Thailand and The World Economy
P-ISSN: 2630-0931
E-ISSN: 2651-0529
Homepage : https://www.tci-thaijo.org/index.php/TER
Vol. 36, No. 3, September - December 2018 Page [66-89]

Firm Heterogeneity and Export Margins – Evidence from Firm-Transaction Matched Data

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Received 6 September 2018, Received in revised form 25 November 2018,
Accepted 3 December 2018, Available online 24 December 2018

Abstract

This paper investigates what kinds of exporters perform better in extensive (varieties of product) and intensive (exports per product) margins. Using comprehensive within-firm-product panel data of China's electronics industry, we find that firm productivity matters in terms of both the extensive and intensive margins of exports, which potentially provides evidence to support emerging heterogeneous-firm trade theories. Moreover, we note that exporters' financing ability is influential in the two aspects of performance. To deal with problems of sample selection, measures of products, and endogenous causality, we adopt various datasets and variable measurements to implement robustness checks and obtain consistent main findings. Our results can provide trade policy implications for other Asian emerging economies, such as Malaysia and Thailand.

Keywords: Firm heterogeneity, Export margin, Productivity
JEL Classification: F1, F14

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1. Introduction

This paper exploits a detailed firm-product level matched dataset of Chinese electronics firms to investigate how firm heterogeneity in productivity affects firms' exporting behavior at the product level. Over a decade, the heterogeneous firm literature on trade has emphasized the role of firm heterogeneity in terms of productivity in export behavior. In theoretical models such as Melitz (2003) and Bernard *et al*. (2003), firms incur a sunk cost when entering the export market and their technological heterogeneity in productivity explicitly plays a role in determining which firms can export. Researchers further raise questions about how firm heterogeneity differentiates export behavior, and in particular, export margins. Among these questions, a particular one arises: Why do some firms export a greater number of products (extensive margin) and/or export at a higher market value per product (intensive margin)?[1]

An emerging strand in the literature has established models and regularities about export margins (e.g., Besedes and Prusa, 2011; Chaney, 2008; Martincus and Carballo, 2008), considering their vital role for countries that heavily depend on exports for stimulating economic growth. Many emerging countries have experienced such rapid economic development over the past three decades. Among factors facilitating growth, exports are recognized as playing a critical role (Ram, 1987), because most economies tend to implement policy measures to promote exports, even though some maintain high levels of import protection which usually hinders, not promotes, export-led development. The new theory of multi-product exporters pioneered by Bernard et al. (2011), documents that higher firm-level ability raises a firm's productivity across all products and results in a positive correlation with intensive and extensive margins. A small but growing number of empirical studies have also attempted to analyze multi-product exporters in Belgium (Bernard *et al*., 2014), France (Mayer *et al*., 2013) and the U.S. (Bernard *et al*., 2011).

After implementing an open-door policy in 1978, China has experienced an average 9% annual growth rate over the past few decades. One key growth strategy is export-led growth. Embracing the globalization of production by utilizing its advantage in cheaper endowments and increased foreign direct investment (FDI), China has become the so-called "World's Factory" in international markets for a variety of products in information and communication technology (ICT) since the early 2000s. Its market share in global exports increased from 2.9% to over 10% during 1995 to 2011, subsequently becoming the largest exporter since 2010. Such rapid export growth was mainly driven by export margins (Amiti and Freund, 2010).

One specific feature of China's exports involves platform FDI wherein many exporting products, particularly ICT, comprise assembly exports conducted by foreign-owned enterprises (FOEs). For example, FOEs accounted for 37.03% in terms of firm numbers in high-tech industries, while they sold 73.08% of ICT products, of which most were exported, in 2005. However, Amiti and Freund (2010) argue that despite China's export structure shifting into more sophisticated products since the mid-1990s, the skill content of China's manufacturing exports has remained unchanged once processing trade is excluded. Given that more processing exports are conducted by FOEs, this implies that there is technological heterogeneity between FOEs and

[1] The definition of extensive margin might vary in different studies. For example, another kind of export extensive margin is defined as the number of markets served (Besedes and Prusa, 2011). However, most studies within the literature, both theoretical and empirical, define the value of exports per product as the intensive margin, e.g., Besedes and Prusa (2011), Cadot *et al*. (2011), and Chaney (2008).

domestic firms, as well as processing trade and ordinary trade, thereby influencing firms' export margins.

Although there are theoretical studies linking technological heterogeneity and export performance (we will this discuss below), the empirical research is quite limited, except for Bernard *et al*. (2014). Using data from Belgium, Bernard *et al*. (2014) support the positive relation between productivity and export margins, but they do not deal with endogeneity and sample selection problems, which we have taken into account in this study. Unlike Belgium, which is a small open advanced economy, China is a large developing country with a considerable export ratio, accounting for an average of approximate 30% of GDP during the 2001-2007 period.[2] Specifically, China is the largest exporter in the world and a majority of its exports are comprised of platform FDI. A better understanding of the relationship between productivity and export margins would not only provide evidence supporting the new theory of multi-product exporters, but also have policy implications for other export-oriented developing countries.

In this study we use a firm-product level dataset for Chinese electronics firms to investigate what determinants affect the performance of exporters in two aspects: the extensive margin in terms of varieties of exported products, and the intensive margin in terms of export values per product. This study potentially contributes to the emerging literature concerning the nexus between firm heterogeneity and exports in two respects.

First, this unique compiled dataset enables us to characterize the exporting behavior of heterogeneous firms, providing evidence to theoretical research regarding the role of firm heterogeneity in promoting export margins. Focusing on a single industry, China's electronics industry, this study tests Melitz's (2003) model. Our empirical analysis also provides evidence supporting the theoretical model in Bernard *et al*. (2011). Second, we contribute to the current literature by accounting for firm attributes and trade types when determining export margins, in contrast to previous studies focusing on empirical regularities (e.g., Manova and Zhang 2012). Some studies concentrate on linking one firm characteristic or economic institution to export margins, such as firm location in West or East Germany (Wagner, 2016), foreign ownership (Raff and Wagner, 2016), exchange rates or productivity (Bernard *et al*., 2014), and firm age (Wagner, 2015). Our work provides new evidence to test the theoretical arguments.

The remainder of this paper is structured as follows. The following section briefly reviews the related literature. Section 3 describes the data sources and demonstrates several important stylized facts regarding the firm heterogeneity of Chinese exporters in the electronics industry. Section 4 introduces our empirical strategy and Section 5 presents the estimation results and deals with possible measurement and econometric issues for robustness. Section 6 concludes this study and provides potential policy implications.

2. Related Literature

The relation between firm heterogeneity and export behaviors has been studied in both theoretical and empirical literatures for over a decade. In the theoretical literature more sophisticated modeling frameworks have been used to explore this issue and obtain consistent predictions. Resurrecting technological heterogeneity as the force driving international trade, Melitz (2003) develops a dynamic industry model with firm

[2] This ratio is calculated by the authors using export and GDP information in various issues of the China Statistical Yearbook.

level heterogeneity in productivity to analyze the intra-industry effects of international trade. Yeaple (2005) sets up a general equilibrium trade model in which homogeneous firms choose a technology from a set of competing technologies and select employees from a set of workers with heterogeneous skills. The choice gives rise to firm heterogeneity in terms of productivity distribution. The model generates a prediction for the superiority of firms that engage in international trade relative to those who do not.

Extending Melitz's (2003) model, an emerging line of research in the theoretical literature uses the model of multi-product firms to explore the relation between firm heterogeneity and international trade. Nocke and Yeaple (2006) and Eckel and Neary (2010) model how globalization affects the distribution of firm sizes, as well as the scale and scope of firms, respectively. Bernard *et al*. (2011) develop a canonical theoretical model of multi-product firms and analyze their behavior during trade liberalization. They model firm productivity in terms of a given product as a combination of firm-level "ability" and firm-product-level "expertise", both of which are stochastic and unknown prior to the firm's payment of a sunk cost for entry. The model predicts a positive correlation between firm productivity and a firm's intensive (output per product) as well as extensive (number of products) margins. Some studies, such as Feenstra and Ma (2008) and Mayer *et al*. (2014), focus on exploring the influence of market size on the product scope of multiproduct exporters.[3] Arkolakis and Muendler (2010) develop a model of firm-product heterogeneity with entry costs in which barriers might determine the choice of products and span of exporters, and indicate that more productive firms can endure such entry costs and then export more products.[4] Antoneiades (2015) presents a model of heterogeneous firms, endogenous quality choice, and endogenous markups within which the most productive firms respond to competition by raising quality and prices

Consequently, some studies began to examine how firm heterogeneity relates to export margins. By using German firm-level data, Wagner (2016) investigates the differences in extensive and intensive margins of exports in manufacturing firms from East and West Germany, highlighting the importance of human capital in differentiating performance in export margins; Raff and Wagner, (2014) find foreign-owned enterprises export more varieties of goods and export to more countries; Wagner (2015) investigates the links between firm age and extensive and intensive margins of exports. Results show older firms export increasingly more different goods to more diverse destination countries. However, the aforementioned evidence from German firms considers only one kind of firm attribute. Bernard *et al*. (2014) is one exception that examines how technological heterogeneity in terms of firm productivity affects the intensive (extensive) margins of trade. Using exporters in Belgium, they find that more productive firms export more products to more countries and have higher average product-country export flows.

Another line of the literature focuses on the role of intensive and extensive margins in the growth of trade and reaches two opposing conclusions. A number of papers argue that extensive margins are relatively important, such as the cross-country studies in Evenett and Venables (2002) and Hummels and Klenow (2005), and the Philippine case in Adelan and Kakinaka (2018). In contrast, Eaton *et al*. (2008), Felbermayr and Kohler (2006), and Helpman *et al*. (2008) find that intensive margins are more influential. A case study conducted in the Peruvian context conducted by

[3] Redding (2011) provides a comprehensive review of the theories of heterogeneous firms and trade.

[4] Hallak and Sivadasan (2009) and Antoneiades (2015) alternatively focus on the linkage between firm heterogeneity and export quality.

Martincus and Carballo (2008) finds that export promotion policy is more effective for extensive exports, both in terms of markets and products.

Benefiting from the availability of comprehensive customs data in China, several related empirical studies have emerged recently. Amiti and Freund (2010) examine the relative roles of intensive and extensive margins in trade growth and find that the intensive margin played a more important role in China's export growth between 1992 and 2005. Following the emerging theories relating multiproduct firms to international trade, Manova and Zhang (2012) utilize the rich export data from China Customs, which is also used in this study, to establish several stylized facts about quality heterogeneity (measured by export prices) across firms and export destinations. They find two specific features: more successful exporters use higher-quality inputs to produce higher-quality goods, and firms vary in the quality of their products across destinations via using inputs of different quality levels. Although broadly discussing China's exports and imports, their analyses mainly concentrate in linking product numbers and destination characteristics to export prices, but do not examine the relationship between technological heterogeneity and the intensive (extensive) margins of trade.

Ing and Yu (2015) examine how productivity differentiates export activity in a South–South trade framework. Empirical results find that tariff reductions (involving foreign, home output and home input tariffs) significantly increase home country firm productivity and exports via extensive and intensive margins. Brandt and Morrow (2017) examine also the impact of tariff reductions on exports, while they focus on the influence of import tariffs on the organization of its exports between ordinary and processing trade. Falling input tariffs are found to cause an increase in the share of ordinary trade in gross exports, with both intensive and extensive margins playing significant roles.

One more relevant study is that of Yang and Tsou (2015) who examine the determinants of export variety and unit price, while focusing on how the presence of multinational enterprises (MNEs) affects export variety and the unit price of local exporters, i.e., the export spillover effect. Using measures of multinational presence constructed at regional and industry levels, they find no multinational spillovers in the export variety of domestic firms, whereas the growing presence of multinational firms negatively impacts the export unit value of domestic exporters.

Compared with the extant literature, our study aims at systematically linking firm heterogeneity to export margins, especially in exploring the role of firm technological heterogeneity in enhancing export performance in terms of extensive and intensive margins by providing the following empirical novelties. First, rather than focusing on the effects of one firm attribute on differentiating export margin performance, this study considers various aspects of firm heterogeneities. Second, this study carefully deals with problems of sample selection, measures of products and endogenous causality, resulting in reliable and robust results.

3. Data and Stylized Facts

3.1 Data

To investigate what kinds of firms export more varieties of goods and export at a higher value per product, we use the within-firm-product panel data merged from two Chinese databases: (1) customs data collected by China Customs and (2) the Survey of Large and Medium Size Enterprises (LMEs) conducted by China's National Bureau of Statistics (NBS) during 2003-2006. The rule of matching is to identify the same

company in the two databases by exactly the same company name (in Chinese). As for firms having similar names in the two databases, we use zip codes as criteria to implement further compilation. The customs data provide detailed information on 8-digit HS product codes, exporter/importer identity, product units, quantity, unit value, total value, type of ownership, origin, destination, type of trade, etc. The NBS survey contains all state-owned enterprises (SOEs) and non-SOEs with sales of over RMB 5 million, which are the so-called "scale-above" enterprises. It is a nationally representative sample of China's manufacturing sector, accounting for about 88% of value-added in the manufacturing sector. The survey questionnaire consists of three parts: basic information such as company name, establishment date, industry code, and main products; financial information related to financial statements; and production information like sales, output and export volume.

We focus our analysis on the electronics industry, with the two-digit industry code of 40 and official name "manufacture of electronic and telecommunication equipment", which consists of nine three-digit sub-industries. The reasons we focus on only the electronics industry are twofold. First, it stays true to Melitz's (2003) theory that models firm productivity distribution within an industry and links it to exports. Second and crucially, the electronics industry is the most important in China's manufacturing sector in the mid-2000s. For example, it accounts for 28.56% of exports in the manufacturing sector in 2007, suggesting that this industry heavily relies on international trade.[5] The firms surveyed in this industry may vary in different years since the NBS survey only includes firms with sales higher than RMB 5 million. Firms disappearing in some years may probably be attributed to changes in sales driving them below the RMB 5 million threshold, rather than their exiting the market. To deal efficiently with unobserved firm heterogeneity in the panel data, we utilize balanced panel data for the period of 2003-2006. Moreover, as this paper examines the productivity effect on export margins, we include only exporters to implement estimations. Including both firms with and without exports will lead to the self-selection problem as discussed in the productivity-export nexus literature within which more productive firms self-select to enter the international market. To mitigate the problem of selection bias, we thus use only exporters, helping simplify the discussion. However, for robustness checks, we will also use all electronics firms, including exporters and non-exporters, to conduct our empirical analysis.

Ownership may also play an important role in affecting the decisions and behavior of businesses in China. Considering this, we divide the firms selected into three ownership types according to a widely adopted classification (e.g., Jefferson *et al*., 2000; Yang *et al*., 2010). They are: (1) state-owned enterprises (SOEs), including state-owned and collectively-owned enterprises; (2) foreign-owned enterprises (FOEs), including Hong Kong, Macau, Taiwan, and other foreign-owned enterprises; and (3) private-owned enterprises (POEs), including shareholding and private enterprises.

3.2 Stylized Facts of Export Heterogeneity in China's Electronics Industry

We document some stylized facts mainly for firm heterogeneity in the extensive margins of exports, i.e., the variety of exported goods. In Table 1 we report firm distribution in terms of product variety number per electronics firm. We can see that, in 2003, 37.76% of the firms exported only one product (8-digit HS code). The

[5] The empirical specifications in the paper are not specific to the electronics industry. They can be extended by including data from various industries to estimate the effects of firms, helping understand firm productivity and export margins in a general sense.

corresponding shares of exporting two, three and four kinds of products are 21.17%, 11.52%, and 8.04%, respectively. The actual distribution of exported product numbers ranges between 1 and 115; the higher the product number, the lower the share. We summarize firms which export five and more products to foreign destinations, together accounting for 21.05% of total firms. Table 1 basically suggests a right-skewed distribution in the number of product varieties, with a high frequency at the right tail. Although this pattern seems to remain stable during the period of 2003-2006, the average number of products exported had begun increasing gradually. The share of exporters that exported one product decreased from 37.76% in 2003 to 30.44% in 2006, whereas the corresponding share for exporters that exported more than five varieties of products increased from 21.50% to 25.80% in this period. Overall, multi-product exporters constitute the majority of firms and demonstrate an increasing ratio, reaching an average of 66%. As indicated in Bernard *et al*. (2014), the corresponding figures are 65% in Belgium in 2005 and 58% in USA, respectively. This suggests the prevalence and importance of multi-product firms in China.

Table 1: Number of Exporting Products per Firm

Number of products	2003	2004	2005	2006
	% of firms			
1	37.76	34.15	33.64	30.44
2	21.17	20.05	19.82	20.02
3	11.52	14.02	13.74	14.06
4	8.04	8.15	8.58	9.68
5 and above	21.05	23.64	24.23	25.8
Total	100	100	100	100

Source: Authors' estimations

We further observe the varieties of export products at the firm level, but under different ownership types in Table 2. Let us first look at the exporters of SOEs. As seen in Table 2, most SOE exporters export a few products overseas, while their contribution to overall export value is quite limited. For example, 66.74% of SOE exporters ship two products or less, while only making up a minor share of 23.11% of the export value of SOEs. As for FOE exporters, the majority of export value (69.26%), however, is contributed by a relatively few firms (27.96%) that export more than five varieties of products, implying that these exporters actually play an important role in total export value. As for POE exporters, on the one hand, similar to SOE exporters, a majority (66.81%) export two products or less, and they contribute 35.31% to export value; on the other hand, similar to FOE exporters, a small group of POE exporters ship more than five products (13.52%), yet contribute a large share of 42.37% to the export value.

Table 2: Number of Exporting Products per Firm by Ownership Type

Number of Products	State-Owned		Foreign-Owned		Private-owned	
1	45.31	(15.00)	28.94	(10.67)	44.64	(16.24)
2	21.43	(8.11)	19.80	(8.27)	22.17	(19.07)
3	17.97	(38.39)	13.61	(5.46)	12.59	(9.36)
4	5.86	(6.29)	9.69	(6.31)	7.08	(12.96)
5 and	9.37	(32.21)	27.96	(69.26)	13.52	(42.37)
Total	100	(100)	100	(100)	100	(100)

Note: The observations are of Chinese exporting firms in the period of 2003-2006. All numbers are in percentage terms. The numbers in the parentheses are the shares of firms exporting different numbers of product varieties in overall export value within one ownership type.
Source: Authors' estimations

4. Empirical Model and Measurement of Productivity

To investigate the determinants of export performance in terms of extensive and intensive margins, we propose the following two empirical models. In particular, equation (1) is for varieties of exported products (extensive margin), and equation (2) is for export value per product (intensive margin):

$$\begin{aligned} VEP_{it} = {} & \alpha_0 + \alpha_1 \ln TFP_{i,t-1} + \alpha_2 \ln SIZE_{it} + \varepsilon_3 AGE_{it} + \alpha_4 LEVERAGE_{it} \\ & + \alpha_5 \ln WAGE_{it} + \alpha_6 FOE_{it} + \gamma \cdot Location + \delta \cdot Year + u_i + \varepsilon_{it}; \end{aligned} \tag{1}$$

$$\begin{aligned} \ln VALUE_{ipt} = {} & \beta_0 + \beta_1 \ln TFP_{i,t-1} + \beta_2 \ln SIZE_{it} + \beta_3 AGE_{it} + \beta_4 LEVERAGE_{it} \\ & + \beta_5 \ln WAGE_{it} + \beta_6 FOE_{it} + \beta_7 \ln PRICE_{ipt} + \beta_8 PROCESS_{ijt} \\ & + \gamma \cdot Location + \delta \cdot Year + v_p + \zeta_{ipt}. \end{aligned} \tag{2}$$

In equation (1), the dependent variable VEP_{it} represents the varieties of exported products that the *i*th firm exports in year *t*, denoting that it is a count variable; while in equation (2), the dependent variable $\ln VALUE_{ipt}$ denotes the natural logarithm of *p*th product's value that *i*th firm exports in year *t*. This measure is widely adopted in the literature, e.g., Besedes and Prusa (2011), Cadot *et al*. (2011), and Chaney (2008). In other words, it represents the export value per product of each firm. As the export value is reported in US dollars and the studying period (2003-2006) covers year 2005 when China implemented exchange rate system reforms, it is deflated by exchange rate using the 2003 as the base year.

Regarding the independent variables, *TFP* stands for a firm's total factor productivity (TFP) and is the key variable of our interest. Theoretical studies such as Melitz (2003) and Yeaple (2005) emphasize the critical role of firm heterogeneity in affecting exporting behavior, and they generally model firm heterogeneity using the distribution of productivity. Different from the traditional TFP measure used in Bernard *et al*. (2014), herein TFP is calculated with the strict and widely used methodology proposed by Levinsohn and Petrin (2003).[6] To mitigate the endogeneity problem of productivity, it enters the equation in a one-year lag form. The empirical literature thus far finds that more productive firms seem to be able to export more products, enter more markets (Bernard *et al*., 2014) and have higher export quality because of taking advantage of their better operation efficiency (Bastos and Silva, 2010). Specifically, the model developed by Bernard *et al*. (2011) predicts a positive correlation between firm productivity and intensive margins. We thus expect the sign of *TFP* in equations (1) and

[6] Van Beveren (2012) provides an overview of the methodological issues that arise when estimating TFP at the establishment level, as well as of the existing (parametric and semi-parametric) techniques designed to overcome them. He suggests that semi-parametric estimators, including the TFP measure of Levinsohn and Petrin (2003), are to be preferred. We have also tried to replace TFP by labor productivity and obtained similar results.

(2) to be positive.[7]

The variable *SIZE* denotes firm size, and we use the total employment of a firm as its proxy. Larger firms in general tend to achieve economies of scale and hence are more inclined to export (Roper *et al*., 2006; Bernard *et al*., 2007). We expect that such an advantage of economies of scale would induce them to export a greater variety of products, as well as more value per product. Namely, we expect the sign of *SIZE* to be positive. The variable *AGE* represents the total years since a firm was established. The effect of this variable on a firm's export performance is rarely examined in the literature. For example, Roper *et al*. (2006) finds that older firms have lower export intensities, while Gumede (2004) posits the opposite conclusion. Wagner (2015) finds older firms export progressively more different goods than their younger exporter counterparts. Consequently, a positive sign regarding this variable is expected.

Another variable of particular interest concerns the financing ability of a firm, denoted as *LEVERAGE*, and we use the ratio of total liabilities to total assets of a firm as a proxy. In this study we consider firms with a higher debt to asset ratio to be those that have *better* financing ability. At first glance, this measure seems to be counter-intuitive, but it should be applicable in the case of China since firms there in general cannot easily gain access to external financing due to the immature capital market and banking system. Firm-level financing ability is important in the export decision making of an operation in the heterogeneous firm structure. By assuming an imperfect capital market, a liquidity constraint might make it difficult for highly productive firms to cover upfront fixed costs, even though the expected future profits from exporting are sufficiently large. Given that exporters usually need to bear higher expenditure than non-exporters, the accessibility of funds thus becomes a key factor in production and in running overseas businesses. Manova (2013), for example, extends the Melitz model by emphasizing the role of financial constraints in determining a firm's export status, and finds that financially advanced economies export a wider range of products and their exports experience less product turnover, suggesting the importance of the financial environment. Besides, Minetti and Zhu (2011) find that firms with a higher leverage ratio (total liabilities to total equity) are more likely to export. Egger and Kesina (2014) point to a negative relationship between credit constraints (liquid debt to sale ratio) and export-sale ratios in China. We therefore include this variable in our analysis and expect that firms with more effective financing ability will perform better.[8] WAGE represents a firm's average wage expenditure. As mentioned, while the literature has found that exporters on average are able to pay higher wages (Bernard *et al*., 2012), how this variable affects the performance of exporters, however, remains t unclear. We expect the sign of the estimated coefficient of *WAGE* to be positive, since average wage can act as a proxy for the quality of human resources. The finding of Haltiwanger *et al*. (1999) that human capital investment

[7] It is worth noting that according to the prominent research of Melitz (2003), the competitiveness of a firm counts in terms of price; only the cheapest goods are the most competitive. This implies that the relationship between a firm's productivity and product price could be negative. However, if consumers really care about product quality, then goods with the highest observed prices will be the most competitive since the quality-adjusted price is lower (Baldwin and Harrigan, 2010). This implies that if a firm's productivity is positively associated with product price, then it suggests that a more productive firm is able to provide high quality goods and also indicates that the unit price of exports is indeed a sound proxy variable for product quality.

[8] Compared with financial constraints, there exists another line of research focusing on financial health in explaining a firm's export behavior. For example, Bellone *et al*. (2010) uses the liquidity variable as the proxy for finance health and finds that a firm with a higher liquidity level is likely to become an exporter.

undertaken by firms plays a critical role in improving productivity might suggest that *WAGE* can have an indirect effect on export performance.

Given that FOEs play a critical role in the development of China's high-tech industries (Jongwanich *et al*., 2014) and they mostly conduct assembly exports, we therefore control the ownership type of FOEs (denoted by *FOE*) to compare the differences with domestic firms in terms of export margins. Monava and Zheng (2012) observe that FOEs export fewer products to fewer destinations, suggesting that the estimated coefficient of *FOE* in equation (1) to be negative, whereas Wagner (2016) finds FOEs export more numbers of products in Germany. For equation (2), however, since electronics FOEs generally conduct assembly exports for international brands, they might enjoy the advantage of mass production and thus be associated with a positive coefficient.

In equation (2) we consider two more variables. The variable of *PRICE* denotes the unit price of an exported product. The variable should be controlled for China's exporters because they set higher prices in richer, larger, bilaterally more distant and overall less remote countries (Manova and Zhang, 2012). Moreover, the unit price of various products varies considerably. After controlling for product price, it enables us to examine the role of productivity in affecting intensive margins. The variable *PROCESS* is a dummy variable for processing trade, which equals unity if an exporting product belongs to the processing trade.[9] China dominates the international markets in a variety of electronics products by being a country where a large share of firms are subcontractors serving international brands for assembly. Hence, an exported product belonging to the processing trade in general tends to have higher sales, compared with one belonging to ordinary trade. Also, Amiti and Freund (2010) argue that the skill content of manufacturing exports is mostly promoted by the processing trade, suggesting that the processing trade might help enhance trade margins more. We will add this variable as a model specification and, based on the argument above, we expect the signs of the estimated coefficients of *PROCESS* to be positive.

The last two series of independent variables are dummy variables of location and years. Among Chinese electronics firms, the overwhelming proportion are located in Beijing, the Yangtze River Delta and Guangdong Province (approximately 97%), we thus include two location dummies - Beijing (*BEJ*) and the Yangtze River Delta (*YZRDELTA*) - by taking the location of Guangdong Province (i.e. the Pearl River Delta) and other districts as the reference group. Moreover, a series of year dummies are also included. Lastly, the terms u in equation (1) and v in equation (2) denote unobserved firm-level and product-level fixed effects, respectively. Correspondingly, the terms ε and ζ are error terms which capture unobserved characteristics.

Notice that all the independent variables above are in logarithmic form except *AGE*, *LEVERAGE*, and the dummy variables. As the dependent variable in equation (1) represents a positive integer value, we assume the conditional distribution of VEP_{it} given vector of covaraites ($\boldsymbol{X}_{it}$) follows the Poisson distribution with a mean equal to $\exp(X_{it}^{'}\beta)$. Thus, the fixed effect count-panel-data model is adopted to implement empirical estimation, while simultaneously reporting the heteroscedastic-consistent standard errors suggested by Gourieroux *et al*. (1984). We list the detailed variable definitions and basic descriptive statistics in Table 3.

[9] Processing export indicates that the exported product is made using imported inputs. In contrast, ordinary export implies the product exported is made using domestic inputs.

Table 3 Variable Definitions and Basic Statistics

Variable	Definition	Mean (S.D.)
VEP	Variety of product exported	3.98 (6.02)
VALUE	Value of export of firms (in logarithm)	12.55 (2.27)
PRICE	Price of export per product (US$ thousand)	1.08 (31.37)
TFP	Index of TFP developed by Levinsohn and Petrin (2003) (in logarithm)	3.75 (1.86)
LEVERAGE	Ratio of total liabilities over total assets	0.69 (8.88)
Wage	Average wage expenditure per person (in logarithm)	3.07 (0.69)
AGE	Years since company established	11.05 (5.87)
SIZE	Firm size: total employment (in logarithm)	6.93 (1.46)
FOE	Ownership dummy: a foreign-owned enterprise	0.76 (0.43)
BEJ	Location dummy: a firm located in Beijing	0.02 (0.16)
YZRDELTA	Location dummy: a firm located in Shanghai or Jiangsu (Yangtze River Delta)	0.10 (0.30)
PROCESS	Export type dummy: export product made from import inputs	0.58 (0.49)
RD	R&D expenditure (in logarithm)	2.10 (3.30)
COMPEN	Compensation expenditure per employment, including expenditure on insurance and pensions (in logarithm)	0.94 (1.26)

Note: The means and standard errors are calculated by pooling data for the 2003-2006 period.
Source: Authors' estimations

5. Empirical Results

5.1 The Determinants of Export Extensive and Intensive Margins

We report and analyze the estimation results drawn from equations (1) and (2) in this subsection. Table 4 reports the estimating results of equation (1): the export extensive margin equation. To mitigate the endogenous problem of productivity, we adopt various strategies. In specifications (1) and (2), the productivity measure used is a one-year lagged TFP. In columns (3), the two-stage predictor substitution (2SPS) method (see Terza *et al*., 2008 for a comprehensive discussion) is employed. In the first-stage of 2SPS, the TFP regression is estimated as follows.

$$\ln TFP_{it} = f(\ln COMPEN_{it}, Z_{it}). \quad (3)$$

Term ln*COMPEN* is the instrumental variable and it is measured by the sum of insurance and pension expenditure. Though valid instruments relating to TFP are difficult to find, the "compensation expenditure (insurance and pensions) per employee" (lnCOMPEN) might be the most feasible alternative. Before implementing the "Labor Contract Law" in 2008, it was not compulsory for employers to contribute to

employees' social security in China. If a firm invests more in insurance and pensions, it may induce a higher level of productivity. This phenomenon has been witnessed in China's electronics industry (Yang *et al*., 2010) Thus, the investment in workers exhibits a high correlation with TFP, whereas it is less relevant to export margins. Term *Z* is a vector of covariates that comprises all explanatory variables included in equation (1), except for productivity. That is, it includes ln*SIZE*, *AGE*, *LEVERAGE*, ln*WAGE*, *FOE*, location dummies, and year dummies. Using the panel model to estimate equation (3), it generates predicted values for the endogenous variable, TFP. The second-stage regression is then conducted for the outcome equation of interest after replacing the endogenous variables with the predicted values. Estimates in columns (1)-(3) are obtained by using the panel Poisson model and the marginal effects for explanatory variables are also reported. Moreover, if we treat the wide range of product numbers as a continuous value, the traditional linear panel model is adopted. Estimates are shown in column (4) as a robustness check.

As shown in Table 4, the coefficient for *TFP* is significantly positive in all specifications with a similar magnitude. This implies that more productive firms tend to export more varieties of products, which is in line with the theoretical predictions in Bernard *et al*. (2011) and Arkolakis and Muendler (2010) that highlight the importance of firm technological heterogeneity in export performance in terms of extensive margins. It is also consistent with empirical findings from Belgium (Bernard *et al*., 2014). The estimated marginal effect of TFP varies within the range between 0.242 and 0.432 in columns (1)-(3), suggesting that an increase in TFP of about 3% produces one more product, on average. Although we have adopted various strategies to mitigate the endogenous problem of productivity in the Poisson model estimation for columns (1)-(3), the estimated magnitude of the export variety effect of TFP might remain inconsistent and it should be interpreted conservatively. Bernard *et al*. (2014) find the product variety effect of TFP to be 0.027 for Belgium firms using the linear estimation. Our estimate in column (4) shows a marginal effect of 0.304; again suggesting the importance of TFP for multi-product exporters in China.

For other regressors, we are particularly interested in the financing ability (*LEVERAGE*) of a firm. In Table 4, all coefficients of *LEVERAGE* are positive and significant at the 1% level, suggesting that firms facing less financial constraints export a greater variety of products, consistent with the findings in Bellone *et al*. (2010), Manova (2013), and Egger and Kesina (2014). Financing ability is probably more relevant for local firms, because foreign operations could rely partly on loans from their MNEs, while local firms would be unable to follow suit. The effect of firm size (*SIZE*) is significantly positive at the 1% level in all specifications. Although the NBS survey contains LMEs only, the size distribution of LMEs remains quite dispersed, thereby still playing a key role in differentiating productivity. Our result suggests that larger firms tend to export more varieties of products, which is probably because these firms are more likely to have more product lines, therefore exporting more varieties. In addition, neither firm age (*AGE*), nor average wage expenditure (*WAGE*) affects the extensive margins of exports. Among explanatory variables, firm size is associated with the largest marginal effect on export varieties. This result highlights the advantage of economies of scope enjoyed by large firms.

Table 4: Panel Poisson Model: Number of Products Exported (Fixed Effect)

	(1)		(2)		(3)		(4)	(5)
		Marginal effect		Marginal effect	Two-stage 2SPS	Marginal effect	Linear panel	Linear Panel, IV
lnTFP(-1)	0.069**	0.293*	0.064**	0.242*			0.304**	
	(2.75)	(1.83)	(2.53)	(1.74)			(2.03)	
lnTFP-hat					0.100*	0.432*		
					(1.89)	(1.68)		
lnTFP (IV)								0.448**
								(2.17)
lnSIZE	0.131***	0.554**	0.122***	0.462**	0.115***	0.498**	0.570***	0.567**
	(3.78)	(2.53)	(3.50)	(2.42)	(2.94)	(2.21)	(2.86)	(2.10)
AGE	-0.001	-0.005	-0.001	-0.004	-0.0003	-0.001	5.6e-05	0.011
	(-0.21)	(-0.22)	(-0.22)	(-0.22)	(-0.06)	(-0.06)	(0.00)	(0.38)
LEVERAGE	0.002***	0.009**	0.002***	0.008**	0.002***	0.010*	0.008***	0.010***
	(3.49)	(2.21)	(3.36)	(2.15)	(3.10)	(1.94)	(2.75)	(2.71)
lnWAGE	-0.014	-0.061	-0.012	-0.046	-0.029	-0.125	-0.040	0.003
	(-0.59)	(-0.61)	(-0.50)	(-0.51)	(-0.94)	(-0.80)	(-0.29)	(0.01)
FOE	0.049	0.205	0.053	0.200	0.038	0.166	0.198	0.567
	(0.95)	(0.90)	(1.03)	(0.97)	(0.74)	(0.72)	(0.64)	(1.35)
Location Dummy	No		Yes		Yes		Yes	Yes
Year Dummy	Yes		Yes		Yes		Yes	Yes
Log-Likelihood	-5,038		-5,029		-5,031			
Exogeneity (Wald)								2.84
R-square							0.177	0.156
Firms	1,303		1,303		1,303		1,303	1,303
Observations	4,555		4,555		4,555		4,555	4,555

Note: t statistics in parentheses are based on heteroscedastic-consistent standard errors.

*p < 0.10, ** p < 0.05, *** p < 0.01. On column (3), the t statistics in parentheses are based on bootstrap standard errors. The first-stage of TFP equation is estimated by the fixed effect of panel data model. The result is as follows:

lnTFP= 2.901+ 0.016lnCOMPEN+0.189lnSIZE-0.009AGE-0.007LEVERAGE+0.268lnWAGE+0.165FOE+ Location Dummy + Year dummy

(29.51)*** (8.22)*** (9.94)*** (-4.48)*** (-20.9)*** (18.05)*** (6.01)***

On columns (5), the instrumental variable included is lnCOMPEN.

Source: Authors' estimations

As for the variable of ownership of our concern, the estimated coefficient of *FOE* is, as expected, positive, but not statistically significant, in contrast to the finding of a positive relation in the context of German exporters (Wagner, 2015). This suggests that the ownership type, either foreign-owned or domestic, is irrelevant to the extensive margin of exports. Foreign-owned electronics firms in China are more productive and mainly conduct processing trade activities according to Amiti and Freund (2010), yet here we find that on average they do not tend to export more varieties of products. One interpretation might be that assembly production may focus on mass production rather than producing more varieties.

Although using one-year lagged TFP could mitigate the endogenous problem of productivity to some extent, this problem might remain, as productivity is generally persistent. The two-stage approach used in column (3) might be invalid if some variables on the right-hand in the first stage regression are also endogenous. We thus further adopt the panel IV approach to consolidate the estimating results. An adequate choice of IV is a hard task, but fortunately we have an attractive candidate: lnCOMPEN, which is as defined and discussed in Equation (3). Results are displayed in column (5) of Table 4.

As shown in the bottom panel of Table 4, we find the Wald test of exogeneity is insignificant, which provides guidance on the usefulness of the instrumental variable method. Using the IV approach, TFP continues to have a significant positive influence on export varieties accompanied with a larger marginal effect. This confirms our main finding that productivity is positively related to export varieties, supporting the new theory of multi-product exporters proposed by Bernard *et al*. (2011).

Next, we investigate how productivity and other determinants relate to export intensive margins, and illustrate the results of the estimating equation (2) in Table 5. The arrangement of various estimating strategies are similar to those in Table 4, in which the estimates in columns (1) and (2) are obtained using one-year lagged TFP, whereas TFP in columns (3) and (4) represent the predicted values of the first-stage estimation on the TFP equation. Column (5) shows the results using the panel IV method.

Table 5: Panel Model: Export Value per Product (Fixed Effect)

	(1)	(2)	(3)	(4)	(5)
lnTFP(-1)	0.187***	0.164***			
	(3.27)	(3.08)			
lnTFP-hat			0.249***	0.235**	
			(2.37)	(2.08)	
lnTFP (IV)					0.255***
					(2.76)
lnSIZE	-0.011	-0.001	-0.018	-0.006	0.002
	(-0.18)	(-0.16)	(-0.22)	(-0.09)	(0.15)
AGE	-0.019***	-0.014*	-0.016**	-0.011*	-0.016*
	(-2.22)	(-1.77)	(-1.99)	(-1.66)	(-1.79)
LEVERAGE	0.002***	0.003***	0.001**	0.001***	0.002***
	(2.54)	(2.98)	(2.07)	(2.29)	(2.64)
lnWAGE	0.001	-0.002	0.001	-0.001	0.001
	(0.01)	(-0.06)	(0.01)	(-0.05)	(0.07)
PRICE	0.477***	0.390***	0.475***	0.379***	0.371***
	(10.98)	(11.12)	(10.29)	(10.72)	(8.24)
PROCESS		2.435***		2.289***	2.764***
		(12.79)		(11.05)	(12.57)
FOE	-0.052	-0.044	-0.040	-0.031	-0.10
	(-0.46)	(-0.47)	(-0.39)	(-0.29)	(-0.22)

Location Dummy	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes
Adj. R-square	0.27	0.34	0.26	0.34	0.35
Exogeneity					2.36
(Wald)	1,341	1,341	1,341	1,341	1,341
Firms	1,212	1,212	1,212	1,212	1,212
Product	54,465	54,465	54,465	54,465	54,465
Observations					

Note: The *t* statistics in parentheses are based on robust standard errors clustered by firm. * p < 0.10, *** p < 0.01. In columns (3) and (4), the predicted TFP is obtained from the first-stage estimation of the TFP equation as that in the note of Table 4. On columns (5), the instrumental variable included is lnCOMPEN.

Source: Authors' estimations

Table 5 demonstrates that productivity measures, either as a one-year lagged form, predicted value, or as an instrumental variable, are associated with a positive and significant coefficient across all model specifications. This suggests that more productive firms tend to have higher export sales, after controlling for the unit price of an exported product. This result not only supports the theoretical prediction in Bernard *et al*. (2011) that firm technological heterogeneity in productivity is positively related to intensive margins, but also is consistent with the stylized fact found in Manova and Zhang (2012). Again, the IV estimate in column (5) shows a larger marginal effect on intensive margins, whereas a smaller and similar figure is shown in columns (1)-(4) ranging between 0.164 and 0.249. Compared with the estimated elasticity of TFP with respect to intensive margins for Belgium firms, 0.40 (Bernard *et al*., 2014), productivity is more crucial to the intensive margin of exports for exporters in China.

It is interesting to compare the relative magnitude of the effects of productivity on the extensive and intensive margins of exports in Table 4 and 5, respectively. The magnitude of estimated coefficients *TFP* in Table 5 hovers between 0.164 and 0.249, suggesting an elasticity of about 0.18 wherein firms with a 1% increase in *TFP* can raise the export value of one product by 0.18%. Compared with the magnitude of the counterparts in Table 4, we find a higher elasticity of productivity on the extensive margins of exports than on the intensive margins. The marginal effect reaches at least 0.242 on various estimations, as illustrated in Table 4.

Surprisingly, firm size has an insignificant influence on the intensive margins of exports in all specifications. Although economies of scale might still play a role influencing intensive margins here, given this study is within a firm-product level analysis might also mitigate its role after controlling for unit price. In contrast, the effect of firm age turns out to be negatively significant, suggesting that younger electronics firms tend to have higher exports per product than their older counterparts, *ceteris paribus*. This is probably because of the feature of creative destruction within the electronics industry, so that the late comers might be able to produce higher-value products.

The coefficients of financing ability (*LEVERAGE*) are all significantly positive in all specifications at the 1% level, suggesting that firms with better financing ability tend to have a higher level of intensive margins of exports. This, again, indicates the importance of the role of financing ability in firms' export behavior, supporting Manova's (2013) theoretical prediction. The unit price of an exported product (*Price*) is, as expected, a significant and positive coefficient across all specifications, as a product with a higher price generally leads to a higher value of sales, with other things being equal.

We next find that the variable *PROCESS* is, as expected, significantly and positively related to export value per product. This finding is intuitive, since the distinct feature of China's electronics industry is that it mainly conducts assembly activities for export. For example, Apple products and most brands of laptop are assembled in China and then exported overseas, and therefore the products of the processing trade are generally associated with a larger amount of sales. Lastly and surprisingly, we do not find that FOEs have a higher export value per product. One possible reason is that most Chinese affiliates of FOEs undertake assembly exports, eroding the real effect of this ownership variable *FOE*.[10] This result might also partly support Amiti and Freund's (2010) finding that the intensive margin, an important factor in China's export growth, is contributed to by both foreign-owned and domestic enterprises.

5.2 Measurement and Sample Selection Issues

We thus far have shown that firm technological heterogeneity in terms of productivity is relevant to the extensive and intensive margins of exports, after considering the endogeneity of productivity. In this subsection we implement some robustness checks for both extensive and intensive margins to deal with the following potential measurement and sample selection issues. Since similar results are found in Table 4 and 5, after using various TFP measures to mitigate the endogeneity problem, we adopt only one-year lagged TFP measure in this section. For the extensive margin, i.e., equation (1), we mainly deal with two issues. First, how to define the scope of a product is an essential issue since the extensive margin is defined as the varieties of exported products. That many electronics products share similar functions implies that the 8-digit HS code, the product classification used in the previous analyses, is a very narrowly defined method of classification. For robustness, we adopt a broader definition of products using the 6-digit HS codes.

Second, the well-known self-selection hypothesis in the trade literature states that, if the fixed cost of access to foreign markets is higher, only firms with high productivity will find it profitable to enter international markets (Roberts and Tybout, 1997). This implies that the above analyses based only on exporters may encounter selection bias. To deal with this issue, we include all electronics firms during 2003-2006 in the estimations. As a result, the sample will contain a high frequency of extra zeros as the variety of exported products of non-exporters is uniformly zero. We therefore apply two approaches to conduct estimations. One involves using a two-step Heckman selection model to deal with the selection problem. We use also the Zero-Inflated Poisson (ZIP) model to handle such zero-inflation issues. One point worth noting is that the ZIP model is applicable for regression analysis when the dependent variable is non-negative integral. Hence, the ZIP model is used only for extensive margin estimation, rather than intensive margin estimation.

The Heckman two-stage estimating procedure is specified by:
The first-stage selection equation:

$$EXP_{it}^{*} = W_{it}'\gamma + \tau_{it} \tag{4}$$

where $EXP_{it} = 1\{EXP_{it}^{*} > 0\}$

[10] As shown in the appendix table, the correlation between *FOE* and *PROCESS* is 0.44. The correlation is significant at the 5% statistical level. Actually, the impact of foreign ownership on export margins (extensive and intensive) may depend on various foreign ownership variables. Unfortunately, the lack of FOEs' nationality information prevents us from separating FOEs into various groups by their nationalities.

The dependent variable *EXP* is a binary variable that equals 1 if a firm has positive export sales and 0, otherwise. Regarding covariates, referring to Bernard and Jensen's (2004) specification, we include firm size (lnSIZE), firm age (AGE), lagged productivity (lnTFP(-1)), and ownership type (FOE). Moreover, locations are also controlled. The selection equation is estimated using the random effect of a panel Probit model to determine export decisions based on the whole sample of exporters and non-exporters. A vector of inverse Mills ratios can be generated from the parameter estimates and then they are included as an additional covariate in the second-stage estimation, i.e., equations (1) or (2).

Table 6 displays the results of various robustness checks. Columns (1)-(4) are robustness checks for the extensive margins of exports: columns (1) and (2) display the second-stage results of the two-stage model, while columns (3) and (4) list the results of the ZIP model. On the other hand, columns (5)-(6) represent the second-step estimations of the Heckman selection model for the intensive margin equation.

For the extensive margin of exports, we first see that, the same as in Table 4, all the estimated coefficients on TFP are positive and significant at the 5% or 1% statistical levels in columns (1)-(4), suggesting the important role of firm technological heterogeneity in determining the extensive margin of exports, as claimed by the theoretical models (e.g., Bernard *et al*., 2011; Nocke and Yeaple, 2006; Eckel and Neary, 2010; Arkolakis and Muendler, 2010) and empirical findings (Bernard *et al*, 2014). After considering the sample selection problem, the positive effect of TFP on varieties of export products becomes much larger, suggesting the significant role of TFP in enhancing firms' ability to export greater varieties of products is underestimated if the sample selection problem is not corrected. On the other hand, the magnitude of estimated coefficient on TFP is similar when the varieties of exported products are measured by either HS 8-digit or HS 6-digit alternatives.

The results concerning firm size (*SIZE*) and financing ability (*LEVERAGE*) in Table 6 are also the same as those in Table 4. The effect of firm age (*AGE*) on the extensive margin of exports turns to be significantly positive in columns (1)-(2), implying that older electronics firms tend to export more varieties of products in terms of both narrow-defined and broad-defined products, echoing the German evidence (Wagner, 2015). The variable *WAGE* has statistically significant coefficients in all specifications with contrasting results in two different estimating strategies.

One distinct difference between Table 6 and Table 4 is that the dummy variable *FOE* turns to be significantly positive in all specifications, which is consistent with the findings in the context of German exporters (Wagner, 2016). However, as firms rarely change their ownership types, the estimates regarding such rarely changing variables obtained from the fixed effect model are inconsistent (Plümper and Troeger, 2007). The different results between the two tables might come from adding an extremely large number of non-exporters, and thus increasing the variability of this ownership variable. Compared with domestic firms, foreign-owned firms tend to export a wider variety of products, probably because they generally conduct processing trade and export highly sophisticated products. Furthermore, on the one hand they obtain more advanced knowledge and technologies from their parent firms and become more productive and on the other hand the parent MNEs are more experienced in international trade and thus help their Chinese affiliates access global market more easily. As a result, FOE takeovers perform better than other firms in terms of extensive margins of exports.

Table 6: Robustness Checks on Extensive Margins

	Panel Probit – two-stage Extensive Margin		ZIP model (fixed effect)		Heckman two-stage Intensive Margin	
	(1) 8-digit	(2) 6-digit	(3) 8-digit	(4) 6-digit	(5)	(6)
lnTFP(-1)	0.163**	0.179***	0.112***	0.106***	0.059***	0.091***
	(2.44)	(2.66)	(10.65)	(9.80)	(2.84)	(3.79)
lnSIZE	1.806***	1.831***	0.290***	0.272***	-2.16e-5***	-2.03e-5***
	(4.84)	(4.08)	(24.01)	(21.78)	(-6.03)	(-5.68)
AGE	0.205***	0.233***	-0.002	-0.002	-0.049***	0.001
	(2.92)	(2.77)	(-1.68)	(-1.25)	(-6.98)	(0.11)
LEVERAGE	0.546***	0.447**	0.039***	0.033***	0.218***	0.122*
	(3.00)	(2.11)	(4.32)	(3.48)	(3.01)	(1.68)
lnWAGE	-0.020**	-0.023**	0.004***	0.002***	0.235***	0.338***
	(-2.23)	(-2.19)	(6.85)	(4.86)	(2.58)	(3.70)
FOE	3.695**	3.476**	0.371***	0.385***		-0.258***
	(2.51)	(2.23)	(14.55)	(14.65)		(-12.58)
lnPRICE					0.335***	0.334***
					(89.82)	(89.74)
PROCESS					2.415***	2.406***
					(103.90)	(103.52)
Mills λ	7.144***	6.954***			2.080***	2.448***
	(4.89)	(4.40)			(3.25)	(3.82)
Location Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Wald Test	32.33***	31.75***			8.582***	8.398***
Vuong test			28.84***	29.28***		
Observations	2,604	2,604	10,060	10,060	68,928	68,928

Note: The *t* statistics in parentheses are based on robust standard errors clustered by firms. * p<0.1, ** p < 0.05, *** p < 0.01.
Source:Authors' estimations

We now turn to the robustness checks of the intensive margin, as displayed in columns (5) and (6). The estimated coefficient of TFP continues to be positive and significant, providing robust evidence for the theoretical predictions in Bernard *et al*. (2011) - that is, productivity serves as a key factor in fostering the intensive margins of exports. Again, a larger magnitude is witnessed associated with the estimated coefficient of the TFP variable, highlighting the importance of dealing with the selection problem.

Firms setting a higher product unit price tend to have higher export revenues, suggesting that product quality might be a dominant determinant of export sales (Manova and Zhang, 2012). Consumers prefer higher quality electronics products if unit prices are similar, implying that the quality of a product with higher export sales is probably better. The above analysis thus lends a supportive view to the importance of firm technological heterogeneity on export quality and price, as Hallak and Sivadasan (2009) claim.

Some effects of firm characteristics on the intensive margins of exports seem to change considerably. The coefficient of firm size turns from insignificant into significantly negative, which suggests that, among the sample of medium and large firms, smaller ones tend to experience a sales premium after controlling for other variables. Gibrat's Law, in which smaller firms grow faster in terms of sales, provides a possible interpretation. Foreign ownership also turns to out to be associated with a significantly negative coefficient in columns (5) and (6), indicating that FOEs have a lower export value per product compared with their exporter counterparts among local firms. Combined with the above two findings on variables of size and ownership, a possible interpretation is twofold. Most electronics FOEs undertake assembly exports, but do not necessarily export more varieties of products. For example, most laptop computer companies are exporters, but export only one product. Moreover, within exporters in the electronics industry a large share comprises Taiwan-owned enterprises, which are generally small firms.

5.3 Policy Discussion

The various estimations shown in Tables (4)-(6) overall suggest an endogenous quantity of productivity and a bias caused by the selection problem. Although the effect of productivity on extensive and intensive margins changes in an upward and downward direction respectively, our study overall tends to support a causal direction from productivity to the extensive and intensive margins of exports for Chinese exporters. This inspires some important policy implications.

As both the extensive and intensive margins of exports are related together they determine an exporter's total export value., This suggests that productivity is not only a critical factor determining exports, as claimed in Melitz (2003), but also affects export performance, highlighting the critical role of productivity in fostering exports. One point worth noting is that foreign-owned electronics firms are more productive than local electronics operations in China (Yang *et al*., 2010; Yang *et al*., 2013), promoting the productivity of local firms is thus a pertinent topical issue. It can potentially be facilitated by indigenous R&D, importing technologies, and other measures.

Manova (2013) argues that financial market imperfections severely restrict international trade flows and this argument is also evidenced in this study. China is not a financially well-developed economy, preventing private firms from easily accessing financial markets and obtaining loans, particularly in the case of small- and medium-sized enterprises (SMEs). China relies on exports to drive economic growth but suffers from weak financial institutions, it thus needs financial system reforms to

consolidate and improve financial efficiency, because better export performance needs stronger financing foundations.

Given that our within-firm-product estimation controls for unobserved firm heterogeneity, the varieties of products and the unit price of products, the positive effect of productivity on export sales thus suggests that firms with higher productivity tend to export higher quality products.[11] This finding might shed some light on the industrial transformation of China. An export-led economy like China almost inevitably faces the challenge of structural transformation in the export sector during the course of economic development, since purely pursing growth in trade volume eventually cannot guarantee its future export competitiveness. Some studies such as Amiti and Freund (2010) find that the intensive margin plays a more important role in China's export growth, which suggests that it might be time for China to shift its focus on how to improve the quality of its export products so as to enhance the value-added and profits of exporting firms. Without doing so, China might gradually face increasingly severe competition from newly emerging economies, because of the latter's advantage in the cost of production factors, especially labor.

6. Concluding Remarks

A firm's export performance in terms of extensive and intensive margins is one of the most important issues within the international trade literature in recent years. However, empirical studies on this issue are quite limited, suggesting the need of a systematic re-examination of the field. In this paper we empirically explore the determinants affecting the extensive and intensive margins of exports at the firm level, using detailed firm-product level panel data of Chinese exporters in the electronics industry. More specifically, we focus on the role of firm heterogeneity in terms of productivity that is widely discussed in the heterogeneous-firm trade models.

Various estimations dealing with the endogeneity of productivity and selection problem of entering international markets yield several conclusive findings. First, firms with higher productivity perform better in two aspects: they export more varieties of products and export at higher values per product. This is consistent with predictions in the existing theoretical and empirical heterogeneous firm literature that more productive firms outperform less productive operations.

Second, the financing ability of firms plays a significant role in both aspects of exporters' performance. In other words, constructing a friendly and complete financial environment is important not only for economic development, but also for enhancing the competitiveness of exporters.

Third, processing exports generate higher export value per product, after controlling for unit price, probably because ICT products among China's processing exports are mainly conducted by OEM firms producing on behalf of international brands with products usually of a premium quality nature.

Our findings have policy implications for Asian emerging economies, such as Thailand. China's competitive performance in terms of exports has deeply impacted the exports of other Asian countries. Eichengreen et al. (2008) find that China's exports generate a crowding-out effect in markets for consumer goods and, hence, severely

[11] Bastos and Silva (2010) use unit values within narrow product categories as the measure for product quality. They find that more productive Portuguese firms export products of higher quality. We adopt unit value as the dependent variable to implement empirical estimations and also find a positive relation between productivity and unit value.

affect less-developed Asian countries, whereas there is no impact on the capital goods trade of more advanced Asian economies. Facing export competition from China, members of the Association of Southeast Asian Nations (ASEAN) have to examine their export structure from a comparative perspective, and consider exchange rate and other trade policies, in order to cope with the staunch competition from China under the trade liberalization of the China-ASEAN free trade area agreement.

Acknowledgement

The previous version of this paper titled "Heterogeneous Firms and Trade: The Determinants of Exporters' Performance in Destinations, Varieties, and Quality" was presented at the Empirical Investigations in Trade and Investment (EITI) workshop in Bangkok. We thank Anne-Celia Disdier for very helpful comments. Suggestions from Andrew Bernard, Beata Javorcik, Fukunari Kimura, Marc-Andreas Muendler, Miaojei Yu, and the audience at the workshop are also highly appreciated, as were the insightful comments from two referees and the editor.

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