Trade Scopes across Destinations: Evidence from Chinese Firm

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Trade Cost and Export Diversification: Evidence from Chinese Firms

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Abstract

We examine how Chinese exporters adjust their number of exported varieties with respect to different characteristics of destination countries and varying trade cost. Using the Chinese firm-level customs data from the years 2001 and 2006, we show that: (i) firms export fewer varieties (indexed by HS6 code) to the destinations which are with higher exchange rate volatility, farther from China, or impose higher import-tariff rate; (ii) in response to the tariff reduction process by the destination countries after China entering to the WTO in 2001, the high productivity firms expanded the export scope while the low productivity firms reduced it.With a theoretical framework which considers firms' optimization decision involving both production and export varieties, we explain all our empirical findings, highlighting the relation between the exchange rate volatility and the number of export varieties.

JEL Classification: F12 F14 F31

Key words: Multiproduct firm; Product scope; Exchange rate volatility; Transportation distance; Tariff Reduction; China

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1 Introduction

1.1 Background

How characteristics of the destination countries play roles in the decisions of export firms (e.g. entry decision, the price or quantity strategies, and the number of product varieties to produce and export) has been widely discussed in recent years. The importance of a firm's decision on how many product varieties to produce and trade lies on two points: (i) as indicated by Melitz (2003), consumers prefer diversity of products and thus firms' decisions on product varieties are directly correlated with consumers' welfare; (ii) it helps to reduce the market risks a firm facing by providing more varieties to the market. Indeed, if a firm offers only one variety to the market, it will face relatively high level of demand risks (equal to individual risks of this variety); but if the firm sells plenty number of varieties and the individual risks of these varieties are independent, then the market risks faced by the firm will be reduced. This point stands on firms performance as it points to the firms' profits and their future growth, i.e. the low-risky firms are easier to borrow money from financial institutions and more likely to make R&D investment. Several papers studies how firms adjust the number of production and export varieties in response to the trade liberalization, e.g. Qiu and Yu (2014), Lopresti (2016), or how the export varieties are adjusted with different levels of exchange rate volatility, e.g. Hericourt and Poncet (2015) and Berthou and Lionel (2013). However, the answers to some questions are still unknown or incomplete: (i) how a single firm adjusts the number of export varieties with varying transportation cost and tariff rate (empirical evidence is missing among the existing literature); (ii) what is the mechanism that exchange rate volatility affect firms' decisions on export varieties; (iii) how the heterogeneous firms (differentiated in productivity) adjust their export varieties in response to a tariff reduction. Several papers did some empirical analysis on the third point. Qiu and Yu (2014) looked at how the heterogeneous firms adjust their total number of exported varieties (we define it as production scope) in response to the trade liberalization. Lopresti (2016) and Berthou and Lionel (2013) study how the firms adjust their export scopes in response to a trade liberalization. Berthou and Lionel (2013) uses the introduction of the Euro as the treatment to French firms in deciding their export scope. Yet despite its implications for firm production and export performance, there are fundamental differences between product scope and export scope, and how firms adjust the number of exported variables towards each single market (defined as export scope) and how does this effect differ in firm heterogeneity in productivity remain poorly understood.

In this paper, we examine how Chinese exporters adjust their export scope (the number of product varieties) with respect to different characteristics of destination countries and varying trade cost. Theoretically, we present a flexible heterogeneous firm trade model involving both production and export scopes decisions in regard to the exchange rate volatility, tariff rate and distance of the destination countries. A firm's export scope is defined as the number of product varieties exported to a specific market. Specifically, we consider two products belong to different varieties if either they are produced by different firms, or if their HS6 classification codes are different. Our research focuses on the change of the number of varieties (differentiated by the HS6 code) provided by the single firm in response to the features of the destination countries. Using the Chinese firm-level customs data from the years 2001 and 2006, we show that firms export fewer varieties (indexed by HS6 code) to the destinations which are with higher exchange rate volatility, more distance from the home country, or larger tariff rate; Moreover, we exploit China's accession to the WTO in 2001 and show that the high productivity firms expanded the export scope while the low productivity firms reduced. Our research is aimed to answer the following research questions which are analyzed rarely: (i) how do exporting firms adjust their export scopes to destination countries that differ in exchange rate scheme and trade cost, i.e. import-tariff rate and transportation distance to the home country; (ii) how do heterogeneous firms with different productivity levels adjust their export and production scopes in response to the trade liberalization. With the empirical analysis, we find three main results: (i) the firms export fewer varieties to the destinations with farther distance to China, higher tariff rate or higher exchange rate volatility; in response to a tariff-reduction process in a destination country, the high productivity firms expand while the low productivity firms reduce their export scopes to this country; (iii) in response to the trade liberalization, the change of production scope is insignificant.

Our theoretical framework illustrates how heterogeneous firms arrange export scope across destinations with different characteristics. Following the method by Melitz and Ottaviano (2008), Dhingra (2013), and Qiu and Yu (2014), we construct a theoretical model to materialize our preliminary empirical findings to work. In the model, a firm decides production scope before realization of the market state and the export scope is thus adjusted based on the realization of the market state. Due to the different length of the processing time, export scope decreases in the level of exchange rate volatility, transportation distance, and tariff rate of a destination country. Further, firm-level high productive firms pursue cost-saving advantage in producing high quality products than the low productive firm.

Guided by this conceptual framework, we analyze the operations of firms using transaction-level data for China on the universe of export and import transactions in 2001 and 2006. We take advantage of the observations of price and sales for all of a firm's exports by destination and product, which allow us to examine the relationship between export scope across different destinations where the exchange rate volatility, distance and tariff rate differ. We perform several empirical exercises, and conclude that firms export fewer varieties (indexed by HS6 code) to the destinations which are with higher exchange rate volatility, more distance from the home country, or larger tariff rate. Moreover, we exploit China's accession to the WTO in 2001 and show that the high productivity firms expanded the export scope while the low productivity firms reduced.

1.2 Related literature on exchange rate uncertainty

We contribute to the international trade literature on the interaction of destination markets characteristics and operations of multi-product firms and on firm heterogeneity in efficiency. There is a rapidly increasing number of papers studying how exporters behave react to varying characteristics of the destination markets. Among the literature, the most studied topic is about the changes of the firms' choices in price and quality levels. However, to the best of our knowledge, very few papers studied how firms adjust their export scopes towards different characteristics of the destination markets, i.e. the exchange rate scheme, transportation distance and import tariff rate. Hericourt and Poncet (2015) studied how the Chinese firms adjust their export scopes react to different exchange rate schemes among destination countries. However, they didn't provide the theoretical model to explain their results. In addition, they didn't study the other variables of the trade cost that involved in our analysis, i.e. the transportation distance and the tariff rate. One of our research targets is to fill up these gaps among the relevant studies by: providing theoretical foundations to the linkage between exchange rate volatility and export scope; and providing firm-level empirical evidence of the effect of transportation distance on export scope.

We study the effects of two features of the destination markets, i.e. the exchange rate volatility and the distance to the home country, on the choices of export scopes by firms. Among the previous papers, Hericourt and Poncet (2015), Sauer and Bohara (2001), and Aghion et al. (2009) studied how the exchange rate volatility in the destination markets would affect the performance of the export firms.These authors focus on the effect of exchange rate volatility on the firms' price, quality, and investment strategies. Among them, the study by Hericourt and Poncet (2015) is mostly related to ours. Hericourt and Poncet (2015) used the real effective exchange rate to estimate the exchange rate risks in the target country, while many other papers using the nominal exchange rate to do the estimation. Our view is that the real exchange rate risk is more relevant than nominal exchange rate risk, because the real exchange rate is the one which measures the deviation of the country's price index from the world price and thus reflects the demand uncertainty in the market, while the movement of the nominal exchange rate cannot fully reflect the demand changes in the market if the change of a currency's value is fully translated in the price and wage levels. The basic purpose of involving the exchange rate risks in our study is to use it as a measure of the demand uncertainty in the destination market. In this case, following Hericourt and Poncet (2015) we use the real effective exchange rate to measure the demand uncertainty of the market. Basically, there are two main findings in Hericourt and Poncet (2015): the exchange rate risks have negative effects on the firms' entry decision, the trade volume, and export scopes to the foreign markets; the negative effects are more significant among firms that have severe financial constraints. We repeat their works of investigating the relation between exchange rate volatility and export scope with using both the real effective and nominal exchange rate to construct our key independent variable. We find a similar result as theirs, i.e. the exchange rate volatility negatively affect the number of export varieties. As addressed by Hericourt and Poncet (2015), Greenaway and Kneller (2007) and Ethier (1973), the effect of exchange rate volatility is equivalent to that of an increase in the variable and sunk costs in trading. However, none of the papers constructed the theoretical frameworks to show how this mechanism works. To fill up this gap among Hericourt and Pocet (2015) and other existing literature, we construct a theoretical framework to explain how the exchange rate volatility affects the firms' choices on export scopes.

Some other recent papers which studied the firms' behaviors and market uncertainty include Chen and Juvenal (2016), Berman et al. (2012), Nguyen (2012), Lopez and Nguyen (2015), and Bekes et al. (2015). Chen and Juvenal (2016) found that in response to the movements of the exchange rate, the price of the high-quality products changes dramatically but the volume changes insignificantly. Berman et al. (2012) found results that are similar to Chen and Juvenal (2016) with the French firm-level data between the years 1995 and 2005. Nguyen (2012) attempted to provide a theoretical explanation for the stylized fact that the firms entry some foreign markets shortly but then leave the market later on. He (2012) found the uncertainties existing in the new markets force the firms to make its entry decision before making the output supply decision for that market. Using Chile firm level data from 1995 to 2007, Lopez and Nguyen (2015) studied how the fluctuation of the real exchange rate affects the input-importation by the Chilean plants. The paper found that the exchange rate movements reduced the volume of the imports but didn't affect the firms' decision on the importation.

1.3 Related literature on transportation cost

On the effects of the geographic features on trading, the works by Bastos and Silva (2010), Manova and Zhang (2012), and Lugovskyy and Skiba (2016) are mostly related to our study. The first two papers looked at the firms' price strategies in the foreign markets with different distance to the home market. Using the Portugal firm level data, Bastos and Silva (2010) found that the plants tend to charge higher f.o.b. prices to the longer distance countries, and their explanation for this phenomenon is that a greater proportion of high productivity firms export to the farther markets with higher quality products (usually higher price). Contrarily, using the Chinese data, Manova and Zhang (2012) found the f.o.b. exporting price decreases in the transportation distance with the sample of the poor destinations, but the relation turns to be positive with the rich destinations. Manova and Zhang (2012) did not provide an explanation for these results. In another paper, Lugovskyy and Skiba (2016) found the contrary results to the findings by Manova and Zhang (2012) with the firm level data from nine Latin American countries, i.e. the distance elasticities of export price is positive for the poor destinations but negative for the rich destinations. Lugovskyy and Skiba (2016) explained their results by considering two types of firms: the first type faces the fixed cost for each specific variety and the second type faces the market-specific fixed cost for each variety. The first type of firms provide the same quality products with the same price across the markets while the second type of exporters provide more high quality products to the richer countries. However, the relation between the quality of the products and the rich level of the destination will become weak if the destination is far from the home country. That means the exporting proportion of the second type of the products is decreasing in the distance. For the rich countries, the average price of the second type products is higher than the first type products due to the high quality of the second type. In this case, we will observe that within the group of the rich countries, the average price of the exporting products is decreasing in the distance due to the reduced proportion of the second type products. For the poor countries, the situation will be opposite. As the price of the second type products is lower than the first type, the average price will be increasing in the distance. Following the model by Qiu and Yu (2014), our theoretical framework focuses on the analysis of the change of the export scope and doesn't include the variable indicating the quality of the products. However, our results show a new source for the occurrence of the negative impact of the distance, i.e. the export scope bridges the marginal cost of the products and the distance of the market (only the low marginal cost products are sold in the far markets due to the high transportation cost).

The other related papers concerning the impacts of the characteristics of the destinations on the exporting strategies include Brambilla and Porto (2016), Di Comite et al. (2014), and Gorg (2016). With the multi-national data, Brambilla and Porto (2016) found that the high-income countries prefer to import products from the plants with high average wage, indicating that the rich countries prefer high-quality products. Gorg (2016) reached the same conclusion from the empirical evidence with the Hungarian firm level data. Di Comite et al. (2014) proved that the consumers in different countries have different preferences on the same variety, and thus we will observe the price of the same products varies across countries.

1.4 Relation literature on trade liberalization and heterogeneous firms

We also shed light on how the firms adjust the production and export scopes in response to the tariff reduction by the importing destination countries during the periods 2001 to 2006. The study of the impacts of the trade liberalization on product scope is not new. Most of them focus on the study of production scope, e.g. Qiu and Yu (2014) and Lopresti (2016), and few of them studied the export scope, e.g. Berthou and Fontagne (2013). Among all the relevant literature, the paper which is mostly related to ours is Berthou and Fontagne (2013), which studied how the French exporters adjusted their export scopes reacting to the introduction of the Euro in 1999. Berthou and Fontagne (2013) indicated that the introduction of the Euro will eliminate the nominal exchange rate volatility among the Euro-member countries, and the process is equivalent to the elimination of trade cost among the trade partners within the Euro district. Using the French firm-level data, Berthou and Fontagne (2013) found that, in response to the introduction of the Euro, the high productivity firms expanded their export scopes but the change of the export scopes by the low productivity firms was insignificant. Our study is different from the Berthou and Fontagne (2013) in four points: firstly, our study focuses on the tariff reduction (the direct trade-cost reduction) by the destination countries rather than the financial integration process; secondly, our study makes the distinction between a firm's production scope and its export scopes to different destinations; thirdly, our empirical results show that the high productivity firms expand their export scopes while the low productivity firms shrink the export scope, however the change of the production scopes are insignificant; lastly, we construct a theoretical model to nest the change of both the production and export scopes. Among the theoretical literature, with the exception of Qiu and Zhou (2013), almost all the papers reached the conclusion that the multi-product firms reduce the number of the export varieties in response to the trade liberalization, e.g. Bernard et al.(2011), Dhingra (2013), Eckel and Neary (2010), and Mayer et al. (2011). Consistent with the empirical findings of Berthou and Fontagne (2013) and ours, Qiu and Zhou (2013) proved that the high productivity firms may increase the product scopes in response to the trade liberalization. Similarly, Dhingra (2013) made a theoretical analysis and showed that in response to the market expansion (higher intensity of the market competition), the firms would shrink the product scopes but invest more in process innovation in order to reduce the marginal cost. The differences between our study and Qiu and Zhou (2013) lies on two points: firstly, Qiu and Zhou (2013) didn't distinguish the production scope by the firm and the export scope in each firm-country-year transaction, and their product scope is supposed to be the same as the production scope in our analysis; secondly, Qiu and Zhou (2013) only reached the theoretical results and didn't provide the empirical evidence,while our analysis is fully supported by the empirical results. Our theoretical model contributes to the existing literature in two points: firstly, our model distinguishes the production scope and the export scope to each single market; and secondly, we consider the product quality by the heterogeneous firms and the firm's ability to adapt to the increased competition after the trade liberalization. The rest of the relevant literature which studied the firms' production scopes include the Goldberg et al. (2009) and Lo Turco and Maggioni (2015). The former paper analyzed how the firms adjust their production scopes in response to the trade liberalization (reduction of import tariff). Using the Indian firm level data, they found that the reduction of the import tariff incentives the firms to invest in the product innovation and expand their production scopes. The latter paper investigated the relation between the firm's exporting status and the production scopes through the evidence from Turkey, and found that the exporting has a prominent role for firm product innovation (expansion of the production scopes).

The rest of the content is arranged as follows. Section 2 introduces our data set and illustrates our main empirical results; Section 3 develops the model and provide theoretical fundamentals to our empirical findings; Section 4 checks the robustness of our empirical results. and Section 5 concludes all our empirical and theoretical findings.

2 Empirics

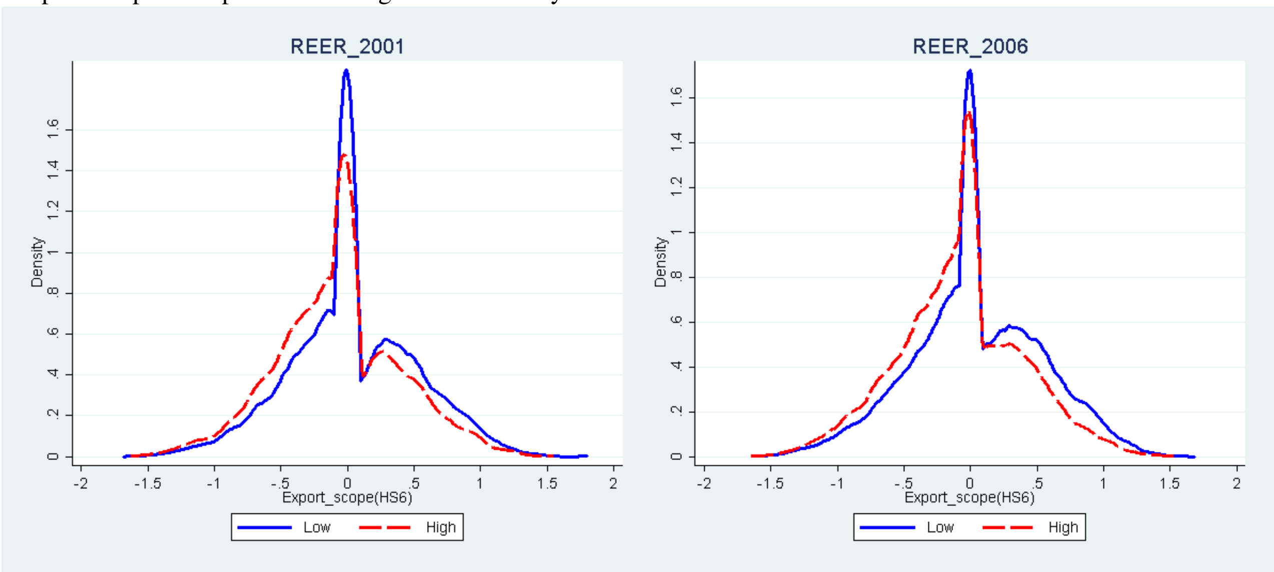
Recall that we have two research targets: (i) provide firm level evidences on the effects of trade cost and exchange rate volatility on firms' decision on their export scopes; (ii) figure out how heterogeneous firms adjust their export and production scopes in response to trade liberalization. In this section, we attempt to explore our research questions using the Chinese firm-product-level data. Firstly, we introduce our data set and discuss some stylized facts we found from the data; secondly, we construct estimation models to explore our research question; lastly, we summarize and briefly explain our empirical findings. In section 3, we further explain our empirical findings with a theoretical framework which distinguishes the export and production scopes.

2.1 Data

Our first data set is retrieved from the replicable data set of Fan et al. (2015). The data set is part of the Chinese customs data which is by the firm, six-digit Harmonized System (HS) category, trade mode and destination country, covering the years 2001 and 2006 (two years). For each firm-product-country observation, we observe the total nominal value and quantity exported as well as the exporting destination associated with each transaction. Counting the number of the different HS6 codes associated with each firm-country transaction, we construct the number of the varieties for each firm to each market, i.e. the export scope, and sum up the number of firm-product transactions as the production scope. Following Hericourt and Poncet (2015), we measure the exchange rate schemes using the monthly standard deviation of both the real effective and nominal exchange rates for each country at each year.[1] The geographic database regarding the distances between China and other countries is retrieved from the website of the CEPII, and the tariff rate data comes from the database of the WTO. We use the straight distance between the largest cities of the two countries as the distance of the two countries. The tariff rate is categorized by the country and the HS2 codes (industry level). The following graphs illustrate the correlation between the firm-country-specific trade scope and the exchange rate volatility and distance to the home country.

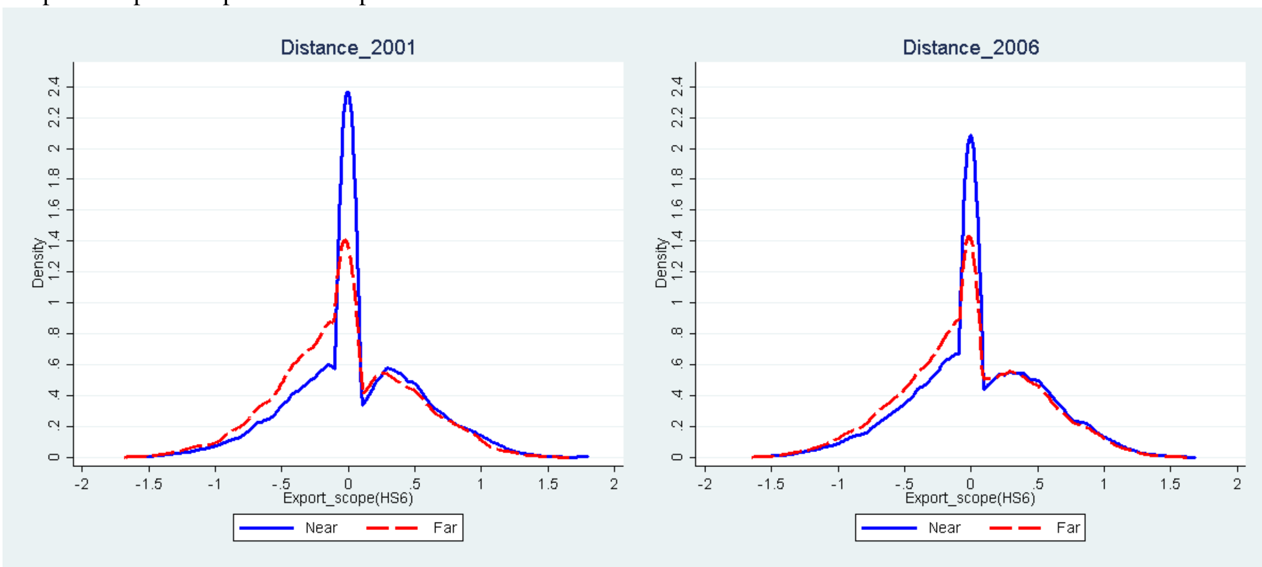
[1]Real effective exchange rate is computed as the weighted average of exchange rate of a country's currency in terms of a basket of currencies with adjusting the inflation of the country.

Graph 1. Export Scope and Exchange Rate Volatility



Notes: we use the yearly average level of exchange rate volatility across all countries in our sample to distinguish the high and low volatility levels; the export scope in the distribution is normalized as $ln(export\_scope_{j\iota t}) - \overline{ln(export\_scope_{j\iota t})}$, *where* $ln(export\_scope_{j\iota t})$ *is the logged form of firm-country-year level of export scope (firm* ι *in market* j *at time* t*) and* $\overline{ln(export\_scope_{j\iota t})}$ *is the average export scope across all countries for firm* ι *at time* t*; the dashed line denotes the export scopes towards the countries with relatively high exchange rate volatility and the solid blue line denotes the export scopes towards the countries with relatively low exchange rate volatility; the left graph illustrates the distribution for the year 2001 and the right graph illustrates the distribution for the year 2006. The diagram shows that the distribution for the export scope towards the high risk countries is to the left of that associated with the risk-free countries. That means the export scopes towards the risk countries are relatively low.*

Graph 2. Export Scope and Transportation Distance



Notes: we use the average level of logged form of distance to China across all countries to distinguish the near and far countries; the export scope in the distribution is normalized as $ln(export\_scope_{jtt}) - \overline{ln(export\_scope_{jtt})}$*, where* $ln(export\_scope_{jtt})$ *is the logged form of firm-country-year level of export scope and* $\overline{ln(export\_scope_{jtt})}$ *is the average export scope across all countries for firm* $\imath$ *at time* t*; the dashed line denotes the export scopes towards the countries those are far from China and the solid blue line denotes the export scopes towards the countries those are near to China; the left graph illustrates the distribution for the year 2001 and the right graph illustrates the distribution for the year 2006. The diagram shows that the distribution for the export scope towards the far countries is to the left of that associated with the near countries. That means the export scopes towards the far countries are relatively low.*

Both diagrams above show negatively effects of the exchange rate volatility and transportation distance on firms' export scopes. The distributions of export scope towards countries which conducting flexible exchange rate schemes or far away from China (denoted as solid blue lines) are to the left of those associated countries which conducting relatively stable exchange rate schemes or located near to China (denoted as dashed red lines). Note that we didn't illustrate the distributions associating with varying tariff rates here, because the tariff rate is in the country-variety-year level, which makes it difficult to illustrate graphically. In next section, we will show our specific estimation methodologies.

2.2 Methodologies

Following Hericourt and Poncet (2015), we specify our estimation model for the effect of the trade cost on export scope as follows. [2]

$$Export\_scope_{\iota jt} = \beta_1 * exchange\_rate\_volatilaty_{jt} + \beta_2 * distance_j + \beta_3 tariff\_rate_{jvt} + X_{jt}\gamma_1 + \lambda_{\iota t}\gamma_2 + \eta_t + \kappa_v + \varepsilon_{\iota jt}$$

where ι , j, v and t denote each individual firm, destination country, industry (HS2 code) and the time respectively. All variables are in logged form except the exchange rate volatility and the tariff rate. $Export\_scope_{\iota jt}$ measures the single firm's export scope associated with each destination at each year, which is computed as the (log) number of the varieties by the firm-country-year level, i.e. $Export\_scope_{\iota jt} \equiv ln(number\_of\_varieties)_{\iota jt}$. The key explanatory variables include the exchange rate volatility ($exchange\_rate\_volatilaty_{jt}$), and the distance between China and destination j ($distance_j$). Exchange rate volatility is computed as the yearly standard deviation of the exchange rate for country j at year t using the monthly data, and the distance to the home country is computed as the logged value of distance between the largest city in country j and the largest city in China. X_{jt} controls for the scale of sales for firm ι in market j and some other macro characteristics of market j, i.e. GDP, GDP per capita and price index.[3] $\lambda_{\iota t}$ controls the firm level characteristics, i.e. input-import duty, domestic output-import tariff, number of varieties of the imported inputs, TFP, wage rate, labor number, capital labor ratio, and industrial competition intensity. [4] The time (i.e. time-dependent unobservable or unmeasurable factors) and industry fixed effects (scale of product scope varies across industries) are controlled by η_t and κ_v respectively. As our dependent variable is count number, we estimate our model using both OLS and Poisson methods.

To test the responses of the heterogeneous firms to the tariff reduction, we construct the estimation models as follows.

$$\Delta Export\_scope_{\iota j} = \beta \Delta tariff\_rate_{\iota j} + \theta TFP_{\iota} * \Delta tariff\_rate_{\iota j} + \Delta\lambda_{\iota}\gamma + \delta_v + \kappa_j + \varepsilon_{\iota j}$$

[2] This construction is also theoretically specified by lemma 1 and proposition 1 in section 3. Our model differs from Hericourt and Poncet (2015) by involving transportation distance and import tariff rate.

[3] GDP and GDP per capita control the firm-country level trade scale and the taste heterogeneity among countries, e.g. the parameters in the preference function may different across countries; price index controls the effect of the inflation on the market demand in the destination market.

[4] The firm level variables control the cost and market power to initiate a new product variety.

5

$$\Delta Production\_scope_{\iota} = \beta \Delta tariff\_rate_{\iota} + \theta TFP_{\iota} * \Delta tariff\_rate_{\iota} + \Delta\lambda_{\iota}\gamma + \delta_{v} + \varepsilon_{\iota}$$

where ι, j, and v denote each individual firm, destination country, and the industry (HS2 code) respectively. The change of firm-country level export scope is constructed as $\Delta Export\_scope_{\iota j} \equiv \Delta ln(number\_of\_varieties)_{\iota j}$; The change of tariff rate is computed in two ways. Firstly, we compute the simple difference of the country-industry level of the tariff rate; and secondly we computed the firm-country level of the average tariff rate using the country-variety level of tariff data weighted by the trade volume, i.e. $\Delta tariff\_rate_{\iota j} \equiv \left[\sum\limits_{i \in I_{\iota j}} \Delta\left(tariff\_rate_{ij}\right) \times volume_{ij\iota t}\right] / \sum\limits_{i \in I_{hj}} volume_{ij\iota t}$ (i distinguishes the variety with HS6 code). We use both the trade volumes in 2001 and 2006 to construct our indicator. In summary, we have three different indicators for our export scope, i.e. (i) change of the tariff rate in country-industry level, (ii) change of firm-country level of average tariff rate weighted by the 2001 trade volume, and (iii) change of firm-country level of average tariff rate weighted by the 2006 trade volume. The construction for production scope is similar as the export scope. The production scope is constructed as the log value of the total number of export varieties by firm ι in the year t, i.e. $\Delta Production\_scope_{\iota} \equiv \Delta ln(number\_of\_varieties)_{\iota}$. We construct two types of the tariff rates: change of firm level of average tariff rate weighted by the trade volume in 2001 value and 2006 value, i.e. $\Delta tariff\_rate_{\iota} \equiv \left[\sum\limits_{i \in I_{\iota}} \Delta\left(tariff\_rate_{ij}\right) \times volume_{ij\iota t}\right] / \sum\limits_{i \in I_{h}} volume_{ij\iota t}$. The firm level control variables (captured by λ_{ι}) are the same as the previous model except that they are in the changed form (the reason for controlling each variable has been discussed in previous text). δ_{v} and κ_{j} control the industry and country level fixed effects respectively. The reason for controlling the country fixed effect is that some countries changed significantly in GDP, GDP per capita, price index or other unobservable factors during the observation period 2001 to 2006, which may alter the consumption tastes for Chinese products among these countries. The details regarding the estimation results will be illustrated and discussed in next section.

2.3 Results

Tables 1a below shows the results of the first estimation model which explores the effects of exchange rate volatility, transportation cost, and tariff on firms' export scopes. [6] The results show significant negative coefficients on the

[5] We use both the country-industry level and firm-country average tariff rates in our regression.

[6] The estimation results which using the logged form of exchange rate volatility are reported in table 1b which can be found in Appendix.

variables exchange rate volatility, the distance to home country, and the tariff rate, which indicates a negative impact of these factors on export scope. Our estimation results are similar as Hericourt and Poncet (2015), except that we involve the transportation distance and import tariff rate in our estimation. It is easy to understand the impact of the transportation distance and tariff, but the mechanism for the effect of exchange rate volatility is not obvious. As discussed previously, the intuition for this result is that when the destination's currency depreciates, the firms need to reduce their export scopes, but when the currency appreciates, the firms cannot expand their export scopes due to the constraint of production capacity. In this case, the average export scope towards the risky will be less than stable countries.

Table 1a. Trade cost and the Export Scope

	Dependent Variable: Export scope					
	Panel A: Real Exchange Rate Volatility			Panel B: Nominal Exchange Rate Volatility		
Distance	-0.0397***	-0.0199***	-0.0142***	-0.0441***	-0.0164***	-0.00970***
	(0.00286)	(0.00353)	(0.00317)	(0.00278)	(0.00341)	(0.00307)
$Exchange\_rate\_volatility$	-1.334***	-0.611***	-0.313***	-1.695***	-1.114***	-0.679***
	(0.0548)	(0.0717)	(0.0654)	(0.0669)	(0.0882)	(0.0804)
$Tariff\_rate$	-0.590***	-0.310***	-0.213***	-0.594***	-0.297***	-0.200***
	(0.0303)	(0.0383)	(0.0333)	(0.0297)	(0.0372)	(0.0324)
Observations	143,644	94,226	94,226	162,509	104,428	104,428
R-squared	0.088	0.127	0.279	0.086	0.126	0.277
Trade Volume Control	NO	NO	YES	NO	NO	YES
Firm Level Controls	NO	YES	YES	NO	YES	YES
Country Level Controls	NO	YES	YES	NO	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: All variables are in logged form except the exchange rate volatility and tariff rate. The real exchange rate volatility is computed as the yearly standard deviation using monthly data of real effective exchange rate. [7] *The nominal exchange rate volatility is computed as the yearly standard deviation using monthly data of nominal exchange rate in terms of the U.S. dollars. Panel A shows the effects of trade cost on real exchange rate volatility and Panel B shows the results of nominal exchange rate volatility. The transportation distance is computed as the geographic distance between the largest city of two countries. The tariff rate is the industry level importing tariff by the destination market.*[8] *The firm level controls include the variables TFP, labor number, capital to labor ratio, wage rate, average industrial level of import tariff rate imposed by China, number of imported inputs by each firm and the industry's competition intensity. Trade volume control is the aggregate trade volume in specific country by the firm. The country level controls include the GDP, GDP per capita, and CPI. The estimation results show that the export scope is decreasing in transportation distance, tariff rate and exchange rate volatility.*

Another important finding is that during the observation period, i.e. 2001 to 2006, the tariff rates on Chinese products imposed by destination countries are widely cut down, and the reduction of trade cost incentivates high

[7] The real effective exchange rate is the weighted average of a country's currency relative to an index or basket of other major currencies, adjusted for the effects of inflation.

[8] Industry is classified by HS2 code.

productivity firms to expand their export scopes, however, the low productivity firms reduce their export scopes due to increase of market competition *(see table 2a below)*. This result is consistent with Berthou and Fontagne (2013), who found that in response to the introduction of Euro (reducing trade cost from converting between different currencies), French firms with high productivity will expand their export scopes but the adjustment by low productivity firms is not significant. Our explanation to this result lies on two channels: firstly, due to the cost-saving advantage in improving quality by high productivity firms, the high productivity firms produce and export high quality products while low productivity firms produce and export low quality products; secondly the firms with providing high quality products would obtain more benefits from tariff-reduction process, but the products offered by the low productivity firms may be crowed out of market due to the increase of market competition arisen by trade liberalization.

Table 2a. Trade Liberalization, Heterogeneous Firms, and Change of the Export Scope

Dependent Variable: Change of logged form of export scope between 2001 and 2006									
Tariff Specification	Panel A: Country-industry Level			Panel B: Firm-country Level Average, 2001 Weights			Panel C: Firm-country Level Average, 2006 Weights		
$\Delta Tariff$	-0.180	4.343***	3.756***	-0.122	2.01***	2.35**	0.104	1.96***	2.55**
	(0.473)	(0.922)	(1.087)	(0.255)	(0.715)	(1.15)	(0.240)	(0.710)	(1.11)
$TFP_{2001} * \Delta Tariff$		-1.083***	-0.947***		-0.510***	-0.539**		-0.415**	-0.527**
		(0.206)	(0.236)		(0.167)	(0.244)		(0.162)	(0.235)
ΔTFP	0.0277***	0.0549***	0.0312***	0.0283***	0.0457***	0.0297***	0.0282***	0.0455***	0.0296***
	(0.00890)	(0.00725)	(0.00894)	(0.0107)	(0.00847)	(0.0108)	(0.0107)	(0.00847)	(0.0108)
Observations	6,351	11,359	6,351	4,849	8,850	4,849	4,849	8,850	4,849
R-squared	0.208	0.048	0.210	0.212	0.063	0.213	0.212	0.063	0.213
Firm Level Controls	YES	NO	YES	YES	NO	YES	YES	NO	YES
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: We use three indicators for the change of the tariff rate, i.e. country-industry level, firm-country level weighted by trade volume in 2001, and firm-country level weighted by trade volume in 2006. The first indicator is computed as the difference of the industry level importing-tariff rates imposed by the destination country in the years 2001 and 2006. The second indicator is computed as the weighted average of the change of the tariff rate faced by a single firm in a specific country between the years 2001 and 2006, using the firm-product-country level of trade volume as the weight factor. The last indicator is similar as the second one except that it uses the trade volume in 2006 as the weight factor. The firm level controls include the change values of logged labor number, capital labor ratio, logged wage rate, industrial level of input and output tariff rates imposed by China, number of imported inputs by each firm and the industrial competition intensity. The estimation results show that in response to a tariff reduction, the high productivity firm expands while the low productivity firms reduces their export scopes.

Among the regressions regarding the production scope, the coefficients on tariff rate and product of tariff rate and TFP are insignificant or positive *(see table 2b below)*, which means that in response to the trade liberalization process, firms didn't expand their production scopes or even reduce them. We suppose result is caused through two ways: firstly, when the other countries reduce tariff to Chinese firms, China also reduces trade obstacles to foreign firms, and thus the domestic competition intense increases; secondly, during the observation periods, a plenty number of new-born firms entry the market, and these observations are not included in our regressions. [9] The old firms in the market face the increase of the market competition due to the entering of new-born firms and foreign firms, and thus they reduce their production scope. The detailed explanation regarding this result can be found in section 3.4.

Table 2b. Trade Liberalization, Heterogeneous Firms, and Change of the Production Scope

Dependent Variable: Change of logged form of production scope between 2001 and 2006						
Tariff Specification	Panel A: Firm Level Average, 2001 Weights			Panel B: Firm Level Average, 2006 Weights		
$\Delta Tariff$	0.857*	0.143	-0.936	0.653	-0.228	-1.69
	(0.507)	(1.52)	(1.66)	(0.475)	(1.62)	(1.85)
$TFP_{2001} * \Delta Tariff$		0.179	0.453		0.246	0.550
		(0.387)	(0.424)		(0.414)	(0.466)
ΔTFP	0.0455	0.0345	0.0453	0.046	0.0337	0.0444*
	(0.0285)	(0.0213)	(0.0267)	(0.0285)	(0.0213)	(0.0267)
Observations	816	1,627	870	816	1,627	870
R-squared	0.193	0.071	0.202	0.192	0.070	0.201
Firm Level Controls	YES	NO	YES	YES	NO	YES
Country FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: We use two indicators for the change of the tariff rate, i.e. firm level weighted by trade volume in 2001 and firm level weighted by trade volume in 2006. The first indicator is computed as the weighted average of the change of the tariff rate faced by a specific firm between the years 2001 and 2006, using the firm-product level of trade volume as the weight factor. The last indicator is similar as the second one except that it uses the trade volume in 2006 as the weight factor. The firm level controls include the change values of TFP, labor number, capital labor ratio, wage rate, and the industrial competition intensity. The estimation results show that in response to a tariff reduction, the firms may reduce the production scope, but the correlation is weak. Our results are similar as those in Qiu and Yu (2014), who found that in response to the trade liberalization, both high an low productivity firms reduce their production scopes and only the firms with low management cost (one type of fixed cost for producing new variety) increases their production scopes.

In summary, our empirical analysis has the following findings and contributions to the existing literature: (i) our estimation is the first one to provide firm level evidence about the effect of the transportation cost on export diversification; (ii) our study is the first one to distinguish the production and export scope among relevant literature and study the effect of trade liberalization on export scopes among heterogeneous firms with different TFP levels; (iii) our study is the first one to find the evidence that in response to the tariff reduction the high productivity firms expand their export scopes. In Section 4, we also try some other estimation methods or use alternative indicators as the dependent variable to confirm the robustness of our empirical results. In next section, we will discuss and explain our empirical results under a theoretical framework.

[9] Recall that the variables in the regressions are in difference form. In this case, the new-born firms are not included in our sample.

3 Theoretical frameworks

How do multi-product firms arrange their production and export scopes across different markets? In this section, we model multi-product firms choice on production and export facing exchange rate risks and different market characteristics. Three decisions that firms make in order to maximize profits in each destination are highlighted: the optimal range of products to produce, the optimal range of markets to enter, and the optimal product varieties to export to each market. We identify the key economic mechanisms that govern these decisions, and derive empirically testable predictions that allow us to validate them in the data. We highlight that the existence of exchange rate risks and a two-step decision making process play critical roles on observable firm outcomes. We examine multi-product exporters in a stylized conceptual framework with standard assumptions about underlying demand, production and market structure. Our theoretical framework is aimed to explain our main empirical findings: (i) the export scope decreases in the level of exchange rate volatility, transportation distance, and tariff rate of a destination country; (ii) in response to a tariff reduction in a destination market, the high productivity firms expand while the low productivity firms reduce their export scopes; (iii) in response to the tariff reduction process, the change of the production scope of each firm is not significant. Before our theoretical analysis, some questions regarding our empirical findings arise. Firstly, as most views, the firm is risk neutral, but how could the risk-neutral agent behaves like a risk-aversion agent when facing the exchange rate risks across many destination countries. Secondly, why the empirical results are quite different between the two types of scopes, i.e export and production scopes. In this section, we suppose a theoretical framework which distinguishes some fundamental differences between production and export scopes to explain all our findings.

The main difference between our theoretical model and the ones among the previous literature is that we distinguish the number of product varieties as two types, i.e. the production scope and export scope. The production scope refers to the total number of varieties exported by the firm and the export scope refers to the number of varieties exported to a specific market by the firm. There are several differences between these two scopes: (i) the expansion of production scope incurs higher level of fixed cost, e.g. R&D investment, product's standardization, management cost and advertisement, while the enlargement of export scope is not necessary to incur larger fixed cost; (ii) it takes a relatively long period (at least several years) to initiate a new variety (expanding production scope) but the adjustment of export scope can be made each year; (iii) due to the different length of the processing time, the decision regarding the production scope is made before the realization of the market state while the export scope can be adjusted based on the realization of the market state. With all these considerations, our intuitive explanations to the empirical findings are as follows.

Consider a world with countries conducting different exchange rate schemes. Some countries conduct a relatively stable exchange rate policy, e.g. fixed exchange rate scheme or pegged exchange rate scheme, while some other countries conduct a relatively flexible exchange rate scheme. Like the tariff and the transportation cost, currency depreciation would incur extra cost for firms to export while the currency appreciation could benefits the exporting firms. The firms need to take the fluctuation of the exchange rate in the destination countries into account when they decide their production and export scopes. As discussed previously, it takes a long period to set up the production of a new variety. In this case, the production scope can only be determined before the realization of the market states (currency depreciation or appreciation), while the decision on the export scope can be made after the realization of the market condition. In this case, the production scope is decided according to the predictions of market conditions over several years and the decision on the export scope to each market can be made annually according to the specific condition in that year. If the country's currency depreciates, the firm will reduce the total number of exported varieties to this country and focus in exporting the products with highest demand or lowest marginal cost. In this case, if the countries are with low transportation cost, low tariff rate or experiencing currency appreciation, then the firm will be likely to export more varieties to these countries. However, at most times, this extra exporting is constrained by the production scope. As initialing a new variety incurs fixed cost, the production scope is determined according to the demand of a typical country with average trade cost. For instance, if a new variety is only demanded by a small number of countries which are near to China, with low tariff rate, or experiencing currency appreciation, then this variety will not be produced just because the market revenue cannot cover the fixed cost. In this case, the firms will usually invest and produce the number of varieties just to meet the demand of an average market. In this case, when some countries experience currency appreciation, the firms couldn't offer more varieties to these countries due to the limitation of their production capacity. In this case, the firms exports less when the market status goes bad (depreciation of destination's currency) but they are prevent to export more when the status goes well (appreciation of destination's currency). On average, the export scopes towards the countries with the exchange rate risks will be less than those towards the countries with relative stable exchange rate schemes.

For the second and third empirical findings, our intuitive explanations are as follows. The high productive firms pursue cost-saving advantage in improving the quality level of products than the low productive firms. In this case, the high productive firms will produce and export high quality products while the low productive firms will export low quality products. Before the tariff-reduction process, the firms export the varieties that they are good at producing (with relatively low marginal cost). When the destination market reduces their import tariff rates, then two directed effects will apply: firstly, the marginal revenue for each product will raise up and then it incentives the firms to expand their export scopes and start to export the varieties that require higher marginal cost; secondly, as the increase of the exporting volume and varieties, the market competition in the destination market will be more intensive, which will crow out some varieties. As the prices and markups for high quality products are higher than those for the low quality products, the firms who exporting the high quality products (high productive firms) will receive more tax returns by each unit of products in the trade-liberalization process. In this case, the high productive firms are expected to expand more of their export scope than the low productive firms. At the same time, as the increase of the exported varieties and volume, the competition among destination markets become more intensity. The increase of the market-competition intensity could crowd out some varieties. If the crowding out effect is large enough, then the net effect on the low productive firms will be negative. That means the low productive firms will reduce their export scope. Our empirical result further shows that in response to the trade liberalization, the change of the production scopes for both types of firms is insignificant. The explanation for this result is as follows. Firstly, the firms do not export their whole varieties to every country. The variety with the highest marginal cost is exported to the countries where the tariff rates are relatively low. We call these countries as marginal countries and the rest of countries as non-marginal countries. If the tariff rate is not reduced deeply enough, then the change of the export scope in the non-marginal countries won't touch the production constraint. In another words, the firms are no necessary to expand their production scope to meet the change of the market demand in the non-marginal countries. Contrarily, if the tariff reduction occurs among the marginal countries, the firms need to expand their production scope in order to meet the increasing demand among these countries. However, during our observation periods (2001 to 2006), the tariff reduction occurs mostly among the countries which impose relatively high level of initial tariff rates and the tariff reduction among the marginal countries is not significant. In this case, the firms adjust little on their production scopes.

Starting from next section, we will show how our theoretical framework is constructed and how it describes our empirical findings. Generally, we propose two agents in our model, i.e. household and firm. Firstly, we exhibit and discuss our assumptions regarding the households and firms; then we reach the market equilibrium with solving the best strategies of firms in response to different market conditions; lastly, we explain our theoretical results intuitively.

3.1 Households

Following Melitz and Ottaviano (2008), Dhingra (2013), and Qiu and Yu (2014), we assume the consumers' utility function for country j is the form of the quasi-linear preference:

$$U = q_{j0} + \alpha \int_{i\in\Omega_j} q_{ji} di - \frac{1}{2}\beta \left(\int_{i\in\Omega_j} q_{ji} di\right)^2 - \frac{1}{2}\gamma \int_{i\in\Omega} q_{ji}^2 di$$

where q_{j0} is her consumption of the numeraire good; Ω_j is the set of all varieties sold in country j ; and q_{ji} is the consumption of variety i in country j.

The quasi-linear preference assumes a constant marginal utility of the numeraire good (captured by the first term), a decreasing marginal utility for the differentiate good (captured by the second and fourth terms with quadratic formula), and a measure of the competition among the differentiate products (captured by the third term). The quasi-linear preference captures the consumption feature that consumers compare and decide purchasing amount among different varieties and also decide whether or not to buy a variety. For example, if the price of one variety is relatively high compared with other varieties, then the sales of this variety will be relatively low. If the price of the variety increases further, then the consumers may decide not to buy this product and save the money on consumption of the numeraire good.

The consumer maximizes the utility subject to the budget constraint, i.e.

$$p_{j0}q_{j0} + \int_{i\in\Omega_j} p_{ji}q_{ji} di \le M$$

where M is the income of a typical consumer.

From the above it follows that the demand function for variety i in country j as:

$$q_{ji}^L = L_j q_{ji} = L_j \left(\frac{\alpha}{\gamma} - \frac{1}{\gamma} p_{ji} - \frac{\beta}{\gamma} Q_j\right)$$

where $Q_j \equiv \int_{i\in\Omega} q_{ji} di$ is an index of the consumption of all the differentiated products in country j; and L_j denotes the population size of country j .

Here we have a conventional assumption about the product's variety. The variety comes from two sources: the products are provided by different firms; or the same firm provides the products in different horizontal scopes.

3.2 Firms

The heterogeneity of firms come from the productivity φ_i when producing variety i, and $i \in (0, +\infty)$. Firm-specific productivity for variety i is assumed to be given by $\varphi_i = \kappa i^{-r}$, where κ and r are firm-specific general productivity measurements, representing overall efficiency factors including management level, transferable technologies, etc. The cost function for the firm ι is composed of two parts:

$$C_{ij} = \int_{j \in J_h} \left[\int_{i \in \Omega_h} \left(\frac{c}{\varphi_i} q_{ji}^L di + F_i \right) di \right] dj$$

[10]

F_i is the sunk cost for the firm ι to be able to produce variety i . As a conventional assumption following Qiu and Yu (2014), we assume an non-decreasing marginal cost function in variety i. In this case, we have $r \geq 1$. Then we can write the expected profit function for firm ι as followings:

$$E\pi_\iota = E \int_{j \in J_h} \left\{ \int_{i \in \Omega_h} \left[\varepsilon_j (1 - \tau_j) p_{ji} q_{ji}^L - \left(\frac{c}{\varphi_i} - t_j \right) q_{ji}^L - F_i \right] di \right\} dj$$

where ε_j is the exchange rate in country j with the mean $\bar{\varepsilon}$; τ_j is the import tariff rate in country j ; and t_j is the transportation cost to the destination j.

Among previous relevant studies, some of them rely on the real effective exchange rate (REER), e.g. Aizenman and Marion (1999) and Hericourt and Poncet (2015), while others studied the effect of the nominal exchange rate, e.g. Schnabl (2008). In our analysis, we involve both of the real effective exchange rate and the nominal exchange rate. The real effective exchange rate is computed as the weighted average of exchange rate of a country's currency in terms of a basket of currencies with adjusting the inflation of the country; and the nominal exchange rate is measured with U.S. dollar.

The firms make decisions on both the price of each variety in the specific country and the horizontal scope of the products they produced. We assume the scope decision is made before the realization of the exchange rate and the price strategy is decided after observing the exchange rate. Recall from Section 1, it takes long period and incurs fixed cost

[10]Here, to avoid cumbersome notation, we have omitted the subscript h in the symbol for the firm-specific productivity level.

to invest in a new variety but the decision regarding the export scope can be made each period. In this case, the firms can adjust their exported products with specific exchange rate level but the scope sunk cost is made with an expectation of the situations in the market.

Without loss of generality, to simplify our analysis, we make the following conventional assumptions:

ASSUMPTION 1.

[1] The sunk cost for each variety is the same, i.e. $\int_0^I F_i di = \mu I$*;*

[2] the transportation distance is bounded within a range, i.e. $t_j \in [0, t_{max}]$*;*

[3] the exchange rate in any country is bounded within a range with an identical mean value, i.e. $\varepsilon_j \in [\varepsilon_{min}, \varepsilon_{max}]$ *and* $E\varepsilon_j = \bar{\varepsilon}$ *for* $\forall j$*;*

[4] the tariff rate, aggregate variety and population size are constant and identical across countries, i.e. $\tau_j = \tau$ *,*$\alpha - \beta Q_j \equiv B_j = B$ *and* $L_j = L$ *for* $\forall j$*;*

[5] the negative realization of the exchange rate doesn't cause the firm to exit the market, i.e. $B\varepsilon_{min} > t_{max}$*.*

The firm faces a two-stage decision problem. In the first stage, the firm determines its production scope I^* . In the second stage, it decides how many varieties to export to each country. We must solve the problem using backward induction, i.e. solve the results in the second stage at first. In the second stage, before solving for the export scope for each destination market, we need to state the firm's optimal price strategy (and the resulting quantity) for each variety i for each country j, conditional on variety i being made available for country j, i.e.

$$\begin{cases} p_{ij} = & max\left\{0, \frac{\alpha}{2} - \frac{\beta}{2}Q_j + \frac{c}{2(1-\tau)\varphi_i\varepsilon_j} + \frac{t_j}{2(1-\tau)\varepsilon_j}\right\} \\ q_{ij} = & max\left\{0, \frac{\alpha}{2} - \frac{\beta}{2}Q_j + \frac{c}{2(1-\tau)\varphi_i\varepsilon_j} + \frac{t_j}{2(1-\tau)\varepsilon_j}\right\} \end{cases}$$

With all the assumptions above and the solution for the price strategy, we can rewrite the expected profit function for the typical firm as follows.

$$E\pi_\iota = \int_{i\in\Omega_h}\int_{j\in J_h}\int_{c_{ij/(1-\tau)B}}^{\varepsilon_{max}} \frac{L}{4\gamma(1-\tau)\varepsilon_j}\left[(1-\tau)B\varepsilon_j - \frac{c}{\varphi_i} - t_j\right]^2 \phi(\varepsilon_j;t_j)\,d\varepsilon_j dj di - \mu I$$

where $c_{ij} \equiv \frac{c}{\varphi_i} + t_j$ and $\phi(\varepsilon_j;t_j)$ is the joint density function of ε_j and t_j .

Next, we can solve the export scope in the second stage as follows.

LEMMA 1. *Given the production scope chosen in the first stage, the firm chooses the export scope towards the* *stable market as:*

$$\bar{i}_j = \begin{cases} 0 & if\, t_j > (1-\tau) B\overline{\varepsilon}; \\ \left\{ \left[(1-\tau) B\overline{\varepsilon} - t_j \right] \left(\frac{\kappa}{c} \right) \right\}^{\frac{1}{r}} < I & if\, (1-\tau) B\overline{\varepsilon} \geq t_j > \hat{t}\left(\overline{\varepsilon}, I\right); \\ I & if\, t_j \leq \hat{t}\left(\overline{\varepsilon}, I\right). \end{cases}$$

and towards the risk market as:

$$i_j^* = \begin{cases} 0 & if\, \varepsilon_j < \frac{t_j}{(1-\tau)B}; \\ \left\{ \left[(1-\tau) B\varepsilon_j - t_j \right] \left(\frac{\kappa}{c} \right) \right\} < I & if\, \frac{t_j}{(1-\tau)B} < \varepsilon_j < \hat{\varepsilon}\left(t_j, I\right); \\ I & if\, \hat{\varepsilon}\left(t_j, I\right) < \varepsilon_j \leq \varepsilon_{max}. \end{cases}$$

where $\hat{t}\left(\overline{\varepsilon}, I\right) \equiv (1-\tau) B\overline{\varepsilon} - \left(\frac{c}{\kappa}\right) I^r$ *and* $\hat{\varepsilon}\left(t_j, I\right) \equiv \frac{t_j}{(1-\tau)B} + [\frac{c}{\kappa(1-\tau)B}] I^r.$

See the proof in the Appendix.

In what follows, we assume that t_j belongs to the interval $[0, t_{max}]$, and that the random variable ε_j belongs to the interval $[\varepsilon_{min}, \varepsilon_{max}]$. As $(1-\tau) B\varepsilon_{min} > t_{max}$, so that i_j^* is always positive.

Given the solutions for $\bar{i}$ and i_j^*, we can obtain the lemma 1 below.

LEMMA 2. *Given the same transportation distance, the expected exporting scope towards the markets with the exchange rate volatility is on average lower than that towards the countries without the volatility, i.e.* $Ei_t^* \leq \overline{i_t}$.

See the proof in the Appendix.

In the first stage, we can solve the optimal production scope which is given by the following equation.

$$N \int_0^{\hat{t}(\overline{\varepsilon}, I)} \left\{ \frac{L}{4\gamma(1-\tau)\overline{\varepsilon}} \left[(1-\tau) B\overline{\varepsilon} - \frac{c}{\kappa} I^r - t \right]^2 \right\} \rho\left(t\right) g\left(t; S_f\right) dt +$$

$$N \int_0^{t_{max}} \int_{\hat{\varepsilon}(t,I)}^{\varepsilon_{max}} \left\{ \frac{L}{4\gamma(1-\tau)\varepsilon} \left[(1-\tau) B\varepsilon - \frac{c}{\kappa} I^r - t \right]^2 \right\} [1-\rho\left(t\right)] \phi\left(\varepsilon; t\right) h\left(t; S_v\right) d\varepsilon dt = \mu$$

where N is the total number of the destination countries; $g\left(t; S_f\right)$ is the density function of the distance for countries belonging to set S_f and $g\left(t; S_v\right)$ is the density function of the distance for countries belonging to set S_v ; and $\rho\left(t\right) \in (0,1)$

is the fraction of the destination countries that are located at distance t and that have the fixed exchange regime.[11]

Next, we need to solve the optimal production scope I^* in the first stage and show that $Ei_t^* < \overline{i_t}$ for some transportation distance t_j.

Consider the set S_f of destination countries that have a fixed exchange rate. (For simplicity, assume their exchange rate are the same, and call this fixed rate $\overline{\varepsilon}$. Given I, the firm's marginal variety $i = I$ are sold only in a subset of this set, i.e. in those countries in S_f with $t_j \leq \hat{t}(\overline{\varepsilon}, I)$. The aggregate profit (in these markets) for the marginal variety $i = I$ is

$$R^f(I) = N \int_0^{\hat{t}(\overline{\varepsilon}, I)} \left\{ \frac{L}{4\gamma(1-\tau)\overline{\varepsilon}} \left[(1-\tau) B\overline{\varepsilon} - \frac{c}{\kappa} I^r - t \right]^2 \right\} \rho(t) g\left(t; S_f\right) dt$$

where $g\left(t; S_f\right)$ is the density function of the distance for countries belonging to set S_f , and $\rho(t) \in (0,1)$ is the fraction of the destination countries that are located at distance t and that have the fixed exchange regime.

LEMMA 3. *$R^f(I)$ is a decreasing function of I .*

See the proof in the Appendix.

Consider next the set S_v of destination countries that have a variable exchange rate. Given I and any $t < t_{max}$, the Chinese firm's marginal variety $i = I$ are sold in a subset of this set, i.e. in those countries in S_v with $t_j = t$ and with some realized exchange rate ε in the range $\hat{\varepsilon}(t, I) \leq \varepsilon \leq \varepsilon_{max}$. The aggregate expected profit earned for this set of countries (for this marginal variety $i = I$) is

$$R^v(t, I) = [1 - \rho(t)] N \int_{\hat{\varepsilon}(t,I)}^{\varepsilon_{max}} \left\{ \frac{L}{4\gamma(1-\tau)\varepsilon} \left[(1-\tau) B\varepsilon - \frac{c}{\kappa} I^r - t \right]^2 \right\} \phi(\varepsilon; t) d\varepsilon$$

where $\phi(\varepsilon; t)$ is the conditional density function of the random variable ε (conditional on location t). Integrating over all possible locations, we get

$$R^v(I) \equiv \int_0^{t_{max}} R^v(t, I) h(t; S_v) dt$$

where $h(t; S_v)$ is the density function of distance for countries belonging to set S_v .

LEMMA 4. *$R^v(I)$ is a decreasing function of I .*

[11] S_f is the set of the countries that conduct the fixed exchange rate scheme and S_V is the set of the countries that conduct the volatile exchange rate scheme.

See the proof in the Appendix.

Finally, expected aggregate profit earned for the marginal variety $i = I$ is

$$R(I) \equiv R^f(I) + R^v(I)$$

The function $R(I)$ is decreasing in I, and I^* is the value of I such that

$$R(I^*) = \mu$$

where μ is the sunk cost for each variety. We assume that μ is not too big, so that I^* is positive.

Thus, the equation that determines I^* is

$$N\int_0^{\hat{t}(\overline{\varepsilon},I)} \left\{ \frac{L}{4\gamma(1-\tau)\overline{\varepsilon}} \left[(1-\tau)B\overline{\varepsilon} - \frac{c}{\kappa} I^r - t \right]^2 \right\} \rho(t)\, g\left(t; S_f\right) dt +$$

$$N\int_0^{t_{max}} \int_{\hat{\varepsilon}(t,I)}^{\varepsilon_{max}} \left\{ \frac{L}{4\gamma(1-\tau)\varepsilon} \left[(1-\tau)B\varepsilon - \frac{c}{\kappa} I^r - t \right]^2 \right\} [1-\rho(t)]\, \phi(\varepsilon;t)\, h(t;S_v)\, d\varepsilon dt = \mu$$

With all the lemmas and results above, we reach the proposition below.

PROPOSITION 1. *Given the transportation distance $t \in [0, t_{max}]$, the expected exporting scope towards the markets with the exchange rate volatility is on average lower than that towards the countries without the volatility, i.e. $Ei_t^* \leq \overline{i_t}$, and for some transportation distance, the strict inequality holds, i.e. $Ei_t^* < \overline{i_t}$ if $t \in [0, \widetilde{t})$.*

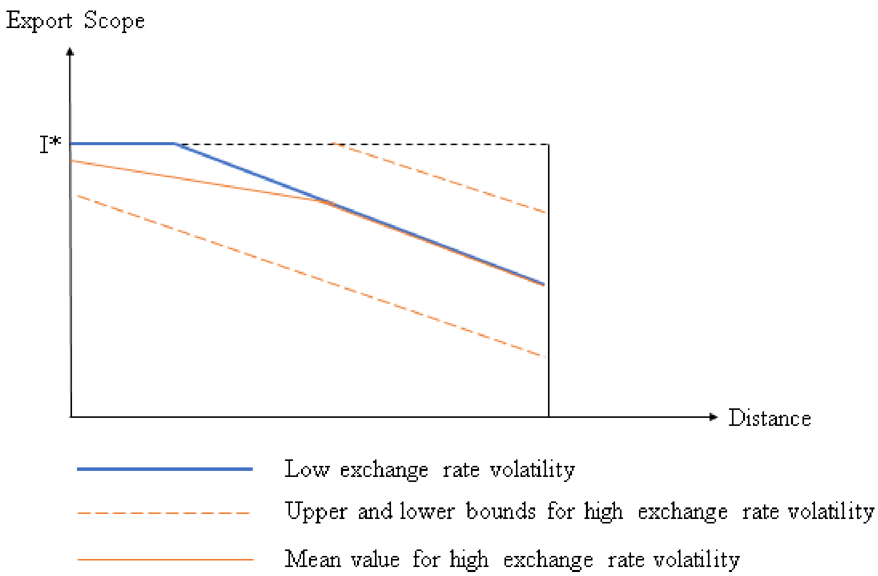
See the proof in the Appendix.

Based on the results obtained above, we can further explain the empirical results about the trade scopes and the transportation cost. Assume the exchange volatility is zero, i.e. $\varepsilon_j = 1$. From the equations $R(I^*) = \mu$ and $i_j^* = min\left\{ \left\{ [(1-\tau)B - t_j] \frac{\kappa}{c} \right\}^{\frac{1}{r}}, I^* \right\}$, we can easily see that the export scope in country j , i.e. i_j^*, is decreasing in the transportation cost t_j, and only the low marginal cost products are exported to the far destinations.

3.3 Discussion on the theoretical results

3.3.1 Intuitive explanation

Graph 1. Exchange Rate Volatility, Transportation Cost and the Export Scope



The intuition for the result of the transportation cost and the trade scopes is very straightforward: the rising of the marginal cost lowers the marginal profits for each variety and thus forces the firms to withdraw some varieties that they are not good at producing. The mechanism behinds the correlation between the exchange rate risks and the trade scopes is a little complex. As shown in the theoretical model, each firm faces identical consumers across the nations.Since firms must incur sunk costs for each product variety, they will decide the total number of the invested scopes based on the average demand across the world. However, among the countries, the specific number of the varieties for each country may be different due to the variety of the exchange rate risks and the transportation cost. In the markets with highly volatile exchange rates, the firms will decrease their export scopes if the destination's currency depreciates a lot, however, when the currency appreciates the firms may not be able to increase their export scopes due to the constraints by the pre-invested scopes. This intuitive explanation is similar to the one by Hericourt and Poncet (2015), who argued that the export volume will decrease if the destination's currency depreciates and this process is equivalent to wasting part of the pre-invested sunk cost in the trade. In this case, the firms would be averse to enter into the markets with highly exchange rate risks. Graph 1 above illustrates how the export scope towards the countries with flexible exchange rate schemes is on average less than that towards the countries with relatively stable exchange rate schemes. The red dashed lines label the upper and lower bounds for the export scopes towards the risk markets, i.e. when the currency appreciates the export scope increase and when the currency depreciates the movement will be opposite, and the red solid line refers to the average export scopes towards these countries. The blue line denotes the export scopes towards the risk-free markets. All the export scopes are constrained by the upper bound of the production scope. The horizontal line describes the heterogeneous transportation cost among countries (to simplify our analysis, without loss of generality we assume all countries conduct the same import tariff in this section). From the graph, we observe that the export scopes towards the risk countries are on average less than or equal to those towards the risk-free countries, and for some group of countries (near to China) strict inequality holds.

3.3.2 Link with the previous literature: The role of financial constraints

In the literature on the effect of exchange rate volatility on the firms' overall investment, some authors mentioned the role of financial constraints (see, for example, the papers by Aghion et al. (2009) and Hericourt and Poncet (2015)). However, they do not provide a model that sorts out how the exchange rate volatility negatively affected the firm's export performance and how financial constraints reinforce such effect. In this sub-section, we show that our model (which does not necessarily include financial constraints) can be re-interpreted as a model where firms face financial constraints, and thus our model can be seen as complementary to the literature on financial constraints in that our model nests the intuition of previous models in a two-stage framework where in the first stage firms decide on their production scope. Recall that the firm determines its optimal production scope based on the formula

$$N\int_{0}^{\hat{t}(\overline{\varepsilon},I)}\left\{\frac{L}{4\gamma(1-\tau)\overline{\varepsilon}}\left[(1-\tau)B\overline{\varepsilon}-\frac{c}{\kappa}I^{r}-t\right]^{2}\right\}\rho\left(t\right)g\left(t;S_{f}\right)dt+$$

$$N\int_{0}^{t_{max}}\int_{\hat{\varepsilon}(t,I)}^{\varepsilon_{max}}\left\{\frac{L}{4\gamma(1-\tau)\varepsilon}\left[(1-\tau)B\varepsilon-\frac{c}{\kappa}I^{r}-t\right]^{2}\right\}\left[1-\rho\left(t\right)\right]\phi\left(\varepsilon;t\right)h\left(t;S_{v}\right)d\varepsilon dt=\mu$$

Let us re-interpret μ as U divided by ω, i.e. $\mu\equiv\frac{U}{\omega}$, where U is the lumpy set up cost for each variety, and omega is the prescribed number of years over which U has to be paid back in equal yearly installments. Financial constraint may impact the decision in three ways: first, the length of the pay-back period; second, the costs of loans; and third, the ceiling on loans. Consider the first factor. If firms do not face financial constraints, they can make long-term investments. They can extend their investment to less profitable product varieties, which take longer time to recover the sunk cost. This means that on average ω would be bigger, i.e., μ would be smaller. The decrease in μ will lead to an increase in the production scope. As discussed above, with a greater production scope, the effect of volatility on export performance will be reduced. The second factor is the cost of loans. Firms that face more severe financial constraints will face higher cost of financing. For example, when a Chinese firm cannot borrow from state-owned banks with relatively low interest rates, it has to find help from the private banks or the shadow banks, in which case it has to bear higher financial costs. This means that the marginal cost of expanding the scope is higher. The third mechanism is that credit rationing in its strongest form can effectively eliminate the firm's plan to invest in new varieties. In this case, the realized production scope would be below the optimal scope. All these mechanisms reduce the production scope of the firm and weakens its ability to cope with exchange rate risks.

3.4 Tariff reduction, product variety and the heterogeneous firms

As another important contribution, we explore the impacts of the reduction of trade cost on the adjustment of export scopes by heterogeneous firms. According to the findings of Berthou and Fontagne (2013), in response to the introduction of Euro, high productivity firms expanded their export scopes but the changes among low productivity firms were insignificant. Berthou and Fontagne (2013) did not provide any theoretical model to explain these results.[12] Here, we would like to re-explore the issue studied by Berthou and Fontagne (2013) with another type of policy change, i.e. the tariff-reduction process. We also attempt to explain the results of Berthou and Fontagne (2013) and ours with a theoretical framework.

The period under study, 2000–2006, corresponds both to a drastic increase in Chinese foreign trade (e.g., the yearly export growth increased by 50% over the period) and to a significant episode of trade liberalization. Following China's accession to the WTO in December 2001, the authorities undertook a series of important commitments to open and liberalize the economy and to offer a more predictable environment for trade and foreign investment. In turn, foreign trade partners also gradually provide reduced tariffs, non-tariff measures, licenses and quotas. We make use of this policy variation in tariff reductions to capture the impact of the trade liberalization on the export scopes conducted by heterogeneous firms. In order to address issues of endogeneity, we must verify that tariffs were set independently of industries' expected exports and lobbying activities. First, Branstetter and Lardy (2006) confirm that China's accession

[12] All the previous theoretical literature focus on the analysis of the production scope.

into WTO is mainly motivated by the domestic reform agenda and willingness to become a market economy. Thus it is hard to believe that exporters would have expected or have influence on the change of foreign countries' tariff. Moreover, Brandt et al. (2012): the convergence in tariffs is more likely to reflect a requirement from WTO to reach low tariffs in all sectors rather than a selective allocation of tariff reduction in response to sector performances or lobbying activities. Lastly, there is a growing literature take advantage of China's accession into WTO, Fan et al. (2015); Bas and Strauss-Kahn (2015) for example, analyze exporters performance using this policy variation.

The first empirical finding is that when the import tariff rates are reduced by destination countries, the high productivity firms will expand more export varieties than the low productivity firms in the destination countries. (*See the table 2a in* the previous section) This may be due to the quality difference among the products provided by the heterogeneous firms. When the tariff is cut down in the destination country, more firms and product varieties will enter the market. In this case, the competition tends to be higher and some varieties could be crowded out of the market. In this section, we will show that, compared with the high quality products, the low quality products are easier to be crowded out of the market. In this case, if the high productivity firms commit to provide high quality products, then the expansion of their product varieties will be less affected by the crowding-out effect than the low productivity firms.

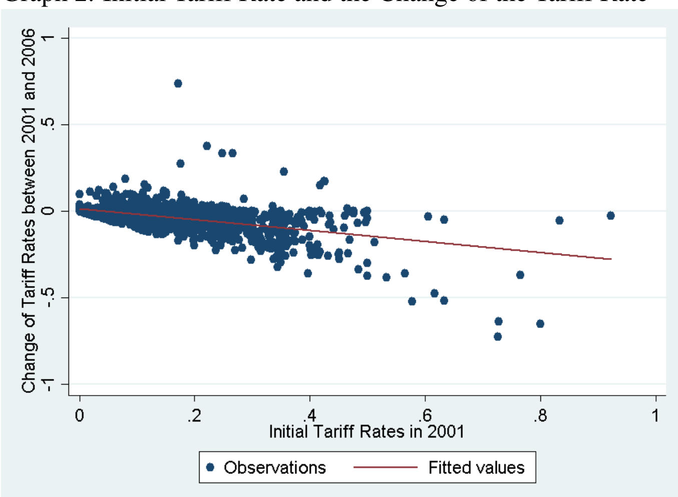
Another empirical finding is that among the production-scope regressions, the coefficients on the change of tariff rate are insignificant or positive. That means during the trade liberalization process, firms adjust little or even reduce their production scopes. The intuition for this result is as follows. The tariff reduction process mostly takes place in the countries where the initial tariff rates are relatively high. *(See the graph 2 below)* From the data set, we observe that countries with low initial tariff rates are unlikely to reduce the tariff rate further, and we suppose this is due to two reasons: firstly, as the tariff rates in these countries are already so low, there is little space to continue cutting down the tariff rates; secondly, the initial tariff rates among these countries are low enough that meet the requirement of the WTO agreement, thus it is no necessary for them to reduce their tariff rates further. As discussed in the previous sections, the number of exported varieties to the destination country is decreasing in the tariff rate of this country. In this case, the export scope towards the high tariff countries will not touch the constraints of the production scope, i.e. $i_j^* < I^*$; however, the export scope to the low tariff countries will be bounded by the production scope, i.e. $i_j^* = I^*$. If the tariff reduction only takes place among the high tariff countries, then we will observe that the firms increase the country-specific export scope but do not expand their production scope in response to the tariff-reduction process. In other words, the firms will have an incentive to make new investment in their production scopes only if the low tariff countries cut the trade costs substantially.

$$\int_{j\in J_c} \frac{L}{4\gamma(1-\tau_j)\varepsilon}\left[(1-\tau_j)B_j\varepsilon - \frac{c}{\kappa}(I^*)^r - t\right]^2 dj = \mu$$

where the collection set J_c collects the countries where $\tau_j \leq 1 - \frac{\frac{c}{\kappa}(I^*)^r + t}{B_j\varepsilon}$.[13]

The equation above determines the optimal production scope by a typical firm. As the profits in each market should be positive, we can further obtain that the variety I^* only shows up in the market where the tariff rate is low enough, i.e. $\tau_j \leq 1 - \frac{\frac{c}{\kappa}(I^*)^r + t}{B_j\varepsilon}$. If the tariff reduction only takes place among the countries where the tariff rate is relatively high, i.e. $\tau_j \geq 1 - \frac{\frac{c}{\kappa}(I^*)^r + t}{B_j\varepsilon}$, then the production scope cannot be expanded.

Graph 2. Initial Tariff Rate and the Change of the Tariff Rate



In the rest part of this section, we will focus on the discussion of the change of export scopes with the following assumptions: firstly, the tariff reduction takes place among the countries where the export scope is below the production scope; secondly, the expansion of the export scope is not constrained by the initial production scope. To model all the empirical findings in this section and simplify our analysis without loss of generality, we make the following additional assumptions:

ASSUMPTION 2.

[1] There are two levels of quality, i.e. z_H *and* z_L*, and the parameter* α *of the utility function increases in the quality level of the product, i.e.* $\alpha(z_H) > \alpha(z_L)$ *;*

[13]Different from the previous model, we assume the transportation cost and the exchange rate scheme are identical across countries but the competition index is endogenous now.

[2] there are two types of firms ,ι = h and l, and they are heterogeneous in the fixed cost to export to the destination country, i.e. $\varsigma_l(z_H) > \varsigma_h(z_H) \geq 0$ *and* $\varsigma_l(z_L) = \varsigma_h(z_L) = 0$*;*

[3] the firms make decision on the choices of the quality, export scopes and the market price to the destination country simultaneously;

[4] the transportation distance, exchange rate, and population size are constant and identical across countries, i.e. $t_j = t$, $\varepsilon_j = \varepsilon$ *and* $L_j = L$ *for* $\forall j$*;*

[5] Q_j *measures the competition intensity among Chinese products only.* [14]

The profit for firm ι in country j as:

$$v_\iota = \int_{i\in\Omega_h} \frac{L}{4\gamma(1-\tau_j)\varepsilon}\left[(1-\tau_j)(\alpha(Z)-\beta Q_j)\varepsilon - \frac{c}{\kappa}i^r - t\right]^2 di - \varsigma_\iota(Z)$$

where $Z = z_H$ or z_L.

It is easy to prove that Q_j is bounded, i.e. $Q_j \in [Q_{min}, Q_{max}]$, where Q_{min} is captured when all firms export the low quality products and Q_{max} is when all firms export the high quality products. Next, we define the following functions.

$$f(Q_j) \equiv \int_{i\in\Omega_h} \frac{L}{4\gamma(1-\tau_j)\varepsilon}\left[(1-\tau_j)(\alpha(z_H)-\beta Q_j)\varepsilon - \frac{c}{\kappa}i^r - t\right]^2 di - \int_{i\in\Omega_h} \frac{L}{4\gamma(1-\tau_j)\varepsilon}\left[(1-\tau_j)(\alpha(z_L)-\beta Q_j)\varepsilon - \frac{c}{\kappa}i^r - t\right]^2 di$$

$$G_{max} \equiv \max_{Q_j} f(Q_j)$$

$$G_{min} \equiv \min_{Q_j} f(Q_j)$$

where $Q_j \in [Q_{min}, Q_{max}]$.

Then we can get the following lemma.

LEMMA 5. *If the quality cost for the high productivity firm is small enough, i.e.* $\varsigma_h(z_H) \leq G_{min}$ *; and the quality cost for the low productivity firm is large enough, i.e.* $\varsigma_l(z_H) \geq G_{max}$ *; then the high productivity firms will choose to export the high quality products and the low productivity firms choose to export the low quality products. (See the proof in the Appendix)*

Directly, we can get the export scope to country j by different types of firms as followings.

$$\begin{cases} i_{jl} = & [\alpha(z_L) - \beta Q_j](1-\tau_j) - t_j \\ i_{jh} = & [\alpha(z_H) - \beta Q_j](1-\tau_j) - t_j \end{cases}$$

[14] The purpose of this assumption is to make the competition index endogenous to the firms' strategies. The same assumption was also imposed in Qiu and Yu (2014).

Then the changes of the export scope in response to the change of the tariff rate are given by:

$$\begin{cases} \frac{\partial i_{jl}}{\partial(1-\tau_j)} = & \alpha(z_L) - \beta Q_j - \beta(1-\tau_j)\frac{\partial Q_j}{\partial(1-\tau_j)} \\ \frac{\partial i_{jh}}{\partial(1-\tau_j)} = & \alpha(z_H) - \beta Q_j - \beta(1-\tau_j)\frac{\partial Q_j}{\partial(1-\tau_j)} \end{cases}$$

Firstly, we need to guarantee that at least one type of the firms increase the export scope in response to the tariff reduction, i.e. $\frac{\partial i_{jh}}{\partial(1-\tau_j)} > 0$. To make the inequality hold, we need $\alpha(z_H)$ to be large enough, i.e. $\alpha(z_H) > \beta Q_j + \beta(1-\tau_j)\frac{\partial Q_j}{\partial(1-\tau_j)}$. As $\alpha(z_H) > \alpha(z_L)$, thus we can get directly get that $\frac{\partial i_{jh}}{\partial(1-\tau_j)} > \frac{\partial i_{jl}}{\partial(1-\tau_j)}$. In addition, if $\alpha(z_L)$ is small enough, i.e. $\alpha(z_L) < \beta Q_j + \beta(1-\tau_j)\frac{\partial Q_j}{\partial(1-\tau_j)}$, then we will observe that in response to a tariff reduction, the high productivity firms will increase the export scope while the low productivity firms will reduce it.

4 Robustness checks

As discussed in Section 2, we need to examine whether our results are reached due to the specification of the construction of variables or the estimation methods. Firstly, we replace our dependent variable with another indicator for export diversification which is firstly proposed by Lopresti (2016) to see whether the results vary with the specification of our key variable; Secondly, as our dependent variable is a count number, we re-estimate the first empirical model with Poisson regression method; Lastly, we use the initial year's value of TFP as an independent regressor in our second estimation model to check the robustness of the estimation.

4.1 Alternative indicator for the export diversification

Another indicator that measuring the export diversification is the Herfindahl-Hirschman index (HH-index), and it was firstly applied into the analysis by Lopresti (2016). This index describes the export diversification more accurately than the aggregated number of the export varieties. The value of the HH-index is increasing in the export diversification. The specific formula of the index is as following.

$$HH\_index_{\iota jt} = 1 - \sum \left(\frac{Sale_{\iota ijt}}{\sum\limits_{i} Sale_{\iota ijt}} \right)^2$$

where ι, j, i and t identify the firm, country, variety (indexed by HS6 code) and time respectively. We use the HH-index as our measurement of the export diversification and the estimation model is specified as follows.

$$HH\_index_{\iota jt} = \beta_1 * exchange\_rate\_volatilaty_{jt} + \beta_2 * distance_j + \beta_3 tariff\_rate_{jvt} + X_{\iota jt}\gamma_1 + \lambda_v + \eta_t + \varepsilon_{\iota jt}$$

where v denotes the industry (indexed by HS2 code).

The results are reported in table 3 which are consistent with our previous ones using the export scope as the dependent variable, i.e. significantly negative coefficients on the variables exchange rate volatility, transportation distance, and the tariff rate.

4.2 Alternative estimation methods

4.2.1 Estimations with Poisson regression

To assure our estimation results are invariant with estimation methods, following Qiu and Yu (2014) and some other previous literature, we also run our main regressions with the Poisson regression method. The estimation results can be found in table 4 *(see in Appendix)*. The results show that the export scope decreases in the trade cost, i.e. transportation distance, exchange rate volatility, and the import tariff rate imposed by the destination country. These results are consistent with our previous analysis, i.e. significantly negative coefficients on the variables exchange rate volatility, transportation distance, and the tariff rate.

4.2.2 Logged form of tariff rate

As many previous papers use the logged form of tariff rate in their study, e.g. Fan et al. (2015), we construct the indicator for the change of the tariff rate using the same method as theirs and check the robustness of our estimation. The indicator for the change of the firm-country level of weighted average tariff rate now becomes $\Delta tariff\_rate_{jh} \equiv$

$\left[\sum_{i\in I_j} \Delta ln\,(tariff\_rate_{ij}+1)\times volume_{ijht}\right] / \sum_{i\in I_j} volume_{ijht}$, where $\Delta ln(tariff\_rate_{ij}+1)$ is the tariff rate for variety i (in HS6 level) at country j , and $volume_{ijht}$ is the trade volume (sales) of product i for firm h to country j in the year t. Here, we use both the trade volume for the years 2001 and 2006. [15] Table 5 shows the relevant estimation results, and the results are consistent with our previous estimations, i.e. the coefficient on $\Delta tariff\_rate_{jh}$ is significantly positive and coefficient on $TFP_h \times \Delta tariff\_rate_{jh}$ is significantly negative.

4.2.3 Including the initial TFP as a regressor

As the initial levels of TFP in 2001 are used as interaction factors in our regressions, we also run the regressions with including this variable as a regressor to test whether our main results hold robustness. Table 6 shows the relevant estimation results, and the results are consistent with our previous estimations, i.e. the coefficient on $\Delta tariff\_rate_{jh}$ is significantly positive and coefficient on $TFP_h \times \Delta tariff\_rate_{jh}$ is significantly negative.

5 Conclusion

In this paper, we explore two questions which are rarely studied among literature: how Chinese firms decide their export scopes in response to different characteristics of destination countries, i.e. exchange rate scheme, transportation distance, and tariff rate; and how heterogeneous firms with different TFP adjust their production and export scopes react to the trade liberalization. We also provide theoretical fundamentals to all our empirical findings.

Using the Chinese firm-level data from the years 2001 and 2006, we obtained the following empirical findings : the firms export fewer varieties (indexed by HS6 code) the destination which has farther distance to the home country or higher exchange rate volatility; in response to the tariff-reduction process in the destination market, the high productivity firms expand while the low productivity firms shrink their export scopes. As indicated by Greenaway and Kneller (2007), the intuition behind the first finding is that the geographic distance and the exchange rate risks increase the trading cost of the exporters and thus worsen the exporter's performance in the destination market. Following the

[15] As explained by Fan et al. (2015), the reason for adding one to tariff rate is to keep positive value for $ln(tariff\_rate_{ij}+1)$, which operation will reduce bias in estimation.

theoretical framework by Melitz and Ottaviano (2008) and Qiu and Yu (2014), we explain our empirical findings as the following mechanism: the firms will reduce the export scope if the destination countries suffer negative demand shock, however when the positive demand shock occurs the firms find it difficult to expand the export scope due to the insufficient pre-investment in the production capacity. For the second finding, we suppose the mechanism is as follows: the high productivity firms export relatively high quality product while low productivity firms provide relatively low quality products; in response to a tariff-reduction process, the market competition becomes more intensive; as the tariff rate is reduced, the demand for high quality products increases more than the low quality products; then the high productivity firms expand their export scopes but the low productivity firms reduce their export scopes due to the increase of the market competition.

Among all the related literature, our research is the first one to provide the firm-level evidence regarding the export scope and the transportation cost and the adjustments of the export scopes among heterogeneous firms in response to the tariff reduction process. We are also the first one to provide theoretical explanation to the linkage between the exchange rate volatility and export scope.

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Appendix

Proof of lemma 1.

For any given I that has been chosen in the first stage, the firm must decide in the second stage how many varieties it offers to country j . We call this the "export scope". The optimal export scope for market j depends on two parameters: the distance t_j and the exchange rate ε_j. We assume that ε_j is observed before the firm makes its output decision q_{ij}, for all $i \in [0, I]$.

Clearly since the sunk cost has been incurred, the firm will sell any variety $i \leq I$ up to the positive output level that equates marginal revenue with marginal cost (unless, of course, $\varepsilon_j \leq \frac{\frac{c}{\varphi_i}+t_j}{(1-\tau)(\alpha-\beta Q_j)}$, in which case, the optimal output q_{ij} is zero). The firm's realized export scope in country j depends on the exchange rate. To show how the exchange rate volatility affects the firm's decision on the choice of the export scope, it is sufficient to compare the countries with the fixed exchange rate and countries with a fluctuating exchange rate.

For countries with a fixed exchange $\overline{\varepsilon}$: Assuming $t_j \leq (1-\tau) B\overline{\varepsilon}$, then all varieties i such that

$$(1-\tau) B\overline{\varepsilon} \equiv (1-\tau)(\alpha-\beta Q_j)\overline{\varepsilon} > \frac{c}{\kappa} i^r + t_j$$

will be exported, i.e. the cut-off value for i is

$$\bar{i}_j \equiv min\left\{I, \left\{[(1-\tau) B\overline{\varepsilon} - t_j]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}\right\}$$

Thus, the export scope decreases as t_j increases.

Given $\overline{\varepsilon}$ and I, define $\hat{t}(\overline{\varepsilon}, I)$ by the equality

$$I = \left\{[(1-\tau) B\overline{\varepsilon} - \hat{t}(\overline{\varepsilon}, I)]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}$$

i.e.

$$\hat{t}(\overline{\varepsilon}, I) \equiv (1-\tau) B\overline{\varepsilon} - \left(\frac{c}{\kappa}\right) I^r$$

Then,

$$\bar{i}_j = \begin{cases} 0 & if\, t_j > (1-\tau)B\bar{\varepsilon} \\ \left\{[(1-\tau)B\bar{\varepsilon} - t_j]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} < I & if\ (1-\tau)B\bar{\varepsilon} \geq t_j > \hat{t}(\bar{\varepsilon}, I) \\ I & if\, t_j \leq \hat{t}(\bar{\varepsilon}, I) \end{cases}$$

For countries with a variable exchange rate, let ε_j be the realized exchange rate. Assuming $t_j \leq (1-\tau)B\varepsilon_j$, then all varieties i such that

$$(1-\tau)B\varepsilon_j \equiv (1-\tau)(\alpha - \beta Q_j)\varepsilon_j > \frac{c}{\kappa}i^r + t_j$$

will be exported, i.e., the cut-off value for i is

$$i^* \equiv min\left\{I, \left\{[(1-\tau)B\varepsilon_j - t_j]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}\right\}$$

Thus, when a country's exchange rate appreciates relative to the yuan (ε_j increases), the Chinese export scope for that country increases.

Given $t_j$and I , define $\hat{\varepsilon}(t_j, I)$ by the equality

$$I = \left\{[(1-\tau)B\hat{\varepsilon}(t_j, I) - t_j]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}$$

i.e.

$$\hat{\varepsilon}(t_j, I) \equiv \frac{t_j}{(1-\tau)B} + \left[\frac{c}{\kappa(1-\tau)B}\right]I^r$$

Then

$$i_j^* = \begin{cases} 0 & if\, \varepsilon_j < \frac{t_j}{(1-\tau)B} \\ \left\{[(1-\tau)B\varepsilon_j - t_j]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} < I & if\, \frac{t_j}{(1-\tau)B} < \varepsilon_j < \hat{\varepsilon}(t_j, I) \\ I & if\, \hat{\varepsilon}(t_j, I) < \varepsilon_j \leq \varepsilon_{max} \end{cases}$$

Q.E.D.

Proof of lemma 2.

If the risk-free countries that are near enough to the home country, the exporting scope will touch the upper bound of the production scope, i.e. $\left\{\left[(1-\tau)B\overline{\varepsilon}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} \geq I^*$. Then we have $\bar{i}_t = I^*$. Given the transportation distance unchanged, the exporting scope towards the risk countries will be adjusted as the following rule $i_t^* = I^*$ whenever $\varepsilon_j \geq \overline{\varepsilon}$, but $i_t^* = \left\{\left[(1-\tau)B\varepsilon_j - t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} \leq I^*$ whenever $\varepsilon_j \leq \overline{\varepsilon}$. In this case, $Ei_t^* = \int_{\varepsilon_{min}}^{\overline{\varepsilon}} i_t^* d\varepsilon + \int_{\overline{\varepsilon}}^{\varepsilon_{max}} I^* d\varepsilon \leq \bar{i}_t = I^*$. If $\left\{\left[(1-\tau)B\varepsilon_{min}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} < I^*$, then we have the strict inequality, i.e. $Ei_t^* = \int_{\varepsilon_{min}}^{\overline{\varepsilon}} i_t^* d\varepsilon + \int_{\overline{\varepsilon}}^{\varepsilon_{max}} I^* d\varepsilon < \bar{i}_t = I^*$.

If the risk-free countries are far from the home country, the exporting scope will be interior solution, i.e. $\bar{i}_t = \left\{\left[(1-\tau)B\overline{\varepsilon}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} < I^*$. Next, we need to discuss whether the exporting scope towards the risk markets will touch the upper bound of the production scope, i.e. $\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} > or \leq I^*$.

When $\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} > I^*$, we define $\hat{\varepsilon}(t_j, I) \in [\overline{\varepsilon}\,\varepsilon_{max}]$ such that $\left\{\left[(1-\tau)B\hat{\varepsilon}(t_j;I)-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} = I^*$. Recall that $r \geq 1$, then we have $Ei_t^* = \int_{\varepsilon_{min}}^{\hat{\varepsilon}(t_j;I)} \left\{\left[(1-\tau)B\varepsilon-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} + \int_{\hat{\varepsilon}(t_j;I)}^{\varepsilon_{max}} I^* d\varepsilon < \int_{\varepsilon_{min}}^{\varepsilon_{max}} \left\{\left[(1-\tau)B\varepsilon-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} d\varepsilon \leq \left\{\left[(1-\tau)B\overline{\varepsilon}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} = \bar{i}_t$.

When $\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} \leq I^*$, we have $Ei_t^* = \int_{\varepsilon_{min}}^{\varepsilon_{max}} \left\{\left[(1-\tau)B\varepsilon-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} d\varepsilon \leq \left\{\left[(1-\tau)B\overline{\varepsilon}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} = \bar{i}_t$.

In summary, we have $Ei_t^* \leq \bar{i}_t$, and the strict inequality holds for some cases.

Q.E.D.

Proof of lemma 3.

$$\frac{dR^f(I)}{dI} = N\int_0^{\hat{t}(\overline{\varepsilon},I)} \left\{-\frac{L}{4\gamma(1-\tau)\overline{\varepsilon}}\left(\frac{2c}{\kappa}rI^{r-1}\right)\left[(1-\tau)B\overline{\varepsilon}-\frac{c}{\kappa}I^r-t\right]\right\}\rho(t)\,g\left(t;S_f\right)dt+$$

$$\left\{\frac{L}{4\gamma(1-\tau)\overline{\varepsilon}}\left[(1-\tau)B\overline{\varepsilon}-\frac{c}{\kappa}I^r-\hat{t}(\overline{\varepsilon},I)\right]^2\right\}\rho\left(\hat{t}(\overline{\varepsilon},I)\,g\left(\hat{t}(\overline{\varepsilon},I);S_f\right)\right)\frac{d\hat{t}(\overline{\varepsilon},I)}{dI}$$

The integral on the R.H.S. is negative, and second term on the R.H.S. is zero because $\hat{t}(\overline{\varepsilon}, I) \equiv (1-\tau)B\overline{\varepsilon} - \frac{c}{\kappa}I^r$.

Q.E.D.

Proof of lemma 4.

Differentiating $\frac{dR^v(I)}{dI} = \int_0^{t_{max}} h(t;S_v)(1-\rho(t))\int_{\hat{\varepsilon}(t,I)}^{\varepsilon_{max}} \left\{-\frac{L}{4\gamma(1-\tau)\varepsilon}\left(\frac{2c}{\kappa}rI^{r-1}\right)\left[(1-\tau)B\varepsilon-\frac{c}{\kappa}I^r-t\right]\right\}\phi(\varepsilon;t)\,d\varepsilon dt < 0$.

Q.E.D.

Proof of proposition 1.

Based on the proof of the lemma 1, the sufficient condition for the holding of the strict inequality is that $\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} > I^*$ for some $t\in[0,\widetilde{t})$,where $\widetilde{t}\in(0,t_{max})$.

At the second stage, the I^* variety shows up in the market j only if the net value of the price and the marginal cost is non-negative, i.e. $(1-\tau)B\varepsilon_j-\frac{c}{\varphi_i}-t_j\geq 0$. In this case, whenever $(1-\tau)B\varepsilon_j-\frac{c}{\varphi_i}-t_j\geq 0$, the profit from selling the variety I^* in the market j ,$\nu(\varepsilon_j,t_j)\equiv\frac{L}{4\gamma(1-\tau)\varepsilon_j}\left[(1-\tau)B\varepsilon_j-\frac{c}{\varphi_i}-t_j\right]^2$, is increasing in ε_j and decreasing in t_j; and when $(1-\tau)B\varepsilon_j-\frac{c}{\varphi_i}-t_j<0$, $\nu(\varepsilon_j,t_j)=0$. Thus $\nu(\varepsilon_j,t_j)\equiv\frac{L}{4\gamma(1-\tau)\varepsilon_j}\left[(1-\tau)B\varepsilon_j-\frac{c}{\varphi_i}-t_j\right]^2$ is non-decreasing in ε_j and non-increasing in t_j.

If for $\forall t_j\in[0,t_{max}]$, $\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}<I^*$, then we get we get $\left\{\left[(1-\tau)B\varepsilon-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}<I^*$ for any ε and t_j. In this case, $R(I^*)=0<\mu$, then the variety I^* won't be invested , which conflicts the assumption that the production scope is I^*. Thus we have for some $t_j\in[0,t_{max}]$, $\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}\geq I^*$. Next, we need to show that the strict inequality holds for some $\varepsilon\in[\varepsilon_{min},\varepsilon_{max}]$ and $t_j\in[0,t_{max}]$. To achieve this target, we just need to show $\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}>I^*$. Actually, this condition holds naturally. Because if $\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}=I^*$, then $\nu(\varepsilon_j,t_j)=0$ for any $\varepsilon\in[\varepsilon_{min},\varepsilon_{max}]$ and $t_j\in[0,t_{max}]$ ($\nu(\varepsilon_j,t_j)$ is non-decreasing in ε_j and non-increasing in t_j).

Because $\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}>I^*$, and $\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}$ is continuous in t_j, so we can find some $\widetilde{t}\in(0,t_{max})$ such that $\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}>I^*$ for some $t\in[0,\widetilde{t})$.

Q.E.D.

Proof of lemma 5.

As $G_{min}\geq\varsigma_h(z_H)$, thus $\int_{i\in\Omega_h}\frac{L}{4\gamma(1-\tau_j)\varepsilon}\left[(1-\tau_j)(\alpha(z_H)-\beta Q_j)\varepsilon-\frac{c}{\kappa}i^r-t\right]^2di-\varsigma_h(z_H)\geq$
$\int_{i\in\Omega_h}\frac{L}{4\gamma(1-\tau_j)\varepsilon}\left[(1-\tau_j)(\alpha(z_L)-\beta Q_j)\varepsilon-\frac{c}{\kappa}i^r-t\right]^2di$ for any $Q_j\in[Q_{min},Q_{max}]$. In this case, the high productivity firm will choose to export the high quality products.

As $G_{max}\leq\varsigma_l(z_H)$, thus $\int_{i\in\Omega_h}\frac{L}{4\gamma(1-\tau_j)\varepsilon}\left[(1-\tau_j)(\alpha(z_H)-\beta Q_j)\varepsilon-\frac{c}{\kappa}i^r-t\right]^2di-\varsigma_l(z_H)\leq$

$\int_{i\in\Omega_h}\frac{L}{4\gamma(1-\tau_j)\varepsilon}\left[(1-\tau_j)(\alpha(z_L)-\beta Q_j)\varepsilon-\frac{c}{\kappa}i^r-t\right]^2di$ for any $Q_j\in[Q_{min},Q_{max}]$. In this case, the low productivity firm will choose to export the low quality products.

Q.E.D.

Table 1b. Trade cost and the Export Scope, Logged Form of Exchange Rate

	Dependent Variable: Export scope					
	Panel A: Real Exchange Rate Volatility			Panel B: Nominal Exchange Rate Volatility		
Distance	-0.0406***	-0.0171***	-0.0129***	-0.0509***	-0.0204***	-0.0121***
	(0.00286)	(0.00353)	(0.00317)	(0.00279)	(0.00340)	(0.00307)
$Exchange\_rate\_volatility$	-0.0567***	-0.0401***	-0.0189***	-0.0226***	-0.0217***	-0.0131***
	(0.00218)	(0.00274)	(0.00248)	(0.00102)	(0.00148)	(0.00133)
$Tariff\_rate$	-0.525***	-0.297***	-0.206***	-0.560***	-0.273***	-0.185***
	(0.0294)	(0.0380)	(0.0331)	(0.0290)	(0.0365)	(0.0320)
Observations	143,644	94,226	94,226	162,509	104,428	104,428
R-squared	0.089	0.128	0.279	0.086	0.126	0.277
Trade Volume Control	NO	NO	YES	NO	NO	YES
Firm Level Controls	NO	YES	YES	NO	YES	YES
Country Level Controls	NO	YES	YES	NO	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: All variables are in logged form except tariff rate. The difference between table 1a and 1b is that in table 1b the exchange rate volatility is in logged form. Similar as table 1 a, the estimate results show that the export scope is decreasing in transportation distance, tariff rate and exchange rate volatility.

Table 3. Trade Cost and the Export Diversification

	Dependent Variable: Herfindahl-Hirschman index					
	Panel A: Real Exchange Rate Volatility			Panel B: Nominal Exchange Rate Volatility		
Distance	-0.00920***	-0.00561***	-0.00443***	-0.00959***	-0.00465***	-0.00326***
	(0.000940)	(0.00117)	(0.00112)	(0.000915)	(0.00113)	(0.00108)
$Exchange\_rate\_volatility$	-0.280***	-0.134***	-0.0723***	-0.349***	-0.225***	-0.135***
	(0.0191)	(0.0253)	(0.0244)	(0.0236)	(0.0310)	(0.0299)
$Tariff\_rate$	-0.120***	-0.0578***	-0.0378***	-0.121***	-0.0541***	-0.0339***
	(0.00922)	(0.0121)	(0.0111)	(0.00905)	(0.0117)	(0.0108)
Observations	143,644	94,226	94,226	162,509	104,428	104,428
R-squared	0.075	0.086	0.146	0.074	0.087	0.146
Trade Volume Control	NO	NO	YES	NO	NO	YES
Firm Level Controls	NO	YES	YES	NO	YES	YES
Country Level Countrols	NO	YES	YES	NO	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: Computation of the dependent variable can be found in section 2.2. The specifications of all the other variables are the same as in table 1a. The estimation results show that the export diversification (defined by the Herfindahl-Hirschman index) is decreasing in the transportation distance, exchange rate volatility and the tariff rate.

Table 4. Trade cost and the Export Scope, Poisson regression

	Dependent Variable: Export scope					
	Panel A: Real Exchange Rate Volatility			Panel B: Nominal Exchange Rate Volatility		
Distance	-0.0648***	-0.0522***	-0.0361***	-0.0763***	-0.0437***	-0.0261***
	(0.00548)	(0.00771)	(0.00663)	(0.00546)	(0.00740)	(0.00638)
$Exchange\_rate\_volatility$	-4.135***	-1.955***	-0.900***	-4.414***	-2.723***	-1.164***
	(0.239)	(0.249)	(0.197)	(0.215)	(0.266)	(0.217)
$Tariff\_rate$	-1.336***	-0.604***	-0.269***	-1.379***	-0.527***	-0.204***
	(0.0704)	(0.102)	(0.0801)	(0.0698)	(0.0970)	(0.0753)
Observations	143,644	94,226	94,226	162,509	104,428	104,428
Trade Volume Control	NO	NO	YES	NO	NO	YES
Firm Level Controls	NO	YES	YES	NO	YES	YES
Country Level Controls	NO	YES	YES	NO	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The model specification is the same as in table 1a except that we use the Poisson regression method. The estimation results show that the export scopes is decreasing in transportation distance, exchange rate volatility and the tariff rate.

Table 5. Trade Liberalization, Heterogeneous Firms, and Change of the Export Scope, Logged Form of Tariff Rate

	Dependent Variable: Change of logged form of export scope between 2001 and 2006								
Tariff Specification	Panel A: Country-industry Level			Panel B: Firm-country Level Average, 2001 Weights			Panel C: Firm-country Level Average, 2006 Weights		
$\Delta Tariff$	-0.831	4.840***	4.216***	-0.206	3.045***	2.681**	0.0105	2.555***	2.355**
	(0.622)	(1.179)	(1.411)	(0.341)	(1.083)	(1.178)	(0.304)	(0.990)	(1.109)
$TFP_{2001} * \Delta Tariff$		-1.251***	-1.168***		-0.779***	-0.680**		-0.574***	-0.523**
		(0.254)	(0.293)		(0.247)	(0.265)		(0.217)	(0.238)
ΔTFP	0.0273***	0.0553***	0.0309***	0.0398***	0.0459***	0.0412***	0.0397***	0.0455***	0.0407***
	(0.00892)	(0.00726)	(0.00896)	(0.0106)	(0.00843)	(0.0106)	(0.0106)	(0.00843)	(0.0106)
Observations	6,389	11,456	6,389	4,880	8,885	4,880	4,880	8,885	4,880
R-squared	0.206	0.046	0.208	0.213	0.060	0.214	0.213	0.060	0.214
Firm Level Controls	YES	NO	YES	YES	NO	YES	YES	NO	YES
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6. Trade Liberalization, Heterogeneous Firms, and Change of the Export Scope, with initial TFP as a regressor

Dependent Variable: Change of logged form of export scope between 2001 and 2006						
Tariff Specification	Panel A: Change of Tariff Rate			Panel B: Change of Logged Tariff Rate		
	Country-industry Level	2001 Weights	2006 Weights	Country-industry Level	2001 Weights	2006 Weights
$\Delta Tariff$	2.644**	2.04*	2.33**	2.896**	2.413*	2.737*
	(1.106)	(1.15)	(1.12)	(1.452)	(1.426)	(1.397)
$TFP_{2001} * \Delta Tariff$	-0.704***	-0.466*	-0.496**	-0.864***	-0.613**	-0.621**
	(0.238)	(0.242)	(0.235)	(0.304)	(0.305)	(0.295)
TFP_{2001}	0.0305***	0.0442***	0.0438***	0.0391***	0.0438***	0.0435***
	(0.0104)	(0.0119)	(0.0119)	(0.0104)	(0.0120)	(0.0120)
ΔTFP	0.0464***	0.0454***	0.0453***	0.0485***	0.0454***	0.0452***
	(0.0102)	(0.0120)	(0.0120)	(0.0101)	(0.0120)	(0.0120)
Observations	6,377	4,854	4,854	6,389	4,854	4,854
R-squared	0.208	0.221	0.221	0.210	0.221	0.221
Trade Volume Control	YES	YES	YES	YES	YES	YES
Firm-level Controls	YES	YES	YES	YES	YES	YES
Country-level FE	YES	YES	YES	YES	YES	YES
Industry-level FE	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1