Spring 1-1-2017

Essays on Product Quality, Exports, and Trade Policy

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A thesis submitted to the

Faculty of the Graduate School of the

University of Colorado in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

Department of Economics

2017

This thesis entitled:
Essays on Product Quality, Exports, and Trade Policy
written by Nan Xu
has been approved for the Department of Economics

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The final copy of this thesis has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.

Xu, Nan (Ph.D., Economics)

Essays on Product Quality, Exports, and Trade Policy

Thesis directed by Professor James R. Markusen

This dissertation explores the trade patterns of quality-differentiated goods and the welfare effects of rules of origin. Chapter 1 studies a taste for quality channel through which a destination's income per capita causes the variety-quality tradeoff in product exports. I find that, holding market size constant, the elasticity of consumer taste for quality with respect to income per capita determines the differences between rich and poor countries in productivity thresholds, firm market shares, and number of varieties produced. Using firm-level data, empirical support for the theoretical predictions are found. Conditional on entry, low-quality export sales are decreasing in the destination country's GDP per capita, while the relationship between high-quality export sales and income per capita exhibits an inverted-U shape.

Chapter 2 considers the effects of import tariff reductions on the quality of China's exports. I focus on a composition effect arising from firm self-selection into the ordinary and the processing trade regimes following tariff reductions and provide an explanation for the over time declining trend of China's exports quality documented in trade literature. Processing firms produce higher quality goods than ordinary firms due to tariff exemptions on the processing activity. A lower import tariff favors ordinary exporting firms in that cheaper imported inputs induce firms to upgrade product quality and compete for larger market shares.

Chapter 3 investigates the impacts of rules of origin (ROOs) on FTA utilization rates and on country welfare. I develop a general equilibrium model featuring both variable and fixed costs of complying with ROOs. A binding ROO forces exporters to employ more locally produced inputs instead of using the most efficient manufacturing process. Additionally, firms face fixed documentation costs due to the administrative process of obtaining certificates of origin. Whether firms utilize an FTA depends on the tariff benefits net of the extra costs. I show that: (1) as the ROO becomes stricter, the FTA utilization rate decreases and the dominant extensive margin drives down the wage rate in the downstream country; (2) the welfare effects of ROOs are ambiguous depending on the elasticity of substitution between varieties.

Dedication

To my dear parents.

Acknowledgements

I would like to express my deepest thanks to my main advisor, Jim Markusen, for his continuous help and encouragement through the completion of this dissertation. Jim has shaped my understanding of economics with his invaluable guidance and rigorous scholarship. His support has made my graduate study less stressful.

I am indebted to Jeronimo Carballo. It has been a great honor to have him as my advisor. Not only has his immense knowledge enriched my thesis, but also his dedication to economic research and his attention to students have set an excellent example to follow.

My sincere thanks also go to other faculty members, Keith Maskus, Wolfgang Keller, Jin-Hyuk Kim, Chrystie Burr, and Edward Balistreri. I would like to thank them for their helpful comments and thoughts.

Very special thanks to my parents for their unconditional and constant love and support throughout my life. I also want to thank my friends, who have accompanied me at moments of joy and stress.

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Chapter 1

Per-capita Income, Taste for Quality, and Exports across Countries

1.1 Introduction

Disaggregate data on exporters, their products, and their destinations facilitate empirical research on firm level export activity across foreign destinations. It is well established in the literature that a firm's exporting performance depends not only on its productivity, but on importing countries' characteristics, such as market size, income level, and remoteness. As product quality becomes an important dimension of international competition, variety margin and quality margin are both considered as important channels through which trade improves welfare. However, it remains unclear on the role of income per capita in shaping consumers' preferences for quality upgrading versus more varieties. Consequently, the relationship between cross-country exports of quality differentiated goods and destinations' GDP per capita has not been well explained. Motivated by the fact that consumers' tastes for quality vary considerably across countries and its relations to income and firm exports are rarely examined in the literature, this chapter features income per capita as a demand base determinant of trade in that it affects consumers' valuations on product quality. Empirically, this chapter shows that the cross-country variation in GDP per capita succeeds in explaining the differential patterns of export entry and sales of high- and low-quality goods across destinations.

Quality-augmented Melitz models rationalize the empirical findings that more productive firms produce high-quality goods and charge higher prices. The profitability of producing and exporting high-quality goods is jointly determined by supply and demand. On the supply side, producing better quality goods incurs additional production costs, as it requires advanced technology, functional designs and high-quality intermediate inputs. On the demand side, consumers' perceptions of a product's intrinsic features and qualities affect markups and market demands, and the perceptions vary with income levels. In this chapter, I focus on the demand side and argue that the elasticity of taste for quality with respect to income per capita is crucial in predicting whether consumers prefer quality upgrading or more varieties as they get richer. To this end, I use a model combining quality evaluation mechanism and non-homothetic preferences over quality differentiated varieties which allows rich consumers to demand more high-quality goods. As such, a higher income per capita gives rise to a larger market size as well as a stronger taste for product quality which affect market demands for high- and low-quality goods in a disproportionate way. In equilibrium, when consumers' tastes for quality are income-elastic, a higher income leads to a higher average product quality and a smaller number of varieties in consumption bundles, with market shares shifting from low- towards high-quality varieties. When tastes for quality are inelastic to income, rich consumers prefer variety more than quality, resulting in a greater number of varieties and shrinking market shares of individual products.

An important feature of my model is that it does not predetermine whether consumers prefer quality upgrading or more varieties when they get richer. It allows for both cases and emphasizes the role of elasticity of taste for quality in determining which way it goes. Such a flexibility of consumption behaviors is crucial in accounting for cross-country variations in exports at the firm-product level. Compared to the trade literature, my model unifies the predictions of non-homothetic preference models. There are two main strands of research aimed at exploring the roles of per-capita income in shaping exports. One is built on the assumption that consumers purchase a single vertically differentiated product, like Fajgelbaum et al (2011) and Brambilla and Porto (2016), and predicts a positive correlation between quality and price of consumption goods and income per capita. The other strand of literature utilizes models in which consumers purchase a range of horizontally differentiated products, with rich individuals consuming a wider set of varieties, and concludes that the extensive margin of imports is positively related to income per capita, such as Foellmi et al (2010) and Simonovska (2015). The non-linear relationship between firm exports and income level, as shown in the empirical analysis in this chapter, suggests differing consumption patterns across countries and necessitates a unified framework to study consumers' preferences for quality and variety.

My model differs from Antoniades (2015) on the supply side in the sense that quality upgrading is assumed to be through the use of higher quality inputs, rather than through fixed investments in research and development. As such, firms' choices of output quality are independent of destination market size. In Antoniades (2015), a larger market size leads firms to upgrade quality since the average costs of producing quality decline as firms scale up, which provides a supply side explanation of market size effect on product quality. By assuming quasi-linear preferences, the income effect on consumers' perception of quality is ignored in that paper. In my model, the non-homothetic preferences allow consumers with high income to demand more high-quality goods than the ones with low income, which makes it more profitable for firms to produce and sell higher quality goods in rich countries. In other words, firms producing high-quality goods have higher market shares because of consumers' tastes for quality, rather than because of lower costs of quality production. The firm selection resulting from the model is a pure demand side explanation.

This chapter documents stylized facts on differential impacts of GDP per capita of importing country on export prices and sales by quality at the product level, which motivates an explanation based on tastes for quality. Consistent with Simonovska (2015), I find a positive relationship between export price and consumer income, especially for products of high quality. Controlling for aggregate income, consumers in a rich country (high income per capita) not only pay more for, but also demand more high-quality goods. However, GDP per capita has a negative effect on sales of low-quality goods, which is mainly driven by the decline in quantity demanded. The empirical evidence shows that, in addition to the market size effect, GDP per capita plays a separate role in shaping cross-country variations in exports of products at different quality levels.

Specifically, I conduct an empirical analysis by using disaggregate Chinese custom data in the Household Audio & Video Equipment industry in 2005. The processing firms in this industry are chosen as the sample for three main reasons. First, the Household Audio & Video Equipment industry is a typical Chinese manufacturing sector which relies heavily on imports of sophisticated intermediate inputs from a limited number of developed countries and exports to a wide set of destinations around the world after processing and assembly. This ensures enough within firm-product variations in exports and also allows me to infer product quality from the sources and prices of the imported inputs that a firm employs. Second, the products in this industry are quality differentiated, supported by the empirical evidence that more productive firms produce high-quality goods and charge higher fob export prices. Third, processing firms in this industry choose to upgrade quality via importing better intermediate inputs, rather than via undertaking fixed investment in product designs and innovations. There is no evidence showing that large scale firms produce high-quality goods. Instead, firms that export to rich countries tend to produce high-quality products, implying that firms' quality choices are demand-driven. These three characteristics together fit the industry well in the model set-up and facilitate my empirical study.

Guided by the model's predictions, I further investigate within-firm-product variation in exports across destinations. Taking advantage of highly concentrated origins of inputs in the sample, I construct a quality index based on the import price ranking of an input originating from a certain country. I then calculate the average ranking of multiple inputs within firms, weighted by import value and source country's export unit value index. According to the quality index, I categorize exporting products into five quality groups, and then test the differential impacts of income per capita on export sales of goods in different quality groups across countries. Given that only a subset of firms export to a particular destination, the disaggregate data contain many non-random zero export values. Thus, the standard OLS estimates may be biased by firm selection to exporting. To address this problem, I adapt the two stage estimation procedure proposed in Helpman et al. (2008), with a lagged participation index as the exclusion restriction. The results show that, conditional on entry, individual low-quality exporters make fewer export sales in richer countries when controlling for market size, gravity variables, and other destination characteristics. In contrast, the relationship between high-quality export value and the destination's GDP per capita exhibits an inverted-U shape, which is consistent with the taste for quality mechanism discussed in the theoretical model. The nonlinear relationship is generated from the fact that consumers prefer quality upgrading over more varieties in low and middle income countries while variety effect dominates in rich countries.

I carry out robustness checks in five aspects. An alternative explanation of the cross-country variations in prices and sales is that firms export different quality versions of a product to rich and poor countries. In order to rule out within firm-product quality differentiation, I restrict the data sample to the firms that import an input from a single source country. The results remain robust and consistent, suggesting that the identified per-capita income effects stem from consumers' tastes, rather than the production side. The second robustness check concerns the estimation approach. I run censored Tobit regressions, an alternative way to control for selection, by picking the minimum export value among Chinese firm exports as the censoring point for each destination-product, as in Eaton and Kortum (2001). The results are consistent with the two stage estimation. I also check that the results are robust to alternative measures of product quality, and can be generalized to other years (e.g. 2006) and to other industries (e.g. Women's, Misses', and Juniors' Outerwear industry, SIC 233).

My work contributes to a growing literature on the relationship between quality and trade. It rationalizes and documents the differential impacts of a destination's GDP per capita on exports of high- and low-quality goods at the firm-product level. In the existing literature, at the product level, Baldwin and Harrigan (2011) and Johnson (2012) show that export prices increase with distance and decrease with destination's GDP and GDP per capita. Quality raises prices by a more than offsetting amount such that higher quality firms sell more. At the firm level, Manova and Zhang (2012) establishes the fact that across destinations within a firm-product, firms set higher prices in richer and larger countries. Verhoogen (2008) and Kugler and Verhoogen (2012) find the empirical evidence that larger plants pay more for their material inputs and charge more for their outputs. My work is consistent with the previous studies in that it presents evidence on the increase of export prices with importing country's GDP per capita, especially for the products of high quality. However, the separate role of GDP per capita in shaping quantity demanded at the firm-product level differs by product quality, which, to my best knowledge, has not been examined in the literature. The observed decline in exports of low-quality goods with destination's GDP per capita implies that the negative income effect on quantity outweighs the positive effect on price.

This chapter also adds to the literature on the quality evaluation mechanism. Verhoogen (2008), Fajgelbaum et al. (2011), and Handbury (2014) incorporate a positive correlation between consumers willingness to pay for quality and income into utility functions. Consistent with these studies and inspired by the urban economics literature, I interpret consumers' quality of life as a reflection of their preferences for product quality in terms of both willingness-to-pay and quantity demanded. This is because people living in a rich country have a higher standard of living, and consider product quality as a more important determining factor of consumption decisions than product price. Moreover, the increase of taste for quality with income per capita is not sufficient to characterize the model equilibrium. The effects depend on the elasticity of taste for quality with respect to income. Consequently, the cross-country differences in income elasticity of taste for quality account for within firm-product variations in exports across countries.

The results suggest the need to tread carefully when attempting to infer quality by using information on prices and quantities sold in a market. The market share approach of estimating product quality (Khandelwal, 2010) is widely used in the trade literature. It argues that controlling for price, the product that has a larger market share is of higher quality. This approach fails to take into account that rich and poor consumers possess different quality valuations and therefore would like to pay for and demand high-quality goods in different manners. As a result, the market share approach would overestimate the degree of quality differentiation in a low-income country and underestimate it in a high-income country.

1.2 Empirical Evidence

This section aims to show the empirical evidence on differential impacts of income per capita on export prices and values by quality at the HS 8-digit level. I find that high-quality products are sold at higher prices in richer countries, which is consistent with the results in Manova and Zhang (2012) and Simonovska (2015), and there are no significant effects of income per capita on prices of low-quality products. The export quantities and values of high-quality products increase with importing country's GDP per capita, controlling for market size, distance, and other gravity variables, and a strong positive change in income effect takes place at lower levels of GDP per capita and tails off at high GDPs per capita. However, low-quality goods sell less and make less sales in richer countries. This differential patterns emphasize the roles of GDP per capita in shaping consumers' tastes for quality and product exports across countries.

1.2.1 Data

My main data source is the Chinese Custom database which reports the free-on-board value of firm exports and imports in U.S. dollars at the 8-digit HS level. The data also record the quantity traded, the type of shipment, and the destination/origin of each transaction. Unit price is calculated as the ratio of value to quantity based on yearly frequency data. According to the types of trade regimes, Chinese Custom Office classifies trade into 19 categories in which ordinary and processing using imported inputs regimes account for the two largest proportions. The data on GDP and GDP per capita across countries come from the Penn World Tables (Version 6.2). I obtain the country level export and import unit value index from WITS.

1.2.2 The Household Audio & Video Equipment Industry

In order to investigate variations in export prices and revenues across destinations within a product, I choose the data on processing firms in the industry of Household Audio & Video Equipment (SIC 365) in 2005 for study for essentially three reasons. First, the prices and the sources of the intermediate inputs employed by the processing firms in the industry are a reasonable proxy for output quality. The Household Audio & Video Equipment industry is a typical Chinese manufacturing industry which imports intermediate inputs from a limited number of developed countries but exports to a wide set of destinations worldwide. Processing exporters obtain sophisticated intermediate inputs from abroad under zero import tariffs and export final goods after processing the inputs locally. The cheaper access to high-quality foreign intermediate inputs promises processing firms a success in the international market compared to ordinary exporters. Moreover, since processing firms are not allowed to sell their products in the domestic market, the imported inputs are only used in the production of goods for foreign markets. For these reasons, the quality of imported inputs plays an essential role in determining export quality. In the spirit of Manova and Zhang (2012), Kugler and Verhoogen (2012), and Bastos et. al (2014), I construct quality index for exports according to the prices of imported inputs that the producers use. In the Household Audio & Video Equipment industry, the firms engaged in the regime of processing using imported inputs obtain imported inputs from 22 countries and export their products to 108 countries. The fact that input sources concentrate on a few developed countries gives an advantage in inferring input quality from import prices at the origin-product level, which serves as the basis of constructing firm level quality index. The detailed discussion on quality index is given in the following section. In contrast to the concentration of input source countries, firms export to a wide range of destinations, which ensures enough variations of price and revenue across markets within a firm. In the data, each firm exports to 13.37 foreign countries on average. The distribution at the firm-product level shows a similar pattern as at the firm level, and each firm-product on average exports to 9.68 destinations.

The second reason for choosing the Household Audio & Video Equipment industry as the sample is that products are quality differentiated in the industry and export prices increase in quality and in firm productivity. The key difference between the standard and the quality augmented Melitz models lies in how prices change in physical productivity. When taking into account product quality in an industry with a large scope for quality differentiation, more productive firms tend to produce high-quality goods and charge higher market prices. As such, quality serves as an innegligible dimension of firm heterogeneity. Empirically, an indicator of the scope of quality differentiation is the Rauch (1999) dummy which is recorded for SITC-4 digit categories. By matching it to the Chinese HS-8 digit classification, I find the products traded in the sample are all differentiated goods that are not traded on an organized exchange or listed in reference manuals.

Furthermore, among the 451 processing firms considered, the weighted average price each firm pays for imported inputs spreads out widely, with a large proportion of firms standing in the middle and fewer firms paying more than or less than the average. Therefore, firms export products at different quality levels. This provides the ground for the study on differential impacts of per-capita GDP on products of different qualities across markets. The relationship between price and productivity can be examined by running the following specification:

$$\log p_{fpd} = \beta_0 + \beta_1 \log revenue_{fp} + \delta_{pd} + \varepsilon_{fpd}, \tag{1.1}$$

where p_{fpd} represents the export price of product p charged by firm f in destination d. $revenue_{fp}$ denotes firm f's worldwide export sales of product p, which captures firm's ability of producing and selling product p. δ_{pd}, product-destination fixed effects, are used to control for product specific features of the importing country that affect all firms selling there, such as market size, per-capita income, legal institutions, and exchange rates. Error terms ε_{fpd} are clustered at product-country level. Table 1.1 column (1) presents robust evidence on a positive and significant correlation between price and revenue at firm-product level. Firms earning more from selling a product tend to charge higher prices for the product in a given market. Similarly, the results of the firm-level regression is given in 1.1 column (2). Firm's average export price in a destination weighted by sales of products it sells is positively correlated with its worldwide revenues. All in all, large firms produce high-quality products and sell them at higher prices across markets.

Third, processing firms in the Household Audio & Video Equipment industry improve quality through using better imported inputs, rather than through doing fixed investments. In other words, there is no evidence suggesting scales of economy in quality production. Thanks to the duty free treatment, it is a less costly and time saving way for processing firms to source better key parts and intermediate inputs from abroad in order to cater rich consumers' picky tastes for quality. This is thought of as an important feature in the theoretical model in characterizing impacts of per-capita income on consumers' tastes and on market outcomes, since it rules out alternative explanations

Table 1.1: Variations in Export Prices across Firms

	(1) $logp_{fpd}$	(2) $logp_{fd}$
$logrevenue_{f(p)}$	0.166***	0.111***
	(0.062)	(0.034)
Product-Destination FE	Yes	
Destination FE		Yes
Observations	1,211	956
R-squared	0.797	0.107

Standard errors are reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

from the supply side. A larger market size does not induce firms to improve product quality. Instead, the level of per-capita GDP in the destination country and firms' own productivities are positively related to export quality. Empirical evidence in this regard will be given in the next section after quality index is defined.

1.2.3 Quality Index

I adopt a new method to construct firm level quality index. Different from the common way of inferring product quality from weighted average prices of imported inputs across source countries, I exploit the information on the rankings of import prices of a given input from a certain source country and calculate the average rankings of the inputs weighted by import value and export unit value index of the source country. Directly comparing prices of imported inputs across countries cannot generate solid inferences about input quality, because it ignores some factors, such as exchange rates and trade costs, that also affect the prices firms pay for imported inputs but are unrelated to input quality, which makes prices of inputs originating from different countries incomparable.

Taking advantage of highly concentrated origins of inputs in the sample, I first calculate the average import prices by origin-product and compare the price of each transaction to the average. The difference generates a certain reference value. The higher the price is above the average, a larger value is assigned, indicating a higher quality level of the input among the same type of inputs imported from the same origin. Since firms import multiple inputs, I then calculate the weighted average quality reference value at the firm level, called quality index, by incorporating two more factors. One is the value share of each input in a firm's total imports which captures the importance of the input in firm's production. The other is the source country's export unit value index, as it generally represents a country's manufacturing productivity. In particular, the firm level quality index is constructed as follows:

$$qualityindex_f = \sum_m Ref_{mo} * imsh_m * EI_o,$$

where f, m, o stand for firm, intermediate input, and origin. Ref_{mo} is the assigned reference value according to price ranking at the origin-product level, $imsh_m$ is the share of input m in a firm's import value, and EI_o is the unit value index of exports of origin country o. If a firm has a large expenditure share on the inputs which originates from a country with high export price and possess a higher ranking of import price within the origin-product group, it ends up with a large quality index. The quality indexes of the 451 firms in the sample vary from 0 to 10.15.

The relationship between quality and destination market conditions can be tested by looking into the following estimating equation:

$$qualityindex_f = \beta_0 + \beta_1 \log wgdp_f + \beta_2 \log wgdppc_f + \beta_3 \log revenue_f + \varepsilon_f, \tag{1.2}$$

where $wgdp_f = \frac{\Sigma_d revenue_{fd} GDP_d}{\Sigma_d revenue_{fd}}$ and $wgdppc_f = \frac{\Sigma_d revenue_{fd} GDPpc_d}{\Sigma_d revenue_{fd}}$ are export sales weighted average GDP and GDP per capita over destinations the firm exports to, and $revenue_f$ denotes firm level total export revenues. The results are reported in Table 1.2 . In Column (1), the dependent variable is quality index constructed above. The coefficient on weighted GDP per capita is positive and statistically significant, suggesting that firms those sell to rich countries produce high-quality products on average, conditional on firm size and destination market sizes. However, the coefficients on weighted GDP and firm revenue are both insignificant. The results support the argument that product quality of processing firms is essentially determined by the income levels, rather than the market sizes, of the countries they serve. In Column (2), I use weighted prices of imported inputs as the dependent variable for further check. The results confirm the positive and significant correlation between per-capita income and product quality, and even show a negative sign to the weighted GDP term. Thus, all else equal, market size is not a determinant of firm choices of product quality, which in turn implies that the main means of upgrading quality of processing firms is employing better intermediate inputs.

Table 1.2: Variations in Product Quality across Firms

	(1) *Quality Index*	(2) *Avg Input Price* $logp_{fim}$
$logwGDPpc_f$	0.269***	0.562***
	(0.104)	(0.093)
$logwGDP_f$	0.091	-0.265***
	(0.075)	(0.057)
$logrevenue_f$	0.011	-0.074*
	(0.047)	(0.040)
Observations	956	956
R-squared	0.029	0.056

Standard errors are reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

1.2.4 Effects of Income Per Capita

I equally divide the products in the sample into five groups according to quality index, with group 1 as the lowest quality group and group 5 as the highest quality group. Since the data do not allow me to distinguish the use of inputs for different outputs within a firm, the most disaggregate level I can calculate quality index for is at the firm level. In the sample, a processing firm focuses on producing few types of products. The average number of products that each firm produces is about 3, which mitigates the seriousness of treating all products produced by a firm as of the same quality level.

Similarly, destination countries are also cut into five groups by GDP per capita, and country group 1 contains the poorest countries and country group 5 includes the richest ones. In order to investigate the potential differential impacts of income per capita on export price by quality, I run the following specification:

$$\log y_{fpd} = \beta_0 + \beta_{GDP} \log GDP_d + \sum_l \sum_k \beta_{kl} Q_l \times D_k + \beta_g X_d + \beta_{im} Imsh_d + \delta_p + \varepsilon_{fpd}, \tag{1.3}$$

where y_{fpd} represents firm f's export outcomes of product p in country d. GDP_d denotes country d's GDP. Q_l is a quality index dummy which equals 1 if product p produced by firm f belongs to the corresponding quality category l and equals 0 otherwise, where $l \in \{1, 2, 3, 4, 5\}$. D_k denotes a destination income dummy which takes a value of 1 if product p is exported to a country belonging to category k, where $k \in \{1, 2, 3, 4, 5\}$. I include all the interactions of quality dummy and country income dummy to fully pin down the pattern of price and exports variations across countries by quality, with term $Q_1 D_1$ omitted to avoid collinearity. X_d contains distance to destination country and standard gravity controls[1]. $Imsh_d$ denotes the share of Chinese exports in country d's total imports of products HS85 and it captures the overall competitiveness of Chinese exports in that country. δ_p is product fixed effects and aims to control for the differences across products in units of measure and other product characteristics that affect producers equally. Standard errors are

[1] Data on gravity variables are obtained from Head, Mayer, and J. Ries (2010).

clustered at the product level.

The results on fob export prices are shown in Columns (1) and (2) of Table 1.3. The coefficients on the low quality dummies (Q_1, Q_2) interacted with country income dummies (D_k) are statistically insignificant, suggesting that there are no effects of GDP per capita on export prices of low-quality goods. For the goods in quality groups 3, 4, and 5, the coefficients on the interactions are positive and significant and the magnitudes rises with destination country's income level. Thus, export prices of high-quality products increase in importing country's GDP per capita monotonically. Moreover, within each country group, the magnitudes of the income effect on export prices is positively related to the quality level of the product. Column (1) reports the results with HS8 level fixed effects, and the fixed effects in Column (2) are at the HS6 level. Both of them show the same pattern of price variations. In sum, the cross-country variations in export prices within a product is consistent with the results in Simonovska (2015): firms charge higher prices in richer countries. And my results also show that this positive effect gets magnified as the quality of the product rises.

Columns (3) and (4) report the results of regression (1.3) with log of quantity as dependent variable. Within the lowest quality group (group 1), the effect of GDP per capita on export quantity decreases from 57.7% down to -56.4%, implying that low-quality products are sold less in rich countries. Products in the second lowest quality group (group 2) also experience a decline in the income effect on quantity sold. However, the positive impacts of GDP per capita on quantities sold in quality groups 3 and 4 are significant and get stronger as destination country's income level rises. For the products at the highest quality level (in group 5), GDP per capita has a negative effect on export volume in the poorest countries (D_1), and there are no significant income effects when selling to richer countries. Hence, how export quantity of a product varies with importing country's GDP per capita depends on the quality of the product. The last two columns of Table 1.3 show the results for (1.3) with log of export values on the left hand side. The effects of GDP per capita on export sales differ by product quality. In the low-quality groups (groups 1 and 2), the income effect decreases with GDP per capita and it turns to be even negative for Q_1 products

Table 1.3: Variations in Export Prices, Quantities, and Sales by Eestination and Quality

	(1)logp_{fpd}	(2)logp_{fpd}	(3)logq_{fpd}	(4)logq_{fpd}	(5)logx_{fpd}	(6)log x_{fpd}
$Q_1 \times D_2$	-0.119	-0.155	0.576**	0.654***	0.457*	0.498**
	(0.112)	(0.138)	(0.245)	(0.253)	(0.239)	(0.244)
$Q_1 \times D_3$	-0.113	-0.040	0.526**	0.497**	0.412*	0.457**
	(0.099)	(0.123)	(0.218)	(0.225)	(0.212)	(0.217)
$Q_1 \times D_4$	-0.069	-0.029	0.408*	0.402*	0.338	0.372*
	(0.096)	(0.119)	(0.211)	(0.218)	(0.206)	(0.210)
$Q_1 \times D_5$	-0.050	-0.069	-0.564***	-0.541***	-0.614***	-0.610***
	(0.092)	(0.114)	(0.203)	(0.210)	(0.198)	(0.202)
$Q_2 \times D_1$	0.038	-0.067	0.219	0.348	0.258	0.281
	(0.122)	(0.151)	(0.268)	(0.276)	(0.261)	(0.266)
$Q_2 \times D_2$	-0.007	-0.041	0.852***	0.883***	0.845***	0.841***
	(0.108)	(0.133)	(0.237)	(0.244)	(0.231)	(0.236)
$Q_2 \times D_3$	0.011	0.097	0.808***	0.782***	0.819***	0.879***
	(0.099)	(0.122)	(0.217)	(0.224)	(0.211)	(0.216)
$Q_2 \times D_4$	-0.009	0.085	0.711***	0.659***	0.702***	0.744***
	(0.096)	(0.119)	(0.212)	(0.218)	(0.206)	(0.210)
$Q_2 \times D_5$	0.107	0.176	0.728***	0.656***	0.635***	0.633***
	(0.093)	(0.114)	(0.204)	(0.210)	(0.199)	(0.203)
$Q_3 \times D_1$	0.284**	0.074	0.033	0.251	0.318	0.325
	(0.119)	(0.146)	(0.262)	(0.269)	(0.255)	(0.260)
$Q_3 \times D_2$	0.173	0.055	0.504**	0.675***	0.678***	0.731***
	(0.111)	(0.136)	(0.244)	(0.251)	(0.237)	(0.242)
$Q_3 \times D_3$	0.311***	0.396***	0.551**	0.544**	0.863***	0.941***
	(0.101)	(0.124)	(0.221)	(0.228)	(0.216)	(0.220)
$Q_3 \times D_4$	0.281***	0.415***	0.675***	0.651***	0.956***	1.067***
	(0.098)	(0.121)	(0.216)	(0.222)	(0.210)	(0.214)
$Q_3 \times D_5$	0.516***	0.724***	0.642***	0.512**	1.158***	1.236***
	(0.093)	(0.115)	(0.205)	(0.211)	(0.200)	(0.203)

Standard errors are reported in parentheses and are clustered at the HS8 level in (1)(3)(5) and at the HS6 level in (2)(4)(6).
Results remain robust when standard errors are clustered at the country level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 1.3: (continued)

	(1)logp_{fpd}	(2)logp_{fpd}	(3)logq_{fpd}	(4)logq_{fpd}	(5)logx_{fpd}	(6)logx_{fpd}
$Q_4 \times D_1$	0.316***	0.257*	0.025	0.083	0.341	0.340
	(0.116)	(0.143)	(0.255)	(0.263)	(0.249)	(0.254)
$Q_4 \times D_2$	0.264**	0.223*	0.594**	0.681***	0.859***	0.904***
	(0.108)	(0.133)	(0.237)	(0.245)	(0.231)	(0.236)
$Q_4 \times D_3$	0.435***	0.498***	0.559**	0.553**	0.994***	1.052***
	(0.099)	(0.123)	(0.219)	(0.226)	(0.213)	(0.217)
$Q_4 \times D_4$	0.439***	0.574***	0.431**	0.363*	0.870***	0.937***
	(0.097)	(0.119)	(0.213)	(0.220)	(0.207)	(0.212)
$Q_4 \times D_5$	0.670***	0.826***	0.753***	0.634***	1.424***	1.461***
	(0.093)	(0.114)	(0.204)	(0.210)	(0.199)	(0.203)
$Q_5 \times D_1$	0.737***	0.666***	-0.586**	-0.504*	0.151	0.161
	(0.134)	(0.165)	(0.295)	(0.304)	(0.287)	(0.293)
$Q_5 \times D_2$	0.552***	0.641***	0.326	0.341	0.879***	0.983***
	(0.116)	(0.143)	(0.254)	(0.262)	(0.248)	(0.253)
$Q_5 \times D_3$	0.696***	0.888***	-0.110	-0.144	0.585***	0.744***
	(0.105)	(0.130)	(0.231)	(0.238)	(0.225)	(0.230)
$Q_5 \times D_4$	0.700***	0.986***	0.032	-0.034	0.732***	0.951***
	(0.101)	(0.123)	(0.219)	(0.226)	(0.214)	(0.218)
$Q_5 \times D_5$	0.783***	1.010***	0.199	0.116	0.982***	1.126***
	(0.094)	(0.115)	(0.205)	(0.211)	(0.200)	(0.204)
log GDP_d	0.002	0.026***	0.319***	0.305***	0.321***	0.331***
	(0.006)	(0.007)	(0.013)	(0.013)	(0.012)	(0.013)
$Imsh_d$	-0.041	-0.121*	3.772***	3.663***	3.813***	3.785***
	(0.058)	(0.071)	(0.292)	(0.310)	(0.324)	(0.327)
log $distance_d$	-0.010	0.006	-0.115**	-0.148***	-0.125**	-0.142***
	(0.025)	(0.031)	(0.055)	(0.057)	(0.054)	(0.055)
comlang	0.073*	-0.001	0.466***	0.458***	0.386***	0.457***
	(0.038)	(0.049)	(0.087)	(0.091)	(0.085)	(0.087)
border	0.080**	0.068	0.503***	0.484***	0.429***	0.416***
	(0.040)	(0.047)	(0.085)	(0.088)	(0.083)	(0.084)
timediff	-0.013***	-0.019***	0.070***	0.076***	0.056***	0.057***
	(0.004)	(0.005)	(0.010)	(0.011)	(0.010)	(0.010)
Gatt	-0.046	0.054	-0.017	-0.076	-0.064	-0.022
	(0.038)	(0.047)	(0.084)	(0.087)	(0.082)	(0.084)
Product FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,812	11,812	11,812	11,812	11,812	11,812
R^2	0.77	0.65	0.23	0.18	0.41	0.37

sold in countries D_5. In contrast, products in high-quality groups 3, 4, and 5 make more sales in richer countries, and the income effect gets larger as importing country's GDP per capita rises.

1.3 The Model

1.3.1 Closed Economy

1.3.1.1 Consumers

I first consider a closed economy in which L identical consumers have preferences over varieties of a good. Consumers are also workers, and each supplies one unit of labor and is paid by identical wage. The utility function follows Simonovska (2015) in featuring non-homothetic preferences, but deviates from it by introducing endogenous product quality. In particular, varieties enter in a consumer's utility function as follows:

$$U^c = \int_{\varphi \in \Omega} \log \left[z(\varphi) q^c(\varphi) + \bar{q}(w) \right] d\varphi, \tag{1.4}$$

where $z(\varphi)$ and $q^c(\varphi)$ are the quality and individual consumption of variety φ. Ω denotes the endogenous subset of varieties which are actually consumed. As in Verhoogen (2008) and Brambilla and Porto (2016), the parameter $\bar{q}(w)$ captures quality evaluation. Consumers in rich countries value product quality more than those in poor countries. Thus, $\bar{q}$ is increasing in income w. An alternative interpretation of $\bar{q}(w)$ is that it represents the provision of public goods per person that consumers would enjoy with no private consumption, and Deacon (2009) records that public goods provision is strongly and positively related to per-capita income.[2]

Given the utility function in (3.1), the marginal utility of variety φ increases in its quality level $z(\varphi)$ and decreases in quantity consumed $q^c(\varphi)$ and consumer's taste for quality $\bar{q}(w)$. Not only the product intrinsic characteristics but consumer's subjective tastes for quality determine consumption decisions. Also, individual quality-adjusted consumption of varieties and public goods are assumed to be substitutes in (3.1), which is consistent with the studies on the interaction between provision of

[2] Detailed discussions on quality of life, public goods, and income per capita can be found in Appendix B.1.

public goods and individual private consumption. This is an appropriate assumption given that the model aims to investigate the impacts of per-capita income on product quality choice, rather than to evaluate the effectiveness of fiscal policies. A fast and convenient public transportation system provides consumers easier access to places where they intend to go, which in turn substitutes away purchases of cheap brand cars. Similarly, consumers living in a country with a good heating system would not probably think of clothings barely as warm keepers, but care more about fabric and designs. In other words, in an economy with a relatively high level of amenities, consumers have stronger preferences for product quality and tend to consume more better quality varieties.

The market demand for variety φ can be derived as:[3]

$$q(\varphi) = \frac{L}{p(\varphi)} \left[\frac{w}{N} + \bar{q}(w) \left(\bar{\tilde{p}} - \tilde{p}(\varphi) \right) \right], \tag{1.5}$$

where $p(\varphi)$ and $\tilde{p}(\varphi) = \frac{p(\varphi)}{z(\varphi)}$ stand for price and quality-adjusted price of variety φ, N is the number of varieties actually consumed, and w is each consumer's income. $\bar{\tilde{p}}$ is defined as the average quality-adjusted price in the market, which equals an aggregate quality-adjusted price statistic (P) divided by number of varieties. In particular, it is expressed as

$$\bar{\tilde{p}} = \frac{P}{N}, \quad where\ P = \int_{\varphi \in \Omega} \frac{p(\varphi)}{z(\varphi)} d\varphi. \tag{1.6}$$

A consumer does not have a positive demand for all varieties. The chock quality-adjusted price occurs where market demand equals 0. From equation (1.5), firms have positive demand as longas

$$\tilde{p}(\varphi) < \tilde{p}_{max} = \frac{w + \bar{q}P}{N\bar{q}}. \tag{1.7}$$

The chock quality-adjusted price increases in the aggregate quality-adjusted price statistic and decreases in the total number of varieties, implying that only varieties with low quality-adjusted prices can survive in a more competitive market. To clarify the relationship between individual

[3] See Appendix A.1 for derivation.

income and chock price, I first define the elasticity of taste for quality with respect to income as:

$$\varepsilon_t(w) \equiv \frac{w\bar{q}'(w)}{\bar{q}(w)} > 0, \tag{1.8}$$

where $\bar{q}'(w)$ refers to the first derivative of $\bar{q}(w)$ with respect to income per capita. The value of the elasticity of taste varies with income and plays an essential role in determining the relationship between choke price and per-capita income. If the elasticity is greater than 1, the quality-adjusted choke price declines as individual income goes up. That is, when consumers get wealthier, they become much pickier on product quality and select varieties with relatively low prices conditional on quality. This case is in accordance with several urban economics papers, such as Brueckner, Thisse, and Zenou (1999), which argue that the marginal valuation of urban amenities rises sharply with income. In demand equation (1.5), with $\bar{q}$ positively and elastically correlated with income, rich consumers demand more (less) than poorer consumers for varieties of below (above) average quality-adjusted prices. As will be shown in the firm section, high-quality goods are characterized by low quality-adjusted prices.

If the elasticity of taste for quality is smaller than 1, the quality-adjusted choke price turns to increase in individual income, implying that consumers choose to enlarge their consumption bundles when they get richer by purchasing new and less productive varieties. This case is isomorphic to the model developed in Simonovska (2015). Thus, omitting product quality and consumers' preferences for quality results in a loss of explanatory power of the model, especially in explaining consumption patterns under elastic taste for quality.[4]

An expansion of market size could be driven by either per-capita income increase or population growth. The non-homotheticity of utility function allows market demand to shift disproportionately towards high-quality varieties following an increase in income per capita. The elasticity of demand with respect to income per capita varies with varieties. This can be seen from the

[4]See Appendix B.2 for discussions on two sepecific function forms of tastes for quality.

expression below:

$$\kappa_{iw}(\varphi) = \frac{\partial q(\varphi)}{\partial w}\frac{w}{q(\varphi)} = \frac{\frac{w}{N} + w\bar{q}'(w)\left[\bar{\tilde{p}} - \tilde{p}(\varphi)\right]}{\frac{w}{N} + \bar{q}(w)\left[\bar{\tilde{p}} - \tilde{p}(\varphi)\right]}. \tag{1.9}$$

The sign and the magnitude of income elasticity of demand depends on a variety's quality-adjusted price as well as income elasticity of tastes for quality. When $\varepsilon_t(w) > 1 (< 1)$, income elasticities of demand are greater than 1 (between 0 and 1) for the varieties with below-average quality adjusted prices (as shown in the next section, theses varieties are of higher qualities and produced by more productive firms), are between 0 and 1 (greater than 1) for the varieties with above average quality-adjusted prices but not close to the choke one, and are smaller than 0 (greater than 1) for the varieties close to the choke quality-adjusted price. The results are summarized as below:

$$\kappa_{iw}(\varphi) \begin{cases} > 1\,(< 1) & if\; \tilde{p}(\varphi) < \bar{\tilde{p}}, \\ [0,1]\,(> 1) & if\; \bar{\tilde{p}} \leqslant \tilde{p}(\varphi) \leqslant \bar{\tilde{p}} + \left(N\bar{q}'(w)\right)^{-1}, \\ < 0\,(> 1) & if\; \bar{\tilde{p}} + \left(N\bar{q}'(w)\right)^{-1} < \tilde{p}(\varphi) < \tilde{p}_{max}. \end{cases}$$

In the case of elastic taste for quality, income growth induces consumers to demand disproportionately more high-quality varieties (low quality-adjusted price), to purchase more relatively low-quality varieties in a less proportionate amount, and to drop the low end varieties out of their consumption bundles. In the opposite case where consumers' tastes for quality is inelastic to income, individuals consume a broader set of varieties and the demand for low price varieties increases more in percentage than high price ones as individual income goes up. Hence, income elasticity of demand depends on not only variety's price and quality, but also on consumers' tastes for quality.

Another possible channel through which national income rises is population growth. The demand function shifts upwards in the same proportion for all types of varieties under an increase in L. The income elasticity of demand driven by population growth is equal to 1 and independent of variety's attributes and consumer's tastes:

$$\varepsilon_{iL}(\varphi) = \frac{\partial q(\varphi)}{\partial L}\frac{L}{q(\varphi)} = 1.$$

In sum, like in other non-homothetic preferences, income per capita and population size enter the demand function in two distinct ways. Changes in individual income impact both market size and taste for product quality which in turn generates differential responses in consumption patterns across consumers at different income levels. My model differs from others in an emphasis on the importance of income effect in determining market equilibrium in a quality differentiated sector.

1.3.1.2 Firms

Following Kugler and Verhoogen (2012), I assume a Melitz type production structure by adding an intermediate input sector. Labor is the only factor of production and its supply is inelastic. Workers are homogeneous and each one is paid equally by w. Quality of final products is jointly determined by a firm's productivity and the quality of intermediate inputs it employs.

Intermediate input producers use labor to produce intermediate inputs of different qualities under constant returns to scale and sell them in a perfectly competitive market. The price of an intermediate input of quality c is given by

$$p_I(c) = \frac{cw}{a},$$

where c denotes the quality of the intermediate input and a is the country-specific labor efficiency parameter of producing intermediate inputs at a given level of quality.

Final product producers need to pay a one-time entry cost f_e in order to uncover their random productivity draws from a Pareto distribution with c.d.f. $G(\varphi) = 1 - \left(\frac{\varphi}{\varphi_0}\right)^{-\gamma}$, where $\varphi \geqslant \varphi_0$. Only the firms whose draws are high enough to at least break even will stay in the market and produce. All other firms exit immediately. In such a quality differentiation model, I assume product quality improvements can be achieved by employing better quality and more expensive intermediate inputs. Since firms are assumed to be heterogeneous in terms of productivity, they choose to incur different variable costs to produce varieties at different quality levels. Firms with relatively high productivity draws would be able to afford the additional costs of quality improvements and therefore produce high-quality varieties and sell them at low quality-adjusted prices. In equilibrium, the firms that stay in the market optimally decide not only price but product quality which in turn impacts their production costs and market demand.

To characterize the production of product quality, I assume a complementary relationship between productivity and input quality such that

$$z(\varphi)^{\theta} = \frac{1}{2}\varphi^{b\theta} + \frac{1}{2}c(\varphi)^{2\theta}, \tag{1.10}$$

where $z(\varphi)$ and $c(\varphi)$ denote the endogenous output and input quality of a firm with productivity φ respectively, the parameter $\theta < 0$ captures the degree of complementarity between productivity and input quality, and the parameter $b > 0$ represents the scope for quality differentiation. The larger b is, the more incentives firms have to upgrade quality.

Final good producers are assumed to be price takers in the intermediate input markets, and face the same price schedule $p_I(c)$. Since there is a continuum of entrants operating in the market and consumers' utility is assumed to be additive, each firm is assumed to be small relative to the economy as a whole and hence takes aggregate price index as given. In the final product sector, firms produce and sell differentiated varieties under monopolistic competition and maximize their profits by choosing price and input quality simultaneously. The profit optimization problem is described as

$$\pi(\varphi) = \max_{p,c}\left[p(\varphi) - \frac{p_I(c)}{\varphi}\right]q(\varphi). \tag{1.11}$$

The first order conditions give the optimal solutions to price and input quality. Using (1.10), output quality is uniquely determined.

1.3.1.3 Market Equilibrium

Following models characterized by heterogeneous firms and variable elasticity of substitution preferences, all equilibrium expressions can be written in terms of a firm's productivity and the competition environment which is reflected in the market productivity threshold. Therefore, in order to pin down firms' performances and market outcomes in equilibrium, the first step is to solve for the productivity threshold under which a firm would exit. Formally, it is defined by

$$\varphi^* = \sup_{\varphi \geqslant \varphi_0} \{\pi(\varphi) = 0\}.$$

A firm with the productivity draw φ^* faces zero market demand and the price it charges barely covers variable cost. Plugging the demand equation (1.5) into the maximized profit function (1.11) yields the expression for the productivity cutoff:[5]

$$\varphi^* = \left(\frac{w}{a}\frac{N\bar{q}}{w+\bar{q}P}\right)^{\frac{2}{b+2}}. \tag{1.12}$$

The cutoff measures the degree of difficulty of entering the market. The higher the cutoff is, the more difficult for entrants to survive. φ^* increases in per-capita income w and number of varieties N, but decreases in the aggregate quality-adjusted price statistic P. Intuitively, firm selection is relatively tough in a more competitive market where consumers are rich and care much more about product quality, more varieties are competing, and the quality-adjusted price index is lower. Using equation (3.15) and the first order conditions derived from (1.11), firm φ's market performances can be written as

$$c(\varphi) = \varphi^{\frac{b}{2}}, \tag{1.13}$$

$$z(\varphi) = \varphi^{b}, \tag{1.14}$$

$$p(\varphi) = \frac{w}{a}\varphi^{\frac{b-2}{2}}\left(\frac{\varphi}{\varphi^*}\right)^{\frac{b+2}{4}}, \tag{1.15}$$

$$\tilde{p}(\varphi) = \frac{p(\varphi)}{z(\varphi)} = \frac{w}{a}(\varphi\varphi^*)^{-\frac{b+2}{4}}, \tag{1.16}$$

$$q(\varphi) = \bar{q}(w)\,L\varphi^{-b}\left[\left(\frac{\varphi}{\varphi^*}\right)^{\frac{b+2}{4}} - 1\right], \tag{1.17}$$

$$r(\varphi) = p(\varphi)\,q(\varphi) = \frac{w}{a}\bar{q}(w)\,L(\varphi^*)^{-\frac{b+2}{4}}\left[(\varphi^*)^{-\frac{b+2}{4}} - \varphi^{-\frac{b+2}{4}}\right], \tag{1.18}$$

[5] See detailed derivations in Appendix A.2.

$$\pi\left(\varphi\right)=\frac{w}{a}\bar{q}\left(w\right)L\left[\left(\varphi^{*}\right)^{-\frac{b+2}{4}}-\varphi^{-\frac{b+2}{4}}\right]^{2}. \tag{1.19}$$

Equation (1.14) indicates that the optimal quality level is positively associated with the physical productivity of the firm and the scope for quality upgrading. In the price equation (1.15), the value of parameter b determines how marginal cost varies with productivity. While higher productivity directly drives down the marginal cost of production, higher productivity also induces firms to upgrade quality and pay for more expensive intermediate inputs. The overall effect of productivity on marginal costs depends on the strength of incentives to upgrade quality which is captured by b. In accordance to recent trade papers that uncover the fact that quality raises marginal costs in differentiated good sectors, I assume a firm's marginal production cost is strictly increasing in its productivity by imposing a lower bound on the scope of quality differentiation such that $b > 2$. As shown in the above equations (1.13) to (1.19), when serving a given market, firms endowed with higher productivities employ better quality inputs by paying higher marginal costs, produce better quality outputs, charge higher markups, sell their products at lower quality-adjusted prices, and, as a result, earn more revenues and profits.

In the price equation (1.15), firm φ's markup is negatively correlated with the productivity cutoff. As φ^{*} rises, producers of the lowest quality goods run out of business and the competition among remaining firms gets intensified. As a consequence, firms lose part of market power and decrease their markups and prices. The quantity of outputs sold by each firm also decreases, and accordingly, both sales and profits shrink as well. The taste component does not affect price in a direct way, but raises the quantity demanded. All else equal, firms sell more in a market composed of consumers with high incomes and this taste effect becomes much stronger for high-quality varieties. Therefore, taste heterogeneity is expected to account for the different patterns of price and quantity across markets.

In order to fully pin down the market equilibrium, three more conditions are required: free entry, income balance, and labor market clearing conditions.

The free entry condition states that firms' expected profit covers the fixed entry cost they pay before their productivity draws. I assume each firm has to pay f_e units of effective labor to be entitled to enter. The free entry condition equates expected profit with entry cost:

$$\bar{\pi} = [1 - G(\varphi^*)] \int_{\varphi^*}^{\infty} \pi(\varphi)\, \mu(\varphi)\, d\varphi = \frac{w}{a} f_e, \tag{1.20}$$

where $\mu(\varphi)$ denotes the conditional density of firms operating in the economy

$$\mu(\varphi) = \begin{cases} \frac{g(\varphi)}{1-G(\varphi^*)} & if\ \varphi \geqslant \varphi^*, \\ 0 & otherwise. \end{cases}$$

Furthermore, consumers must run income balance in equilibrium, implying that total labor income equals total expenditure over differentiated varieties:

$$wL = N \int_{\varphi^*}^{\infty} r(\varphi)\, \mu(\varphi)\, d\varphi. \tag{1.21}$$

It is assumed that there are J potential entrants who pay entry costs, but only a subset of them N firms stay in the market after revealing productivity draws. Thus, the relationship between J and N can be described as

$$N = J[1 - G(\varphi^*)]. \tag{1.22}$$

The last condition aims to have labor market clear. The labor demand-equal-supply condition is given by

$$L = J\frac{f_e}{a} + N \int_{\varphi^*}^{\infty} \frac{q(\varphi)}{\varphi} \frac{c(\varphi)}{a} \mu(\varphi)\, d\varphi. \tag{1.23}$$

In a closed economy, I normalize the efficiency adjusted wage rate to be 1 for simplicity, that is $\frac{w}{a} = 1$. Combining equations (1.15) to (1.23) yields explicit solutions to productivity threshold, number of active firms (varieties), and number of entrants:[6]

$$\varphi^* = \left(\frac{D\bar{q}L}{f_e}\right)^{\frac{2}{2\gamma+b+2}}, \tag{1.24}$$

$$N = \frac{4\gamma + b + 2}{b+2}\frac{w}{\bar{q}}\left(\varphi^*\right)^{\frac{b+2}{2}}, \tag{1.25}$$

$$J = \frac{b+2}{2\gamma + b + 2}\frac{aL}{f_e}, \tag{1.26}$$

where $D = \frac{\varphi_0^{\gamma}(b+2)^2}{(4\gamma+b+2)(2\gamma+b+2)}$ is an expression composed of model parameters. In equilibrium, the productivity threshold is determined by population size, quality taste, and entry cost. A population growth is followed by an increase in the productivity cutoff, since more labor for production triggers the entry of new firms, which intensifies competition. Per capita income positively affects the cutoff through consumers' tastes for product quality. In a rich country where technology level and wage rate are high, consumers value not only the quantity but also the quality of the varieties they consume. Only high-quality products which are produced by more productive firms can survive in the market. Thus, a positive shock on consumers' tastes for quality drives up the productivity cutoff. Furthermore, fixed entry cost and the threshold move in opposite directions. A large entry cost serves as a big barrier to new entrants, which to some extent protects the least productive firms who are operating in the market from competition.

The positive relationship between population size and number of varieties can be seen by combining equations (1.24) and (1.25). A more intensified competition pushes the least productive firms out of market and encourages more productive firms to enter. However, it is not straightforward to conclude the effect of per-capita income on number of varieties, since the effects of income per capita on the ratio $\frac{w}{\bar{q}}$ and the productivity threshold φ^* act in the opposite directions, as shown in (1.25). The overall effect remains ambiguous. The detailed discussion on the role of income per capita in determining market equilibrium is given in the next section. Lastly, number of entrants rises with the supply of effective labor and declines with fixed entry cost. The more effective labor

[6]See Appendix A.3 for detailed derivations.

supplied and the less firms have to pay to enter, the more entrants would come into the market.

1.3.1.4 Effects of Income Per Capita

To highlight a separate role of income per capita, aside from the aggregate income effect, in determining market outcomes, I compare the equilibira of a set of closed economies with equal market size, but differing in population sizes and incomes per capita. In a standard model with homothetic preferences, these economies are predicted equivalent. But non-homothetic preferences combined with variable taste for quality account for mixed impacts of income per capita on market equilibrium.

As equation (1.24) shows, per-capita income raises threshold by positively influencing taste for quality. Comparative static exercise yields how productivity cutoff responds to changes in income per capita:

$$\frac{\partial\varphi^*}{\partial w} = \frac{2}{2\gamma + b + 2}\frac{\varphi^*}{w}\left[\varepsilon_t\left(w\right) - 1\right]. \tag{1.27}$$

The sign of the derivative depends on the value of elasticity of tastes for quality. If $\varepsilon_t\left(w\right) > 1$, productivity cutoff turns to be higher in rich than poor economies. If $0 < \varepsilon_t\left(w\right) < 1$, however, rich economies have lower thresholds. With a general function of $\bar{q}\left(w\right)$, $\varepsilon_t\left(w\right)$ could vary with the level of income per capita in two different ways:

$$\begin{cases} \frac{\partial\varepsilon_t(w)}{\partial w} \leqslant 0 & if\ \bar{q}'' \leqslant \frac{\bar{q}'}{w\bar{q}}\left(w\bar{q}' - \bar{q}\right), \\ \frac{\partial\varepsilon_t(w)}{\partial w} > 0 & otherwise. \end{cases}$$

From now on, I stay with a negative relationship between elasticity of taste and income per capita, because this is the case which is empirically relevant and is consistent with the specific functional forms of $\bar{q}\left(w\right)$ discussed in Appendix B.2. That is, poor consumers have more elastic taste for quality relative to rich consumers. But the model itself does not exclude the other possibility that elasticity of taste increases in income per capita. I denote w^* as the critical value of w at which elasticity of taste equals 1. In particular, w^*satisfies $\varepsilon_t\left(w^*\right) = 1$.

Equation (1.27) states that for a set of closed economies with equal market size and in an ascending order of income per capita, productivity threshold rises first and then declines. In poor countries (income per capita below w^*), consumers' tastes for quality are relatively low but sensitive to income, therefore, an income increase induces them to shift expenditure shares from low- towards high-quality varieties and drop low end varieties out of the consumption set, resulting in a higher productivity cutoff. On the other hand, when tastes for quality are at relatively strong levels but not responsive to income changes in rich countries (income per capita above w^*), a further increase in income allows consumers to consume a broader set of varieties and give a smaller expenditure share to each of the varieties. As such, productivity threshold decreases as a result.

The value of elasticity of taste for quality captures consumers' preference over quality versus variety. When it is greater than 1, consumers tend to hold a stronger preference on quality than on variety, and income growth has a positive effect on the average quality of varieties they consume but a negative effect on number of varieties. When the elasticity of taste is smaller than 1, consumers care more about variety than quality, with more varieties coming into the consumption set following an income increase. In other words, firm selection caused by an increase in per-capita income is closely related to the sensitivity of consumers' tastes for quality in response to income growth.

A great number of varieties being produced and consumed is considered as one of the welfare gains from trade. Thus, carefully evaluating the effects of income per capita on number of varieties is of great interest. Holding market size constant, taking derivate of equation (1.25) with respect to per-capita income gives:

$$\frac{\partial N}{\partial w} = \frac{2\gamma\left(b+2+4\gamma\right)}{\bar{q}\left(b+2\right)\left(b+2+2\gamma\right)}\left(\varphi^*\right)^{\frac{b+2}{2}}\left[1-\varepsilon_t\left(w\right)\right].$$

In contrast to productivity threshold, number of varieties decreases in income per capita under elastic taste for quality and increases under inelastic taste for quality, implying a U shape relationship between number of varieties and income per capita. Combing with the results on firm selection, there exists a quality-variety trade off caused by income growth. When consumers' pickiness for product quality is responsive to changes in income at lower income levels, the firm selection becomes strict and the productivity of the marginal surviving firm rises. In the meantime, the number of varieties gets lower in a low income economy as the most productive firms expand market shares and push out low-quality firms. The opposite case applies to rich countries where the average product quality is already high and consumers hold strong and inelastic preference for quality. A further increase in income in such economies leads taste for quality to change less, and the expenditure on above-average quality products would not change much. As a result, more firms which produce differentiated varieties start to enter and the market productivity cutoff goes down.

Will high-quality products obtain more market shares when the economy gets richer and consumers value quality more? To address this question, I first write out the expression for variety φ's revenue in equilibrium using equations (1.18) and (1.24):

$$r(\varphi) = \frac{\bar{q}(w)}{w} (\varphi^*)^{-\frac{b+2}{4}} \left[(\varphi^*)^{-\frac{b+2}{4}} - \varphi^{-\frac{b+2}{4}} \right]. \tag{1.28}$$

Since the economies under consideration are assumed to be of equal market size, changes in firm's revenues also represents changes in market shares. The impact of per-capita income on firms' market shares is mixed under elastic taste for quality ($\varepsilon_t(w) > 1$). There are two opposing forces that take into effect simultaneously as income per capita rises. On the one hand, a higher level of income leads to a stronger preference for quality which turns to shift up the revenue curve, which is reflected by an increase in $\frac{\bar{q}(w)}{w}$ in equation (1.28). This effect serves as a positive and direct driving force. On the other hand, per-capita income influences market share through productivity cutoff. An economy with a high income per capita is characterized by a high cutoff, a low quality-adjusted price index and a intense competition environment, which drives down individual firms' market shares. This effect is a negative and indirect way that income per capita changes firms' market shares. Thus, the overall effect depends on which side dominates.

When it comes to inelastic taste for quality ($\varepsilon_t(w) < 1$), which is more likely to occur among rich countries, per-capita income tends to reduce competition intensity and mitigate the taste effect on firm revenue. As shown in equation (1.28), $\frac{\bar{q}(w)}{w}$ and φ^* decrease in w, resulting in that following an increase in income the firm benefits less from stronger preference for quality but more from loose market competition as less productive firms start to be active in the economy. The combined impact of per-capita income remains ambiguous, depending on firm's productivity and the quality of the product it produces. In particular, given that

$$\begin{aligned}\frac{\partial r(\varphi)}{\partial w} =& \underbrace{\frac{w\bar{q}' - \bar{q}}{w^2} (\varphi^*)^{-\frac{b+2}{4}} \left[(\varphi^*)^{-\frac{b+2}{4}} - (\varphi)^{-\frac{b+2}{4}} \right]}_{taste\, for\, quality\, effect} \\ &+ \underbrace{\frac{(b+2)\,\bar{q}}{2w} (\varphi^*)^{-\frac{b+2}{4}-1} \left[-(\varphi^*)^{-\frac{b+2}{4}} + \frac{1}{2}\varphi^{-\frac{b+2}{4}} \right] \frac{\partial \varphi^*}{\partial w}}_{selection\, effect} \\ =& \frac{2\gamma\bar{q}}{(2\gamma+b+2)\,w^2} (\varphi^*)^{-\frac{b+2}{2}} \left[\varepsilon_t(w) - 1\right] \left[1 - \left(1 + \frac{b+2}{4\gamma}\right) \left(\frac{\varphi^*}{\varphi}\right)^{\frac{b+2}{4}} \right],\end{aligned} \tag{1.29}$$

the income effect can be decomposed into taste for quality effect and competition effect. The signs of the two effects run opposite and are both determined by income elasticity of taste for quality. Consistent with intuition, an elastic consumer taste gives rise to a positive taste for quality effect and a negative competition effect as per-capita income rises and market size is kept constant, while an inelastic taste leads to a negative taste for quality effect and a positive competition effect. In terms of magnitudes, all else equal, high-quality producers (more productive firms) are affected more by both types of effects than low-quality producers (less productive firms) supplying in the same market. For individual firms, the necessary and sufficient condition for the sign of the overall marginal effect of income per capita on market share can be expressed as

(i) $\quad elastic\, taste\, for\, quality\ (\varepsilon_t > 1,\ w < w^*)$

$$\frac{\partial s(\varphi)}{\partial w} \begin{cases} \geqslant 0 & if\ \varphi \geqslant K\varphi^*, \\ < 0 & if\ \varphi < K\varphi^*; \end{cases}$$

(ii) $\quad inelastic\, taste\, for\, quality\ (\varepsilon_t < 1,\ w > w^*)$

$$\frac{\partial s(\varphi)}{\partial w}\begin{cases} <0 & if\ \varphi \geqslant K\varphi^*, \\ \geqslant 0 & if\ \varphi < K\varphi^*; \end{cases}$$

where $s(\varphi)$ stands for market share of firm φ and $K = \left(1+\frac{b+2}{4\gamma}\right)^{\frac{4}{b+2}}$. Among poor countries where consumers' preferences for product quality are sensitive to income levels, only better quality goods are selected to survive and market competition gets intensified as a technological advance brings an increase in per capita income. Consequently, each productive firm obtains a larger market share, while the size of a less productive firm shrinks. Different from poor consumers, rich consumers do not alter their tastes for product quality much when their incomes change, therefore, instead of dropping low priced varieties, income growth among rich countries allows for entry of less productive firms which were not active before and drives down the incumbents' market shares. Resource reallocation following an increase per-capita in income depends on the elasticities of consumers' preferences for product quality.

Consider a set of closed economies with equal market size and a ascendingly ranking by income per capita. For a high-quality producer whose productivity draw is above $K\varphi^*$, its revenues exhibit an inverted-U relationship with the economy's income per capita. At the low levels of income per capita, an increase in income per capita triggers a positive taste for quality effect and a negative competition effect. Given that consumers' preferences for quality are dramatically enhanced by income growth in low income economies, the positive taste effect on individual high-quality variety outweighs that on the price index. As a result, the firm's sales increase in per-capita income. At the high levels of income per capita, consumers tend to hold a relatively stable preference for product quality and prefer to spend the increased income over a wide range of varieties. Hence, income growth generates a negative taste effect on individual demand and a positive effect of competition, with a stronger taste effect leading to a decrease in firm's sales.

However, the sales of a low-quality producer respond differently to changes in economy's income per capita. When there is a slight increase in income per capita among poor countries, the associated negative competition effect dominates the positive taste for quality effect for low-quality varieties, which results in a decline in firm's sales. As moving from the poor to rich country group, consumers turn to alter their tastes for quality less and less following an income growth. Therefore, the market share gains due to a loose competition environment are more than the market share loss caused by picky tastes for quality, and the firm start to market more revenues as consumers' individual incomes rise if it could successfully survive in the rich markets.

In sum, taste for quality effect and competition effect jointly determine how income per capita impacts market shares of individual varieties, and both effects are quality- and income per capita specific. Conditional on aggregate income, individual high-quality varieties develop an inverted-U relationship with income per capita in the economy, as a stronger preference for quality associated with a higher income per capita first rewards high-quality producers, while a further pickier taste on product quality pushes down the market quality-adjusted price index and therefore lowers the probability of successful entry. Low quality varieties experience the opposite to high-quality varieties, with sales going down first and up afterwards as income per capita rises.

As an inverse measure of the degree of differentiation across varieties, elasticity of substitution serves an important factor in firms' pricing decisions and sales. The lower the elasticity of substitution, the more market power, and the higher mark-ups firms charge and the more revenues earned. The analysis on income effect cannot be complete without looking into how elasticity of substitution responses to changes in income per capita and hence in tastes for quality. In a heterogeneous firm model, the elasticity of substitution varies across varieties. In this section, I first show the elasticities of substitution between varieties of the same quality, and then generalize the results to varieties of different qualities.

As equation (1.14) says, the firms who get the same productivity draw produce outputs at the same quality level. The elasticity of substitution between varieties produced by type-φ firms is

$$\sigma(\varphi) = 1 + \frac{\bar{q}(w)}{\tilde{q}(\varphi)}, \tag{1.30}$$

where $\tilde{q}(\varphi) = z(\varphi)\,q(\varphi)$ represents the quality-adjusted output of variety φ. The elasticity of substitution between type-φ varieties is jointly determined by per variety quality-adjusted consumption and consumers' tastes for quality at the income level w. Given that the quality-adjusted output is strictly increasing in productivity, all else equal, the elasticity of substitution decreases in φ. The high-quality varieties produced by more productive firms are being considered less substitutable than low-quality varieties, which accounts for that more productive firms charge higher markups on their products. The second determinant of elasticity of substitution is income varying tastes for quality. Rich consumers tend to be pickier on product quality than poor consumers, in the sense that a stronger taste for quality raises the substitutability between varieties.

Income per capita affects the elasticity of substitution between type-φ varieties through two channels. On the one hand, a higher per-capita income leads to a pickier taste for quality, which raises elasticity of substitution. On the other hand, income growth gives rise to differential impacts on per variety quality-adjusted consumption of products at different quality levels. The quality-adjusted consumption of high-quality goods would increase if the elasticity of taste for quality is greater than 1, while the quality-adjusted consumption of low-quality goods would increase if the elasticity of taste is smaller than 1. As a result, the combining effect of income per capita on elasticity of substitution can be stated as

$$\frac{\partial \sigma(\varphi)}{\partial w} \begin{cases} \leqslant 0 & if\ \varphi \leqslant M\varphi^{*}\ and\ \varepsilon_t < 1 \\ > 0 & otherwise \end{cases},$$

where $M = \left[\frac{2(b+2+2\gamma)}{(b+2)\varepsilon_t + (b+2+4\gamma)}\right]^{\frac{4}{b+2}}$. When consumers hold elastic tastes for quality, $\bar{q}(w)$ plays a dominant role and hence all varieties would end up with higher elasticities of substitution in an economy with a higher income per capita. Regardless of quality levels, varieties are being perceived as less differentiated and market competition gets intensified. Also, the positive effect of income per capita is relatively weak on high-quality varieties compared to on low-quality varieties, as shown by:

$$\frac{\partial^2 \sigma(\varphi)}{\partial w \partial \varphi} < 0.$$

When taste for quality is inelastic to income changes, income growth does a favor to the pricing and consumption of less productive firms which makes it easier for them to survive, since it drives down the elasticity of substitution between the newly entered varieties. In this case, the increase in per variety quality-adjusted consumption more than offsets the change in consumers' taste for quality.

Similarly, the elasticity of substitution between varieties of different quality depends on the quality adjusted consumption of each variety as well as taste for quality. In particular, for any pair of varieties φ and φ', I have

$$\sigma_{\varphi\varphi'} = 1 + \frac{1}{2}\bar{q}(w)\left[\frac{1}{\tilde{q}(\varphi)} + \frac{1}{\tilde{q}(\varphi')}\right].$$

All in all, under elastic taste for quality, a higher per-capita income exposes low-quality varieties to a stronger competition pressure by raising elasticity of substitution and lowering markups, while high-quality varieties are also, to a smaller extent, being perceived as less differentiated as per-capita income moves up. However, under inelastic taste for quality, following an increase in income per capita and a constant aggregate income, less productive firms have a lower elasticity of substitution and it is more likely to have new varieties enter than to have each high-quality variety expand sales.

The utility function in equation (3.1) can be set as a homothetic one by assuming taste for quality is proportional to income per capita. That is $\bar{q}(w) = \alpha w$, where α is a positive constant. As such, all varieties have a unit income elasticity of demand. Consistent with other models with homothetic preferences, any two economies with equal aggregate income are predicted equivalent, and population size and income per capita play exactly the same role in determining the market equilibrium. As a result, the model with such a preference fails to account for the differential effects of income per capita on sales of high- and low-quality varieties in each economy as well as the mixed impacts of income per capita on firm entry and sales across economies in a heterogeneous firm model with free entry, which is observed in the data. In the next section of open economy, a homothetic preference would predict two countries to end up with the same market performances in every aspect as long as they have the same market size. Taking into account changes in consumers' tastes for quality associated with income growth generate differential responses of demand for quality differentiated varieties, which features the important and separate role of income per capita in a quality differentiation model.

1.3.2 Open Economy

I extend the closed economy model to a two-country setting. Consider a world comprised of two countries, Home and Foreign, which trade varieties of a final good. Each country $i = H, F$ has an inelastic labor endowment L_i and the labor efficiency of production is given by a_i. Labor is mobile within a country but immobile across countries.

1.3.2.1 Consumers

As in the closed economy model, the demand for variety φ originating from country i in country j is

$$q_{ij}(\varphi) = \frac{L_j}{p_{ij}(\varphi)} \left[\frac{w_j}{N_j} + \bar{q}(w_j) \left(\bar{\tilde{p}}_j - \tilde{p}_{ij}(\varphi) \right) \right], \tag{1.31}$$

where $p_{ij}(\varphi)$, $\tilde{p}_{ij}(\varphi)$, and $q_{ij}(\varphi)$ are the price, quality-adjusted price, and quantity of variety produced in country i demanded in country j respectively. Country j's labor endowment and per-capita income are given by L_j and w_j. N_j represents the total number of varieties available to consumers in country j, including both domestically produced and imported goods.

1.3.2.2 Firms

The basic setup for the production sectors is as described in the closed economy. When open to trade, firms have the option to export. Iceberg trade costs are assumed to be symmetric such that

$\tau_{ij} = \tau_{ji} = \tau > 1$ and $\tau_{ii} = \tau_{jj} = 1$. Since markets are segmented under the assumption of constant marginal production costs, firms independently choose prices and qualities for each market in order to maximize profits. Countries trade varieties of final products, and there is no trade in intermediate inputs. The production costs and prices of intermediate inputs may differ across countries due to different production efficiencies and labor endowments, but the equilibrium analysis below considers a case of two countries with the same supply of effective labor and therefore the costs of producing intermediate inputs are equal in both countries. By suppressing the variations in production costs across countries, the trade pattern in equilibrium is purely driven by demand side.

Following that product quality is improved by using better intermediate inputs rather than by fixed investments, there is no scales of economy in the production of quality and a firm's quality choice is independent of market size. After opening to trade, the optimal product quality that a firm sells is still determined by its productivity draw and the scope for quality differentiation of the product, as in the case of closed economy:

$$z_{ij}(\varphi) = \varphi^b. \tag{1.32}$$

Firm selection is through competition. Only the firms that charge low enough quality-adjusted prices can survive. The firm at the margin has zero market demand and earns zero profits. Thus, the productivity threshold, under which firms stop serving, for firms producing in i and selling to j is defined as

$$\varphi_{ij}^* = \sup_{\varphi \geqslant \varphi_0} \{\pi_{ij}(\varphi) = 0\}.$$

Using equations for demand and profits, the market specific productivity threshold can be expressed as

$$\varphi_{ij}^* = \left(\frac{\tau w_i}{a_i} \frac{N_j \bar{q}_j}{w_j + \bar{q}_j P_j}\right)^{\frac{2}{b+2}}. \tag{1.33}$$

Substituting equation (1.33) into price, demand, and profits equations, the export performances of a firm φ originating from i selling to j are

$$p_{ij}(\varphi) = \frac{\tau w_i}{a_i}\varphi^{\frac{b-2}{2}}\left(\frac{\varphi}{\varphi_{ij}^*}\right)^{\frac{b+2}{4}}, \tag{1.34}$$

$$q_{ij}(\varphi) = \bar{q}_j L_j \varphi^{-b}\left[\left(\frac{\varphi}{\varphi_{ij}^*}\right)^{\frac{b+2}{4}} - 1\right], \tag{1.35}$$

$$\pi_{ij}(\varphi) = \frac{\tau w_i}{a_i}\bar{q}_j L_j\left[\left(\varphi_{ij}^*\right)^{-\frac{b+2}{4}} - \varphi^{-\frac{b+2}{4}}\right]^2. \tag{1.36}$$

In a differentiated goods sector, a firm's marginal cost increases with productivity, trade cost, and the efficiency adjusted wage rate in the production country. Markup is negatively related to the cutoff. The higher the cutoff, the more difficult to enter the market, implying a more competitive market and less market power of each firm. As before, the output of a firm depends on the market size of the destination country and the productivity cutoff. Controlling for market size, high-quality goods sell relatively more in richer countries.

1.3.2.3 Trade Equilibrium

There are J_h and J_f potential entrants in the two countries respectively. A fraction of entrants whose productivity draws are greater than the thresholds stay and serve the destination market. The number of active firms selling in market j is

$$N_j = N_{ij} + N_{jj} = J_i\left[1 - G\left(\varphi_{ij}^*\right)\right] + J_j\left[1 - G\left(\varphi_{jj}^*\right)\right]. \tag{1.37}$$

Free entry drives firms' expected profits down to zero. That is, the sum of the expected profits from sales in the domestic and the foreign markets is equal to fixed entry costs:

$$\left[1 - G\left(\varphi_{jj}^*\right)\right]\int_{\varphi_{jj}^*}^{\infty}\pi_{jj}(\varphi)\,\mu(\varphi)\,d\varphi + \left[1 - G\left(\varphi_{ji}^*\right)\right]\int_{\varphi_{ji}^*}^{\infty}\pi_{ji}(\varphi)\,\mu(\varphi)\,d\varphi = \frac{w_j}{a_j}f_e. \tag{1.38}$$

Income balance conditions suggest that consumers' total income barely covers their expenditure on differentiated varieties that are produced at home and abroad:

$$w_j L_j = N_{jj} \int_{\varphi_{jj}^*}^{\infty} r_{jj}(\varphi) \mu(\varphi) d\varphi + N_{ij} \int_{\varphi_{ij}^*}^{\infty} r_{ij}(\varphi) \mu(\varphi) d\varphi. \tag{1.39}$$

Lastly, labor market clears. The labor demanded for productions of intermediate inputs and final products is equal to labor endowment in that economy:

$$L_j = J_j \frac{f_e}{a_j} + N_{jj} \int_{\varphi_{jj}^*}^{\infty} \frac{q_{jj}(\varphi)}{\varphi} \frac{c_{jj}(\varphi)}{a_j} \mu(\varphi) d\varphi + N_{ji} \int_{\varphi_{ji}^*}^{\infty} \frac{q_{ji}(\varphi)}{\varphi} \frac{c_{ji}(\varphi)}{a_j} \mu(\varphi) d\varphi. \tag{1.40}$$

Thus, the equilibrium productivity thresholds above which firms start producing and exporting to can be solved as

$$\varphi_{jj}^* = \left\{ \frac{L_j \bar{q}_j D \left(1 - \tau^{-\frac{4\gamma}{b+2}}\right)}{f_e \left[1 - \tau^{-\frac{2\gamma}{b+2}} \left(\frac{w_j a_i}{w_i a_j}\right)^{-1-\frac{2\gamma}{b+2}}\right]} \right\}^{\frac{2}{2\gamma+b+2}}, \tag{1.41}$$

$$\varphi_{ij}^* = \left(\frac{\tau w_i a_j}{w_j a_i}\right)^{\frac{2}{b+2}} \varphi_{jj}^*, \tag{1.42}$$

where $D = \frac{\varphi_0^{\gamma}(b+2)^2}{(4\gamma+b+2)(2\gamma+b+2)}$, φ_{jj}^* denotes the threshold for domestic producers selling in j, and φ_{ji}^* represents the threshold for foreign producers to export to j. Comparing equations (1.24) and (1.41), opening to trade does not necessarily raise the productivity threshold, depending on trade costs and the relative efficiency-adjusted income per capita of the two trading countries. It turns to be $\varphi_{jj}^* \geqslant \varphi^*$, where φ^* denotes the threshold in the closed economy, if and only if the home country's efficiency adjusted income per capita relative to its trade partner is lower such that $\frac{w_j a_i}{w_i a_j} \leqslant \tau^{\frac{2\gamma}{2\gamma+b+2}}$. Intuitively, if home country has the cost advantage in producing intermediate inputs and final products, exporters from foreign country find it hard to penetrate in. Hence, when opening to trade, the entry of foreign competitive producers drives down the quality adjusted price index and the least productive domestic firms have to exit.

The total number of varieties available to consumers and the number of entrants in country

j are

$$N_j = \frac{4\gamma + b + 2}{b+2} \frac{a_j}{\bar{q}_j} \left(\varphi^*_{jj}\right)^{\frac{b+2}{2}}, \tag{1.43}$$

$$J_j = \frac{b+2}{2\gamma + b + 2} \frac{a_j L_j}{f_e}. \tag{1.44}$$

Similar to the autarky case, the number of varieties available in country j is positively correlated to the domestic productivity threshold φ^*_{jj} and negatively to consumers' tastes for quality $\bar{q}_j$, suggesting an ambiguous effect of income per capita in country j on number of varieties. The number of potential entrants is proportional to the aggregate labor supply in country j and decreases in fixed entry cost .

To insulate the separate role of income per capita from the one it plays in market size, I consider the equilibrium in which two trading countries have equal effective labor supply $a_i L_i = a_j L_j$ but differ in population $L_i < L_j$ and technology $a_i > a_j$. Following this assumption, I have:

$$J_i = J_j \qquad and \qquad \frac{w_i}{a_i} = \frac{w_j}{a_j}.$$

If two countries are endowed with the same amount of effective labor, they also share the same number of potential entrants and the same efficiency-adjusted income per capita. Accordingly, the solution to productivity thresholds in equations (1.41) and (1.42) boil down to

$$\varphi^*_{jj} = \left[\frac{L_j \bar{q}_j D}{f_e}\left(1 + \tau^{-\frac{2\gamma}{b+2}}\right)\right]^{\frac{2}{2\gamma+b+2}}, \tag{1.45}$$

$$\varphi^*_{ij} = \tau^{\frac{2}{b+2}} \varphi^*_{jj}. \tag{1.46}$$

The market specific productivity threshold of exporting reflects the degree of difficulty for foreign producers to enter. Firms from country$i$ are more likely to export to j if variable trade costs are small and the domestic productivity cutoff is low. Income per capita affects the thresholds through tastes for quality in the same way as in the autarky case. Conditional on market size, the productivity cutoffs increase in income per capita if the income elasticity of taste for quality is greater than 1, and decrease in income per capita if the income elasticity of taste for quality is smaller than 1.

Consider two destination countries with equal market size, under income elastic(inelastic) preference for quality, the one with a higher per-capita income ends up with greater(lower) productivity thresholds. Therefore, the average quality of products consumed in the rich country is higher(lower) than that in the poor country, while there are fewer(more) varieties sold in the rich than in the poor country. Since the assumption of equal labor supply rules out the cost variations across countries, the differences in market outcomes in equilibrium is explained by the demand side. It is consumers' taste for quality, which varies with per-capita income, that selects better quality varieties (or a wider range of varieties) into the rich country. Variations in threshold across destination markets generate variations in the number of exporting firms, the average quality of exports, and the price index.

1.3.2.4 Firm Sales

Export sales of a firm with productivity φ originating from country i and selling in country j is

$$r_{ij}(\varphi) = \frac{\tau w_i}{a_i} L_j \bar{q}_j \left(\varphi_{ij}^*\right)^{-\frac{b+2}{4}} \left[\left(\varphi_{ij}^*\right)^{-\frac{b+2}{4}} - \varphi^{-\frac{b+2}{4}}\right]. \tag{1.47}$$

As shown in the above expression, a firm's export sales in country j are jointly determined by population size, tastes for quality, and the productivity of survival in the destination country. More revenues would be earned if the destination market is characterized by a large population size, a strong preference for quality, and a low productivity threshold of exporting. Consumer's preference for quality changes with income per capita, so does the productivity threshold. The overall effect of income per capita on a firm's sales is ambiguous, since the relationship between productivity threshold and income per capita is related to the value of income elasticity of taste for quality. Formally, holding aggregate income constant $(w_j L_j)$, I have

$$\frac{\partial r_{ij}(\varphi)}{\partial w_j} = \frac{2\gamma}{2\gamma + b + 2} \frac{\tau w_i}{a_i} \frac{\bar{q}_j}{w_j^2} (\varphi^*)^{-\frac{b+2}{2}} [\varepsilon_t(w_j) - 1] \left[1 - \left(1 + \frac{b+2}{4\gamma}\right)\left(\frac{\varphi_{ij}^*}{\varphi}\right)^{\frac{b+2}{4}}\right].$$

All else equal, how a firm's export revenue relates to the income per capita in the destination country depends on income elasticity of taste for quality and the firm's productivity (quality). A firm realizes higher sales in a richer country if it produces high-quality goods and consumers' tastes for quality are income elastic. If consumers' tastes for quality are not sensitive to income, a high-quality producer would not earn more revenues when selling to a richer country. On the other hand, for a less productive firm whose products are of low quality, its export sales in a rich country are smaller than that in a poor country when consumers care about quality more than variety, while are larger when consumers prefer variety to quality.

The empirical implication of the model is that within a firm that exports a single quality level product to multiple countries, the sales per destination vary with the destination country's income per capita, holding market size constant, and exports of high- and low-quality products display differential sales patterns across countries. Following the assumption that taste for quality increases in income per capita at a decreasing rate, consumers in poor countries are predicted to be more responsive to income growth than rich country consumers in terms of preferences for product quality. Therefore, among developing countries, consumers with a relatively higher income per capita spend more of their incomes on better quality varieties and drop low end varieties. As a result, a higher income per capita allows a high-quality exporter to expand its sales and obtain a larger market share due to consumers' enhanced tastes for quality, while a low-quality exporter makes shrinking revenues or even be pushed out of the market. Moreover, the market share shift from low- to high-quality goods drives down the quality-adjusted price index, and therefore intensifies market competition. In this case, trade improves welfare mainly by improving the average quality of products consumers purchase.

When it comes to developed countries, where consumers already keep a strong taste for quality and tend not to alter their tastes much as income increases, a higher income per capita induces consumers to broaden their consumption sets. As more differentiated varieties enter, the market share of each variety declines. In the meantime, the quality-adjusted price index goes up and the existing firms therefore charge higher markups. The gains from trade in this cases is mainly through a greater number of varieties.

1.4 Firm-product Level Empirical Evidence

1.4.1 Export Value Equation

To investigate how export sales vary with market size and per-capita income at the firm-product level, I first estimate the following specification:

$$\begin{aligned} \log x_{fpd} = \beta_0 + \beta_1 \log GDP_d + \beta_2 \log GDPpc_d + \sum_l \zeta_l \log GDPpc_d * Q_l \\ + \beta_3 \log GDPpc_d^2 + \sum_l \gamma_l \log GDPpc_d^2 * Q_l + \beta_4 X_d + \beta_5 Imsh_d + \delta_{fp} + \varepsilon_{fpd}. \end{aligned} \tag{1.48}$$

Products are divided into five groups according to quality. Q_l is a quality dummy which equals 1 if product p produced by firm f belongs to quality category l and equals 0 otherwise, where $l \in \{1, 2, 3, 4\}$. The quality dummy enters interacted with destination's GDP per capita, which allows for testing differential impacts of per-capita income by quality. A polynomial in log of GDP per capita as well as its interaction with quality dummies are also added into the regression as so to examine if there are non-monotonic relationships between income per capita and exports of high- and low-quality products. Considering the potential collinearity between $\log GDPpc_d$ and $\log GDPpc_d^2$, I run a regression of $\log GDPpc_d^2$ on $\log GDPpc_d$, $\log GDP_d$, and gravity controls X_d, and save the residuals for $\log GDPpc_d^2$ in estimating specification (1.48). I incorporate firm-product fixed effects so that the identification stems from variations of export sales across countries within a firm and a product. Standard errors are clustered at the firm product level, and the results remain robust when clustering at other different levels. $Imsh_d$ denotes the share of Chinese exports in country d's total imports of products HS85 and it captures the overall competitiveness of Chinese exports in that country.

In specification (1.48), β_1 captures market size effect and is expected to be positive, since a bigger market raises the sales of all firms selling there in a proportional way. With an interaction term of per-capita income and quality dummy, β_2 reflects the impact of per-capita income on export revenues of low-quality products. The theoretical model predicts that rich consumers hold stronger preferences over quality and spend less of their incomes on low end products. Therefore, I expect β_2 to be negative. ζ_l should be positive as it reflects a positive role of per-capita income in shaping consumers' tastes for product quality as well as sales of high-quality products in rich countries. The significance of β_3 and γ_l would indicate non-linear relationships between income and export values for products in each quality group, and their magnitudes describe the curvatures of the relationships. The model predicts high-quality varieties to expand their export sales as income per capita rises at lower levels and shrink at higher levels, and the lower the quality is, the faster its sales would drop in richer countries. Hence, β_3 is expected to be negative and γ_l to be positive. Lastly, rich countries import more expensive goods and may switch their preferences away from Chinese exports, which in turn affects export sales of Chinese products at all quality levels. Hence, I expect β_5 to be positive in the sense that firms make more sales in the country where Chinese exports in total occupy a large market share. I also use destination country's import unit value index as an alternative proxy for the competitiveness of Chinese exports. Countries with a higher unit value index of import may tend to purchase more high-quality products produced by developed countries and reduces consumptions of Chinese exports. As such, the coefficient on the import unit value index is expected to be negative. Adding these controls into the regression does not change the pattern of export values with respect to GDP per capita.

A major concern regarding estimating export value by standard OLS method arises from firm selection bias. In the disaggregate data, only a subset of firms export to a certain destination and the presence of zero trade observations is pervasive. As Heckman (1979) points out, if the zeros are not random, deleting can lead to loss of information. There may exist unobservable firm or destination characteristics that affect both selection to exporting and export sales, such as productivity, skill intensity, and cultural similarity, which results in biased estimates of coefficients in linear OLS regressions. In order to control for selection bias, I investigate income effects on export participation and export values by employing a two stage estimation procedure proposed in Helpman et al. (2008). Then, as robustness check, I follow Eaton and Kortum (2001) and use product specific minimum destination exports as censoring points in Tobit regressions.

Another factor that may bias estimates is the potential quality differentiation within firm-product. It is observed in the data that a proportion of firms import an input from multiple source countries, so they may provide different quality versions of the product to different destination countries, which gives rise to cross-country variations in prices and sales. This would not bias the results in a serious way, since the standard deviation of input prices within firm-product is smaller than 5 and therefore the quality of the inputs originating from various countries used by a firm do not vary considerably. In the robustness check, I restrict the sample to the firms which source an input from a single source country and find the relationship between export value and GDP per capita by quality remain robust.

1.4.2 Export Participation Equation

Following the two stage estimation procedure, I first estimate the probability of entry using a reduced form Probit:

$$\Pr\left(T_{fpd}=1\right)=\Pr\left(\log x_{fpd}>0\right)=\mathbf{\Phi}\left(\delta_{fp}+\eta_{\mathbf{d}}Z_d+\eta_{LT}LT_{fpd}\right), \tag{1.49}$$

where T_{fpd} is a binary variable that takes the value one when the firm-product makes positive sales in destination d, δ_{fp} is firm-product fixed effects, Z_d includes the destination specific explanatory variables in the right hand side of specification (1.48), and LT_{fpd} is lagged participation index that equals one if the firm-product was sold in the market in the previous year (year 2004). By assuming a normally distributed error terms μ_{fpd}, running the Probit at the firm-product-destination level yields the estimated inverse Mills ratio $\hat{\lambda}_{fpd}$.

The expected value of exports conditional on observing positive trade flows is

$$\begin{aligned}\boldsymbol{E}\left[x_{fpd} \mid T_{fpd}=1\right] &= \delta_{fp}+\beta_{\mathbf{d}} Z_d+\boldsymbol{E}\left[\varepsilon_{fpd} \mid \mu_{fpd}>-\left(\delta_{fp}+\eta_{\mathbf{d}} Z_d+\eta_{LT} LT_{fpd}\right)\right] \\ &= \delta_{fp}+\beta_{\mathbf{d}} Z_d+\rho \hat{\lambda}_{fpd}.\end{aligned}$$

The selection bias arises from the non-zero correlation between the error terms ε_{fpd} and μ_{fpd} in the export value and the participation equations. Thus, in the second stage, I estimate the export value equation for positive levels of exports by OLS, with the estimated inverse Mills ratio $\hat{\lambda}_{fpd}$ as an additional regressor:

$$\log x_{fpd}=\beta_0+\beta_{\mathbf{d}} Z_d+\rho \hat{\lambda}_{fpd}+\delta_{fp}+\varepsilon_{fpd}, \tag{1.50}$$

where coefficient ρ on the estimated inverse Mills ratio captures the degree to which the error terms of the export value regression is correlated with the error term of the Probit. If it is significant, it indicates that sample selection is present. In (1.50), $\hat{\lambda}_{fpd}$ controls for firm-product selection to exporting, and the estimates of $\beta_{\mathbf{d}}$ reflects the effects of destination characteristics on operating firms whose export sales are strictly positive in a certain destination.

Although the inverse Mills ratio is estimated by the non-linear Probit model, the collinearity between the selection correction term ($\hat{\lambda}_{fpd}$) and the included independent variables (Z_d) in the export value regression can inflate standard errors, since the Probit model is approximately linear for the mid-range values of exports and is truly non-linear only when exports take on extreme values. Effectively addressing this problem requires at least one variable that uniquely determines the participation choice of exporting but not the value of exports. With such a valid exclusion variable, $\hat{\lambda}_{fpd}$ and Z_d in the export value equation would be less correlated, facilitating identification and reducing multicollinearity among regressors as well as the correlation between error terms. I incorporate lagged participation in product exporting (LT_{fpd}) in the Probit as the exclusion restriction. The firms that successfully developed trading relations to a destination in the previous year have lower fixed exporting costs this year compared to new exporters. Hence, lagged participation is a proxy for firm current exporting fixed costs, which increases the probability of entering a foreign market but does not directly affect the levels of exports.

1.4.3 Results

Table 1.4 reports the results of standard OLS estimations of specification (1.48) with standard errors clustered at the firm-product level. Without differentiating products by quality, as shown in column (3), the regression successfully identifies a positive and significant effect of market size (log GDP) at the 1% significance level, while the coefficient on log GDP per capita is insignificant. In column (6), the inclusion of the interaction term of quality dummies and log of GDP per capita reveals the differential effects of income per capita on export sales of high- and low-quality products. Controlling for market size and other related variables, 1% increase in GDP per capita of importing country reduces a low-quality product's sales by 24.1% on average and raises the sales of a high-quality product in group 1, 2, 3, and 4 by 9%, 10.1%, 21%, and 15.8% respectively. These results are statistically significant and economically important. It is worth noting that the coefficient on the import unit value index is negative and significant, suggesting that Chinese exports account for a small market share in a country with high price imports. Table 1.4 also reports the OLS regressions of firm-product price and quantity on the explanatory variables on the right hand side of (1.48). Columns (1) and (4) show that GDP per capita raises export price regardless of product quality: a 1% higher GDP per capita leads to a 2.5% higher price. The income effects on export quantity differ by product quality, as given in columns (2) and (5): as GDP per capita increases by 1 percent, low-quality products sell 26.7% less, and high-quality goods are demanded 7.6%, 7.3%, 17.7%, and 13.5% more respectively.

Considering the OLS estimates may be biased by selection to exporting, Table 1.5 shows the results of two stage estimation and censored Tobit regression. Column (1) reports Probit estimates in the first stage. A larger GDP (market size) improves the likelihood of a firm-product entry, and a higher GDP per capita encourages entry at lower income levels and suppresses entry at higher

Table 1.4: Export Outcomes and Destination Charateristics: OLS

	(1) log p_{fpd}	(2) log q_{fpd}	(3) log x_{fpd}	(4) log p_{fpd}	(5) log q_{fpd}	(6) log x_{fpd}
log GDP_d	-0.002	0.326***	0.337***	-0.001	0.326***	0.325***
	(0.002)	(0.013)	(0.013)	(0.002)	(0.013)	(0.012)
log $GDPpc_d$	0.025***	0.036*	0.033*	0.026***	-0.267***	-0.241***
	(0.004)	(0.021)	(0.020)	(0.007)	(0.035)	(0.033)
log $GDPpc_d \times Q_1$				-0.012	0.343***	0.331***
				(0.011)	(0.048)	(0.047)
log $GDPpc_d \times Q_2$				0.002	0.340***	0.342***
				(0.010)	(0.050)	(0.048)
log $GDPpc_d \times Q_3$				0.007	0.444***	0.451***
				(0.010)	(0.055)	(0.054)
log $GDPpc_d \times Q_4$				-0.005	0.404***	0.399***
				(0.012)	(0.046)	(0.045)
Firm-product FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,812	11,812	11,812	11,812	11,812	11,812

Dependent variables are measured at the firm-product-destination level. Standard errors are clustered at the firm -product level, and are reported in parentheses.
Results remain robust when standard errors are clustered at the product level and at the firm level.
*** p<0.01, ** p<0.05, * p<0.1.

incomes, given that the coefficient on GDP per capita is positive and statistically significant and the polynomial in GDP per capita has a negative estimate. The negative role of income per capita can be explained by the fact that the degree of market competition increases with GDP per capita which makes it more difficult for exporters to survive. Also, all else equal, products are more likely to be exported to the countries that share the same language or a geographical border with China.

Column (3) in Table 1.5 displays the key results of my empirical study. The estimated inverse Mills ratio obtained from the Probit is included as an additional regressor in the second stage OLS estimation of export values. The significance of the coefficient on $\hat{\lambda}_{fpd}$ confirms the necessity of correcting selection bias. Conditional on entry, market size (GDP) has a positive effect on individual firm-product sales, and GDP per capita differ its roles by product quality. In particular, all else equal, 1% higher GDP is associated with a 60% more export sales. The estimates of β_2 and β_3 are both negative, implying that low-quality products earn less revenues in richer countries and the revenues drop even more quickly as GDP per capita goes up. ζ_l are positive and their magnitudes exceed the absolute value of β_2 and increase with quality levels. γ_l are also positive and roughly increase with quality, but they are smaller than the absolute value of β_3. This suggests that high-quality products makes more sales as GDP per capita rises at lower levels and start to decline as income rises further. The relationships between export value and GDP per capita for products in quality groups 1 to 4 display similar patterns, but differ in curvature and turning point. The higher the quality, the larger turning point and the less curvature. In other words, high-quality products' sales keep increasing over a wider range of income levels and decrease at a slower rate in very rich countries. Consumers' income inelastic tastes for quality and the corresponding intensified market competition gives rise to a drop in individual export sales in countries at higher income levels. Moreover, the estimates of β_5 are positive and statistically significant in both the trade participation equation and the export value equation. This implies that if Chinese exports are popular in a country in the sense that the share of Chinese products in its total imports is relatively large, individual firm-products are more likely to export to and make more sales in that country.

Table 1.5: Export Outcomes and Destination Charateristics: 2-Stage

	(1) Probit	(2) 2nd stage	(3) 2nd stage	(4) Tobit
Dependent Var	T_{fpd}	$\log q_{fpd}$	$\log x_{fpd}$	$\log x_{fpd}$
$\log GDP_d$	0.367***	0.613***	0.600***	0.345***
	(0.004)	(0.065)	(0.064)	(0.015)
$\log GDPpc_d$	0.125***	-0.119***	-0.094***	-0.159***
	(0.015)	(0.036)	(0.035)	(0.037)
$\log GDPpc_d \times Q_1$	-0.046**	0.207***	0.197***	0.259***
	(0.020)	(0.046)	(0.045)	(0.053)
$\log GDPpc_d \times Q_2$	-0.069***	0.214***	0.219***	0.291***
	(0.020)	(0.047)	(0.046)	(0.062)
$\log GDPpc_d \times Q_3$	-0.031	0.347***	0.355***	0.363***
	(0.021)	(0.044)	(0.043)	(0.059)
$\log GDPpc_d \times Q_4$	-0.030	0.365***	0.361***	0.299***
	(0.022)	(0.047)	(0.046)	(0.052)
$\log GDPpc_d{}^2$	-0.028***	-0.218***	-0.214***	-0.133***
	(0.007)	(0.025)	(0.024)	(0.033)
$\log GDPpc_d^2 \times Q_1$	-0.018	0.119***	0.118***	0.101**
	(0.011)	(0.033)	(0.033)	(0.042)
$\log GDPpc_d^2 \times Q_2$	-0.001	0.149***	0.150***	0.100**
	(0.010)	(0.032)	(0.032)	(0.047)
$\log GDPpc_d^2 \times Q_3$	-0.009	0.198***	0.203***	0.112***
	(0.011)	(0.034)	(0.033)	(0.036)
$\log GDPpc_d^2 \times Q_4$	0.001	0.185***	0.182***	0.133***
	(0.011)	(0.036)	(0.035)	(0.042)
$\log distance_d$	-0.009	-0.105**	-0.092*	-0.065
	(0.012)	(0.051)	(0.050)	(0.061)
comlang	0.837***	1.962***	1.921***	0.532***
	(0.032)	(0.179)	(0.176)	(0.087)
border	0.092***	0.158*	0.177**	0.398***
	(0.027)	(0.082)	(0.080)	(0.078)
$Imsh_d$	2.191***	4.582***	5.803***	4.829***
	(0.109)	(0.531)	(0.440)	(0.342)
$\hat{\lambda}_{fpd}$		2.286***	2.242***	
		(0.243)	(0.238)	
Firm-product FE	Yes	Yes	Yes	Yes
Observations	110,970	110,970	110,970	11,629

Standard errors are reported in parentheses. Results remain robust when standard errors are clustered at the product level and at the firm level.
*** p<0.01, ** p<0.05, * p<0.1.

An alternative explanation of the results is that the roles of GDP per capita in shaping firm-product level exports across countries work through market size. Such an argument can be ruled out by replacing GDP per capita with population size or market size of the destination country in specification (1.48). The corresponding regression results show that neither the population term nor the interaction of population and high quality dummy is statistically significant, suggesting that the differential impacts of per-capita income on export values by quality category are independent of market size effect.

1.4.4 Robustness Checks

1.4.4.1 Quality Differentiation within Firm-product

An alternative explanation for the increase of export prices and sales with GDP per capita is that firms export different quality versions of a product to different countries. To exclude quality differentiation across markets within a firm-product, I restrict the data sample to the firms which import an input from a single country. The quality of sophisticated intermediate inputs is the most important determinant of output quality produced by processing firms, and as stated above, processing firms upgrade product quality mainly through importing better inputs. Therefore, it is less likely for a processing exporter to produce a product at different quality levels if it sources each input from barely one country. As such, the observed variations in export prices and sales within a firm-product are driven by consumers' tastes for the quality of a given product.

There are 189 firms satisfying the single-source restriction in the data. The restricted sample consists of 1,208 observations. I run regression (1.48) for this subsample using OLS, two-stage estimation, and Tobit approaches. Considering the small sample size, I classify products into two quality groups: high and low and denote Q_H a dummy variable which takes a value of 1 if the product belongs to the high-quality group and 0 otherwise. The results are given in Table 1.6 and confirms the conclusions discussed in the previous section. Comparing Columns (1) and (2), it is found that GDP per capita does not have a significant effect on export values of all products, but the effects become significant when products are differentiated by quality: a higher GDP per capita leads to fewer export sales of low-quality products and more sales of high-quality ones. To control for firm-product selection to exporting, two stage approach is adapted and the results for each step are reported in column (3) and (4). Destination country's GDP per capita influences firm-products' exports' market entry in the opposite directions: a 1% higher GDP per capita lowers the probability of a low-quality product entry by 0.5% but raises the probability of a high-quality product entry by 0.4%. Also, the relationship between export participation and GDP per capita is non-linear for high-quality products, given that the coefficient on the interaction term of GDP per capita and quality dummy is negative and significant. The second stage is OLS regression with the estimated inverse Mills ratio from the first stage as an additional regressor. As can be seen in column (4), high-quality products tend to make more sales in richer countries and low-quality products have shrinking export values when selling to countries with higher GDP per capita. In particular, all else equal, 1% higher GDP per capita is associated with a 20.7% less export sales of low-quality firm-products and a 10.7% more export sales of high-quality firm-products.

1.4.4.2 Censored Tobit Regression

An alternative way to deal with selection bias is running censored Tobit regressions. Given that the trade data contain many zeros and the minimum export revenue from selling a product in a country is strictly positive, the maximum likelihood estimate of the censoring point of exports can be obtained from the value of minimum destination exports in the data, as Eaton and Kortum (2001) suggests. The model presented in Eaton and Kortum (2001) builds on fixed export costs that could be covered by more productive producers, whereas the firm selection to exporting in my model is through market competition. However, fixed exporting costs are non-negligible in reality and the censoring method helps to check the robustness of the results obtained from the two stage estimation. I pool the HS8 level export data on all Chinese exporters, including both ordinary and processing firms, in the Household Audio & Video Equipment industry, and pick the minimum export value as the censoring point for each destination-product. The corresponding estimates

Table 1.6: Quality Differentiation within Firm-product

	(1)OLS	(2)OLS	(3)Probit	(4)2Stage	(5)Tobit	(6)Tobit
Dependent Var	$logx_{fpd}$	$logx_{fpd}$	T_{fpd}	$logx_{fpd}$	$logx_{fpd}$	$logx_{fpd}$
$logGDP_d$	0.271***	0.274***	0.014***	0.172***	0.310***	0.319***
	(0.057)	(0.055)	(0.001)	(0.044)	(0.057)	(0.056)
$logGDPpc_d$	-0.047	-0.214***	-0.005***	-0.207***	-0.208***	-0.218***
	(0.075)	(0.079)	(0.001)	(0.073)	(0.079)	(0.084)
$logGDPpc_d * Q_H$		0.361***	0.009***	0.314***	0.392***	0.375***
		(0.113)	(0.002)	(0.090)	(0.111)	(0.112)
$logGDPpc_d^2$			0.001			-0.113**
			(0.000)			(0.051)
$logGDPpc_d^2 * Q_H$			-0.005***			0.167
			(0.001)			(0.193)
$logdistance_d$	-0.111	-0.163	-0.007***	-0.053	-0.260	-0.254
	(0.208)	(0.209)	(0.002)	(0.162)	(0.196)	(0.193)
comlang	0.717**	0.785***	0.042***	0.466**	0.912***	0.917***
	(0.287)	(0.293)	(0.005)	(0.235)	(0.277)	(0.280)
border	0.717**	0.682**	0.004	0.633***	0.616**	0.621**
	(0.283)	(0.283)	(0.010)	(0.218)	(0.258)	(0.258)
Gatt	0.328	0.232	0.004	0.101	0.038	0.087
	(0.243)	(0.248)	(0.004)	(0.267)	(0.264)	(0.280)
$\hat{\lambda}_{fpd}$				-0.596***		
				(0.065)		
firm-product FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,208	1,208	1,208	1,208	1,157	1,157

Standard errors are clustered at the firm-product level, and are reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

indicate the effects of market characteristics on export sales of the firm-products that are actually active in the foreign markets.

The results for Tobit regressions can be found in Table 1.5 Column (4) and in Table 1.6 Columns (5) and (6). They are consistent with the results from two stage correction approach. the estimates indicate a positive effect of GDP on firm-product export sales as well as a negative effect of GDP per capita on sales of low-quality products and a positive effect on sales of high-quality products. Holding other variables constant, within a low-quality firm-product, 1% increase of the importing country's GDP per capita leads to a 20.8% drop in export values. On the other hand, within a high-quality firm-product, 1% increase of the importing country's GDP per capita is associated with a 18.5% increase of export values from that destination country. Thus, categorizing products by quality is essential to disentangle the differential impacts of per-capita income on export sales across markets at the firm-product level. In column (6), the regression incorporates a polynomial in GDP per capita and its interaction with high quality dummy. The non-monotonicity of income impact on high-quality product sales is significant at the 5% significance level, with exports going up first and down afterwards as GDP per capita rises. Also, the negative coefficient on the GDP per capita squared suggests that export values of low end products decrease with GDP per capita at a faster rate.

1.4.4.3 Alternative Quality Indexes

In the main regression, I construct quality index based on the import price ranking of inputs in the same HS6 product category. The method takes advantage of the concentration of source countries that firms import inputs from in the Household Audio & Video Equipment industry. To make sure the results are not sensitive to quality index, I adapt Manova and Yu (2012)'s approach to calculate firm's input price the weighted average of import prices for inputs, using import values as weights, and it is based on imports in the same HS3 product category. Then, products are equally divided into five quality groups according to firm level input price: higher input prices infer better quality of inputs and outputs.

The regression results with the alternative quality index are displayed in Table 1.7. The key estimates remain as robust and consistent as in the main regressions. The change of quality measure does not alter conclusions. The first three columns report OLS estimations of export price, quantity, and value. Per capita GDP raises export prices regardless of product quality. Rich consumers demand more high-quality goods, and high-quality goods make more export revenues as destination country's GDP per capita rises, controlling for market size, distance, and other related variables. In terms of entry, a higher GDP per capita increases the probability of entry of high-quality goods and a larger import unit value index defers product entry. After correcting selection bias, in column (5), export values of low-quality products drop dramatically following an increase in GDP per capita. The relationship between export values of products in quality groups 1 to 4 and GDP per capita display an inverted-U shape, with better quality goods having a larger turning point. The Tobit estimates in column (6) provide similar evidence.

1.4.4.4 Other Year

To check if the above results are specific to year 2005, I examine the relationship between exports and destination characteristics at the firm-product level by using Chinese custom data on the Household Audio and Video Equipment industry in 2006. The estimation procedure is exactly the same as stated in the previous section. Table 1.8 reports the results. The export pattern is consistent with that in 2005. Column (1) shows a significant and positive effect of GDP per capita on fob export price regardless of product quality. In column (2), the OLS estimates suggest that a 1% higher GDP per capita reduces export value of low-quality product by 15.4% and raises export value of products in quality groups 1 to 4 by 11.4%, 18.8%, 15.8%, and 6.4% respectively. The two stage estimate of the coefficient on GDP per capita is negative and statistically significant, as shown in column (4), implying that, controlling for selection, low-quality products make less sales in richer countries. As for high-quality products (in quality groups 1 to 4), their export values increases and then decreases in destination country's GDP per capita. A higher income level first raises individual sales of high-quality firm-products due to the associated change of consumers'

Table 1.7: Alternative Quality Indexes

	(1)log p_{fpd}	(2) log q_{fpd}	(3) log x_{fpd}	(4) Probit	(5) log x_{fpd}	(6) log x_{fpd}
log GDP_d	-0.001	0.325***	0.324***	0.369***	0.641***	0.345***
	(0.002)	(0.013)	(0.013)	(0.004)	(0.064)	(0.013)
log $GDPpc_d$	0.020***	-0.071**	-0.051*	-0.016*	-0.123***	0.002
	(0.005)	(0.029)	(0.028)	(0.008)	(0.026)	(0.028)
log $GDPpc_d \times Q_1$	-0.009	0.130***	0.121**	0.162***	0.365***	0.074
	(0.010)	(0.050)	(0.048)	(0.013)	(0.048)	(0.049)
log $GDPpc_d \times Q_2$	0.009	0.089*	0.098**	0.115***	0.152***	0.053
	(0.009)	(0.048)	(0.047)	(0.010)	(0.039)	(0.052)
log $GDPpc_d \times Q_3$	0.012	0.246***	0.258***	0.239***	0.540***	0.176***
	(0.010)	(0.055)	(0.055)	(0.019)	(0.053)	(0.052)
log $GDPpc_d \times Q_4$	0.023	0.292***	0.315***	0.309***	0.684***	0.236***
	(0.014)	(0.054)	(0.053)	(0.025)	(0.061)	(0.048)
log $GDPpc_d{}^2$				-0.018***	-0.117***	-0.169***
				(0.004)	(0.017)	(0.047)
log $GDPpc_d^2 \times Q_1$				-0.014	0.052*	0.143***
				(0.008)	(0.030)	(0.037)
log $GDPpc_d^2 \times Q_2$				-0.047***	-0.058**	0.018
				(0.008)	(0.029)	(0.033)
log $GDPpc_d^2 \times Q_3$				-0.042***	0.023	0.121***
				(0.010)	(0.034)	(0.034)
log $GDPpc_d^2 \times Q_4$				-0.059***	-0.028	0.082**
				(0.012)	(0.041)	(0.040)
$\hat{\lambda}_{fpd}$					2.401***	
					(0.236)	
Firm-product FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,812	11,812	11,812	110,970	110,970	11,629

Standard errors are clustered at the firm-product level, and are reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

tastes for quality and then drives it down due to more intensified competition.

1.4.4.5 Other Industry

The data used in the main regression focus on the Household Audio and Video Equipment industry. It remains unknown whether the above export pattern could be applied to other industries. As a robustness check, I use the data on the Women's, Misses', and Juniors' Outerwear industry (SIC 233) in 2005 for study. Table 1.9 reports the results. The estimates of interest remain as consistent and robust as in the above analysis. In column (1), the coefficient on $\log GDPpc_d$ is positive and statistically significant, but the coefficients on interactions of $\log GDPpc_d$ and quality dummies are insignificant, suggesting that GDP per capita has a positive effect on price of all products regardless of quality levels: 1 percent increase in GDP per capita leads to a 1.9% increase in export price. Column (2) corresponds to OLS estimation of export value equation. For the products in the lowest, group 1 and group 2 quality categories, their export values decrease with GDP per capita: 1 percent higher GDP per capita drives down product export sales by 15.7%, 15.7%, and 0.9%. In contrast, for products belonging to quality groups 3 and 4, export sales increase by 2.5% and 3.8% respectively.

Columns (3) and (4) show the results of two stage estimation of export values. The relationship between probability of successful entry and destination's GDP per capita is non-linear: the coefficients on $\log GDPpc_d$ and its second order are both significant. A higher income level first encourages product entry but turns to make it harder as market competition gets more intensified. After controlling for selection to exporting, the impacts of GDP per capita on active exporters differ by product quality. The products in the lowest quality group and group 1 make less sales in richer countries, holding other variables constant. The export value of high-quality products in groups 3 and 4 increases with importing country's income level and then slightly decreases, indicating that richer consumers demand more high-quality products and a further increase in income induce them to buy more varieties. Also, exporters earn less revenue in a distant country and more in a similar country in terms of language and geographical border.

Table 1.8: Export Outcomes and Destination Charateristics: Year 2006

	(1)log p_{fpd}	(2) log x_{fpd}	(3) Probit	(4) log x_{fpd}
log GDP_d	-0.007**	0.292***	0.304***	0.772***
	(0.003)	(0.013)	(0.004)	(0.050)
log $GDPpc_d$	0.026***	-0.154***	0.025***	-0.098***
	(0.010)	(0.039)	(0.006)	(0.032)
log $GDPpc_d \times Q_1$	0.001	0.268***	0.144***	0.475***
	(0.011)	(0.055)	(0.016)	(0.052)
log $GDPpc_d \times Q_2$	-0.005	0.342***	0.102***	0.489***
	(0.012)	(0.053)	(0.016)	(0.049)
log $GDPpc_d \times Q_3$	0.005	0.312***	0.165***	0.537***
	(0.013)	(0.056)	(0.017)	(0.053)
log $GDPpc_d \times Q_4$	-0.019	0.218***	0.120***	0.405***
	(0.012)	(0.055)	(0.016)	(0.051)
$\log GDPpc_d{}^2$			-0.070***	-0.157***
			(0.008)	(0.031)
log $GDPpc_d^2 \times Q_1$			0.025***	0.051
			(0.010)	(0.037)
log $GDPpc_d^2 \times Q_2$			0.032***	0.052
			(0.010)	(0.037)
log $GDPpc_d^2 \times Q_3$			0.022***	0.062*
			(0.011)	(0.036)
log $GDPpc_d^2 \times Q_4$			0.034***	0.085**
			(0.011)	(0.037)
log $distance_d$	-0.007	-0.039	-0.070***	0.086*
	(0.013)	(0.049)	(0.012)	(0.052)
comlang	0.051**	0.597***	0.881***	1.983***
	(0.021)	(0.075)	(0.030)	(0.162)
border	-0.011	0.060	0.059	0.153*
	(0.019)	(0.073)	(0.056)	(0.081)
$Imsh_d$	0.073	3.630***	2.266***	6.976***
	(0.067)	(0.251)	(0.096)	(0.440)
$\hat{\lambda}_{fpd}$				2.224***
				(0.217)
Firm-product FE	Yes	Yes	Yes	Yes
Observations	12,097	12,097	102,726	102,726

Standard errors are reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 1.9: Export Outcomes and Destination Charateristics: SIC233

	(1)log p_{fpd}	(2) log x_{fpd}	(3) Probit	(4) log x_{fpd}
log GDP_d	-0.002	0.351***	0.390***	0.895***
	(0.002)	(0.009)	(0.003)	(0.071)
log $GDPpc_d$	0.019***	-0.157***	0.038***	-0.030
	(0.005)	(0.029)	(0.004)	(0.026)
log $GDPpc_d \times Q_1$	-0.003	0.022	-0.032***	-0.085**
	(0.006)	(0.041)	(0.011)	(0.043)
log $GDPpc_d \times Q_2$	0.002	0.148***	-0.018	0.108**
	(0.007)	(0.041)	(0.013)	(0.045)
log $GDPpc_d \times Q_3$	-0.012	0.182***	-0.024**	0.112***
	(0.007)	(0.038)	(0.012)	(0.043)
log $GDPpc_d \times Q_4$	-0.000	0.195***	-0.014	0.145***
	(0.007)	(0.038)	(0.010)	(0.039)
$\log GDPpc_d{}^2$			-0.031***	-0.158***
			(0.005)	(0.023)
log $GDPpc_d^2 \times Q_1$			0.026***	0.112***
			(0.007)	(0.032)
log $GDPpc_d^2 \times Q_2$			0.035***	0.203***
			(0.008)	(0.033)
log $GDPpc_d^2 \times Q_3$			0.018**	0.151***
			(0.008)	(0.032)
log $GDPpc_d^2 \times Q_4$			0.019***	0.146***
			(0.007)	(0.031)
log $distance_d$	0.001	-0.011	-0.089***	-0.243***
	(0.007)	(0.038)	(0.010)	(0.049)
comlang	0.039***	0.341***	0.513***	1.787***
	(0.011)	(0.063)	(0.025)	(0.136)
border	0.001	0.297***	0.221***	0.602***
	(0.010)	(0.055)	(0.021)	(0.083)
$Imsh_d$	-0.054	5.053***	1.737***	7.195***
	(0.051)	(0.309)	(0.119)	(0.452)
$\hat{\lambda}_{fpd}$				3.358***
				(0.240)
Firm-product FE	Yes	Yes	Yes	Yes
Observations	22,786	22,786	183,296	183,296

Standard errors are reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

1.5 Conclusions

This chapter provides a unified framework to account for the variety-quality tradeoff on exports across countries driven by income effect on tastes for quality. Aside from aggregate income, per capita income plays a separate role in shaping market demand in a quality differentiated sector. In equilibrium, income elasticity of taste for quality determines the effects of income per-capita on firm selection and market shares, since it reflects consumers' relative preferences for quality versus variety.

Consider two importing countries with equal market size but differing in income per capita. When consumers' tastes for quality are income elastic, the richer country tends to select better quality goods into the market and has a higher productivity threshold for firm survival. The much stronger preference for quality of consumers in the rich country induces high-quality producers to expand their market shares and low-quality producers to shrink. As a result, low end varieties are dropped off and the average quality of consumption goods is improved, as consumer expenditure gets more concentrated on high-quality varieties. In contrast, when consumers' tastes for quality are inelastic to income, rich consumers turn to prefer a broader set of varieties compared to poor consumers, which results in a loose firm selection and entry of less productive firms. Consequently, the richer country comes with a greater number of varieties and each producer selling in the market has a smaller market share. If it is further assumed that the elasticity of taste is negatively correlated with income per-capita, the model predicts that at the early stage of development, consumers benefit from economic growth and trade mainly through quality margins, while variety effect becomes the main source of gains at higher levels of per-capita income. If the elasticity of taste rises as income goes up, the opposite case applies.

In the empirical analysis, I construct firm level quality indexes for processing firms in the Household Audio and Video Equipment industry by using trade data collected by Chinese Custom Office. In line with the model's predictions, I find that, controlling for market size and other destination characteristics, there is a negative impact of per-capita income on export sales of low-quality products but a mixed impact on sales of high-quality products. There is an inverted-U shape relationship between high-quality export sales and a destination's income per-capita at the firm-product level, which reflects differing preferences for quality and variety across consumers at different income levels.

Chapter 2

Tariff Reductions, Processing Trade, and Export Quality

2.1 Introduction

Processing trade is an important type of trade in many developing countries, such as China, Indonesia, and Mexico. It is the process by which a domestic firm initially obtains raw materials or intermediate inputs from abroad and, after local processing, exports the value-added final goods (Feenstra and Hanson, 2005). Governments encourage processing trade by offering tariff reductions or even exemptions on the processing of intermediate goods. Such policies have effectively helped firms from developing countries succeed in the international market and promoted the total export volume. Processing trade in China began in the early 1990s. As an important means of trade liberalization, the government encourages Chinese firms to import raw materials and intermediate inputs, and re-export final value-added goods after local processing or assembly. As international production chains have been well developed around the world, processing trade plays an important role in China's exports. As is shown in Figure 1, both ordinary trade and processing trade started off since China's accession to the WTO in December of 2001. Initially, processing trade grew faster than ordinary trade and accounted for more than fifty percent of total exports. After 2004, ordinary trade started to catch up and the value of exports by ordinary firms exceeded that of processing firms. Even though it is observed in data that the share of processing trade in China's total exports decreases as China gradually lowers tariffs, processing trade still plays an important role in China's exports. By 2010, China had established 55 export processing zones. In terms of trade value, processing exports accounted for approximately 49 percent of total exports in 2010.

It is widely accepted that China's trade volume has expanded rapidly over the past decades, but there is not a clear answer to the question about the evolutions of the quality of goods exported from China. In addition to price and quantity, quality is another factor that determines a country's success in exporting activities. A higher quality product is a good which possesses one or more additional characteristics which are valued by buyers. The consequence of higher quality is to allow a higher price without loosing the market. "Made in China" has become a typical tag for low price goods as global trade liberalization significantly reduces trade costs and China engages with global production chains by its abundant labor endowments. But it remains relatively silent on the quality effect of tariff reductions on China's exports. When the government sets lower import tariff rates, firms producing in China could get access to more varieties of imported inputs at lower prices. Therefore, the exposure to more foreign high quality inputs allows firms to upgrade product quality and perform competently in the foreign market without raising total production costs. Moreover, since the coexistence of ordinary trade and processing trade is one of the features of China's exports, it is necessary to consider the different reactions of two types of exporters to tariff reductions in a single framework. A reduction in import tariff would only affect one of the two types of firms' production, but different production strategies conducted by the affected would change the market conditions faced by the unaffected. Given the large share of processing trade in China's total exports, behaviors of processing firms should not be a neglected part when it comes to the analysis of China's overall export quality.

There are a large body of papers in the literature studying trade liberalization and quality upgrading. A big challenge in empirical work is how to measure product quality which cannot be observed directly from data. A common measure of quality is the per-unit value of products, which is obtained by dividing a good's value by its quantity. Since higher quality raises consumers' willingness to pay which is reflected in product prices, Schott (2004) uses unit values as a proxy for quality. However, this approach, while convenient, requires strong assumptions since prices could reflect not just quality, but also variations in manufacturing costs. The variations in product prices are noised by many other factors. By combining the information on prices and market shares, Khandelwal (2010) proposes a market share based measure of quality. It argues that conditional on price, imports with higher market shares are assigned higher quality. The estimation results show that price is a good proxy for quality only in industries with long quality ladder. Feenstra and Romalis (2014) is the first attempt to combine supply and demand side information to estimate quality. In their work, quality estimates are obtained by dividing unit value by quality-adjusted price. An interesting finding in Feenstra and Romalis (2014) is that China's export quality appears to have declined despite substantial economic progress. Their estimation results reports that qualities of exports from most developing countries were below the world average and some of them even had a declining quality trend over time (like Brazil, Indonesia, and China), while most developed countries experienced quality upgrading and their export qualities were above the world average.

To estimate China's export quality, Hallak (2006) adopts the unit value approach and shows the evidence on the rising quality level of goods imported from China by the U.S. compared to the world average, and lowing tariffs promotes quality upgrading. While some other papers hold the opposite views. Rodrik (2006) argues that China exports poor quality varieties of the same products as advanced economies, which explains why it has an "over-sophisticated" export structure on the one hand and has low unit values on the other. The quality estimates report that China's export quality is below world average. A rising trend of unit value of exports reflects the upgrading of export structure, rather than the upgrading of product quality. According to Kneller and Yu (2008), the overall quality level of Chinese exports declines moderately from 1997 to 2002. The exports in machinery and mechanical appliances, transport equipment and plastic industries experience great quality declines, and quality upgrading is present in some other industries. It is worth noting that the industries that experienced large quality declines are those that are largely comprised of processing trade. The electrical machinery and transport equipment industry yields the largest volume of processing imports, accounting for approximately 40 percent of China's total in 2010. Yeaple et al (2014) looks into highly disaggregated Chinese data and documents the increases in the price and quality of outputs that are produced in industries that experienced the largest tariff reduction. But their empirical tests are based on a sub-sample of data which exclude processing trade. As stated above, the presence of processing trade may affect the quality effect of tariff reductions.

This chapter studies how processing trade impacts export quality. Tariff exemptions on the processing of intermediate goods offer processing firms a cost advantage in production and quality upgrading. Since quality is a vertical attribute of product and consumers attach a positive valuation to a high quality good, this type of firms choose to produce higher quality products and obtain more sales in the foreign market. The presence of processing trade drives ordinary exporters who still hope to maintain a certain foreign market share to produce products at a lower quality level compared to the quality level that would be chosen without processing trade. In equilibrium, the average export quality weighted by market shares of two types of firms is higher than the export quality if processing trade is not allowed. In other words, processing trade makes a positive contribution to the upgrading of export quality.

The comparative static analysis reveals that the quality of goods produced by ordinary firms and sold in the domestic and the foreign markets would be improved following reductions in import tariffs. This type of producers respond to tariff reductions by upgrading quality and competing for a larger market share in the foreign market. As for processing firms, who do not pay tariffs before and after tariff reductions and always earn zero profits due to the free entry condition, their quality choice is not influenced by tariff changes. Since ordinary exporters become more competent because of lower import tariffs, processing firms would lose some market share as a result. A reduction in import tariffs leads to quality upgrading of the goods produced by ordinary firms, but the market share shift from processing goods of relatively high quality towards goods produced by ordinary firms could make the average export quality decreases. Overall, it is possible to have a positive relationship between import tariffs and average export quality. I develop a model which delivers a reasonable explanation to the declining trend of China's exports as the government reduces import tariff rates.

Based on the results derived from the theoretical model, I propose two feasible empirical tests. I first utilize the market share approach (Khandelwal, 2010) to estimate the quality of

China's exports to the U.S.. Then with the estimates of quality, I run a regression of export quality on the share of processing exports controlling for factor intensity. A positive coefficient on the share of processing trade indicates that conditional on productivity processing firms produce higher quality goods than ordinary firms. The presence of processing trade also affects the response of export quality to import tariff reductions. This is tested by regressing variety quality on import tariffs and an interaction term of import tariffs with the share of processing trade. Export quality is negatively correlated with import tariffs and this negative correlation is stronger with ordinary firms. With both processing and ordinary firms engaging in export activities, the overall export quality may decline after a tariff reduction if the quality improvement effect is dominated by the market share effect.

2.2 The Model

2.2.1 Demand

There are two identical countries. The population in each country is normalized to be 1. Each consumer's utility function is assumed to be

$$U = q_0 + \alpha \int_{i\in\Omega} q_i di + \beta \int_{i\in\Omega} z_i q_i di - \frac{1}{2}\gamma \int_{i\in\Omega} q_i^2 di - \frac{1}{2}\eta \left(\int_{i\in\Omega} q_i di \right)^2, \tag{2.1}$$

where q_0 is the quantity of homogeneous goods, whose price equals 1. q_i denotes the quantity of variety i. The quality of variety i is given by z_i. The parameter β captures a consumer's valuation for quality, and γ represents the elasticity of substitution between differentiated varieties.

Utility maximization problem yields the demand for variety i:

$$q_i = \frac{1}{\gamma} \left(\alpha + \beta z_i - p_i - \eta Q \right), \tag{2.2}$$

where $Q = \int_{i\in\Omega} q_i di = N q_i$. N is the total number of varieties available in the country. The demand for variety i is linear in its price and quality. High product quality leads to an outward shift of the demand function.

2.2.2 Ordinary Exporting Firms Only

2.2.2.1 Production

Firms are symmetric and differ only in brands. I assume imported intermediate goods are the only factor of production. Product quality upgrading involves both using high quality inputs and investing in product designs and services. Therefore, fixed and variable production costs increase with quality. Producing higher quality goods requires more more expensive inputs and more advanced techniques and product designs. Ordinary firms also need to pay tariffs for each unit of imported intermediate goods used. Firm i's profit function can be expressed as

$$\pi_i = (p_i - c\tau z_i)\, q_i - \frac{1}{2} z_i^2,$$

where $\tau - 1 > 0$ denotes import tariffs. The market is characterized by monopolistic competition with a sufficiently large number of firms. A firm maximizes profits by choosing price and quality, taking other firms' quantities as given.[1] Thus, first order conditions give

$$z_i = \frac{(\alpha - \eta Q)(\beta - c\tau)}{2\gamma - (\beta - c\tau)^2} \tag{2.3}$$

$$q_i = \frac{\alpha - \eta Q}{2\gamma - (\beta - c\tau)^2} \tag{2.4}$$

$$\pi_i = \frac{1}{2} \frac{(\alpha - \eta Q)^2}{2\gamma - (\beta - c\tau)^2}. \tag{2.5}$$

Define $\lambda_1 = 2\gamma - (\beta - c\tau)^2$ as the inverse of the scope for quality differentiation. It's positively correlated to tariffs (τ) and the degree of substitution between varieties (γ), and negatively to consumer's taste for quality (β). When import tariffs on intermediate goods are low, varieties are less substitutable, and consumers appreciate much on the quality of goods, the scope for quality

[1] The solutions are equivalent to those derived under pure Cournot competition, i.e. firms choose quantity and quality to maximize profits.

differentiation is large and the value of λ_1 is small. The distinction from Antoniades (2015) is that here tariff rate is another factor that affects the quality ladder. Import tariff reductions lower the marginal cost of quality improving, and firms are more likely to use better inputs and produce high quality outputs. Also, as cheaper intermediate goods generate more profits, it turns to be easier to cover the fixed cost of improving quality. Therefore, a reduction in import tariffs induce firms to upgrade product quality. To have a positive quality ladder, it requires that $1 < \tau < \frac{\beta - \gamma^{1/2}}{c}$.

As shown in (2.3), the optimal product quality decreases in import tariff and market competition. Import tariffs affect quality choice through the scope for quality differentiation. A lower rate of import tariff implies a larger scope for quality differentiation, and therefore motivates quality upgrading. The degree of market competition is measured by the residual demand faced by firm i $(\alpha - \eta Q)$. When there are a larger amount of final goods sold in the market, the demand for each variety goes down. The reduced market demand dampens a firm's incentive to improve quality. As a result, the firm chooses to produce outputs at a lower level of quality.

2.2.2.2 Free Entry and Market Equilibrium

Firms have to pay a fixed entry cost (f) to enter the industry and can sell their products freely to both domestic and foreign consumers. The free entry condition drives firm i's profits down to 0. So I have

$$2\pi_i = 2 * \frac{1}{2} \frac{(\alpha - \eta Q)^2}{\lambda_1} = f.$$

Thus, combined with equations (2.3) and (2.4), the equilibrium quality and quality chosen by firm i are

$$z_i = \left[\frac{f\,(2\gamma - \lambda_1)}{\lambda_1} \right]^{1/2} \tag{2.6}$$

$$q_i = \left(\frac{f}{\lambda_1} \right)^{1/2}. \tag{2.7}$$

Since the total outputs sold in each market is represented by$Q = Nq_i$ and the free entry condition gives the solution to $Q = \frac{1}{\eta}\left[\alpha - (f\lambda_1)^{\frac{1}{2}}\right]$, the number of active firms (varieties) can be expressed as

$$N = \frac{1}{\eta}\left[\alpha\left(\frac{\lambda_1}{f}\right)^{\frac{1}{2}} - \lambda_1\right]. \tag{2.8}$$

2.2.2.3 Effects of Input Tariff Reductions

Above equations (2.6) and (2.7) state that, as import tariffs decrease, firms choose to produce more outputs of higher quality. When intermediate inputs become cheaper due to import tariff reductions, the costs of production and quality upgrading get reduced. Therefore, incumbent producers can afford more expensive and high-quality intermediate goods and make more profits. Also, profitable productions would attract more firms to enter the industry. It can be shown that $\frac{\partial N}{\partial \tau} < 0$ if $\alpha^2 < 4\lambda_1 f$. A firm's quality choice results from the overall effect of two forces: more fierce competition and lower costs of quality improvement and production. The solutions indicate that firms would upgrade product quality after a reduction on import tariffs ($\frac{\partial z_i}{\partial \tau} < 0$), suggesting that the competition effect is outweighed by the cost saving effect. As a result, the country ends up with more high-quality varieties.

2.2.3 Allowing for Processing Trade

Suppose now the government sets up a processing zone. Firms consider whether to join. There is a tradeoff faced by firms: on one hand, a processing firm is qualified for zero import tariffs and therefore enjoys a cost advantage when competing with other exporters. However, on the other hand, a processing firm cannot sell products in the domestic market. So compared to an ordinary producer, a processing producer of the same productivity pays less for its output and quality production at the expense of the loss of the domestic market.

2.2.3.1 Production of Processing Firms

Since firms producing in the processing zone do not pay tariffs for imported intermediate inputs and sells products to the foreign market only, the profit function of a processing firm is given by

$$\pi_p = (p_p - cz_p)\, q_p - \frac{1}{2} z_p^2,$$

and the demand for each variety is

$$q_p = \frac{1}{\gamma}\left(\alpha + \beta z_p - p_p - \eta Q^f\right),$$

where Q^f stands for the total amount of outputs sold in the foreign market. The profit maximizing quality, quantity and the corresponding profits are given by

$$z_p = \frac{\left(\alpha - \eta Q^f\right)(\beta - c)}{2\gamma - (\beta - c)^2}, \tag{2.9}$$

$$q_p = \frac{\alpha - \eta Q^f}{2\gamma - (\beta - c)^2}, \tag{2.10}$$

and

$$\pi_p = \frac{1}{2} \frac{\left(\alpha - \eta Q^f\right)^2}{2\gamma - (\beta - c)^2}. \tag{2.11}$$

Let $\lambda_2 = 2\gamma - (\beta - c)^2$, which is the inverse of a processing firm's scope of quality differentiation. Since $\lambda_1 > \lambda_2$, import tariff exemptions permit processing firms a larger quality scope. Given the values of the parameters (γ, β, c), there is a fixed scope for quality differentiation for processing firms, which does change with import tariff rates. The optimal product quality depends only on the foreign market competition. If there is a shrinking market demand for each processing variety as more products are poured into the foreign market, a processing firm would downgrade its product quality and sells less out, leading to less profit.

2.2.3.2 Switch to Be a Processing Firm

Once processing trade is allowed, a firm would like to take actions of moving into the processing zone if and only if being a processing one is more profitable. That is

$$\pi_p = \frac{1}{2}\frac{\left(\alpha - \eta Q^f\right)^2}{2\gamma - (\beta - c)^2} \geqslant \pi_i = f. \tag{2.12}$$

By assuming two identical countries, initially, the market conditions in both countries are the same $Q^f = Q$. Hence, the profits that can be earned by a new processing firm is

$$\pi_p = \frac{1}{2}\frac{\lambda_1 f}{\lambda_2}. \tag{2.13}$$

According to (2.12) and (2.13), a firm would like to switch to produce in the processing zone if and only if

$$\lambda_1 \geqslant 2\lambda_2. \tag{2.14}$$

By the definitions of λ_1 and λ_2, equation (2.14) is equivalent to

$$\tau \geqslant \tau^* = \frac{\beta - \sqrt{2(\beta - c)^2 - 2\gamma}}{c}. \tag{2.15}$$

The critical value of import tariff is the rate which makes firms indifferent between producing inside or outside the processing zone. The inequality (2.15) is to say, when the import tariff rate is higher than the threshold, the gains of cost saving would be greater than the loss of domestic sales. Then some ordinary producers prefer to join the processing zone. Otherwise, no producers would choose to move.

2.2.3.3 Ordinary Exporters' Performance

When $\tau \geqslant \tau^*$, some producers turn to be processing type and the remaining ordinary producers would accordingly adopt different production strategies from those adopted in the case where only one type of firms is allowed. Since Manova and Zhang (2012) shows empirical evidence on firms setting different levels of quality across export destinations, I assume an ordinary exporter sets different levels of quality and different prices for the domestic and the foreign markets. In these two markets, firms have the same production conditions but face different market competitions.The profit maximizing quality and quantity for each variety produced by an ordinary firm and sold in the market j (j = d, f) are given by

$$z_{jo} = \frac{\left(\alpha - \eta Q^j\right)\left(2\gamma - \lambda_1\right)^{\frac{1}{2}}}{\lambda_1} \tag{2.16}$$

$$q_{jo} = \frac{\alpha - \eta Q^j}{\lambda_1}, \tag{2.17}$$

where $Q^d = N_0 q_{do}$ and $Q^f = N_0 q_{fo} + N_p q_p$. N_o is the number of varieties produced by ordinary exporters and N_p is the number varieties produced by processing firms. The domestic market is supplied by ordinary firms only, and the foreign market is supplied by both ordinary and processing firms. So the total output available in the foreign market equals the sum of the outputs sold by two types of firms. It is the different market demands for each variety produced by ordinary firms in different markets that motivate firms to choose different prices and different levels of quality.

Accordingly, the profits earned in market j is

$$\pi_{jo} = \frac{1}{2}\frac{\left(\alpha - \eta Q^j\right)^2}{\lambda_1}.$$

The total profits earned by each ordinary firm is given by

$$\pi_o = \sum_{j=d,f} \frac{1}{2}\frac{\left(\alpha - \eta Q^j\right)^2}{\lambda_1}. \tag{2.18}$$

2.2.3.4 Free Entry and Market Equilibrium

Since firms can freely choose to or not to move into the processing zone, if $\lambda_1 \geqslant 2\lambda_2$ holds, firms would keep moving into until two types of firms earn the same profits, both of which are equal to 0 due to the free entry condition. In other words, the free entry condition implies that in the equilibrium either type firm's total profits equals the fixed entry cost. Therefore, I have

$$\pi_p = \pi_o = f. \tag{2.19}$$

By plugging equations (2.12) and (2.18) into (2.19), I get the following two equations which are used to derive the equilibrium total outputs in market j

$$\pi_o = \sum_{j=d,f} \frac{1}{2} \frac{\left(\alpha - \eta Q^j\right)^2}{\lambda_1} = f \tag{2.20}$$

$$\pi_p = \frac{1}{2} \frac{\left(\alpha - \eta Q^f\right)^2}{\lambda_2} = f. \tag{2.21}$$

Thus, in the equilibrium, the behaviors of both types of firms can be summarized as follows. The optimal qualities chosen by ordinary firms for the domestic and the foreign markets are

$$z_{do} = \frac{\left[2f\left(\lambda_1 - \lambda_2\right)\left(2\gamma - \lambda_1\right)\right]^{1/2}}{\lambda_1} \tag{2.22}$$

$$z_{fo} = \frac{\left[2f\lambda_2\left(2\gamma - \lambda_1\right)\right]^{1/2}}{\lambda_1}. \tag{2.23}$$

The corresponding quantities supplied by ordinary firms in the domestic and the foreign markets are give by

$$q_{do} = \frac{\left[2f\left(\lambda_1 - \lambda_2\right)\right]^{1/2}}{\lambda_1} \tag{2.24}$$

$$q_{fo} = \frac{\left[2f\lambda_2\right]^{1/2}}{\lambda_1}. \tag{2.25}$$

The profits earned by ordinary firms in the domestic and foreign markets can be expressed as

$$\pi_{do} = \frac{f\left(\lambda_1 - \lambda_2\right)}{\lambda_1} \tag{2.26}$$

$$\pi_{fo} = \frac{\lambda_2 f}{\lambda_1}. \tag{2.27}$$

The optimal product quality and quantity chosen by processing firms are

$$z_p = \left[\frac{2f\left(2\gamma - \lambda_2\right)}{\lambda_2}\right]^{1/2} \tag{2.28}$$

$$q_p = \left(\frac{2f}{\lambda_2}\right)^{1/2}. \tag{2.29}$$

The equilibrium number of ordinary firms (N_o) and the equilibrium number of processing firms (N_p) are

$$N_o = \frac{\lambda_1}{\eta}\left\{\frac{\alpha}{\left[2f\left(\lambda_1 - \lambda_2\right)\right]^{1/2}} - 1\right\} \tag{2.30}$$

$$N_p = \frac{\alpha}{\eta}\left(\frac{\lambda_2}{2f}\right)^{\frac{1}{2}}\left[1 - \left(\frac{\lambda_2}{\lambda_1 - \lambda_2}\right)^{\frac{1}{2}}\right]. \tag{2.31}$$

Furthermore, it can be shown that the quality ranking is

$$z_p > z_{do} > z_i > z_{fo}.$$

The above inequalities suggest that conditional on productivity, processing firms produce higher quality goods than ordinary firms. Producing in the processing zone allows firms to be eligible for tariff exemptions on the processing of intermediate goods. This type of firms enjoy the cost advantage of final good production and quality upgrading, therefore their products are of the highest quality. Also, the optimal quality does not depend on import tariffs. Compared to processing firms, ordinary firms have to pay tariffs for imported inputs and it is more costly for them to improve product quality. So the levels of quality chosen by ordinary firms in the domestic and the foreign markets are both below the quality level of processing goods. Because of the emergence of processing trade, ordinary firms respond by upgrading the quality of the goods sold in the domestic market and downgrading the quality of goods sold in the foreign market. According to equations (2.22) and (2.25), z_{do} and z_{fo} decrease with λ_1, meaning that a reduction in import tariffs would help ordinary firms improve product qualities in both markets. The quality gap between processing and ordinary exporters will be narrowed down by lower tariff rates. But as long as the condition $\lambda_1 \geqslant 2\lambda_2$ holds, the qualities chosen by ordinary firms cannot exceed the one produced by processing firms.

The presence of processing trade results in stiffer competition in the foreign market. Since $N_p > N$ and $Q^f > Q$, the number of varieties and the amount of outputs supplied in the foreign market climb up. Without cost advantage, ordinary firms faced with stiffer competition choose to produce goods of lower quality and make less profit from their foreign sales. The loss of profits forces some ordinary firms to exit, which can be seen in equation (2.30) and $N_o < N$. Domestic consumers are therefore served by fewer firms and varieties, and a less competitive market permits ordinary firms more profits. As a result, this type of firms prefer to upgrade product quality in the domestic market as the fixed cost of improving quality is easy to be covered. The profits earned by ordinary firms are not equally distributed in the domestic and foreign markets, which occurs with the absence of processing trade. Instead, they make more profits in the domestic market than in the foreign market (i.e. $\pi_{fo} < \frac{1}{2}f < \pi_{do}$). Since $\frac{\partial N_o}{\partial \lambda_1} < 0$ and $\frac{\partial N_p}{\partial \lambda_1} > 0$, a reduction in import tariffs allows for more entry of ordinary firms. And this type of firms regain their competence in exporting when import tariffs become lower.

2.2.4 Weighted Average Export Quality

When import tariff rates are greater than the critical value defined by (2.15), there are two types of firms supplying in the foreign market. The two types of firms adopt different production strategies and exhibit different performances. Moreover, firms take different actions in response to a reduction in import tariffs. This section looks into how the rates of import tariffs affect the overall export quality. Let $\bar{z}$ represent the weighted average export quality, and it is defined as

$$\bar{z} = \frac{N_0 q_{fo} z_{fo} + N_p q_p z_p}{Q^f} = s_o z_{fo} + s_p z_p$$

where s_o and $s_p$stand for the market share of ordinary exporters and processing exporters in the foreign market. Given the optimal quantities chosen by two types of firms and the equilibrium number of varieties, firms' market shares can be expressed as

$$s_o = \frac{\frac{\alpha}{[2f(\lambda_1-\lambda_2)]^{1/2}} - 1}{\frac{\alpha}{(2f\lambda_2)^{1/2}} - 1}$$

$$s_p = 1 - s_o.$$

The foreign market share of ordinary exporters decreases in tariffs. When it is expensive to buy intermediate inputs from abroad due to high import tariffs, more firms choose to produce in the processing zone. These processing firms, who are qualified for tariff exemptions and sell more high quality products to foreign consumers than ordinary firms, crowd out the foreign sales of ordinary firms. Since a reduction in tariffs narrows down the cost difference between the ordinary and the processing firms, the former type firms would upgrade product qualities and regain part of their market shares and the latter type would maintain the same quality level as before. As a result, ordinary firms obtain a larger market share and processing firms have a shrinking share as import tariffs get reduced. But since processing goods are always of the highest quality regardless of tariff rates, the switch of market share towards ordinary exporters may result in a decrease in overall export quality.

The relation between import tariffs and average export quality can be summarized as below

$$\bar{z} = \begin{cases} z_i & if\ \tau < \tau^*, \\ s_o z_{fo} + s_p z_p & if\ \tau \geqslant \tau^*. \end{cases}$$

Thus, processing trade improves the average quality of exports. Compared to the case without processing trade, the average export quality would have been higher if allowing for the coexistence of two trade regimes, especially in industries where import tariffs on intermediate goods are high. That is, $\bar{z} \geqslant z_i$.

High import tariffs on intermediate goods drive more firms to produce as a processing type whose product quality is higher than an ordinary firm. Then the engagement of processing firms in export activities would enhance the overall export quality. The larger market share processing firms occupy, the higher average export quality will be.

Next, I exercise comparative static analysis to investigate the effect of tariff reductions on the average export quality. When $\tau < \tau^*$, all producing firms are of ordinary type, and therefore the first derivative of export quality with respect to tariffs is given by

$$\frac{\partial \bar{z}}{\partial \tau} = -\frac{\gamma}{\lambda_1} \left[\frac{f}{\lambda_1 (2\gamma - \lambda_1)} \right]^{\frac{1}{2}} \frac{\partial \lambda_1}{\partial \tau} < 0. \tag{2.32}$$

Since λ_1 is an increasing function in τ, export quality is negatively correlated with import tariffs. This is consistent with other related papers, such as Kneller and Yu (2008) and Yeaple et al (2014). When import tariffs are higher than the critical value, being a processing firm becomes a profitable option. As a result, in equilibrium, there are both processing and ordinary firms exporting to the foreign country. The average export quality depends on the quality levels chosen by two types of firms as well as their respective market shares. As equation (2.28) shows, the optimal product quality of processing firms is not related to tariff rates, so I get the first derivative as follows:

$$\frac{\partial \bar{z}}{\partial \tau} = s_o \frac{\partial z_{fo}}{\partial \tau} - (z_p - z_{fo}) \frac{\partial s_o}{\partial \tau}. \tag{2.33}$$

The first term is the quality effect of tariffs. A tariff change has an impact on the quality choice of ordinary producers, but not on processing firms. Ordinary exporters take actions of upgrading quality in response to tariff reductions, suggesting the sign of the first term is negative. The second term is the market share effect. With lower import tariffs, ordinary exporters choose to produce higher quality goods and obtain a larger market shares in the foreign country. Therefore, the market share gains are disproportionately shifted to the ordinary firms who are producing relatively low quality varieties. (Even though ordinary exporters have improved their product quality, that would be still below the quality level of processing firms.) This market share shift would result in a lower average quality level after a reduction in import tariffs. The sign of the second term is positive. Since these two effects go in the opposite directions, the overall effect of tariffs on export quality is ambiguous. It can be shown that when a certain condition is satisfied, the average export quality and tariffs are positively correlated.

The relationship between import tariffs and average export quality is presented in Figure 1. When the tariff rate is below the critical value, all firms are of ordinary type, paying tariffs for the imported intermediate inputs and selling products to the domestic and the foreign consumers. Within this range, a reduction in tariffs results in an increase in export quality. When the tariff rate is greater than the critical value, some firms choose to produce in the processing zone, paying zero tariffs on the imported inputs and serving the foreign market only. The solid curve is above the dotted one, suggesting that, at the same level of tariff rate, the average export quality by the combination of two trade regimes is higher than that by ordinary trade only. But within this range, a reduction in tariffs would lead to a decrease in the overall export quality by shifting more market share towards ordinary exporters whose products are of relatively low quality.

Two countries are assumed to be identical in this model. The analysis above does not consider the role of market size. The relative size of the domestic market affects the value of the critical tariff rate which makes producers indifferent between being of ordinary or processing type, and therefore changes the relation between tariffs and export quality. This factor has not been incorporated in the framework. It may be the next step for the model.

2.3 Empirical Work: China's Export Quality and Import Tariffs

2.3.1 Product Quality

This part aims to carry out empirical tests on the theoretical predictions shown in the previous section. In order to investigate the impacts of tariff reductions on overall export quality, the first step is to estimate the quality of Chinese goods imported by the U.S.. I follow Khandelwal (2010) in which the quality measures are derived from a nested logit demand system.

2.3.1.1 Empirical Strategies

The intuition behind the quality estimation in Khandelwal (2010) is that higher market share is assigned to products with higher quality conditional on price.A product's market share depends on price and quality, if controlling for price, the remaining variations are driven by quality differentiations.

Suppose consumer i's utility function is assumed to be

$$u_{icjt} = \lambda_{1,cj} + \lambda_{2,t} + \lambda_{3,cjt} + \alpha p_{cjt} + \xi_{ij} + (1-\sigma)\,\varepsilon_{icjt},$$

where the subscript c denotes export country, j represents variety, and t refers to year. Product qualities are reflected in three terms: $\lambda_{1,cj}$ is the time-invariant valuation that the consumer attaches to variety cj, $\lambda_{2,t}$ captures for time trends common across all varieties, $\lambda_{3,cjt}$ stands for a variety-time deviation from the fixed effect that is observed by the consumer but not the econometrician. Since the third component of quality $\lambda_{3,cjt}$ is not observed, it is treated as estimation errors. p_{cjt} is variety cj's c.i.f. price. ξ_{ij} is the nest. An import from country c within a product is called a variety, and the product (HS-10 level) serve as the nests. The nest structure allows consumer's preference to be more correlated for varieties within product than for varieties across products. ε_{icjt} is the error term which captures the residual utility that is related to consumers and products.

Consumers choose the variety which brings a higher utility level. Since the logit error ε_{icjt} is assumed to be distributed Type-I extreme value, the market share of an import cj compared to the share of U.S. domestically produced goods can be expressed as

$$lns_{cjt} - lns_{0t} = \lambda_{1,cj} + \lambda_{2,t} + \alpha p_{cjt} + \sigma ln(ns_{cjt}) + \lambda_{3,cjt},$$

where s_{cjt} is variety j's overall market share and ns_{cjt} is variety j's market share within the product. The above equation controls for price but not for products' horizontal differentiations. Imports coming from one country may occupy a large market share due to the large number of varieties exported to the U.S.. Various colors of T-shirts reflect the horizontal differentiations which would be appreciated by some consumers but not by all consumers, leading to a zero overall effect on utility. Instead, quality serves vertical product differentiations which would be valued by all individuals. Therefore, a higher quality allows a higher price without losing market shares. Therefore, it is necessary to add another term to control for product horizontal attributes. I add export country's economic size to address this issue. As stated in Khandelwal (2010), a country's population can be used as a proxy for countries' hidden varieties. The estimation equation now becomes

$$lns_{cjt} - lns_{0t} = \lambda_{1,cj} + \lambda_{2,t} + \alpha p_{cjt} + \sigma ln(ns_{cjt}) + \beta lnpop_{ct} + \lambda_{3,cjt}. \tag{2.34}$$

Moreover, equation (2.34) can be rewritten as below

$$ln\frac{s_{cjt}}{1 - s_{0t}} = \lambda_{1,cj} + \lambda_{2,t}^{'} + \alpha p_{cjt} + \sigma ln\frac{ns_{cjt}}{1 - s_{0t}} + \beta lnpop_{ct} + \lambda_{3,cjt}, \tag{2.35}$$

where $\lambda_{2,t}^{'} = \lambda_{2,t} + lns_{0t} + (\sigma - 1)ln\,(1 - s_{0t})$ represents the time fixed effect. The dependent variable is variety cj's market share in the U.S. imports. The advantage of using (2.35) is that it requires only disaggregated trade data to estimate export quality. Since equation (2.34) also needs the data on the U.S. domestic consumption, it makes regressions easier by transforming s_{0t} to $1 - s_{0t}$ and having the dependent variable as a variety's market share in the U.S. imports. I run the estimations of equation (2.35) at the SITC (Rev.2) level.

Next step is to use the estimated fixed effects and the estimated residuals from equations (2.35) to calculate product qualities of China's exports. Quality is decomposed into three parts, and estimated quality can be expressed as

$$\hat{\lambda_{cjt}} = \hat{\lambda_{1,cj}} + \hat{\lambda_{2,t}} + \hat{\lambda_{3,cjt}} + lns_{0t} + (\sigma - 1)ln\,(1 - s_{0t}) \tag{2.36}$$

As quality is initially defined as $\lambda_{cjt} = \lambda_{1,cj} + \lambda_{2,t} + \lambda_{3,cjt}$, the sum of the estimated fixed effects and estimated error terms from equation (2.35) is noised by additional two terms ($lns_{0t} +$

$(\sigma - 1)ln\,(1 - s_{0t}))$. Fortunately, these two terms are constant for a given year for all varieties.

2.3.1.2 Endogeneity

The endogeneity concern arises when p_{cjt} and $\lambda_{3,cjt}$ are possibly correlated. In the theoretical model, firms are assumed to choose the optimal quality and price simultaneously, which results in a possible correlation between the two choice variables. The literature shows evidence that expensive goods are associated with high transportation costs and more insurance expenditure, so I use transportation costs as instruments for the c.i.f price. The data set also provides variety-specific unit transportation costs which can be used directly. As long as a variety's transportation cost does not affect its quality derivation from fixed effect, the exclusion restriction holds and the endogeneity problem is fixed.

2.3.1.3 Data

I use U.S. import data to estimate the quality of China's exports to the U.S. The data are publicly available on Feenstra's website, and record U.S. imports' unit value, quantity, import tariff, and other charges over the period from 1997 to 2006. A variety's unit value is defined as the sum of the value, total duties, and transportation costs divided by the import quantity. The unit value of a variety is also the c.i.f. price faced by U.S. consumers. Feenstra has mapped five-digit SITC industries to ten-digit HS products, which makes it convenient to apply the nested logit framework to the following estimations. The data on the share of processing trade are available in China Trade and External Economic Statistical Yearbooks.

I restrict the estimations in manufacturing industries, so drop the observations whose SITC Rev.2 codes are below 50000 or above 89999. Also, since homogeneous goods do not exhibit quality differentiations, the data on imports of homogeneous goods should be excluded from the sample. According to Rauch (1999) standard, I get rid of the observations on homogeneous imports. There also exist a small fraction of missing values in the data, so I drop those with incomplete information. Variety specific transportation cost will be used as an instrument for c.i.f prices, thus I drop observations without transportation costs. To avoid extreme values, I also drop the observations with import quantity equal to or less than 1 or with gross import value less than \$7,500. In the end, there remain 1,269,983 observations in the sample. Population is included in the regressions to control for product horizontal differentiations. The data on country level population come from Penn World Table 7.0.

With the quality estimates of China's exports to the U.S., I can empirically test the two main results I obtained from the theory part.

2.3.2 Effects of Processing Trade on Export Quality

The theoretical model predicts that conditional on productivity processing firms produce higher quality goods than ordinary firms. The weighted average export quality rises in the presence of processing trade. To test this result, I propose the following specification which regresses variety quality on the share of processing trade and factor intensity:

$$quality_{jt} = \alpha_j + \alpha_t + \beta_1 s^p_{jt} + \beta_2 ki_{jt} + \varepsilon_{jt}, \tag{2.37}$$

where $quality_{jt}$ is the estimated quality of variety j imported from China in year t, α_j is the fixed effect which captures a variety's time-invariant characteristics, α_t is time fixed effect, $processing_{jt}$ is the share of processing trade in China's total exports of variety j, and $capital_{jt}$ denotes factor intensity. The share of processing trade is measured by the ratio of the value of processing exports of variety j to the value of China's total exports of variety j. The coefficient β_1 captures the impact of processing trade on export quality, controlling for other characteristics. The sign of β_1 is expected to be positive, indicating a positive impact of processing trade on export quality.

2.3.3 Effects of Import Tariff Reductions on Export Quality

Featuring the composition effect, the model predicts that the presence of processing trade is likely to lead to less quality improvement or even a quality decline following tariff reductions.

Therefore, I propose the following specification to test the effects of tariff reductions on export quality:

$$quality_{jt} = \alpha_{cj} + \alpha_t + \gamma_1 \tau_{jt} + \gamma_2 s^p_{jt-1} + \gamma_3 \tau_{jt} * s^p_{jt-1} + \varepsilon_{jt}, \tag{2.38}$$

where τ_{jt} is the import tariff on inputs used to produce variety j in year t, and s^p_{jt-1} is the share of processing trade in China's total exports of variety j in year $t-1$. The processing share of a variety's exports at year t is endogenously determined by that year's import tariffs on foreign inputs, giving rise to a biased estimate if regressing on the processing share at year t directly. To address this problem, instead, I use the share of processing trade of exports of j in the previous year, which is uncorrelated with this year's input import tariffs but strongly correlated with this year's share of processing trade. Overtime, China's processing exports are centrally distributed among several industries. The electrical machinery and transport equipment industry accounts for approximately 40 percent of China's total exports in 2010. Along with this industry, three other industries—machinery and mechanical appliances, optical and photographic instruments, and plastic—occupy about 70 percent of China's total (Ge and Lai, 2011), and the ranking maintains stable over the past decade. In addition to import tariffs, some Chinese industries possess other properties which result in a large proportion of processing firms, like the production's factor intensity, the scale of economy, and the technological gap between Chinese and foreign firms. Thus, the previous year's processing share of exports is a good instrument for this year's processing share.

In the specification (2.38), γ_1 captures the quality effect of import tariff reductions on ordinary exports, and it is expected to be negative. Ordinary producers benefit from lower import tariffs and choose to upgrade product quality in response. All else equal, γ_3 reflects the difference in quality effects of tariffs reductions on ordinary and processing exports. In line with the composition effect, I expect a positive value of γ_3, suggesting that export quality is negatively correlated with import tariffs and the correlation is stronger with ordinary firms.

2.3.4 Results

The estimation results are reported in Table 2.1. In Column (1), the effect of processing trade on export quality is positive and statistically significant. The average product quality is higher in the industries in which processing trade accounts for a larger share of total exports. In Column (2), the coefficient on the import tariff term is negative and significant, indicating the negative correlation between export quality and import tariffs. Import tariff reductions induce exporting firms to upgrade product quality by using higher quality inputs. As expected, the coefficient on the interaction term of import tariffs and previous year share of processing trade is positive. The positive impacts of lower import tariffs on export quality turns to be stronger as the export share of processing firms decreases.

To further investigate the composition effect, Table 2.2 reports the differential reactions of ordinary and processing firms as import tariffs decline. v, x, p represent number of varieties (firms), export value, and export price respectively. Subscripts j and t refer to product and year. Superscripts o and p stand for ordinary and processing exports. As seen in Columns (1) and (2), lower import tariffs are associated with a larger number of ordinary exporting firms, while tariff changes have no impacts on the number of processing firms. The correlation between ordinary export value and import tariffs is negative and significant at 5 percent level, but there is no significant relationship between value of processing exports and import tariff rates, as given in Columns (3) and (4). In terms of export price, both ordinary and processing firms charge higher prices as import tariffs are falling, which is supportive evidence on product quality upgrading.

2.4 Conclusions

This chapter studies the effects of input tariff reductions on export quality by featuring the composition change of China's exports. Firms involved in ordinary and processing trade differ in tariff treatment and access to the domestic market. The ordinary form is more profitable if input tariffs are lower and the domestic market is relatively large. Considering processing trade accounts

Table 2.1: Processing Trade and Export Quality

	(1) q_{jt}	(2) q_{jt}
s^p_{jt}	16.97***	
	(5.58)	
τ_{jt}		-0.0031***
		(0.001)
s^p_{jt-1}		-12.32*
		(6.70)
$\tau_{jt} * s^p_{jt-1}$		0.001**
		(0.000)
ki_{jt}	0.171	0.096
	(0.190)	(0.086)
Year FEs	Yes	Yes
Product FEs	Yes	Yes
Observations	4,926	4,926
R-squared	0.74	0.75

The dependent variable is the estimated quality obtained by the market share approach.
Standard errors are reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 2.2: China's Processing and Ordinary Exports and Import Tariffs

	(1)$logv^o_{jt}$	(2) $logv^p_{jt}$	(3)$logx^o_{jt}$	(4)$logx^p_{jt}$	(5)$logp^o_{jt}$	(6)$logp^p_{jt}$
τ_{jt}	-0.004***	0.000	-0.021**	-0.023	-0.012***	-0.002***
	(0.000)	(0.001)	(0.010)	(0.028)	(0.003)	(0.000)
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Product FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,938	3,860	4,938	3,860	4,938	3,860
R-squared	0.28	0.23	0.14	0.15	0.52	0.50

Standard errors are reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

for a large share of China's total exports, I focus on a composition effect arising from firm self-selection into the ordinary and the processing trade regimes following tariff reductions and provide an explanation for the over time declining trend of China's exports quality documented in trade literature. To assess the evidence, I use U.S. import data over the period from 1997 to 2006 to examine the evolutions of product quality exported from China to the US. Following the market share approach to measure quality, I find that Chinese exports experience declines in average quality in a large proportion of industries. Furthermore, there is a positive correlation between the share of processing exports and average export quality at the industry level.

Chapter 3

Effects of Rules of Origin on FTA Utilization Rates and Country Welfare

3.1 Introduction

Free Trade Agreements (FTAs) are one of the most popular forms of trade liberalization in the past 10 years. The World Trade Organization records more than 200 active regional trade agreements by January 2012. FTAs are designed to promote bilateral trade between participating countries by reducing tariffs and other trade barriers. The entry into these agreements is expected to be beneficial for exporters, since preferential market access can help firms export more and earn more profits. Most analyses so far on the impacts of FTAs assume that these agreements are used by all exporters. However, recent statistics reveal that the average FTA utilization rate is far below 100 percent, meaning that only a proportion of exporters actually take advantage of FTA preferences. Why are many exporting firms unwilling to engage in the FTA framework? What are the actual effects of FTAs on bilateral trade and country welfare?

This chapter documents three stylized facts on FTA utilization and the associated costs generated by rules of origin, which motivates a re-examination of FTA welfare effects in the context of partial utilization. First, the utilization rates of FTAs are low in general. Most trade within an FTA region takes place under the MFN tariff rates, rather than under the preferential tariff rates. For instance, the US Generalized System of Preference (GSP) provides duty-free market access to developing countries, but 40 percent of imports qualifying for GSP entered the US market without claiming the tariff benefits in 2008 Similarly, even though the ASEAN-Korea FTA permits 5 percent tariff reduction, only one fifth of Korean exporters utilize the preference (Cheong and

Cho, 2009). This suggests that assuming full utilization would overestimate the benefits of FTAs on economic outcomes. Second, strict rules of origin could be a reason for low FTA utilization rates, as it prevents goods that contain high non-regional value content from being eligible for preferential tariffs, especially in regions where countries have close vertical linkages in production with FTA outside countries. The methods of origin determination vary across products and across FTAs, which further complicates the use of FTA preferences. Third, administrative compliance and documentation costs offset tariff margin attractiveness. Rules of origin are often expensive to document. Exporters must obtain a certificate of origin from its national government and present it to the customs authority of the importing government. Herin (1986) shows that the cost of proving origin leads over a quarter of European FTA exports to pay the MFN tariff, even if the products satisfy origin. These three facts together suggest the necessity of incorporating the variable and fixed costs of complying with ROOs into FTA welfare analysis.

In this chapter, I develop a general equilibrium model in which utilizing FTA preferences incurs extra costs and heterogeneous exporting firms endogenously choose whether to be FTA users. ROOs intend to limit preferences to member parties. Free trade agreements are conditional policies, in that they require exporters to use at least some level of locally produced inputs. Products are eligible for zero tariffs only if they are actually produced in the FTA region. Otherwise, the Most Favored Nation (MFN) tariffs apply. When the ROO is binding, firms have to deviate from their optimal production strategies and employ more domestic inputs, which generates additional costs, in order to meet the ROO criterion. Additionally, to claim the trade preference, exporters must obtain a certificate from its national government attesting that the good has met the ROO. The certificate should be presented to the customs authority of the importing government to qualify for the preferential tariff rate. Going through this administrative procedure incurs additional costs, called fixed documentation costs. Thus, exporting firms face a tradeoff between enjoying lower tariffs and paying more variable and fixed costs due to complying with ROOs. Heterogeneous firms in terms of productivity and intensity of imported inputs would respond differently to the implementation of FTAs, resulting in the general under-utilization of FTAs.

My model differs from previous studies in that it focuses on the case where there is a vertical linkage in production between FTA participating countries. This is an interesting case for study for two reasons. First, ROOs can provide hidden protection for producers of intermediate inputs within the FTA region. The degree of restrictiveness of the ROO could affect compliance costs and the value chain in the most fundamental way. The downstream country could source intermediate inputs worldwide, but turn to import from regional suppliers if the agreement sets a strict rule of origin. For instance, the trade value of automobile parts and intermediate inputs from the US to Mexico increases dramatically after the implementation of NAFTA (Oliver et al., 2002). AFTA also promotes trade in intermediate goods between ASEAN countries (Hiratsuka et al., 2008). Second, such a production connection between countries is important for welfare analysis, since it rationalizes welfare gains following a slightly stricter rule of origin. The conventional studies argue that a stricter rule of origin reduces the FTA utilization rate and mitigates the potential benefits of the preferential trade arrangement. These conclusions are based on the assumption that the FTA countries trade horizontally differentiated goods and there is no vertical production linkage between them. However, as we see in the real world, a large amount of FTAs are signed between developed and developing countries which are good at different stages of production. In such cases, ROOs are not always bad. A binding ROO could not only effectively protect regional producers of intermediate goods from import competition, but also raise country welfare when the elasticity of substitution between varieties are relatively small.

In order to explore the implications of heterogeneous utilization of a free trade agreement, I show global numerical solutions to the model by using GAMS. The further decomposition of welfare effects of ROOs is conducted by local comparative static exercise in the neighborhood of full utilization. The model yields three main results. First, within an industry, more productive firms choose to comply with ROOs and utilize the preferential tariffs granted by FTAs, and less productive firms choose to not comply with ROOs and pay the most favored nation (MFN) tariffs. This is due to the fact that it is more costly for a firm with a lower productivity to switch to more expensive intermediate inputs produced locally, and the firm, as a result, is less likely to comply with the rule and claim preferential tariffs. Also, an industry that heavily relies on imported inputs tends to have a low FTA utilization rate if the agreement sets a small tariff margin, a strict ROO, and complicated documentation procedures.

Second, the intensive use of locally produced inputs due to ROOs generates distortions in the labor market. As ROOs become stricter, there are two opposing factors that influences labor demand. On the extensive margin, the trade preferences will be utilized by fewer exporters. For those who exported under preferential tariffs before, an exit from the FTA framework leads to a reduction in the demand for local inputs, since they no longer need to comply with the origin rule. On the intensive margin, for those who are still using FTA, more domestic inputs are demanded due to the tightening local content requirement. The overall effect on wage depends on the distribution of sales of FTA users and nonusers. The local comparative static analysis and the numerical results show that the extensive margin dominates. The total demand for labor decreases in the restrictiveness of ROOs. So does the equilibrium wage rate.

Third, regarding the welfare effects of ROOs on FTA participating countries, the elasticity of substitution between varieties plays an essential role. The welfare level is measured as real income. The overall effects of ROOs on country welfare can be decomposed into three channels. One is income channel, in that a stricter ROO generates large distortions in manufacturing process and forces more exporters to be FTA non-users and pay the MFN tariffs. Thus, the importing country earns more tariff revenues. Also, labor income changes with ROOs in a general equilibrium framework. The second channel is through terms of trade. The exporting prices charged by the firms which are affected ROOs are jointly determined by the restrictiveness of ROOs, domestic labor cost, and the MFN tariff rates. Higher individual prices benefit the exporting country but hurt the importing country. The last one is variety channel. The price index of differentiated varieties decreases with the number of varieties available in the market. Thus, firm entry raises country welfare. The magnitude of the variety effect depends on how substitutable the varieties are.

The overall effects of ROOs on country welfare are considered in two seperate cases. If the elasticity of substitution between varieties is relatively small, both FTA participating countries experience welfare increase, which is mainly driven by the significant positive variety effect. In such a case, consumers benefit more from the introduction of new varieties. Resources are allocated to the more efficient producers and a tighter ROO induces the production of intermediate goods to move from the outside country to within the FTA area. ROOs help protect regional producers and promote regional trade in intermediate and final goods. If the elasticity of substitution is relatively large, the welfare of the upstream country, which is more efficient in producing intermediate inputs, develops an inverted-U shape relationship with ROOs. When the ROO is slightly binding, the positive income effect and variety effect outweigh the negative price effect, and as a result, country welfare increases with ROOs. As the ROO rises further, the distortions in firm production generated by a strict ROO have a larger impact on product prices and the negative price effect (terms of trade) is a more important determinant of welfare, implying a decrease of welfare with ROOs. The welfare of the downstream country declines following a stricter ROO, since variety effect is negatively correlated to the elasticity of substitution between varieties and the negative terms of trade effect dominates. Both local analytical solutions and simulation results confirm these conclusions.

There is usually a hot debate over a suitable rule of origin for each industry before a free trade agreement is signed. The underlying policy goal of setting ROO is to protect domestic producers and improve returns to local factors of production. But the actual effects of origin rules are not well understood. Demidova et al. (2006) and Ju and Krishna (2005) incorporate binding ROOs which allow firms to escape paying tariffs but involve an additional per-unit cost in order to satisfy local content requirements. They examine the impacts of FTA on wage in a general equilibrium framework, and conclude that stricter ROOs reduce the wage while raising the cutoff for firms invoking ROOs. But their work does not take into account domestic input producers whom ROOs primarily aim to protect. There is also no attention given to the magnitudes of the increase in unit cost caused by rules of origin. The other type of extra costs that may prevent exporters from utilizing FTA preferences is fixed documentation costs. In the literature, Brenton and Manchin (2003) points out that FTAs are not fully exploited because of the costs of proving origin and difficulties in passing though customs. A simpler and less demanding system would make it easier for small companies in developing countries to obtain preferential access to foreign markets. Cherkashin et al. (2009) argue that firm heterogeneity and higher fixed costs of exporting due to using FTAs can rationalize partial utilization. But this strand of literature does not consider firms' responses to local content requirements in order to be qualified for trade preferences. Neither the additional variable costs nor fixed costs accompanied with FTAs are negligible in the analysis of firms' decisions on the use of FTAs.

3.2 Stylized Facts

3.2.1 Utilization Rates of Free Trade Agreements

Free trade agreements are designed to promote regional exports and imports by granting traded goods preferential or even zero tariff rates. Such tariff margins are obviously beneficial to exporting firms, and therefore most studies on the effects of FTAs on trade and welfare assume all exporters in the region are claiming preferential tariffs. However, in fact, the utilization rates of FTAs are far below 100 percent. Utilization rate is defined as the ratio of value of imports granted under FTA preference to value of imports eligible for FTA preference. Table 3.1 lists the actual rates of utilization of several major FTAs. The utilization rates vary considerably from 5.49% to 71.97%, and most of them are below 50%. For instance, only 20 percent of Korean firms import goods from ASEAN countries under Korea-ASEAN FTA, and 13.45% of exports from Singapore to China utilize the preferential tariff rates granted by China-Singapore FTA. NAFTA and China-Pakistan FTA are relatively intensively utilized and the utilization rates are 55% and 71.79% respectively. But none of them are close to full utilization. In other words, within an FTA area, only a proportion of exporting firms choose to export under lower tariffs and there are a large amount of products are not engaged in the free trade arrangement.

Moreover, FTA utilization rates also vary considerably across industries. Under the US Generalized System of Preference (GSP), the average utilization rate across all industries is 60%

Table 3.1: Utilization Rates of Free Trade Agreements

FTA	**Year**	**Utilization Rate**
NAFTA	2005	55%
China-ASEAN FTA	2013	34.95%
Asia-Pacific Trade Agreement	2013	14.34%
China-Singapore FTA	2013	13.45%
China-New Zealand FTA	2013	31.67%
China-Chile FTA	2013	6.55%
China-Peru FTA	2013	5.49%
China-Pakistan FTA	2013	71.97%
Korea-ASEAN FTA	2005	20.11%
US Generalized System of Preference (GSP)	2008	60%
GSP-Electrical Machinery and Equipment	2008	22%
GSP-Iron and Steel	2008	85%

in 2008. The industrial level data reveal that the utilization rate in the Electrical Machinery and Equipment industry is barely 22%, while the rate in the Iron and Steel industry is as high as 85%. The cross-industry variations suggest that factor intensity of production and procurement of intermediate inputs could be determining factors of firms' decisions in FTA participation.

In sum, the utilization rates of FTAs are low in general. Most trade within an FTA region takes place under the MFN tariff rates, rather than under the preferential tariff rates. Assuming full utilization would overestimate the benefits of FTAs on economic outcomes to a large extent. It is worth investigating the reasons for low utilization rates and bringing partial utilization to the related analysis of free trade agreements.

3.2.2 Rules of Origin Hurdles

Free trade agreements are conditional trade policies. The common low utilization rates of FTAs around the world suggest that in addition to tariff benefits, the associated costs of FTA implementation are substantial. It is the additional costs that prevent eligible firms to utilize the preferential tariff rates. Rules of origin could be one of them. Rules of origin require that only the products which are actually produced in the FTA region are qualified for preferential tariff rates. Each free trade agreement assigns specific rules of origins for goods in each category. Table 3.2 lists the product specific rules stated in ASEAN (Annex 3) and NAFTA (Annex 401). There are three main methods of origin determination. The most strict one requires the products are wholly obtained or produced in the exporting member state. The second sets a minimal percent of local value content in the products. For instance, ASEAN FTA testifies the origin of a product if it contains 60 percent or more regional value content, and NAFTA requires a regional value content of not less than 60 percent where the transaction value method is used or 50 percent where the net cost method is used. The third method to confer origin is to show that the production taking place within the region makes substantial transformation to the products so that its tariff heading or subheading is changed. Considering the fact that most ASEAN countries undertake a great volume of production along the global value chain, the rules of origin in ASEAN FTA is relatively strict.

Table 3.2: Free Trade Agreements and Rules of Origin

FTA	Chapter (HS2007)	Rules of Origin
ASEAN FTA	51 - 63	A regional value content of not less than 40 percent; or A significant change in heading/subheading; or Process Rules for Textile and Textile Products as set out in Attachment 1.
	79, 80	Wholly obtained or produced in the exporting Member State.
	84, 85, 87, 90	A regional value content of not less than 40 percent; or A significant change in heading/subheading.
NAFTA	61 - 63	A significant change in heading /subheading; and (a) the good is both cut (or knit to shape) and sewn or otherwise assembled in the territory of one or more of the Parties; and (b) the visible lining fabric listed in Note 1 to Chapter 61 satisfies the tariff change requirements provided therein.
	73, 74, 79	A significant change in heading /subheading; or a regional value content of not less than 60 percent where the transaction value method is used or 50 percent where the net cost method is used.
	84, 85, 87, 90	A significant change in heading /subheading; or a regional value content of not less than 60 percent where the transaction value method is used or 50 percent where the net cost method is used.

Data sources: ASEAN ANNEX 3 Product Specific Rules and NAFTA ANNEX 401.

All in all, rules of origin are an important part of an FTA and vary across products and across FTAs. Strict rules of origin could be a reason for low FTA utilization rates, as it prevents goods that contain high non-regional value content from being eligible for preferential tariffs, especially in regions where countries have close vertical linkages in production with outside countries.

3.2.3 Administrative Compliance and Documentation Costs

In addition to the restrictiveness of ROOs, the costs of complying with the procedures of origin certification are another reason for low FTA utilization rates. Rules of origin are often expensive to document. Exporters must obtain a certificate from its national government and present it to the customs authority of the importing government. Going through such an administrative procedure makes the FTA preferences less attractive. Medalla and Rosellon (2012) conduct a survey on the typical process for acquiring a certificate of origin. The pre-export verification requires documentations like company registration, business license, organization code, etc. Processing time from pre-export verification to issuance of certificate of origin ranges widely, from one working day (as for Australia and New Zealand) to not more than 30 working days (as for China and Brunei). Part of the survey results are reported in Table 3.3. It is the least costly to obtain a certificate for exporters producing in Australia and New Zealand. The pre-export verification can be done within one working day or automatically for electronic application. The entire processing time is within a day. In the case of Korea and Japan, it takes about three working days to complete the administrative procedure. For other countries, like Laos, China, and Malaysia, exporters have to wait five to thirty working days to get a certificate.

Large fixed costs are another hurdle for FTA utilization, including learning about FTA provisions and obtaining certificates of origin. Processing time for origin certification varies across countries. Small and medium size exporters are less able to muster the requisite financial and human resources than large firms, and therefore are less likely to utilize trade preferences. The tariff margin attractiveness granted by an FTA is, at least partially, offset by documentation costs.

Table 3.3: Processing Time of Origin Certification across Countries

Country	Issuing Authority	Examination of Origin	Issuance of Certificate
Australia	Australian Industry Group	Automatic	Within 1 working day
Brunei	Department of Trade Development	30 days	1-2 working days
Cambodia	Ministry of Commerce	Within 7 working days	10 hours
China	Entry-Exit Inspection Bureau	20-30 working days	Within 1 day
Japan	Japan Chamber (JCCI)	Within 3 working days	Within 2 working days
Korea	Korean Customs Service	3-10 working days	Within 1 day
Laos	Ministry of Commerce and Industry	3-7 days	3 days
New Zealand	New Zealand Chamber	1 working day	1 working day
Philippines	Bureau of Customs	Within 5 working days	Within same day
Thailand	Thailand Ministry of Commerce	3 working days	Within 1 day

Sources: ERIA Project (2011) and Medalla and Rosellon (2012).

3.3 The Model

3.3.1 Set-up

Consider a free trade area consists of two countries: country A and country B. There are many downstream firms producing final differentiated goods in both countries, and firm productivities follow the same distribution. The only difference between the final good producers in the two countries lies in the sources of intermediate inputs. Country A is assumed not to produce intermediate goods, and final good producers import intermediate goods from either country B or an outside country, depending on import prices. In country B, there are upstream firms supplying intermediate goods, and final good producers in that country choose to employ domestically produced inputs. Differentiated final products can be sold to the other country at a zero tariff rate if the products meet ROOs. As such, ROOs would affect the productions of exporters in country A only. Since this chapter focuses on the use of FTA, I assume away fixed costs of producing and exporting, meaning that all firms are active exporters but export to the other country at different tariffs. Labor is inelastically supplied and perfectly mobile between upstream and downstream firms. The model builds on Melitz (2003), to which I add intermediate goods, tariff preferences and fixed costs of using FTAs.

3.3.1.1 Preference

On the demand side, the preference of a representative consumer in country j ($j = A,\ B$) is given by a nested Cobb-Douglas utility function:

$$U_j = X_j^{\alpha} H_j^{1-\alpha} \tag{3.1}$$

where

$$X_j = \left[\int_{\Omega_j} x_{ij} \left(\varphi\right)^{1-1/\sigma} d\varphi \right]^{1/(1-1/\sigma)}.$$

Ω denotes the endogenous set of differentiated varieties sold in country j, $x_{ij}\left(\varphi\right)$ is quantity of variety φ produced in i and consumed in j, and the elasticity of substitution between any two varieties within this industry is constant and equals $\sigma > 1$. H_j represents the consumption of homogeneous goods in country j. Homogeneous goods can be traded freely across countries and its price is normalized to be 1. α is the standard Cobb-Douglas parameter which stands for the expenditure share on differentiated varieties. As in Dixit and Stiglitz (1977), the demand for variety φ is given by

$$x_{ij}(\varphi) = \frac{\alpha I_j}{P_{xj}^{1-\sigma}} p_{ij}(\varphi)^{-\sigma}, \tag{3.2}$$

where $p_{ij}(\varphi)$ is the price of variety φ produced in i and sold in j, I_j is the representative consumer's income in country j, and P_{xj} is a price index of differentiated goods in j such that $P_{xj} = [\int_{\varphi\in\Omega_j} p_{ij}(\varphi)d\varphi]^{1/(1-\sigma)}$.

Under monopolistic competition, the optimal price for each variety is a constant mark-up over unit cost. Hence, I have

$$p_{ij}(\varphi) = \frac{\sigma}{\sigma-1}\tau_{ij}c_i(\varphi), \tag{3.3}$$

where $c_i(\varphi)$ denotes variety φ's variable production costs in country i. $\tau_{ij} > 1$ is gross tariff rate imposed by importing country j, and $\tau_{ii} = 1$.

3.3.1.2 Production in Country A

Final goods X are produced using labor (L_a) and intermediate inputs. Since there are no upstream firms in country A, final good producers import intermediate inputs from country B (M_b) and/or an outside country C (M_c). The intermediate inputs originated from different countries are assumed to be perfect substitutes, and how intensively the firm uses the imported inputs depends on the ROOs and import prices. The production function takes a Cobb-Douglas form with constant returns to scale:

$$x_a(\varphi) = \varphi\left(\frac{M_b+M_c}{\beta}\right)^{\beta}\left(\frac{L_a}{1-\beta}\right)^{1-\beta},$$

where φ denotes a firm's total factor productivity. Final good producers are heterogeneous in the sense that they have different productivity draws from the Pareto distribution $G(\varphi) = 1 - \varphi^{-\varepsilon}$, where ε measures the inverse of dispersion. A large value of ε implies that firms are less heterogeneous and the market structure is more competitive. Firms produce horizontally differentiated final goods and each variety is indexed by $\varphi \in [1, +\infty]$. To ensure there exists a closed solution, I assume $\sigma < \varepsilon + 1$. β stands for the cost share of imported inputs in the production, which is independent of wage rate and prices of intermediate inputs.

Firms take the prices of inputs as given. Without any additional restrictions, each firm chooses labor and intermediate goods to minimize unit production costs:

$$\min_{\{M_b, M_c, L_a\}} p_{mb} M_b + p_{mc} M_c + w_a L_a$$

$$s.t.\ x_a(\varphi) \geqslant 1$$

Thus, the unconstrained unit production cost can be expressed as

$$c_a(\varphi) = \frac{p_{mc}^{\beta} w_a^{1-\beta}}{\varphi}. \tag{3.4}$$

For simplicity, I assume the outside country C is more efficient than country B in producing intermediate goods, so that $p_{mb} > p_{mc}$. The final good producers in country A initially choose to import inputs from country C. The unconstrained unit cost is decreasing in productivity and increasing in prices of inputs. Also, the cost share of foreign contents is β. Firms within one industry differ in productivity and unit cost, but spend the same percentage of production costs on intermediate inputs produced abroad.

Accordingly, the unconstrained unit demand for labor and the unconstrained unit demand for intermediate goods are:

$$l_a = \frac{1-\beta}{\varphi} \left(\frac{p_{mc}}{w_a} \right)^{\beta}, \tag{3.5}$$

$$M_c = \frac{\beta}{\varphi} \left(\frac{w_a}{p_{mc}} \right)^{1-\beta}. \tag{3.6}$$

3.3.1.3 Production in Country B

In the intermediate good sector, labor is the only factor of production, and the products are sold in a perfectly competitive market. Thus, I have the price of intermediate goods produced in country B equals costs:

$$p_{mb} = \frac{w_b}{a_{mb}}, \tag{3.7}$$

where w_b is the wage rate in country B and a_{mb} is the labor efficiency in the production of intermediate goods in country B.

Following the same production function as in country A, firms use labor and domestically produced intermediate inputs to produce final products. The variable cost of producing 1 unit of output is given by

$$c_b(\varphi) = \frac{p_{mb}^{\beta} w_b^{1-\beta}}{\varphi}. \tag{3.8}$$

As shown in the cost equation, all inputs are sourced from domestic suppliers. Thus, the final goods produced in country B automatically satisfy the rule of origin, no matter how strict it is. All the exporters producing in country B would utilize the FTA preferences and export to country A under zero tariff rates.

Moreover, country B also produces homogeneous goods, which are the numeraire goods in the model. Producing 1 unit of homogeneous good requires1 unit of labor, and homogeneous goods can be traded freely across countries. Hence, the wage rate in country B is normalized to be 1.

3.3.2 Utilizing FTAs

The preferences granted by the free trade agreement are conditional. To be qualified for zero tariffs, final varieties must satisfy the ROO. Suppose the ROO requires the cost share of local contents to be no less than γ and $0 < \gamma < 1$. As such, the cost minimization problem for the firm with productivity φ is subject to an additional constraint regarding the source of the inputs:

$$\min_{\{M_b, M_c, L_a\}} p_{mb}M_b + p_{mc}M_c + w_aL_a$$

$$s.t.\ x_a(\varphi) \geqslant 1$$

and

$$\frac{p_{mc}M_c}{p_{mb}M_b + p_{mc}M_c + w_aL_a} \leq 1 - \gamma.$$

Then, the constrained unit production cost can be derived as

$$c_{ac}(\varphi) = \lambda c_a(\varphi) \tag{3.9}$$

where

$$\lambda = \begin{cases} 1, & if\ \beta \leqslant 1-\gamma \\ \left[\frac{\beta}{(\beta+\gamma-1)\frac{p_{mc}}{p_{mb}}+1-\gamma}\right]^{\beta}, & if\ \beta > 1-\gamma. \end{cases} \tag{3.10}$$

λ measures the rise in unit production costs due to complying with ROO. If $\beta \leqslant 1-\gamma$, the ROO is not binding. In this case, firms' productions involves more domestic contents than the requirement, therefore the second constraint of the optimization problem is automatically satisfied and firms will stay with their optimal production plans. Comply with ROO does not generate additional production costs, so $\lambda = 1$. If $\beta > 1-\gamma$, the ROO is binding. That is, firms use more foreign intermediate goods than the requirement. In this case, if firms intend to utilize the FTA preferences, they need to deviates from their optimal production strategies by using more local inputs to meet the ROO. Hence, $\lambda > 1$, and it increases with β and γ. The stricter the origin rule is, the more the unit cost will increase by.

The corresponding constrained demands for labor and intermediate inputs are given by

$$l_{ac}(\varphi) = \lambda l_a(\varphi), \tag{3.11}$$

$$M_{cc} = M_c C \quad and \quad M_b = \frac{\beta}{\varphi}\left(\frac{w_a}{p_{mb}}\right)^{1-\beta} B, \tag{3.12}$$

where $C = \left(\frac{1-\gamma}{\beta}\right)^{1-\beta}\left[\frac{1}{\left(\frac{\beta+\gamma-1}{1-\gamma}\right)\left(\frac{p_{mc}}{p_{mb}}\right)+1}\right]^{\beta} < 1$ and $B = \frac{\beta+\gamma-1}{\beta}\left[\frac{\beta}{\beta+\gamma-1+(1-\gamma)\left(\frac{p_{mb}}{p_{mc}}\right)}\right]^{\beta} > 1.$

Since the ROO requires more intensive use of locally produced inputs, the constrained demands for labor and the intermediate goods from country B are greater than in the unconstrained case, and they increase in the restrictiveness of ROO (γ). In contrast, the demand for the intermediate goods originating from country C decreases as a binding ROO takes effect on firm production.

3.3.3 Partial Equilibrium

Whether a firm chooses to utilize the preferential tariffs or not depends on the associated benefits and costs. On the one hand, a firm would charge a lower price and make more sales in the foreign market due to the tariff reductions. On the other hand, the distorted sourcing of inputs generates extra production costs. Moreover, firms have to pay fixed documentation costs (f_d) in order to obtain a certificate of origin and claim the FTA preferences.

Assume there are no fixed costs of production and exporting. If the firm exports under the MFN tariffs, it needs to pay a per unit tariff $\tau_{ij} > 1$ to access the foreign market. The profits are revenues less costs in the domestic and the foreign markets. In particular, the profits of an FTA non-user can be expressed as:

$$\pi_1 = \pi_{ad} + \pi_{an} = \frac{1}{\sigma} p_{ad} x_{ad} + \frac{1}{\sigma \tau_{ij}} p_{an} x_{an}, \tag{3.13}$$

where π_{ad}, p_{ad}, and x_{ad} are firm's profits, price, and quantity sold in the domestic market, and π_{an}, p_{an}, and x_{an} are firm's profits, price, and quantity sold in the foreign market as an FTA non-user.

If a firm chooses to utilize the FTA preferences, it pays zero tariff, constrained unit costs, and a positive fixed documentation cost. Hence, the corresponding profits of an FTA user is given by

$$\pi_2 = \pi_{ad} + \pi_{af} = \frac{1}{\sigma} p_{ad} q_{ad} + \frac{1}{\sigma} p_{af} q_{af} - f_d w_a, \tag{3.14}$$

where fixed documentation costs are paid in units of labor, and π_{af}, p_{af}, and x_{af} are the firm's profits, price, and quantity sold in the foreign market as an FTA user. Comparing the profits of FTA users and no-users, there is a tradeoff between optimizing the source of intermediate inputs and having access to preferential tariffs, given that $\lambda \geqslant 1$ and $\tau_{ij} > 1$. Exporters would enjoy a zero tariff at the expense of using more expensive inputs produced domestically. I assume $\lambda < \tau$, the increase in unit cost due to ROO is smaller than the tariff margin. Otherwise, no one would utilize the preferential tariffs offered by FTA.

From the individual firms' perspective, it is the increased profits that motivate them to join the FTA. Firms are willing to take advantage of zero tariffs if and only if $\pi_2 \geqslant \pi_1$. The productivity threshold for utilizing FTA preferences should be the value which makes the firm indifferent between being and not being an FTA user. That is, $\pi_1(\varphi^*) = \pi_2(\varphi^*)$. Combining the conditions I have derived above, the critical value is determined by

$$\varphi^* = \left[\frac{\kappa f(w_a)^{\sigma-1} f_d}{\lambda^{1-\sigma} - \tau^{1-\sigma}}\right]^{\frac{1}{\sigma-1}} \tag{3.15}$$

where $\kappa = \frac{\sigma^\sigma}{(\sigma-1)^{\sigma-1}} \frac{1}{P_{xb}^{\sigma-1} I_b}$ and $f(w_a) = p_{mc}^{\beta} w_a^{1-\beta}$. κ represents the market demand condition in the importing country, which is held constant in partial equilibrium analysis. A small value of κ is associated with a large foreign market size (I_b) and a low price index (P_{xb}), both of which indicate a strong market demand for variety φ. Similar to Melitz (2003), firms with different productivities end up with different sales patterns. Only firms with productivities above the cutoff φ^* invoke the preferential tariffs while exporting. If $\lambda^{1-\sigma} - \tau^{1-\sigma} \geqslant \kappa f(w_a)^{\sigma-1} f_d$, the FTA will be fully utilized. All firms export under zero tariffs and make more revenues due to a lower trade barrier: $r_2(\varphi) - r_1(\varphi) \geqslant (\frac{\sigma}{\sigma-1})^{1-\sigma} \frac{I_b}{P_{xb}^{1-\sigma}} c_a(\varphi)^{1-\sigma} \kappa f_d > 0$, where $r_1(\varphi)$ and $r_2(\varphi)$ refer to export revenues by not using and using FTA. If $\lambda^{1-\sigma} - \tau^{1-\sigma} < \kappa f_d$, $\varphi^* > 1$ follows. The FTA is partially utilized. Firms with productivities smaller than the cutoff would export under the MFN tariffs. The increase in exporting revenues induced by claiming the zero tariffs is still positive, but it is much less than the revenue gains in the case with full utilization, since it can be shown:

$0 < r_2(\varphi) - r_1(\varphi) < \frac{I_b}{P_{xb}^{1-\sigma}} c_a(\varphi)^{1-\sigma} \kappa f_d$. Therefore, assuming full utilization of trade preferences may overstate the role of FTAs in promoting bilateral trade.

The FTA utilization rate is the fraction of export value that takes advantage of the trade agreement and pays lower tariffs. In this model, it is determined by the productivity threshold of using FTA (φ^*):

$$
\begin{aligned}
u &= \frac{\int_{\varphi^*}^{\infty} r_2(\varphi) dG(\varphi)}{\int_1^{\varphi^*} r_1(\varphi) dG(\varphi) + \int_{\varphi^*}^{\infty} r_2(\varphi) dG(\varphi)} \\
&= \frac{1}{\left(\frac{\tau}{\lambda}\right)^{1-\sigma} \left[(\varphi^*)^{\varepsilon-\sigma+1} - 1 \right]} \qquad (3.16)
\end{aligned}
$$

As shown in (3.16), the larger the threshold is, the lower the utilization rate is. Thus, if an FTA sets a large tariff margin, a loose ROO and simple administrative procedures, there will be a low productivity threshold of utilizing FTA preferences and a high utilization rate. Also, the utilization rate is relatively high in the industries where imported inputs account for a small cost share and it is less costly to comply with ROOs.

3.4 General Equilibrium

Welfare analysis is approachable in a general equilibrium framework. In this section, I present a general equilibrium model to investigate the welfare effects of ROOs and use GAMS to simulate the results. Now consider a world comprised of three countries (A, B, and C). Two of them, country A and country B, sign a free trade agreement in which countries permit zero import tariffs to exports from the partner country if the products satisfy the ROO. Exporters producing in country A are affected by ROOs. They have to reduce the use of inputs imported from country C in order to be qualified for tariff benefits when the ROO is restrictive. Firms have different productivities in producing differentiated final goods and they select themselves into profitable sales patterns. Homogeneous goods are traded costlessly across countries in order to keep trade balanced. Since the firm heterogeneity complicates the computation, I adopt the representation of the average firm operating in each sale pattern, which is proposed by Balistreri and Rutherford (2011) and simplifies the model effectively.

3.4.1 Country A

Country A is one of the participants of the free trade agreement. The labor endowment is denoted as L_a. Workers in country A produce final differentiated goods. The documentation costs and the firm entry costs are paid in units of labor. Workers are also consumers, and the utility function is given by (3.1).

3.4.1.1 Production of Final Goods

As shown in the previous section, more productive firms choose to comply with the ROO and export under zero tariffs. I assume the number of FTA non-users is n_1 who stick with their original production strategies and pay tariffs while exporting, and the rest n_2 firms are FTA users. The average productivity of FTA non-users is denoted by $\tilde{\varphi_1}$ and the average productivity of FTA users is $\tilde{\varphi_2}$. Thus, the unit production costs for two types of firms are

$$c_1(\tilde{\varphi_1}) = \frac{p_{mc}^{\beta} w_a^{1-\beta}}{\tilde{\varphi_1}} \tag{3.17}$$

$$c_2(\tilde{\varphi_2}) = \frac{\lambda p_{mc}^{\beta} w_a^{1-\beta}}{\tilde{\varphi_2}}. \tag{3.18}$$

Under monopolistic competition, heterogeneous firms set a constant markup over the unit costs and the optimal prices for two groups of firms are given by

$$\tilde{p_{1j}} = \frac{\sigma \tau_{ij}}{\sigma - 1} c_1(\tilde{\varphi_1}) \tag{3.19}$$

$$\tilde{p_{2j}} = \frac{\sigma}{\sigma - 1} c_2(\tilde{\varphi_2}). \tag{3.20}$$

Accordingly, the demands for the average varieties in the two countries are

$$\tilde{q_{1j}} = \frac{\alpha I_j \tilde{p_{1j}}^{-\sigma}}{P_{xj}^{1-\sigma}}, \tag{3.21}$$

$$\tilde{q_{2j}} = \frac{\alpha I_j \tilde{p_{2j}}^{-\sigma}}{P_{xj}^{1-\sigma}}, \tag{3.22}$$

where I_j represents consumers' total income in country j and P_{xj} stands for the price index of differentiated goods in country j. The corresponding profits earned by firms can be expressed by

$$\tilde{\pi_{1j}} = \frac{1}{\sigma}\tilde{p_{1j}}\tilde{q_{1j}} \tag{3.23}$$

$$\tilde{\pi_{2j}} = \frac{1}{\sigma}\tilde{p_{2j}}\tilde{q_{2j}} - f_d w_a. \tag{3.24}$$

The indifference condition for the marginal firm can be derived in terms of the average FTA user's revenues and the parameters by linking the average FTA user's and nonuser's productivities and revenues to the marginal firm through the Pareto distribution. The equivalent condition to the cutoff condition (3.15) is given by the equation below:

$$\frac{1}{\sigma}\frac{\varepsilon + 1 - \sigma}{\varepsilon}\left[1 - \left(\frac{\tau}{\lambda}\right)^{1-\sigma}\right]\tilde{p_2}\tilde{q_2} = f_d w_a. \tag{3.25}$$

Moreover, the free entry condition drives firms' profits down to zero:

$$\sum_{j=A,B}\tilde{\pi_{1j}} = \sum_{j=A,B}\tilde{\pi_{2j}} = w_a f_e \tag{3.26}$$

The productivity of the marginal exporter and the fraction of FTA users can be linked by $n_2 = 1 - G(\varphi^*)$. With this relationship, I can express the average productivities of nonusers and users in terms of the number of exporters using FTA as

$$\tilde{\varphi_1} = \left[\frac{\varepsilon}{\varepsilon+1-\sigma}\frac{1-n_2^{\frac{\varepsilon+1-\sigma}{\varepsilon}}}{1-n_2}\right]^{\frac{1}{\sigma-1}} \tag{3.27}$$

$$\tilde{\varphi_2} = \left(\frac{\varepsilon}{\varepsilon+1-\sigma}\right)^{\frac{1}{\sigma-1}} n_2^{-\frac{1}{\varepsilon}}. \tag{3.28}$$

3.4.1.2 Labor Market and Income Balance

The labor market clearing condition is

$$L_a = n_1 l_a \sum_{j=A,B} \tilde{q_{1j}} + n_2 \left(\tilde{q_{2a}} l_a + \tilde{q_{2b}} l_{ac}\right) + n_a f_e + n_2 f_d \tag{3.29}$$

where $n_a = n_1 + n_2$ is the total number of firms producing in country A, and n_1 and n_2 are the number of FTA non-users and users respectively. f_e is the units of labor required to hire to enter the market. Labor demand consists of four parts: the demand by FTA non-users and users to produce outputs, the demand by all active firms to pay entry costs, and the demand by FTA users to pay documentation costs.

Following the free entry condition, consumer's total income is wage payment. Therefore, the income balance condition is

$$I_a = w_a \bar{L_a}. \tag{3.30}$$

3.4.2 Country B

Country B, the second participant in the FTA, produces and exports to country A differentiated goods and homogeneous goods H ($p_H = 1$). The labor endowment is L_b. Consumers' utility is derived over a continuum of differentiated varieties and homogeneous goods.

All exports originating from country B satisfy the ROO and claim preferential tariffs. The free entry condition for firms producing in country B implies that

$$\tilde{\pi_b} = \frac{1}{\sigma}\tilde{p_b}\sum_{j=A,B}\tilde{q_{bj}} = f_b w_b, \tag{3.31}$$

where $\tilde{\pi_b}$, $\tilde{p_b}$, and $\tilde{q_{bj}}$ are the profits, price, and quantity of the average exporter in country B. f_b is the entry costs in country B and is paid by labor. Since all exports from country B are qualified for zero tariffs, firms charge the same price in the domestic and the foreign markets.

The labor market clearing condition equates labor supply and demand:

$$L_b = n_b l_b \sum_{j=A,B}\tilde{q_{bj}} + n_b f_b + \frac{n_2 \tilde{q}_{af} M_b}{a_{mb}} + h_{bp}, \tag{3.32}$$

where n_b is total number of exporters from country B, l_b is the labor demand by producing 1 unit of differentiated good, and h_{bp} is the quantity of homogeneous goods produced in country B. Country B conducts three production activities. The first two terms on the right hand side of (3.32) indicate the labor demand by firms producing final goods. The third term is the labor working in the intermediate good sector, and the last term is the labor demand in the production of homogeneous goods.

Country B's total income comes from two sources. One is labor income by producing differentiated and homogeneous goods, and the other is import tariff revenues imposed on country A's FTA non-users. The income balance condition is

$$I_b = w_b \bar{L_b} + \frac{\tau - 1}{\tau} n_1 \tilde{p_{1b}} \tilde{q_{1b}}. \tag{3.33}$$

3.4.3 Country C

Country C is the outside country. The labor endowment is L_c. People living country C produce intermediate inputs (M_c) and export them to country A. The intermediate inputs are produced using labor only and sold in a perfectly competitive market at the price of $p_{mc} = \frac{w_c}{a_{mc}}$.

Country C also produces homogeneous goods, and therefore the wage rate is normalized to be one. There are no consumption and production of differentiated goods in country C. Homogeneous goods are the only consumption goods.

The labor supply-equal-demand condition yields

$$L_c = n_1 M_c \sum_{j=A,B} \tilde{q_{1j}} + n_2 M_c \tilde{q_{2a}} + n_2 M_{cc} \tilde{q_{2b}} + h_{cp}, \tag{3.34}$$

where $\tilde{q_{2a}}$ and $\tilde{q_{2b}}$ are the quantities of outputs sold by the average FTA user in country A and country B, and h_{cp} is the amount of homogeneous goods produced in country C. A binding ROO forces FTA users to switch from foreign to local intermediate inputs so that the unit demand for intermediate goods originating from country C by FTA users is smaller than by non-users $M_{cc} < M_c$.

The total income can be expressed as

$$I_c = L_c w_c. \tag{3.35}$$

3.4.4 Closing the Model

The trade and payment systems are closed by trade balance conditions. Country A produces and exports differentiated goods to country B under either zero or the MFN tariff rates. It imports intermediate inputs from country B and country C. Country A's imports of final products from country B are under zero tariffs. To keep trade balanced, country A also imports homogeneous goods. The trade balance condition equates value of exports with value of imports:

$$n_1 \frac{\tilde{p_{1b}} \tilde{q_{1b}}}{\tau} + n_2 \tilde{p_{2b}} \tilde{q_{2b}} = n_b \tilde{p_b} \tilde{q_{ba}} + IM_{mc} + IM_{mb} + p_H h_{aim} \tag{3.36}$$

where

$$IM_{mc} = p_{mc} \left(n_1 M_c \sum_{j=A,B} \tilde{q_{1j}} + n_2 M_c \tilde{q_{2a}} + n_2 M_{cc} \tilde{q_{2b}} \right)$$

$$IM_{mb} = p_{mb} n_2 \tilde{q_{2b}} M_b.$$

IM_{mc} and IM_{mb} represent the value of imported intermediate inputs from country C and country B respectively. h_a is the consumption of homogeneous goods in country A. The left hand side of (3.36) is the exporting revenues earned by FTA non-users and users, and the right hand side is the sum of import values.

Country B makes export revenues by selling differentiated goods and intermediate inputs to country A under zero tariffs as well as homogeneous goods. The tariff payments from country A's FTA non-users are redistributed to country B's consumers. The trade balance condition for country B is

$$n_b \tilde{p_b} \tilde{q_{ba}} + \frac{\tau - 1}{\tau} n_1 \tilde{p_{1b}} \tilde{q_{1b}} + EX_{mb} + p_H h_{bex} = n_1 \tilde{p_{1b}} \tilde{q_{1b}} + n_2 \tilde{p_{2b}} \tilde{q_{2b}}, \tag{3.37}$$

where $EX_{mb} = IM_{mb}$ is the export value of intermediate inputs from country B to country A. h_{bex} is quantity of homogeneous goods exported from country B, which could be negative if country B imports homogeneous goods.

Country C consumes homogeneous goods only and conduct productions of intermediate inputs and homogeneous goods. The trade balance conditions comes as

$$EX_{mc} = p_H h_{cim}, \tag{3.38}$$

where $EX_{mc} = IM_{mc}$ stands for the value of intermediate goods exported from country C to country A. h_{cim} is the amount of homogeneous goods imported by country C to keep trade balanced. Also, h_{cim} should be equal to the difference between country C's consumption and production of homogeneous goods.

Lastly, the world demand and supply of homogeneous goods are equalized. The market clearing condition for the homogeneous goods is

$$h_{cim} + h_{aim} = h_{bex}. \tag{3.39}$$

3.4.5 Equilibrium

So far, every dollar paid is a dollar of revenue earned. Given σ, α, β, τ, a_{mc}, a_{mb} and productivity distribution $G(\varphi)$, an equilibrium is a set of numbers of firms ($\dot{n}_1$, $\dot{n}_2$, $\dot{n}_b$), aggregate price statistics (P_{xa}, P_{xb}), wage rate w_a, consumer allocations $\tilde{q_{ij}}$ ($i = 1, 2, b$ and $j = a, b$), firm pricing rules $\tilde{p_b}$ and $\tilde{p_{ib}}(i = 1, 2)$, firm profits $\tilde{\pi_{ij}}$ ($i = 1, 2, b$ and $j = a, b$), and homogeneous good trade value (h_{aim}, h_{bex}, h_{cim}), such that: (i) $\tilde{q_{ij}}$ is given by (3.21) (3.22) and solves the representative consumer's problem; (ii) $\tilde{p_b}$ and $\tilde{p_{ib}}$ are given by (3.19) (3.20) and solves the firm's problem; (iii) $\tilde{\pi_{ij}}$ is given by (3.23)(3.24); (iv) n_1, n_2, n_b, P_{xa}, P_{xb}, w_a, $\tilde{q_{ij}}$, h_{aim}, h_{bex}, h_{cim} jointly satisfy (25)-(39).

There are no analytical solutions to this complicated system of equations. I adopt two approaches to make a progress. First, I conduct comparative static exercise in the neighborhood of full utilization and show the local analytical results. Second, I take advantage of GAMS program to provide global numerical solutions.

3.5 Local Analytical Solutions and Welfare Analysis

In this section, I conduct comparative static exercise in the neighborhood of full utilization. The results show the local effects of a slightly binding rule of origin on market outcomes and welfare.

Consider the equilibrium in which the ROO is exactly satisfied by the Cobb-Douglas cost share of imported inputs, that is $\beta = 1 - \gamma$. Now if there is a slight increase in the local content requirement (ROO), the ROO starts being binding. The producers in country A are faced with choices of whether to utilize the trade preferences. The endogenous variables of the model would change accordingly.

3.5.1 Number of producers

The percentage change of number of FTA users in country A can be expressed as

$$\hat{n_2} = -\frac{\sigma-1}{x}\underbrace{\left[\frac{1}{\left(\beta+\sigma\left(1-\beta\right)\right)\left(1+y/\tau^{\sigma}\right)s_f}+\frac{\tau^{\sigma}\left(1+1/y\right)}{\tau^{\sigma}-1}\frac{1}{s_f}-1\right]}_{(+)}\hat{\lambda}, \tag{3.40}$$

where $x = \left(\frac{f_d}{f_e}+1\right)\left[\alpha\tau^{-\sigma}\left(\tau-1\right)-\tau^{1-\sigma}+1\right] > 0$ and $y = \frac{f_e}{f_d}\left(\tau^{\sigma}-1\right)-1 > 0$. $s_f = \frac{n_2\tilde{p}_{2b}^{1-\sigma}}{P_{xb}^{1-\sigma}}$ is the market share of exports by FTA users in country B. $\hat{n_2} = \frac{dn_2}{n_2}$ and $\hat{\lambda} = \frac{d\lambda}{\lambda}$ represent the percentage changes of number of FTA users and ROO. The effect of a slightly binding ROO on firm production is fully reflected in the change of variable costs λ. Thus, (3.40) states a negative relationship between number of FTA users and the restrictiveness of ROO. As λ increases, n_2 decreases. The total number of exporters originating from country A is negatively correlated with the number of FTA users, since I have

$$\hat{n_a} = -\frac{f_d}{f_e}\hat{n_2}. \tag{3.41}$$

Considering that the number of FTA non-users is equal to the total number less the number of users ($n_1 = n_a - n_2$), a stricter ROO leads to an increase in total number of exporters producing in country A, an increase in number of FTA non-users, and a decrease in number of FTA users. This is consistent with the intuition. When the ROO requires more local inputs, exporters in country A have to alter their productions and produce at a higher cost. The trade preferences are costly to utilize, which results in an exit from being FTA users.

As for the change in number of exporters producing in country B, it can be seen from

$$\hat{n_b} = \frac{\sigma-1}{1-s_f}\left[\frac{\sigma+(1-\sigma)s_f}{\left(1+y/\tau^{\sigma}\right)\left(\sigma+\beta/(1-\beta)\right)}+1-\frac{\tau^{\sigma}}{\tau^{\sigma}-1}\right]\hat{\lambda}. \tag{3.42}$$

Given that $\sigma > 1$, $s_f < 1$, and the sign of the bracket is positive, $\hat{n_b}$ and $\hat{\lambda}$ are positively correlated. As the ROO becomes tighter, more producers in country B start exporting to country

A. This is due to the fact that a higher requirement of local content disadvantages producers in country A. More exporters from country B benefit from the preferential tariffs and make sales in the foreign market.

3.5.2 Wage Rate

In such a framework, country A can be thought of Mexico in NAFTA. An interesting and important question is how the implementation of NAFTA and ROOs affects the wage rate in Mexico. The local comparative static analysis shows that

$$\hat{w_a} = -\frac{\sigma - 1}{\left(1 + y/\tau^{\sigma}\right)\left(\beta + \sigma\left(1 - \beta\right)\right)}\hat{\lambda}. \tag{3.43}$$

When the ROO increases, there are two opposing factors that influences labor demand. On the intensive margin, FTA users demand more labor and local inputs to meet the ROO. On the extensive margin, the trade preferences will be utilized by fewer exporters. For those who exported under preferential tariffs before, an exit from the FTA framework leads to a reduction in the demand for local inputs, since they no longer need to comply with the rule. (3.43) shows that the overall effect is negative. An increase in ROO (λ) leads to a decrease in the wage rate of the downstream country (w_a).

3.5.3 Price Index

The change in ROO reallocates sales of heterogeneous firms. As a result, the price indexes in the FTA participating countries change. Both domestic firms and exporters from country B sell in country A. The price index in country A is given by

$$P_{xa}^{1-\sigma} = n_a \tilde{p}_a^{1-\sigma} + n_b \tilde{p}_b^{1-\sigma}.$$

Accordingly, the percentage change in price index caused by the change in ROO is

$$\hat{P_{xa}} = -\frac{1-s_b}{\sigma-1}\hat{n_a} - \frac{s_b}{\sigma-1}\hat{n_b} + (1-s_b)\,\hat{\tilde{p}}_a, \tag{3.44}$$

where $s_b = \frac{n_b \tilde{p}_b^{1-\sigma}}{P_{xa}^{1-\sigma}}$ denotes the market share of exports from country B in country A. The effect of ROO on price index can be decomposed into two parts. One is variety effect in that a stricter ROO leads more firms to start producing in and exporting to both countries, which drives down the price index and intensifies market competition. The other effect is price index. The domestic producers in country A would charge lower prices following a binding ROO, because the wage rate goes down, as discussed in the previous section. Hence, both variety effect and price effect are negative. An increase in local content requirement reduces the price index in country A.

Similarly, in country B, there are three types of producers supplying differentiated goods. The associated price index is

$$P_{xb}^{1-\sigma} = n_1 \tilde{p}_{1b}^{1-\sigma} + n_2 \tilde{p}_{2b}^{1-\sigma} + n_b \tilde{p}_b^{1-\sigma}.$$

Total differentiating with respect to rules of origin yields

$$\hat{P_{xb}} = -\frac{1-(1+f_d/f_e)\,\tau^{1-\sigma}}{\sigma-1} s_f \hat{n_2} + (1-s_f)\,\frac{\hat{n_b}}{1-\sigma} + s_f \hat{\tilde{p}}_{2b}. \tag{3.45}$$

The sign of the percentage change in price index in country B is ambiguous, depending on the market share of country A's exporters in country B. If the export sales of FTA users account for a large market share in country B, the positive variety effect driven by fewer FTA users and the positive price effect dominate. Thus, country B's price index P_{xb} increases in ROO. If the export sales of FTA users account for a small market share in country B, the negative variety effect due to the firm entry in country B outweighs the other two effects, which decreases the price index P_{xb} as the ROO rises.

3.5.4 Country Welfare

Country welfare is jointly determined by income and price index. A country with more income and a lower price index has a higher welfare level. Specifically, country A's welfare change due to a binding ROO is

$$\hat{Welfare_a} = \left(\frac{1}{1-\beta} - (1-s_b)\right)\hat{\hat{p_a}} + \frac{1-s_b}{\sigma-1}\left(\hat{n_b} + \hat{n_a}\right). \tag{3.46}$$

As shown in (3.46), the terms of trade effect and the variety effect run in the opposite directions. On the one hand, country A's exports become cheaper relative to its imports from country B, because a binding ROO generates distortions in the labor market, which reduces the wage rate. On the other hand, there are more varieties sold in country A, since an increase in ROO encourages firm entry. It can be shown that if $\frac{\tau^\sigma}{\lambda^\sigma - 1} > 1 + \frac{f_d}{f_e}$ is satisfied and the elasticity of substitution between varieties is small, the variety effect dominates. In other words, if the FTA is under-utilized and varieties are less substitutable, country A's welfare rises with the restrictiveness of ROO, as a wider range of varieties are sold in the market. If the elasticity of substitution between varieties is large, the magnitude of variety effect is small. In such a case, the overall effect of ROO on country A's welfare is negative, with the terms of trade effect more than offsetting the variety effect.

The percentage change in country B's welfare due to a tighter ROO can be expressed as

$$\hat{Welfare_b} = \frac{(\tau-1)\,y}{\tau^\sigma s_f}\hat{n_1} + (1-s_f)\,\frac{\hat{n_b}}{\sigma-1} - s_f\hat{\hat{p_{2b}}} + \frac{1-(1+f_d/f_e)\,\tau^{1-\sigma}}{\sigma-1}s_f\hat{n_2}. \tag{3.47}$$

The analysis of country B's welfare involves three channels. In terms of income, as the ROO become tighter, country B's tariff revenues increase, since more of exporters from country A choose to be FTA non-users and pay import tariffs. In the meantime, country's B wage rate is normalized to be 1. Hence, the income effect is positive. The second channel is through the terms of trade effect. Firms producing in country B are not affected by ROO and the wage rate is fixed, therefore, the prices of exports remain the same. But country A's production costs drop, which results in a decrease in the average price of its exports. Facing a higher relative price of exports to imports, country B's welfare rises. Lastly, the sign and the magnitude of variety effect vary with the elasticity of substitution between varieties as well as the market share of country A's exports in country B. Thus, the overall effect of ROO on country B's welfare is ambiguous.

As we can see in (3.47), total differentiation yields a complicated expression for the percentage change in welfare. There are three types of firms supplying differentiated goods in country B, and the prices and the numbers of these firms change with ROO. Based on the analytical solution, I can hardly conclude the direction towards which welfare moves following a stricter ROO. I resort to numerical approach to pin down the relationship between country welfare and ROO.

3.6 Simulation Results

In this section, I take advantage of GAMS program to show global numerical solutions to the model. The results present the effects on key endogenous variables over a full range of ROOs. In the benchmark, I assume the parameters take on the following values: the shape parameter of Pareto distribution $\varepsilon = 5$, the elasticity of substitution between varieties $\sigma = 4$, the expenditure share on differentiated varieties $\alpha = 0.8$, the cost share parameters of Cobb-Douglas production function $\beta = 0.8$, the local content requirement (ROO) $\gamma = 0.2$, the gross import tariffs $\tau = 1.3$, the benchmark wage rates in three countries are equal $w_A = w_B = w_c = 1$, and the efficiency parameters of producing intermediate inputs in countries B and C $a_{mb} = 0.9$ and $a_{mc} = 1$. The fixed documentation costs, fixed entry costs in countries A and B, and the labor endowments in three countries can be calibrated from the model.

Table 3.4 reports the results for the benchmark. The free trade agreement offers a 30% tariff reduction to final varieties whose cost shares of domestically produced inputs are no less than 80%. In the benchmark, since $\beta = 1 - \gamma$, the rule of origin is not binding. There are 20 firms exporting from A to B, and all of them utilize the preferential tariffs. The FTA utilization rate is 100 percent. The number of exporters originating from country B is 20. The outside country C is more efficient in producing intermediate inputs. When the ROO is loose, firms in country A source inputs from country C only. The import value of intermediate inputs from C to A is 11.62, and the import value of intermediate inputs from B to A is 0. The benchmark welfares in countries A and B are 10.35 and 26.72 respectively.

Next, I conduct counterfactual exercises to investigate the impacts of ROOs on country's welfare over the range from 1% to 95%. Figure 3.1 displays the relationship between FTA utilization rate and ROO. When the ROO is loose, the utilization rate is 100 percent. As the ROO increases, the utilization rate decreases monotonically. Once the local content requirement is too restrict (beyond 59%), none of the exporters take advantage of the preferential tariffs and the utilization rate is zero. Figure 3.2 shows the simulation results on the use of FTA by country A exporters. In panel (a), the number of FTA non-users is 0 when the ROO is 20% or below. It rises from 0 to 37.63 gradually when the ROO increases from 20% to 59%. Since all firms choose to be non-users if the local content requirement is 59% or even higher, the number of FTA non-users remains constant when the ROO is greater than 59%. In contrast, the number of FTA users moves in the opposite direction. There is a monotonic decreasing trend over the range of ROO from 20% to 59%, as shown in panel (b). As it is more and more costly for firms to comply with the ROO, fewer exporters find profitable to utilize the trade preferences.

Figure 3.3 shows how ROOs affect the trade value of intermediate goods between countries. In panel (a), there is a non-monotonic relationship between imports of intermediate inputs from country B to country A. Since country B's intermediate inputs are more expensive than those produced in country C, firms in country A choose to import from country C when the ROO is not binding. As the ROO becomes stricter, country A producers have to import intermediate inputs from country B in order to satisfy the ROO criterion. Thus, the trade value between country A and B goes up. However, a further increase in ROO generates large distortions in manufacturing process and therefore makes the conditional trade preferences less attractive. As a result, more and more firms choose to be FTA non-users, and the trade in intermediate goods within the FTA area declines. When the ROO is greater than 59%, no firms use inputs produced in country B, and

Table 3.4: Simulation Results: The Benchmark

Variable Name	Value
Number of exporters from country A: n_a	20
Number of FTA non-users from country A: n_1	0
Number of FTA users from country A: n_2	20
FTA Utilization Rate: u	100%
Number of exporters from country B: n_b	20
Import value of intermediate inputs from B to A: EX_{mb}	0
Import value of intermediate inputs from C to A: EX_{mc}	11.62
Wage rate in country A: w_a	1
Welfare of country A	10.35
Welfare of country B	26.72

Figure 3.1: FTA Utilization Rate and ROOs

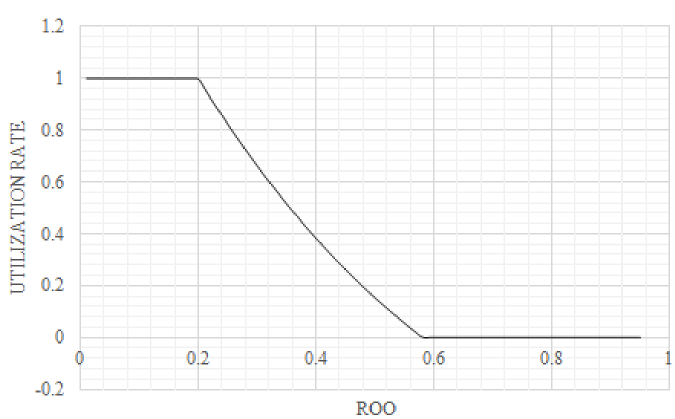
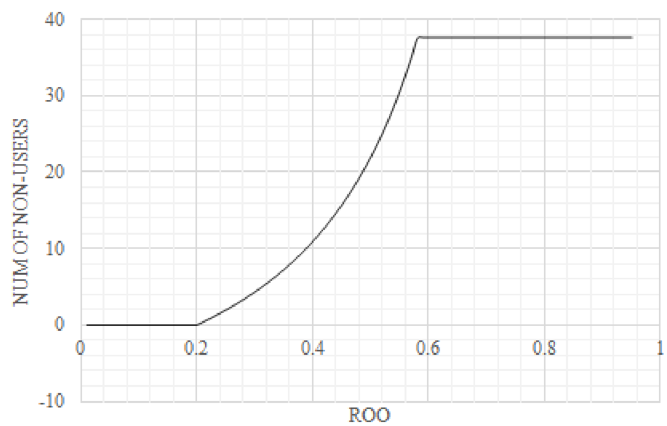
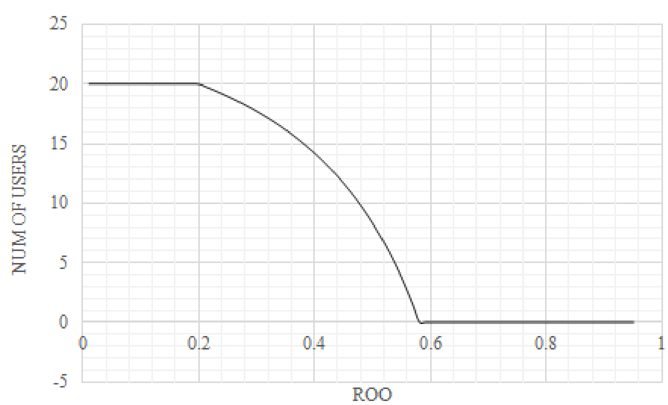


Figure 3.2: Numbers of FTA Non-users and Users and ROOs



(a)



(b)

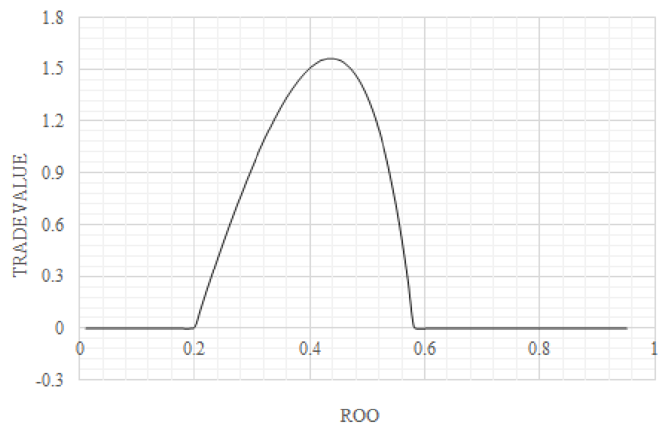
the trade value goes back to zero. Panel (b) shows how the trade value between countries A and C changes with ROO. The highest value occurs when the ROO is smaller than or equal to 20%. This is the case when all firms in country A use the cheaper inputs produced in country C. As the ROO increases, firms demand more locally produced inputs and the import from C to A goes down. The trade value between A and C start to rise when the ROO is too costly to comply with, and eventually it stays at a constant level which is lower than the unbinding case. This is because exporters from A make less sales in country B as they pay import tariffs and charge higher prices. Consequently, firms demand less inputs and produce fewer outputs.

Figure 3.4 gives the relationship between the wage rate of the downstream country and ROOs. A stricter rule of origin generates more demand for locally produced intermediate goods, but less demand for labor in the downstream country. As discussed in the section of local analytical solutions, there are two opposing factors that affect labor demand. The decrease of the wage rate with ROOs implies that the negative extensive margin dominates. The labor released from user to non-user firms is more than the labor demanded by a stricter ROO compliers.

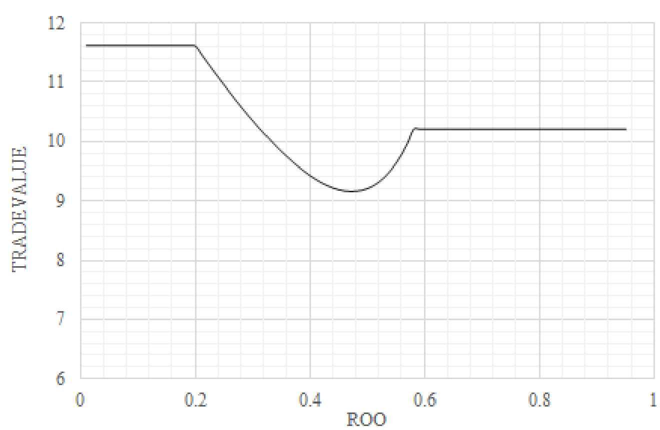
Figure 3.5 and 3.6 report how country welfare changes with ROOs. The results differ by the value of elasticity of substitution between varieties. Figure 3.5 corresponds to the case where $\sigma = 4$, and Figure 3.6 refers to the case where $\sigma = 8$. If the substitution elasticity is relatively small, as shown in Figure 3.5, both countries experience welfare increases as the ROO increases. As the FTA utilization rate ranges from 0 to 100 percent, country A's welfare increases by 4.83% (Panel (a)) and country B's welfare increases by 16.79% (Panel (b)) . When the varieties are less substitutable, consumers benefit more from the introduction of new varieties. Resources are allocated to the more efficient producers in country B and a tighter ROO induces the production of intermediate goods to move from country C to country B. As such, the variety effect for both countries are positive and significant, which is more than offsetting the negative terms of trade effect. Hence, a stricter ROO effectively protects regional producers and promotes within FTA area trade. Such conditional trade preferences benefit both participating countries.

Country welfare exhibits different patterns when the elasticity of substitution is large ($\sigma = 8$).

Figure 3.3: Trade Value of Intermediate Inputs Between Countries



(a)



(b)

Figure 3.4: Wage Rate and ROOs

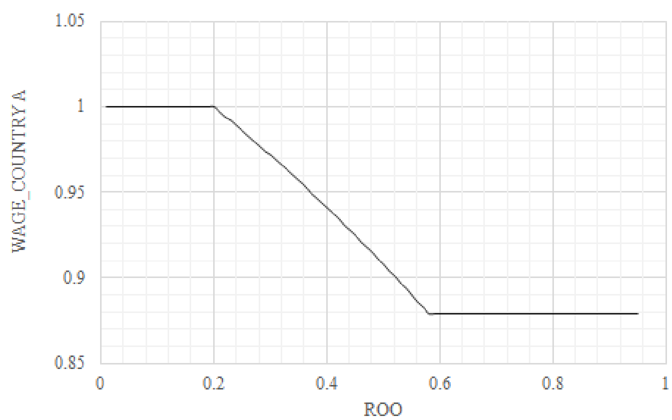
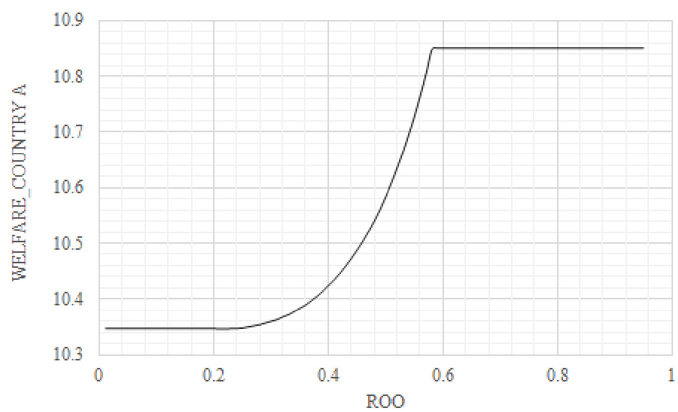
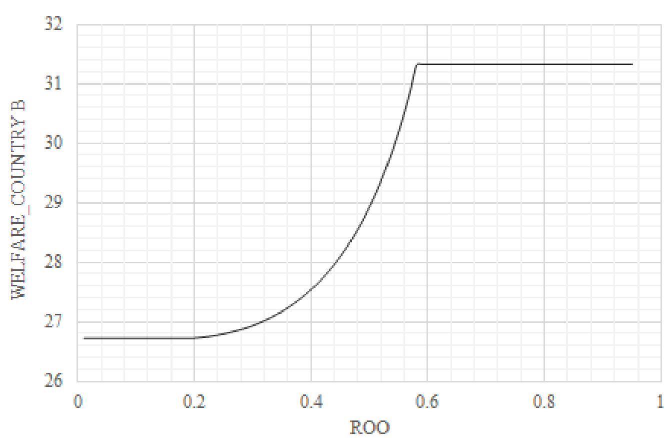


Figure 3.5: Country Welfare and ROOs: $\sigma = 4$

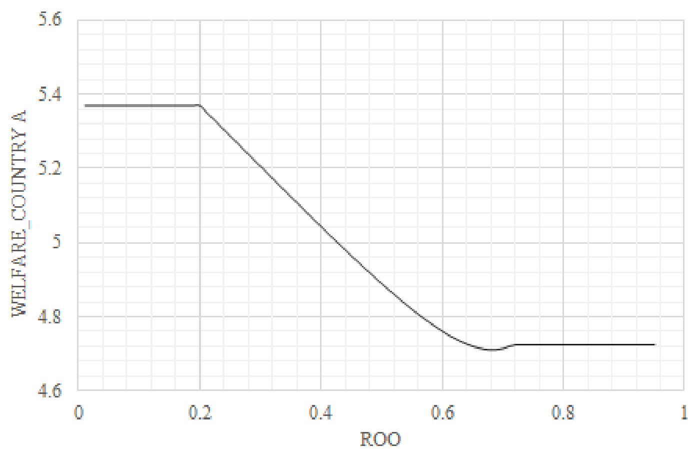


(a)

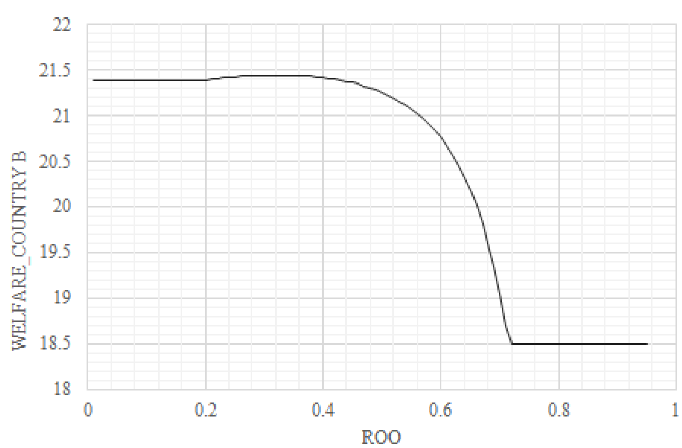


(b)

Figure 3.6: Country Welfare and ROOs: $\sigma = 8$



(a)



(b)

In Figure 3.6, when the ROO starts binding, country A's welfare decreases, while country B's welfare increases slightly. Following a stricter ROO, the wage rate in country A drops and therefore the income effect is negative. The price index depends on the prices of individual varieties as well as the number of varieties available in the market. A lower wage rate reduces the production costs of firms producing in country A. The prices of domestically produced differentiated goods become cheaper. Considering that the prices of imported products from country B are not affected by ROOs, the average price decreases with ROOs. In the meantime, firm entry introduces new varieties, which would further reduce the price index. But this variety effect turns to be small when the elasticity of substitution between varieties is large. The simulation results show that the income effect is more negative and the overall effects of ROOs on country A's welfare are negative.

In Figure 3.6 Panel (b), country B's welfare increases and then decreases with the restrictiveness of ROOs. When the ROO is binding and the FTA is under-utilized, country B obtains more tariff revenues and the income effect is positive. Country A's producers have to employ more expensive intermediate goods to comply with ROOs and their production costs rise accordingly. But as another factor of production, domestic labor is cheaper as the ROO increases. Also, more firms choose pay the MFN tariffs when the ROO is too costly to satisfy, which in turn raises the prices of imports in country B. These three elements together determine the prices of imported differentiated goods from country A. Consumers in country B may face a higher price index of differentiated varieties and a lower real income. Moreover, similar to the analysis on country A, a large elasticity of substitution between varieties mitigates the variety effect on welfare. The numerical solutions imply that when the ROO is slightly binding (between 20% and 40%), the positive income effect and the variety effect outweigh the negative price effect, and as a result, the country welfare increases with ROOs. As the ROO rises further (greater than 40%), the distortions in production generated by a strict ROO have a larger impact on product prices and the negative price effect is a more important determinant of welfare. Hence, ROOs reduce country B's welfare.

3.7 Conclusions

Motivated by the fact that free trade agreements are actually under-utilized and the associated costs accompanied with trade preferences are substantial, this chapter investigates how rules of origin reallocate profits and incomes among countries when not all firms export by invoking preferential tariffs. I develop a general equilibrium model in the context where there is a vertical linkage between FTA member countries, featured the effects of ROOs on firms' decisions on the use of trade preferences. Tariff margin, rules of origin, and fixed documentation costs are identified as three key determinants of FTA utilization rates. Exporters are more likely to benefit from claiming the preferential tariffs offered by an FTA if the agreement sets a large tariff margin, a loose origin rule, and a simple administrative procedure.

The welfare patterns across countries differ by elasticity of substitution between varieties. When differentiated goods are highly substitutable, a slightly binding origin rule serves as a protection device to regional producers. Final good exporters may have an incentive to source intermediate inputs from even a higher cost local producer in order to satisfy the ROO criterion. However, a further stricter rule of origin would hurt exporters and domestic workers because of the low utilization rate of FTAs and the large distortions in manufacturing process. As such, there is an inverted-U shape relationship between the welfare of the upstream country, and the downstream country's welfare decreases with ROOs. When differentiated goods are less substitutable, variety effect dominates and both countries experience welfare increase as the ROO becomes stricter.

The model consists of a number of non-linear equations and lacks a closed form solution. I adopt two methods to proceed. First, I conduct comparative statics analysis in the neighborhood of full utilization and show the local effects of ROOs on endogenous variables. Second, I employ the numerical approach and provide a visualized example and intuitive explanations. Both the analytical solutions and counterfactual simulations yield consistent results.

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Appendix A

Algebraic Appendix

A.1 Demand Function

A consumer's utility maximization problem can be stated as follows:

$$\max U^c = \int_{\varphi\in\Omega} \log\left[z(\varphi)\, q^c(\varphi) + \bar{q}\right] d\varphi \tag{A.1}$$

$$s.t. \quad \int_{\varphi\in\Omega} p(\varphi)\, q^c(\varphi)\, d\varphi \leqslant w. \tag{A.2}$$

Given income and prices of varieties, a consumer chooses $q^c(\varphi)$ to maximize utility. The first order conditions yield:

$$\frac{z(\varphi)}{z(\varphi)\, q^c(\varphi) + \bar{q}} = \lambda p(\varphi), \tag{A.3}$$

where λ is the Lagrange multiplier, indicating the marginal utility of income. Hence, for two distinct varieties φ and φ', the following equation must hold:

$$p(\varphi)\, q^c(\varphi) + \frac{p(\varphi)}{z(\varphi)}\bar{q} = p(\varphi')\, q^c(\varphi') + \frac{p(\varphi')}{z(\varphi')}\bar{q}. \tag{A.4}$$

By summing over all varieties φ' that a consumer actually consume, I have

$$N\left[p(\varphi)\, q^c(\varphi) + \frac{p(\varphi)}{z(\varphi)}\bar{q}\right] = w + \bar{q}P, \tag{A.5}$$

where

$$P = \int_{\varphi' \in \Omega} \frac{p(\varphi')}{z(\varphi')} d\varphi \quad \textit{and} \quad w = \int_{\varphi' \in \Omega} p(\varphi') \, q^c(\varphi') \, d\varphi. \tag{A.6}$$

Thus, the individual demand for variety φ can be derived as

$$q^c(\varphi) = \frac{1}{p(\varphi)} \left[\frac{w}{N} + \bar{q} \left(\frac{P}{N} - \frac{p(\varphi)}{z(\varphi)} \right) \right]. \tag{A.7}$$

By the definition of quality adjusted price, the demand equation can be rewritten as

$$q^c(\varphi) = \frac{1}{p(\varphi)} \left[\frac{w}{N} + \bar{q} \left(\bar{\tilde{p}} - \tilde{p}(\varphi) \right) \right]. \tag{A.8}$$

Therefore, the total demand for variety φ in an economy endowed with L identical consumers is

$$q(\varphi) = \frac{L}{p(\varphi)} \left[\frac{w}{N} + \bar{q} \left(\bar{\tilde{p}} - \tilde{p}(\varphi) \right) \right]. \tag{A.9}$$

A.2 Profit Maximization and Productivity Threshold

The first order conditions derived from profit maximization problem are:

$$\frac{\partial \pi(\varphi)}{\partial p(\varphi)} = q(\varphi) - L \left[p(\varphi) - \frac{cw}{a\varphi} \right] \frac{w + \bar{q}P}{N} p(\varphi)^{-2} = 0 \tag{A.10}$$

$$\frac{\partial \pi(\varphi)}{\partial c(\varphi)} = L \left[p(\varphi) - \frac{cw}{a\varphi} \right] \bar{q} z(\varphi)^{-2} \frac{\partial z(\varphi)}{\partial c(\varphi)} - q(\varphi) \frac{w}{a\varphi} = 0. \tag{A.11}$$

Combining with $z(\varphi)^{\theta} = \frac{1}{2}\varphi^{b\theta} + \frac{1}{2} c(\varphi)^{2\theta}$, the optimal choices of quality, price, and output are

$$c(\varphi) = \varphi^{\frac{b}{2}}, \qquad z(\varphi) = \varphi^{b}, \tag{A.12}$$

$$p(\varphi) = \left(\frac{w}{\bar{q}} \frac{w + \bar{q}P}{N} \right)^{\frac{1}{2}} \varphi^{\frac{3b-2}{4}}, \tag{A.13}$$

$$q(\varphi) = L\varphi^{-b} \left[\left(\frac{a\bar{q}}{w} \frac{w + \bar{q}P}{N} \right)^{\frac{1}{2}} \varphi^{\frac{b+2}{4}} - \bar{q} \right]. \tag{A.14}$$

To derive the productivity threshold, setting the market demand equation equal to 0 yields

$$L\varphi^{-b}\left[\left(\frac{a\bar{q}}{w}\frac{w+\bar{q}P}{N}\right)^{\frac{1}{2}}(\varphi^{*})^{\frac{b+2}{4}}-\bar{q}\right]=0. \tag{A.15}$$

Therefore, I have

$$\varphi^{*}=\left(\frac{w}{a}\frac{N\bar{q}}{w+\bar{q}P}\right)^{\frac{2}{b+2}}. \tag{A.16}$$

A.3 Market Equilibrium Solutions in Closed Economy

In equilibrium, plug firms' optimal choices of quality and price into the aggregate quality-adjusted price statistic:

$$P=\int_{\varphi\in\Omega}\frac{p(\varphi)}{z(\varphi)}d\varphi=\frac{4\gamma}{4\gamma+b+2}\frac{w}{a}N(\varphi^{*})^{-\frac{b+2}{2}}. \tag{A.17}$$

Then, substituting the expression of productivity threshold given by equation (4) into the price statistic yields:

$$P=\frac{4\gamma}{b+2}\frac{w}{\bar{q}}. \tag{A.18}$$

Next, plugging the new expression of the price statistic back gives

$$(\varphi^{*})^{\frac{b+2}{2}}=\frac{b+2}{4\gamma+b+2}\frac{N}{a}\bar{q}. \tag{A.19}$$

Equivalently, that is

$$N=\frac{4\gamma+b+2}{b+2}\frac{a}{\bar{q}}(\varphi^{*})^{\frac{b+2}{2}}. \tag{A.20}$$

The quality-adjusted price statistic is negatively correlated with per-capita income. This implies that consumers would like to purchase more high-quality goods whose quality-adjusted prices are relatively low as their income rises.Also, the increase in productivity threshold raises the number of varieties that consumers actually consume.

Above expressions yield an equation which links the threshold and number of potential entrants:

$$(\varphi^*)^{\frac{2\gamma+b+2}{2}} = \frac{b+2}{4\gamma+b+2}\frac{\bar{q}}{a}\varphi_0^{\gamma}J. \tag{A.21}$$

From the free entry condition, I have

$$\left(\frac{\varphi^*}{\varphi_0}\right)^{-\gamma}\int_{\varphi^*}^{\infty}\frac{w}{a}\bar{q}L\left[(\varphi^*)^{-\frac{b+2}{4}} - \varphi^{-\frac{b+2}{4}}\right]^2\gamma\,(\varphi^*)^{\gamma}\,\varphi^{-\gamma-1}d\varphi = \frac{w}{a}f_e, \tag{A.22}$$

$$\gamma\varphi_0^{\gamma}\frac{w}{a}\bar{q}L\frac{(b+2)^2}{\gamma\,(4\gamma+b+2)\,(2\gamma+b+2)}\,(\varphi^*)^{-\gamma-\frac{b+2}{2}} = \frac{w}{a}f_e, \tag{A.23}$$

$$(\varphi^*)^{\frac{2\gamma+b+2}{2}} = \frac{D\bar{q}L}{f_e},\ where\, D = \frac{\varphi_0^{\gamma}\,(b+2)^2}{(4\gamma+b+2)\,(2\gamma+b+2)}. \tag{A.24}$$

Therefore, the equilibrium number of entrants is

$$J = \frac{b+2}{2\gamma+b+2}\frac{aL}{f_e}. \tag{A.25}$$

Appendix B

Descriptive Appendix

B.1 Quality of Life, Public Goods, and Income Per Capita

Quality of life embraces multiple dimensions of human experience that affect well being. Much of urban economics literature examines the relationship between economic growth and quality of life, where GDP per capita is taken as a summary index of the level of economic development. Cross sectional studies show successfully causal relations from economic growth to quality of life, although it has been found mixed changes in quality of life based on time series evidence (Easterly, 1999). Supported by empirical results, I assume a positive relationship between quality of life $\bar{q}$ and per-capita income w, that is $\frac{d\bar{q}}{dw} > 0$. Consumers living in a rich country, on average, lead a life of better quality overall, since they are provided with more and better public goods and service, which are non-rival and non-excludable and consumers do not have to pay for. Taxes system is assumed away in this model. Empirical studies point out that individual well-being is significantly enhanced in rich countries where consumers pay more taxes out of their income. Hence, taking taxes into account does not contradict the arguments stated in this paper. An alternative interpretation of $\bar{q}(w)$ in the utility function is that it represents the individual consumption of outside goods which is excluded from the model but positively correlated with income.

Given the substantial differences across countries in the provision of public goods and service, ignoring the impacts of quality of life on consumers' utility would be an important omission. Since a comfortable and convenient living environment is attractive to workers, countries would be much better off redirecting their economic development efforts to improving amenities such as schools, transportation, and cultural venues. Thus, in the spirit of Albouy et al (2013) , in addition to quantity, quality, and number of varieties, I assume quality of life also raises a consumer's utility in a direct way. Consumers who keep a high standard of living are more likely to have a favorable taste for product quality. As shown below, income-related $\bar{q}$ also represents consumers' taste for product quality and plays an essential role in explaining the differential consumption patterns of consumers with different levels of income.

B.2 Examples of Taste for Quality Functions

The function of $\bar{q}(w)$ is assumed to be general so far, and there are a wide range of functions which allows $\bar{q}$ and w positively correlated. Here I list two specific function forms of $\bar{q}(w)$ which satisfy the positive correlation assumption and are supported by empirical evidence. The first stems from a strand of literature which documents positive and diminishing impacts of GDP per capita on well-being in cross-sectional analysis.Layard et al. (2008) regress several alternative measures of well-being on log income and its square, and find the quadratic term has a negative effect. Such results are also confirmed by Akay et al. (2012) and Easterlin and Angelescu (2007). Related studies establish a clear positive link between average levels of well-being and GDP per capita across countries, and find evidence of a satiation point beyond which wealthier countries have insignificant further increases in well-being. Hence, it is reasonable to assume $\bar{q}(w)$ takes a natural log of income per capita:

$$\bar{q}(w) = \eta \ln w,$$

where η is a positive parameter representing a positive and flexible effect of per-capita income on quality of life as well as on tastes for product quality. The corresponding elasticity of taste with respect to income can be expressed as $\varepsilon_t(w) = (\ln w)^{-1}$, which shows a negative correlation between elasticity of taste for quality and per capita income. The value of $\varepsilon_t(w)$ ranges from positive infinity to zero as individual income rises from 1 to extremely high, with poor consumers holding elastic tastes for quality and rich consumers being relatively inelastic.

The second example is inspired by the work of Easterly (1999) and Prados (2010) which emphasize the role of a country's relative income level compared to the world average. Easterly (1999) studies the rate of changes of quality of life as relative income hikes by adding a quadratic term of per-capita income into regressions. The results turn out that two fifths of the indicators of quality of life, such as mail per capita and health and nutrition, exhibit a relationship in which there is not much improvement at low incomes but there is much more at higher incomes, and the rest of indicators show a relationship to income in which there is a strong change at lower levels of income that tails off at high incomes. Relative income raises quality of life at variable rates in different aspects. Similar arguments can be found in Prados (2010). The Kuznets curve is widely used to pin down the relationship between environmental quality and economic growth: early stage economic development is accompanied by deterioration of environmental quality, but further increases of income levels start to improve environmental quality significantly. As such, I assume the following function form:

$$\bar{q}(w) = (w - \lambda)^{\alpha},$$

where λ stands for the world poverty line which is common across countries and α is a positive parameter which indicates the degree of concavity or convexity of the function. The more a country's per-capita income exceeds the world poverty line, the higher quality of life consumers enjoy by living in that country. Such a function form ensures that consumers' tastes for quality $\bar{q}(w)$ increase with per-capita income and gives rise to a negative relationship between elasticity of taste and income. The value of elasticity of taste varies considerably, given $\varepsilon_t(w) = \frac{\alpha w}{(w-\lambda)}$, where $\varepsilon_t(w) > 1$ if $w < \frac{\lambda}{(1-\alpha)}$ and $\alpha < 1$ while $\varepsilon_t(w) < 1$ otherwise.