-by-exporting and learning-from- importing by utilizing firm-custom matched data from China, one of the largest trading countries in the world. Second, it considers the potential differences in the productivity effect of international trade as differentiated by trade heterogeneity, involving destination, variety of products, trade type, and unit price. Third, we compare the learning effects of trade between exports and imports, as well as between domestic firms and foreign affiliates.

Using a unique firm-custom matched dataset, we conduct a rigorous analysis of the panel data over six years, comprising nearly 16,000 firm-level observations. The analyses have yielded a number of key results on firms' persistent participation in international trade. The learning-by-exporting and learning-from-importing hypotheses are both overall supported, suggesting that engaging in persistent and greater international trade can help firms learn knowledge and technologies, thereby promoting their productivity. Despite there being a productivity-enhancing effect that comes through international trade, trade heterogeneity does matter for this effect. Exporting to (importing from) advanced countries, processing exports (imports), and exports (imports) with a higher unit price can all lead to productivity gains mediated by the learning effect. The variety of exporting products seems to matter less to promoting productivity for persistent exporters, whereas product variety of imports does matter to the productivity enhancing effect.

Exporting overall tends to result in a higher productivity premium than that for importing, while the effect of individual dimensions of trade heterogeneity varies just a little. Exporting to advanced countries and export prices are associated with large productivity gains versus the corresponding effects brought about by importing, whereas a larger variety of importing products rather than exporting products is helpful to productivity. This supplemental analysis on comparing the productivity effect of trade heterogeneity between domestic firms and foreign affiliates shows that the learning-by-exporting effect is stronger for domestic firms and is mainly attributed to processing exports. Conversely, learning-from-importing is more relevant to firm productivity for foreign affiliates, as they import key components and technologies from their parent firms in advanced countries.

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Figure 1a Distribution of exporting variety

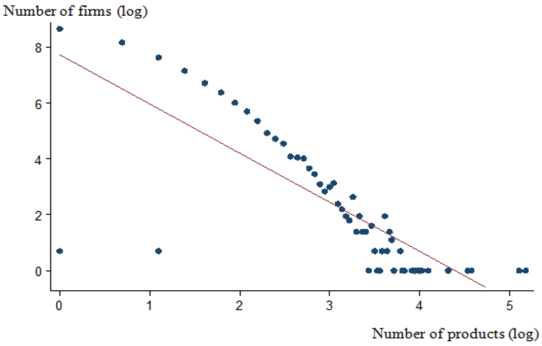

Figure 1b Distribution of importing variety

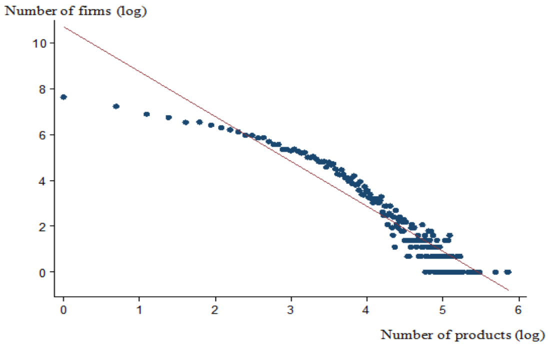

Figure 2a Distribution of exporting destination

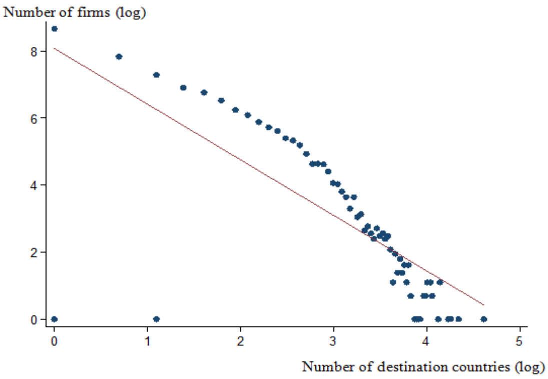

Figure 2b Distribution of importing destination

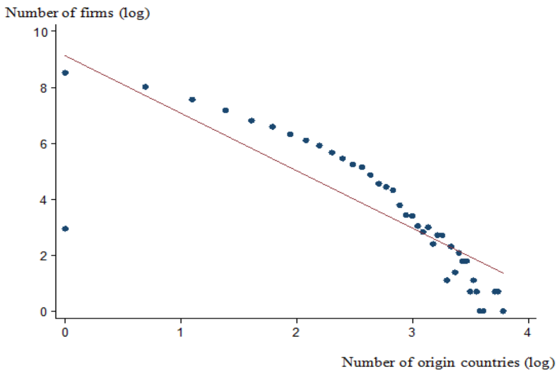

Figure 3a Distribution of exporting price

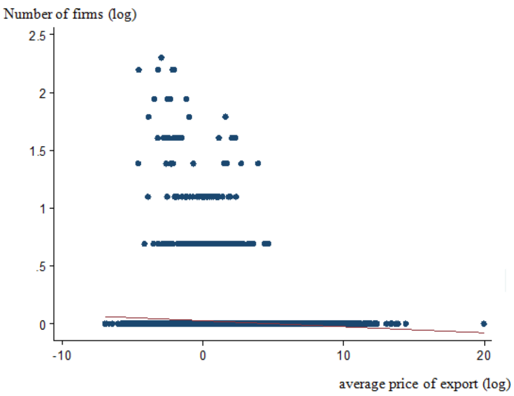

Figure 3b Distribution of importing price

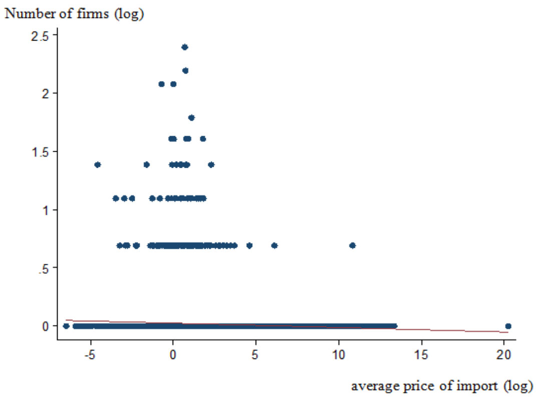

Table 3 Variable Definition and Basic Statistics

Variable	Definition	M(SE)
SIZE	Number of employees	790.712 (2496.978)
RD	R&D expenditure (in million US dollars)	0.588 (12.700)
AGE	Firm age (in months)	113.079 (73.069)
KL	Capital intensity: ratio of fixed assets to total employment (in million US dollars)	0.136 (0.719)
FOES	Firm’s share of capital invested by foreign-owned enterprise(s)	0.422 (0.466)
FOE	Ownership dummy: foreign-owned enterprise	0.899 (0.300)
PRIVATE	Ownership dummy: private-owned enterprise	0.086 (0.281)
EXPORT	Value of exports (in million US dollars)	2.747 (28.407)
IMPORT	Value of imports (in million US dollars)	2.079 (16.781)
EXPORT_Adv	Value of exports to advanced countries (in million US dollars)	2.454 (27.530)
EXPORT_Dev	Value of exports to developing countries (in million US dollars)	0.292 (3.016)
IMPORT_Adv	Value of imports from advanced countries (in million US dollars)	1.565 (10.471)
IMPORT_Dev	Value of imports from developing countries (in million US dollars)	0.514 (7.399)
EX_Variety	Number of exported products measured in 6-digit HS product code	3.286 (4.379)
IM_Variety	Number of imported products measured in 6-digit HS product code	16.062 (21.816)
EX_Process	Value of export processing trade (in million US dollars)	2.558 (28.235)
EX_Ordinary	Value of export ordinary trade (in million US dollars)	0.014 (0.137)
IM_Process	Value of import processing trade (in million US dollars)	1.619 (15.744)
IM_Ordinary	Value of import ordinary trade (in million US dollars)	0.014 (0.103)
EX_Price	Average unit price of exported products (in thousand US dollars)	30.708 (3725.34)
IM_Price	Average unit price of imported products (in thousand US dollars)	42.401 (4995.334)
TFP	Total factor productivity developed by Levinsohn and Petrin (2003)	4.693 (0.918)

Note: All monetary figures are deflated to year 2005. Sample size is 15,904.

Table 4 Learning by Trade – Total Exports and Imports

	(1) RE	(2) FE	(3) RE	(4) FE
Constant	1.945***	2.361***	1.968***	2.375***
	(0.022)	(0.035)	(0.019)	(0.032)
ln*SIZE*	0.005***	-0.021***	0.005***	-0.021***
	(0.002)	(0.002)	(0.002)	(0.002)
ln*RD*	0.0023***	0.0009***	0.0024***	0.0009***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
ln*AGE*	0.001	0.010**	0.001	0.010**
	(0.002)	(0.004)	(0.002)	(0.004)
ln*KL*	-0.085***	-0.101***	-0.085***	-0.101***
	(0.001)	(0.002)	(0.001)	(0.002)
FOES			0.007***	-0.002
			(0.003)	(0.002)
FOE	0.022*	0.014		
	(0.012)	(0.016)		
PRIVATE	0.044***	0.012		
	(0.012)	(0.016)		
ln*EXPORT*	0.009***	0.004***	0.009***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
ln*IMPORT*	0.009***	0.0014*	0.008***	0.0014*
	(0.001)	(0.0008)	(0.001)	(0.0008)
Region Dummy	Yes	No	Yes	No
Year Dummy	Yes	Yes	Yes	Yes
R-square	0.290	0.147	0.288	0.147
Number of obs.	15,904	15,904	15,904	15,904

Note: Figures in parentheses are standard error. *, ** and *** represent significance at the 10%, 5%, and 1% statistical levels, respectively.

Table 5 Trade Heterogeneity and Productivity – Destination and Variety

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	FE	FE	FE	FE	FE	FE	FE
Constant	2.384***	2.387***	2.398***	2.391***	2.391***	2.397***	2.413***
	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.031)
ln*SIZE*	-0.020***	-0.019***	-0.018***	-0.019***	-0.019***	-0.019***	-0.019***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ln*RD*	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
ln*AGE*	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
ln*KL*	-0.100***	-0.100***	-0.100***	-0.100	-0.100	-0.100***	-0.100***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
FOES							-0.002
							(0.003)
FOE	0.014	0.014	0.014	0.014	0.014	0.015	
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	
PRIVATE	0.012	0.013	0.014	0.014	0.014	0.014	
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	
ln*EXPORT_Adv*	0.002***	0.002***					
	(0.001)	(0.001)					
ln*EXPORT_Dev*	0.0001		0.0001				
	(0.0002)		(0.0002)				
ln*IMPORT_Adv*	0.001			0.0011**			
	(0.001)			(0.0005)			
ln*IMPORT_Dev*	0.0001				0.0001		
	(0.0002)				(0.0002)		
ln*EX_Variety*						-0.0004	-0.0004
						(0.0019)	(0.0019)
ln*IM_Variety*						0.0034**	0.0034**
						(0.0016)	(0.0016)
Reg. Dummy	No	No	No	No	No	No	No
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-square	0.136	0.133	0.129	0.132	0.128	0.132	0.132
# of obs.	15,904	15,904	15,904	15,904	15,904	15,904	15,904

Note: Figures in parentheses are standard deviations. ** and *** represent significance at the 5% and 1% statistical levels, respectively.

Table 6 Trade Heterogeneity and Productivity – Trade Type and Price

	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE	(6) FE	(7) FE
Constant	2.391***	2.396***	2.397***	2.394***	2.399***	2.397***	2.412***
	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.031)
ln*SIZE*	-0.019***	-0.019***	-0.018***	-0.019***	-0.018***	-0.019***	-0.019***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ln*RD*	0.0010***	0.0010***	0.0010***	0.0010***	0.0010***	0.0009***	0.0009***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	0.0002	(0.0002)	(0.0002)
ln*AGE*	0.011**	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
ln*KL*	-0.100***	-0.100***	-0.100***	-0.100***	-0.100***	-0.100***	-0.100***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
FOES							-0.002
							(0.003)
FOE	0.015	0.014	0.015	0.015	0.014	0.014	
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	
PRIVATE	0.014	0.014	0.014	0.014	0.014	0.013	
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	
ln*EX_Process*	0.0006	0.0006**					
	(0.0004)	(0.0003)					
ln*EX_Ordinary*	0.0010***		0.0008***				
	(0.0003)		(0.0003)				
ln*IM_Process*	0.0008**			0.0008***			
	(0.0004)			(0.0003)			
ln*IM_Ordinary*	0.0003				0.0002		
	(0.0003)				(0.0002)		
ln*EX_Price*						0.0012**	0.0012**
						(0.0006)	(0.0006)
ln*IM_Price*						0.0008**	0.0008**
						(0.0004)	(0.0004)
Reg. Dummy	No	No	No	No	No	No	No
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-square	0.134	0.130	0.130	0.130	0.129	0.133	0.133
# of obs.	15,904	15,904	15,904	15,904	15,904	15,904	15,904

Note: Figures in parentheses are standard deviations. ** and *** represent significance at the 5% and 1% statistical levels, respectively.

Table 7 Time Lag Structure of Learning Effects

	(1)	(2)	(3)
Time lag of trade variable	1-year	2-year	3-year
ln*EXPORT_Adv*	0.0024***	0.0020***	0.0008*
	(0.0002)	(0.001)	(0.0005)
ln*EXPORT_Dev*	0.0007***	0.0001	0.0001
	(0.0002)	(0.0002)	(0.0003)
ln*IMPORT_Adv*	0.0022***	0.0011**	-0.0001
	(0.0002)	(0.0005)	(0.0005)
ln*IMPORT_Dev*	0.0006***	0.0001	-0.0005**
	(0.0001)	(0.0002)	(0.0002)
ln*EX_Variety*	0.0037***	-0.0004	-0.002
	(0.0008)	(0.0019)	(0.002)
ln*IM_Variety*	0.0072***	0.0034**	-0.0005
	(0.0007)	(0.0016)	(0.0014)
ln*EX_Process*	0.0010***	0.0006**	0.0001
	(0.0002)	(0.0003)	(0.0003)
ln*EX_Ordinary*	0.0007***	0.0008***	-0.0001
	(0.0002)	(0.0003)	(0.0003)
ln*IM_Process*	0.0010***	0.0008***	0.0004
	(0.0002)	(0.0003)	(0.0003)
ln*IM_Ordinary*	0.0005***	0.0002	0.0001
	(0.0001)	(0.0002)	(0.0002)
ln*EX_Price*	0.0013***	0.0012**	0.0002
	(0.0003)	(0.0006)	(0.0006)
ln*IM_Price*	0.0005***	0.0008**	0.0002
	(0.0002)	(0.0004)	(0.0003)
Covariates	Included	Included	Included

Note: Figures in parentheses are standard deviations. *, ** and *** represent significance at the 10%, 5%, and 1% statistical levels, respectively.

Table 8 Comparison between Domestic and Foreign Firms

	(1)	(2)
Specification	Domestic firms	Foreign firms
ln*EXPORT*	0.0047***	0.0039***
	(0.0013)	(0.0012)
ln*IMPORT*	0.0007	0.0020**
	(0.0011)	(0.0012)
ln*EXPORT_Adv*	0.0015*	0.0025***
	(0.0008)	(0.0007)
ln*EXPORT_Dev*	0.0003	-0.0001
	(0.0004)	(0.0003)
ln*IMPORT_Adv*	0.0004	0.0022**
	(0.0007)	(0.0009)
ln*IMPORT_Dev*	-0.0001	-0.0005
	(0.0003)	(0.0004)
ln*EX_Variety*	0.0002	-0.0005
	(0.0030)	(0.0027)
ln*IM_Variety*	0.0005	0.0045*
	(0.0020)	(0.0023)
ln*EX_Process*	0.0011**	0.0007
	(0.0005)	(0.0005)
ln*EX_Ordinary*	0.0012**	0.0008*
	(0.0005)	(0.0004)
ln*IM_Process*	0.0001	0.0013***
	(0.0005)	(0.0005)
ln*IM_Ordinary*	0.0005	0.0002
	(0.0004)	(0.0004)
ln*EX_Price*	0.0021**	0.0061***
	(0.0010)	(0.0008)
ln*IM_Price*	0.0007*	0.0019***
	(0.0005)	(0.0006)
Covariates	Included	Included
Observations	8,276	7,628

Note: Figures in parentheses are standard deviations. *, ** and *** represent significance at the 10%, 5%, and 1% statistical levels, respectively.