Firm Exporting Behaviour and Trade Policy in China

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Abstract

This thesis analyses firm exporting behaviour and trade policy in China. China's astonishing export growth is largely driven by pure exporting behaviour and low priced goods. Therefore this thesis focuses on the firm pure exporting behaviour and firm quality specialization between a poor country and a rich country. Moreover, this thesis explores the roles of trade policy in Chinese trade. A commonly used and frequently adjusted policy of value-added tax rebates (VATRs) for exporters is analysed.

Chapter 2 introduces heterogeneity in productivity, entry cost and demand in both domestic and foreign markets to explain pure exporters. Pure exporters face lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost. The presence of pure exporters makes the average productivity of exporters be lower or higher than non-exporters. The pure exporting products are analysed under a multiproduct firm framework in chapter 3. The study develops a general equilibrium model which allows for heterogeneity in productivity and fixed export cost across products. We find high productive firms can manage more products in export than in domestic market due to pure exporting products. Both chapters investigate the effects of trade and trade liberalization on pure exporting behaviour.

Chapter 4 analyses the quality specialization pattern between a poor and a rich country in international trade. In the model, there is one to one relationship between income of consumers and quality they buy. The model shows a home market effect on quality specialization. When a poor country trades with a rich country, low (high) qualities are completely specialized in the poor (rich) country, while medium qualities are incompletely specialized, i.e. produced by both countries and exported to each other. Furthermore, this chapter also provides some empirical evidence.

Chapter 5 assesses the trade policy of VATRs in China. Based on the correction for potential endogeneity of VATR adjustments, the estimation suggests one percentage point increase of VATR does not affect export price significantly while increasing export quantity by 1.15%. 1.43% more firms are induced to export the adjusted product while the number of destinations the product exported is raised by 0.77%. Furthermore, firm welfare measured as the net profit is increased by 2.15%, which translates into $2.14 in revenue for a $1 additional rebate from government

Dedication

To my parents, the reason I become myself today.

I am proud of you. Thank you for your supports and care.

To my old sisters, thank you both for your encouragement to me and your care to our parents when I am pursuing the dream abroad.

Acknowledgement

At this stage, I would like to thank Professor Mich Tvede, Dr. Nils Braak-mann and Dr. Sara Maioli for their valuable supervisions, continuous supports and inspiring encouragement. Undoubtedly, without their help, I would never be approaching this stage of my PhD study. When I look back at myself at the start, I realize surely that they "raise me up, to more than I can be".

I would like to acknowledge my scholarship provider Economic and Social Research Council (ESRC). Without its support, it would be almost impossible to conduct my PhD study overseas, and it would be impossible as well that I attended several conferences at which I received some valuable comments to my research.

I would like to acknowledge all the supports from the school, colleagues and friends. All these make my PhD journey interesting, challenging and rewarding.

Declaration

The main contribution of this thesis is mine. However my supervisors Professor Mich Tvede, Dr. Nils Braakmann and Dr. Sara Maioli have provided great supervisions throughout the whole thesis. Here I would like to emphasize their contributions especially in chapter 2 and chapter 5, which we are formalizing two potential journal articles.

In chapter 2, I benefit a lot from the discussions with Professor Mich Tvede. I did all the statistical analysis and theoretical derivation. Mich contributes to some key adjustments of the direction of the chapter. At the beginning, I was developing the model that groups the firms by foreign entry cost and finding the equilibrium for each group. With these equilibria, I was trying to conclude the effects of foreign entry cost. Mich pointed out that it would be realistic and better to analyse all the firms with different foreign entry cost in one general equilibrium and see the behaviours of different firms. I conducted the studies on the effects of trade liberalization in terms of from autarky to trade and a decrease in variable export cost. Mich suggested it would be very interesting to see the effects of a decrease in foreign entry cost and innovation in terms of shifting distribution of firms, for which we conducted the analysis shown as in the chapter that conditional distributions are shifted. At the start, I built the model where foreign entry cost is heterogeneous, but domestic entry cost is only heterogeneous in a section. Instead Mich suggested that we can include the heterogeneity of domestic entry cost across the whole paper. Without Mich's contributions, this chapter would be very different compared with the current one.

In chapter 5, I benefit from the discussions with Dr. Nils Braakmann and Dr. Sara Maioli. I did all the data construction, regression, presentation and interpretation of results. At the start, I was trying to use export VATRs as an instrument to identify the elasticity of China's export and further see the determinants of elasticity. However, Nils pointed out that the empirical strategy is very weak. Instead, Nils and Sara suggested that to analyse whether the trade policy is effective to adjust China's export is still an interesting and valuable question. During the analysis, Nils and Sara provided great contributions to the empirical strategies, e.g. fixed effects, cluster variable and etc., and the how the results could be interpreted in relation to literature. Without Nils and Sara's contributions, this chapter would explain a totally different story.

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Chapter 1

Introduction

This thesis analyses firm exporting behaviour and trade policy in China. China's astonishing export growth is largely driven by pure exporting behaviour and low priced goods. Therefore this thesis focuses on the firm pure exporting behaviour, i.e. pure exporters (chapter 2) and pure exported products (chapter 3). This thesis also studies firm quality specialization between a poor country and a rich country to shed light on why China may export low priced goods (chapter 4). Moreover, this thesis studies a commonly used and frequently adjusted policy in China, value-added tax rebates (VATRs) (chapter 5), i.e. exports are exempt from VAT and input VAT for production, distribution and sales is fully or partially refunded to exporters.

In this chapter, I introduce the motivation of this thesis, from which the importance and necessity of this study are shown. Moreover, I describe the structure of this study. Furthermore, I summarize the contributions of this thesis.

1.1 Motivation

1.1.1 China's Export

China has experienced a nearly 30-year-long period of high economic growth rate. Without any doubt, international trade plays a very important role, which has been supported by numerous literatures from Chinese scholars and international scholars. According to China Statistical Yearbook, in average export accounts 23.5% of GDP from year 1990 to 2013. Meanwhile export in average contributes to 26.6% of the total economic growth from year 1990 to 2000 (Lin and Li, 2003).

With accession to WTO, in 2002 China ranked the fourth of the exports to the world below USA, Germany and Japan. Since then, the export share of Japan, USA and Germany are decreasing in general, though share is increasing for USA (Germany) was slightly increased after 2011 (2012). On the contrary, the export share of China has increased from 5.1% in 2002 to 13.1% in 2014. As shown in Figure 1.1, China exceeded

Janpan in 2004, USA in 2007 and Germany in 2009. Since 2009, China has been the largest exporter in the world.
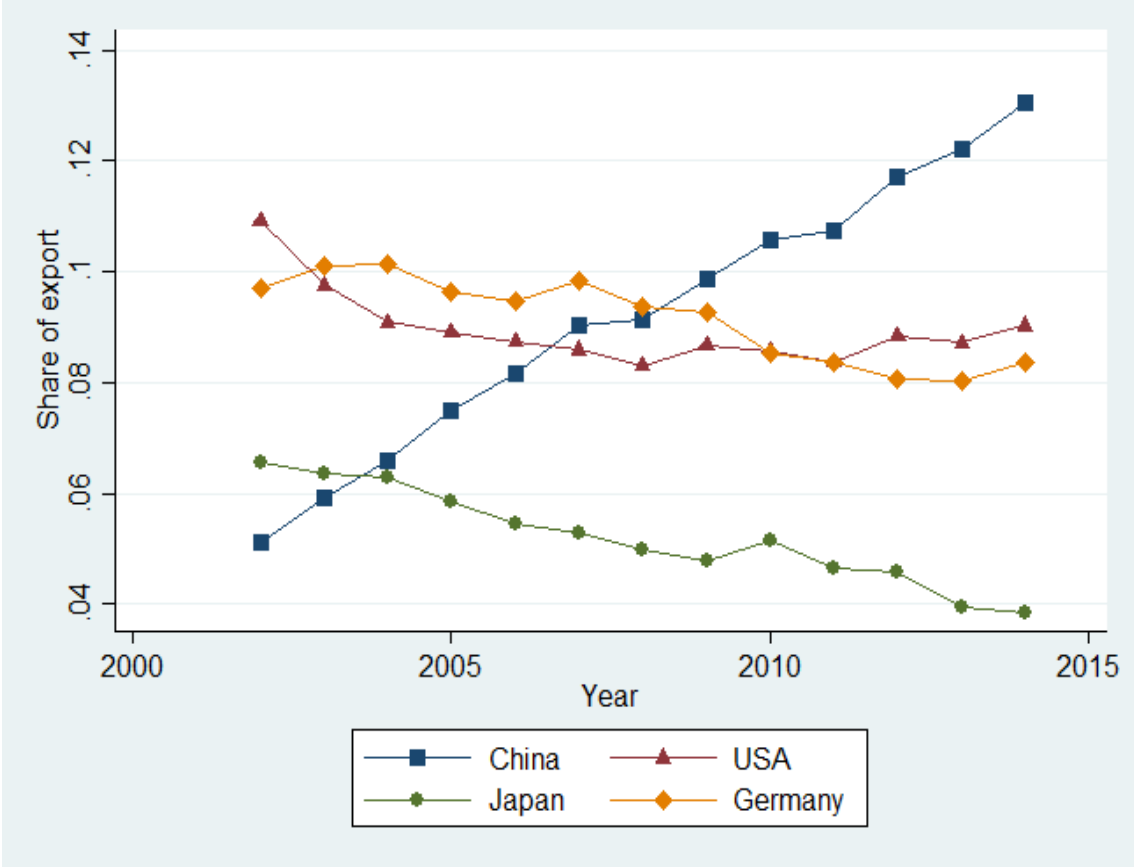
Note: The data is from UN comtrade database.

Figure 1.1: Export share of top four countries

China's export is not only important for China's economic growth, but also accounts large share of world trade. Therefore, to investigate China's export is not only of its own interest, but also meaningful for the world. China's astonishing export growth is largely driven by pure exporting behaviour and low priced goods. Trade policy in China also plays an important role in the growth of export.

This thesis studies these contributing factors to export growth in different chapters, e.g. pure exporting behaviour in chapter 2 and 3, quality specialization (low priced goods) in chapter 4 and trade policy in chapter 5. By assembling these chapters together, this thesis presents a comprehensive framework to understand China's export.

1.1.2 Pure Exporting Behavior

In a dominant part of the literature on international trade it is assumed that firms serve the domestic market (non-exporters) or serve both the domestic market and the foreign market (ordinary exporters). However, some firms serve exclusively the foreign market (pure

exporters). Likewise, some products are purely exported by the firms. In China, around 90 percent of exports are under "ordinary trade (OT)", "processing trade with purchased materials (PTPM)" or "processing trade with supplied materials (PTSM)". PTPM, also known as import-assembly trade, refers to "business activities in which the operating enterprise imports materials/parts by paying foreign exchange for their processing and exports finished processed products for sale abroad". PTSM, also known as pure assembly trade, refers to "the business activities in which the imported materials are supplied by the overseas enterprise, and the operating enterprise need not pay foreign exchange for the import, but just carries out processing or assembling in accordance with the requirements of the overseas enterprise, and charges for the processing, with the finished products being marketed by the overseas enterprise". According to these definitions, it is obvious that PTPM and PTSM are among the forms of pure exporting behaviour. In Fig 1.2, we draw the share of export under ordinary trade, processing trade (PTPM and PTSM) and other trade. As shown, processing export accounts for a very large share of total export. From 2006 to 2010, export share of processing trade is higher than export share of ordinary trade. From 2006 to 2014, the average export share of processing trade is 45.45%, which is very close to the export share of ordinary trade 46.70%.
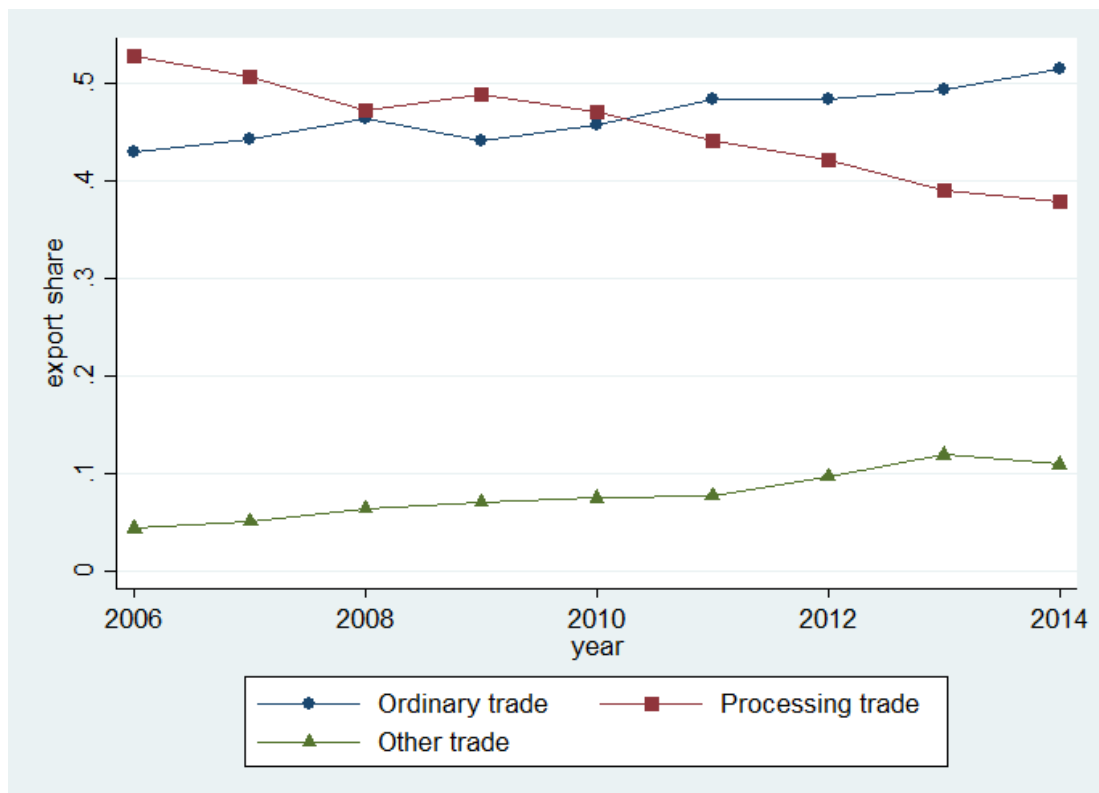
Note: The data is from Report on International Trade of China by comprehensive department of Ministry of Commerce (http://zhs.mofcom.gov.cn/article/cbw/201511/20151101156345.shtml accessed on 26 April, 2016).

Figure 1.2: Export share of processing trade

From the analysis of export share of processing trade, it is evident that pure exporting behaviour is very important in China's export. With Chinese firm-level data, we can further see the role played by pure exporters. In China 6.7% of all firms and 27.4% of all exporting firms are pure exporters. Pure exporters exist in 88.4% of all sectors and 90.5% of all exporting sectors. Moreover, pure exporters contribute 29.1% of the total exports and 8.7% of total employment. Furthermore, pure exporters have larger average value of exports than ordinary exporters. The existence of pure exporters is not restricted to China. World Bank Enterprise Surveys offers an expansive array of economic data on 130,000 firms in 135 countries. More than 90% of the countries are developing countries. From the survey, pure exporters account at least 7% of all firms in more than 25% of the countries, and account at least 19% (10%) of all exporters in more than 50% (75%) of the countries.

Pure exporting behaviour is non-trivial both in China and in large range of developing countries. However, the studies on pure exporting behaviour are far behind. Chapter 2 and 3 are aiming to fill this gap.

1.1.3 Quality Specialization

Besides pure exporting behaviour, another mark of China's export is that goods produced by China (here we are not talking about the products that are assembled in China, e.g. iPhone, which fall into pure exporting behaviour) are low priced. "Made in China" has been a mark of low price and low quality.
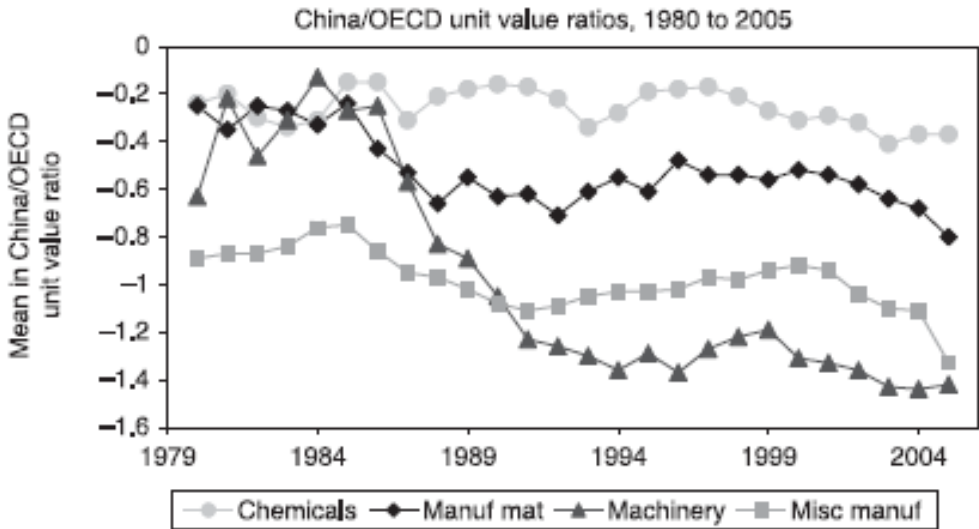
Note: The figure is from Schott (2008). This figure displays mean natural log OECD / China unit value ratio across products in noted industry, by year. Log unit values for each year and industry are significantly different from zero at the 1 percent level in almost all cases.

Figure 1.3: China/OECD log unit value ratios, 1980-2005

Schott (2008) compares the relative price between China and OECD countries. The results are shown in Fig 1.3. All log ratios are less than zero, which means China export price is lower than OECD countries in chemicals, manufactured materials and machinery from 1980 to 2005. Moreover, the ratio is decreasing, especially for machinery (from 90% in 1984 to 25% in 2005).

The price of China exort is lower than price of OECD export. Though the price has been used as a proxy for product quality in numerous research, some papers are trying to directly estimate the quality across countries. From these studies, we can compare China's export quality to the export quality to other countries. Pula and Santabárbara (2012) find that China's export quality is much lower than Japan, US and EU countries. Moreover, as shown in Fig 1.4 from Hallak and Schott (2011), China quality is lower than developed countries and it is even lower than Thailand. More surprisingly, it is almost not upgraded at all in the past decades.
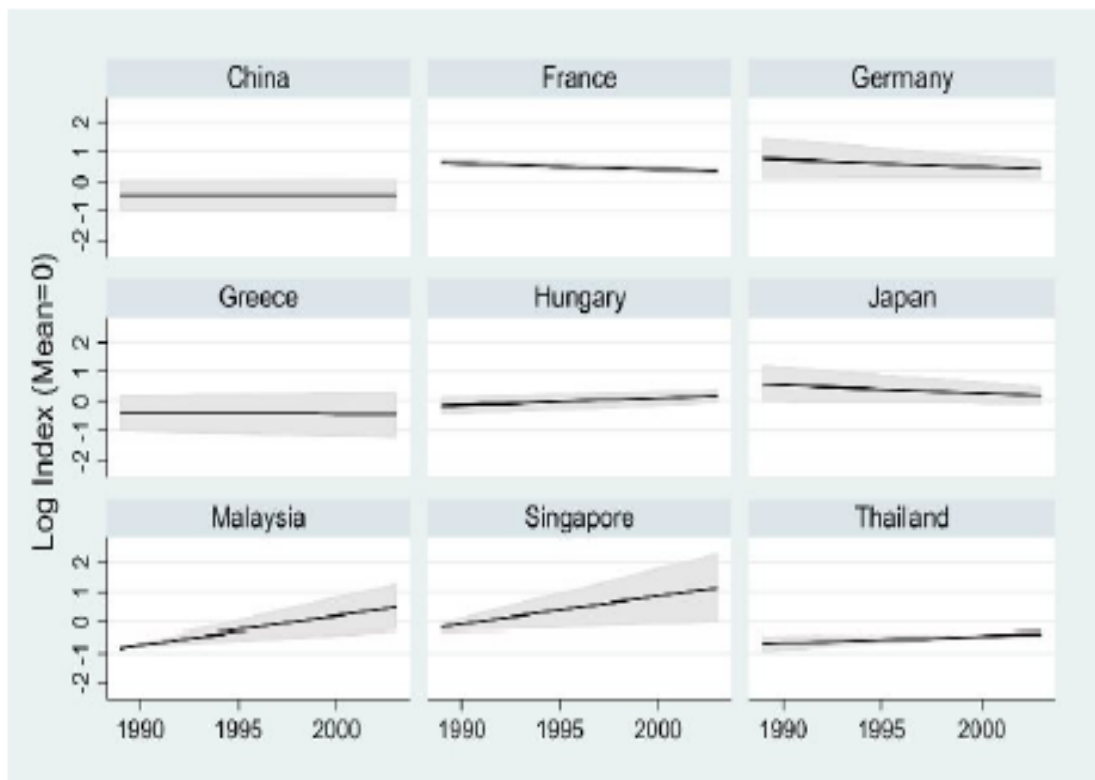
Note: The figure is from Hallak and Schott (2011). Index is normalized by the mean across countries. If the log index is zero, the quality is equal to the mean.

Figure 1.4: China's export quality

Chapter 4 studies the quality specialization between a poor country and a rich country, in order to explain why China may export low qualities. Moreover, as shown in Manova and Zhang (2012) China's exporting prices across destinations within firm-product pair is positively correlated with the income per capita of the destinations, which suggests that

quality differentiation is related to income. Therefore chapter 4 focuses on the demand side determinants of quality specialization. However, to use income per capita for each country is silent on the explanation of quality differentiation within a country and quality specialization across countries. Therefore chapter 4 assumes a general distribution for each country to investigate the roles of income distribution in quality specialization.

1.1.4 Trade policy

China's astonishing export performance is partially attributed to several trade policies. The major policy instruments that significantly influence China's international trade include reform and opening up, southern tour, accession to WTO, regional agreement and VAT rebates (VATRs).

Started in December 1978, the wind of Reform and Opening Up flowed all over China quickly. Before 1978, there is nearly no statistics about international trade in China's public database or yearbook. After the reform and Opening Up, central government established some institutions that can export and import, and granted export licenses to some firms as well. China's international trade, as well as foreign direct investment, took off from then. However the product varieties are strictly limited and controlled.

In the spring of 1992, the starter of reform and opening up, Xiaoping Deng made his famous southern tour of China. He visited Guangzhou, Shenzhen, Zhuhai and spent the New Year in Shanghai. During his tour, he stressed the importance of economic reform. The southern tour pushed the opening up to a new stage facilitating international trade. At the beginning of 1993, there is a huge decrease of varieties subject to export license. By the end of 1993, only a very small portion of export varieties were under control.

At the end of 2001, China became a member of WTO and from 2002, China began to reduce the tariffs and other trade barriers, with the overall tariff rate falling from 15.3% in 2001 to about 12% in 2002, 11.3% in 2003, 10.5% in 2004, and 10% in 2005. Depicted in picture 1.5, both export and import grew rapidly from 2002. Access to WTO is the most important trade policy in China's history.

As for regional agreement, the most important regional agreement for China is China-ASEAN Free Trade Area, which is a free trade area among the ten member states of the Association of Southeast Asian Nations (ASEAN) and China. The agreement was signed in 2002 and came into effect in 2010. There is a long time period between the two dates, therefore to analyse the effects of the agreement might be biased by the anticipation effect.

China's export VATRs was introduced in 1985. In 1994, China reformed its tax system with VAT becoming a major tax since then. The current VATRs system stems from this reform but has experienced a number of adjustments over the years. After the shock of the 1997 Asian Financial Crisis, rather than depreciating its currency, the government chose to increase VATRs to help stabilize exports. From January 1998 to December 1999,
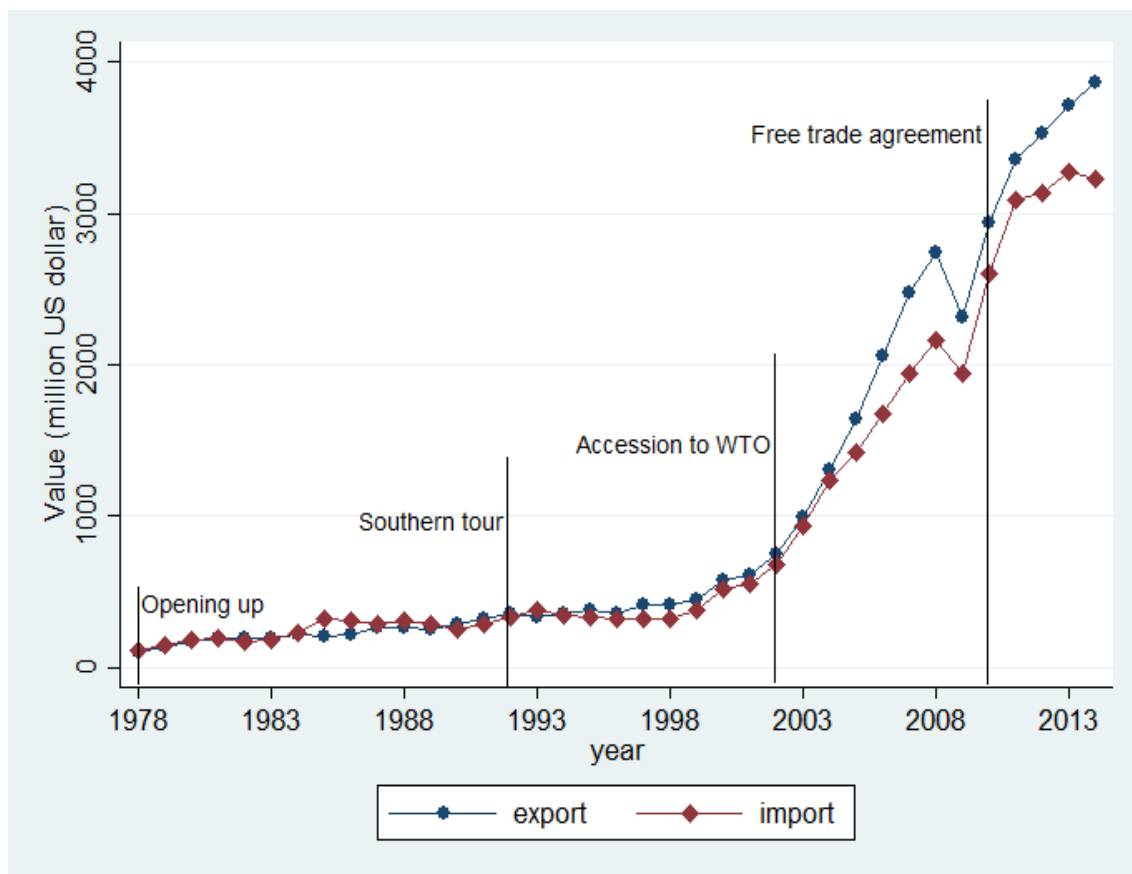
Note: The value of export and import are deflated by CPI index with the base year 1978. The data is from National bureau of statistics of China.

Figure 1.5: China's export and import

VATRs was adjusted more than 10 times. From 2003 to 2007, China's VATRs experienced adjustments more than 10 times as well. During this period, the main aim of these adjustments was to upgrade the economy structure, optimizing resource consumption and reducing environmental pollution. VATRs was increased for agricultural products, high-tech equipment and IT products. During 2008 and 2009, China's export was influenced by the global financial crisis. Consequently, VATRs for the products whose exports were significantly affected were increased, which included textiles, clothing, furniture, toys and electromechanical products. China's initial adoption of VATRs was to promote exports. After these increases in exports were achieved, further adjustments of VATRs were primarily aimed at upgrading the economy structure and responding to external export shocks.

Chapter 5 focuses the trade policy of export VATRs in China. One reason is that VATRs is product specific and frequently adjusted in China. Therefore the variations of VATRs across time and products give rise to the possibilities to dissect the VATRs to different margins of export. Another reason is that trade policy of VATRs is far under-studied in international trade. Chapter 5 is the first study to analyse the VATRs at a very

disaggregated level.

1.2 Structure

The rest of this thesis is organized as follows. In chapter 2 exporting behavior as pure exporters is analysed while pure exported products are studied in chapter 3. In chapter 4, export quality and export price distribution are investigated. In chapter 5, export VATRs as the trade policy is assessed. Chapter 6 is the concluding remarks.

In chapter 2, under a single-product firm framework, the study introduces heterogeneity in productivity, entry cost and demand in both domestic and foreign markets to explain pure exporters. This chapter builds a general static equilibrium model, and then characterizes the properties of the equilibrium, including that the presence of pure exporters makes the average productivity of exporters be lower or higher than non-exporters. After characterization of the equilibrium, this chapter studies the effects of trade liberalization: from autarky to trade, a decrease in foreign entry cost and a decrease in variable export cost. And then this chapter analyses the effects of innovation as well. A decrease in foreign entry cost and innovation are studied by shifting the conditional distribution of foreign entry cost and productivity respectively. The last section is the conclusion.

In chapter 3, the pure exported products are analysed under a multiproduct firm framework. The study develops a general equilibrium model which allows for heterogeneity in productivity and fixed export cost across products. This chapter starts with the equilibrium model of closed economy and then takes the model to the open economy. Then this chapter studies the effects of trade liberalization on pure exported products: from autarky to trade, a decrease in foreign entry cost and a decrease in variable export cost. The last section is the conclusion.

In chapter 4, the study analyses the quality specialization pattern in international trade. This chapter starts with a model of closed economy, where the impacts of income distribution on quality and price distribution are shown. Then the chapter introduces the open economy where two countries trade with each other. In the open economy, the chapter firstly characterizes the incomplete specialization and complete specialization of qualities, and then proceeds to the equilibrium that determines which qualities are under incomplete specialization or complete specialization. This chapter also provides a section with some empirical evidence. Two pieces of evidence are shown: income-quality relationship and link between income distribution and export price distribution. The last section is the conclusion.

In chapter 5, the study assesses the trade policy of export VATRs in China. This chapter firstly introduces the history and implementation of China's export VATRs. Then the chapter provides a simple model of VATRs to motivate the empirical implementations. After describing the constructed data, this chapter discusses the empirical results of VA-

TRs effects on export price, quantity, extensive margins and firm welfare. A robustness check follows before the conclusion.

Chapter 6 is the concluding remarks. This chapter describes the results of the thesis. Moreover, the policy implications are discussed. Last but not least, the chapter proposes some future studies.

1.3 Contributions

This thesis contributes to research on international trade in various aspects both in theoretical and empirical views. The contributions of each chapter are summarized as follows.

The contributions of chapter 2 on pure exporters include: 1) the chapter builds a general model of pure exporter which can be applied to a wide range of countries; 2) a wider range of firm heterogeneity including productivity, market entry cost in domestic and foreign market as well as demand shocks in domestic and foreign market is introduced; 3) the presence of a large portion of pure exporters can make the average productivity of exporters lower than average productivity of non-exporters; 4) depending on the portion of pure exporters, the effect of trade on average productivity can be positive or negative; 5) entry and exit of firms are significantly affected by pure exporters; 6) Innovation and trade liberalization in terms of a decrease of foreign entry cost are analysed by shifting the distribution of firms.

The contributions of chapter 3 on pure exported products are: 1) the model of multiproduct firms allows the heterogeneity of firms and products within a firm; 2) within a firm, learning by exporting is represented as the decrease of fixed export cost; 3) a high productive firms manage pure exported products because of the ability of decreasing fixed export cost; 4) trade will increase the extensive margin of high productive firms due to pure exported products; 5) trade liberalization generates reallocation between and within firms.

The contributions of chapter 4 on quality and export price distribution include: 1) the model features a non-homothetic preference; 2) instead of income per capita, this chapter introduces a general income distribution into the model; 3) the chapter delivers a one to one income-quality relationship, thereby endogenously determining a continuum of qualities; 4) quality specialization in international trade follows home market effect, i.e. the low (high) qualities are completely specialized in the poor (rich) country while medium qualities are incompletely specialized; 5) the chapter builds a link between export price distribution and destination income distribution which is supported by the empirical evidence.

The contributions of chapter 5 on trade policy of export VATRs are: 1) this chapter is the first study to dissect VATRs effects into different margins of export, i.e. price, quantity and extensive margins; 2) the chapter provides a simple model of VATRs where VATRs

affects both marginal revenue and marginal cost of firms; 3) the potential endogeneity of VATRs is corrected by choosing period when VATRs adjustments are not responses to export shocks and including fixed effects to control sectoral demand shocks; 4) VATRs significantly contributes to export growth mainly through extensive margin; 5) VATRs significantly increases firm welfare, and the more intensively the firms use imported materials the smaller the effect is.

Chapter 2

The Impact of Trade with Pure Exporters

The present chapter introduces heterogeneity in productivity, entry cost and demand in both domestic and foreign market to show how firms choose to be pure exporters serving solely foreign markets. Pure exporters face lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost. The presence of a large portion of pure exporters can make the average productivity of exporters lower than average productivity of non-exporters. It is also found that depending on the portion of pure exporters, the effect of trade on average productivity can be positive or negative. However, the effect of trade on welfare is positive because of the access to more varieties. Furthermore, this chapter explores the effects of trade liberalization and innovation. In particular, a decrease of foreign entry cost or innovation across firms pushes some pure exporters and non-exporters out of the market and some ordinary exporters to become pure exporters or non-exporters.

2.1   Introduction

In a dominant part of the literature on international trade it is assumed that firms serve the domestic market (non-exporters) or serve both the domestic market and the foreign market (ordinary exporters). However, some firms serve exclusively the foreign market (pure exporters). As shown in table 2.1, in China 6.7% of all firms and 27.4% of all exporting firms are pure exporters. Pure exporters exist in 88.4% of all sectors and 90.5% of all exporting sectors. Moreover, pure exporters contribute 29.1% of the total exports and have larger average value of exports than ordinary exporters. The existence of pure exporters is not restricted to China. As shown in Fig 2.1, according to the World Bank enterprise surveys in 135 countries, pure exporters account for at least 7% of all firms in more than 25% of the countries, and account for at least 19% (10%) of all exporters in more than 50% (75%) of the countries. The present chapter provides a general model of

pure exporters and studies the impact of trade with the presence of pure exporters. The results suggest that depending on the portion of pure exporters the average productivity of exporters can be lower or higher than the average productivity of non-exporters. The presence of pure exporters makes average productivity with trade lower or higher than in autarky, though welfare with trade is higher than in autarky.
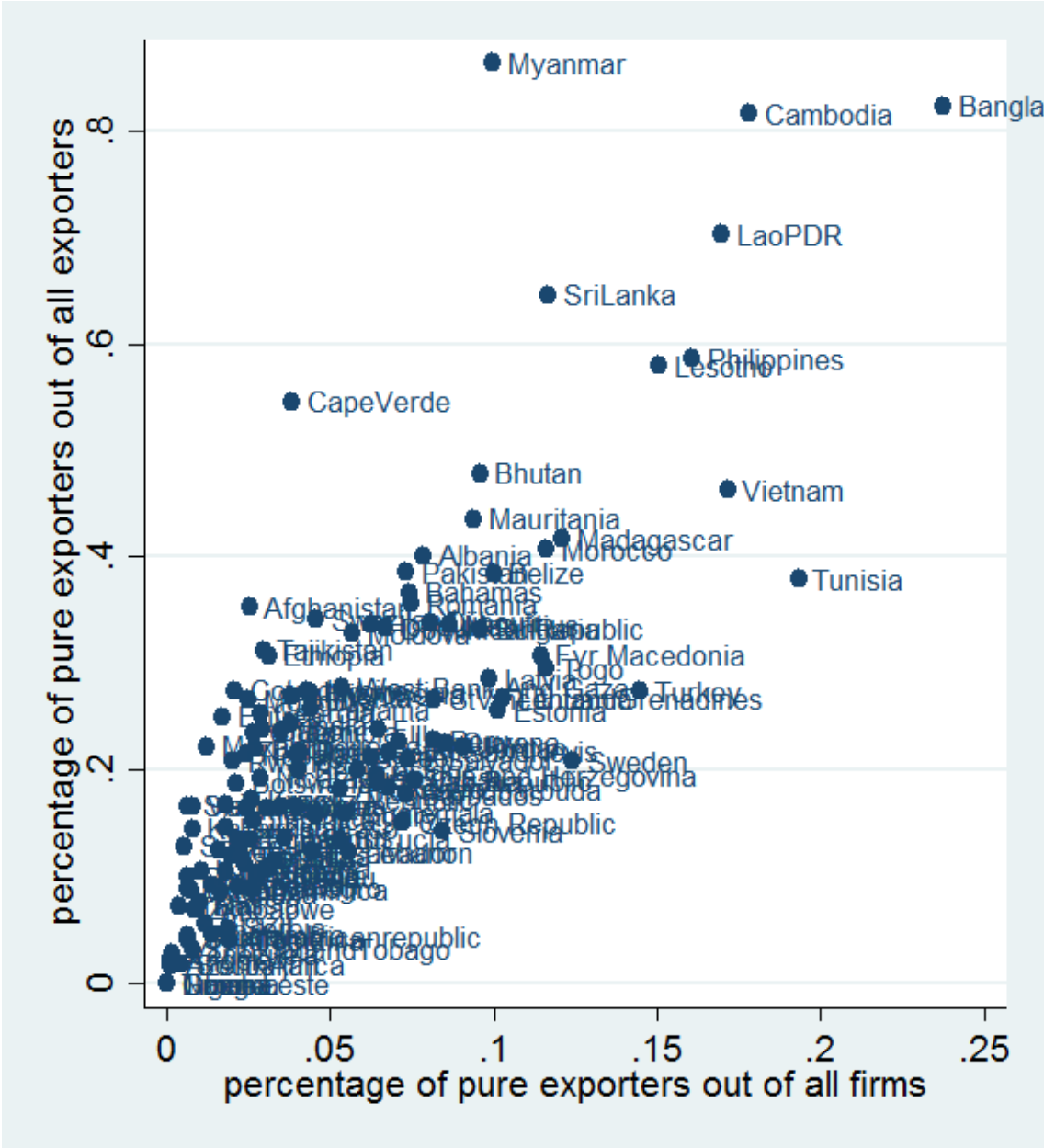
Note: The data is from World Bank Enterprise Surveys, which offers an expansive array of economic data on 130,000 firms in 135 countries. More than 90% of the countries are developing countries. The pure exporters are defined as the firms that export more than 90% of total output as in Defever and Riaño (2012). Fig 2.1 shows that a large portion of pure exporters exist in a wide range of countries. In particular, pure exporters account at least 7% of all firms in more than 25% of the countries, and account at least 19% (10%) of all exporters in more than 50% (75%) of the countries.

Figure 2.1: Percentage of pure exporters across countries

Table 2.1: Descriptive statistics of pure exporters from 1999 to 2008 in China

	1999	2001	2003	2005	2007	2008	All years
# number of pure exporters	9,193	11,676	14,592	20,473	22,556	22,306	145,415
Ratio to all exporting firms	0.266	0.287	0.287	0.271	0.285	0.253	0.274
Ratio to all firms	0.059	0.070	0.076	0.076	0.067	0.054	0.067
# number of sectors with pure exporters	394	408	394	433	440	410	732
Ratio to all exporting sectors	0.697	0.722	0.773	0.841	0.861	0.865	0.905
Ratio to all sectors	0.656	0.674	0.750	0.825	0.838	0.858	0.884
Exports							
Percentage in total exports	0.310	0.291	0.294	0.281	0.302	0.292	0.291
Average exports ratio to ordinary exporters	1.242	1.023	1.032	1.050	1.084	1.221	1.091
Gross sales							
Ratio to all exporting firms	0.105	0.101	0.109	0.109	0.122	0.115	0.112
Average gross sales ratio to ordinary exporters	0.325	0.281	0.302	0.329	0.346	0.386	0.335
Ratio to all firms	0.051	0.051	0.057	0.054	0.056	0.050	0.053
Asset							
Ratio to all exporting firms	0.057	0.059	0.069	0.077	0.084	0.083	0.074
Average asset ratio to ordinary exporters	0.167	0.157	0.183	0.223	0.231	0.267	0.212
Ratio to all firms	0.025	0.027	0.031	0.035	0.037	0.034	0.033
Employment							
Ratio to all exporting firms	0.139	0.168	0.201	0.219	0.222	0.219	0.196
Average employment ratio to ordinary exporters	0.447	0.503	0.625	0.753	0.712	0.826	0.648
Ratio to all firms	0.056	0.072	0.090	0.104	0.101	0.093	0.087

Notes: Source from China Industrial Firm-level database which covers manufacturing firms with sales more than 5 million RMB and accounts for more than 90% of Chinese industrial output. We do not include data of year 2004 as some data is missing in our database.

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We consider a general equilibrium model with a continuum of heterogeneous firms and identical countries. However firm heterogeneity is not restricted to differences in productivity as in Melitz (2003). Indeed firms also have heterogeneous entry cost for foreign marke (e.g. Schmitt and Yu, 2001; Jørgensen and Schröder, 2006, 2008; Das et al., 2007; Arkolakis, 2010; Krautheim, 2012; Kasahara and Lapham, 2013). In this chapter firms face idiosyncratic shocks with respect to productivity, entry cost for domestic market as well as foreign market and demand in domestic as well as foreign market as in Eaton et al. (2011). We focus on firm's selection between the domestic and foreign market, and more importantly we study the impact of trade with pure exporters. Instead, Eaton et al. (2011) study the pattern of firm entry and sales across foreign markets. In the present chapter, shocks on productivity and market entry costs as well as demands are jointly drawn from a common probability distribution. Based on their shocks firms choose to be pure exporters, non-exporters, ordinary exporters, or non-active. Hardly surprising we find that: a pure exporter faces lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost; and, its productivity allows it to earn profit in the foreign market, but its productivity is not high enough for it to earn profit in the domestic market. On the contrary, a non-exporter faces lower demand-adjusted domestic entry cost than demand-adjusted foreign entry cost and can only earn profit in the domestic market given its productivity. A ordinary exporter earns profit in both domestic and foreign market given its productivity, while a non-active firm cannot make profit in any market.

Lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost has two possible sources, i.e. relatively low foreign entry cost compared with domestic entry cost and relatively high foreign demand compared with domestic demand. Taking China as an example, provinces (and in some cases even cities) compete with provinces building barriers to protect their firms (Young, 2000). Therefore the domestic market is quite segmented. As a consequence firms in some markets face relatively high domestic entry cost. Moreover firms participating in the global production fragmentation can face relatively low foreign entry costs because of their experiences. Relatively low domestic demand can happen for some firms when they locate in a small or developing country. Inevitably, there are connections between pure exporters and processing firms, where processing firms simply produce final products or intermediaries for foreign firms. However pure exporters are not necessarily processing firms and processing firms are not necessarily pure exporters. In Defever and Riaño (2012) it is found that 51.6% of processing firms are pure exporters and 37.0% of pure exporters are processing firms. In our model all firms transform inputs to outputs, so there is no role for processing firms. However, the model can potentially explain why processing firms become pure exporters because the logic behind the decision to become a processing firm should be the same as the logic leading firms to become pure exporters, namely profit maximization. Since firms sell their production to other multinational firms that may allocate the sales across the world, they

face low demand-adjusted foreign entry cost, i.e. low foreign entry cost and (or) high foreign demand.

In Theorem 1 we show that there is a unique equilibrium. In Corollary 1 we observe that non-exporters, pure exporters and ordinary exporters co-exist in equilibrium. The distribution of firms determines the portion of pure exporters. Therefore, as the distribution of firms changes, portion of pure exporters varies as a result. Though we observe a small portion of pure exporters now, it is very likely that distribution of firms may entitle a large portion of pure exporters in some countries or in some future time. This chapter studies the impact of trade given a distribution that generates a large portion of pure exporters.

For any given demand-adjusted domestic entry cost, the productivity of pure exporters is lower than productivity of non-exporters. In Theorem 2 we show that the average productivity of exporters can be lower than the average productivity of non-exporters given a large portion of pure exporters. Exploring the impact of trade on equilibrium we next study a move from autarky to trade. The move on the one hand pushes firms with low productivity and high demand-adjusted foreign entry cost out of the market; on the other hand induces some firms with even lower productivity and low demand-adjusted foreign entry cost into the market as pure exporters. Therefore given a large portion of pure exporters the move from autarky to trade can result in lower average productivity as we show in Theorem 3. However trade is welfare improving as shown in Theorem 4. The reason is that a greater variety of goods are available with trade than in autarky.

We study the effects of trade liberalization interpreted as changes of the conditional distribution of foreign entry cost and variable export cost. Similarly we study the effects of innovation interpreted as a change of the conditional distribution of productivity. A decrease in foreign entry cost raises the minimum productivity needed to serve both domestic and foreign market. Therefore among firms with any given combination of demand-adjusted domestic and foreign entry costs, the least productive firms (pure exporters or non-exporters) are pushed out of the market while the least productive ordinary exporters become pure exporters or non-exporters. This result is described in Theorem 5. A decrease in variable export cost raises the minimum productivity needed to serve the domestic market and decreases the minimum productivity needed to serve the foreign market. Hence some non-exporters are pushed out of the market, some non-active firms and ordinary exporters become pure exporters as described in Theorem 6. Innovation has the same effects as an decrease in foreign entry cost as described in Theorem 7. The effects of trade liberalization and innovation are channelled through labor markets, where competition for labor becomes more intensive resulting in higher real wage à la Melitz (2003).

Lu (2010), Defever and Riaño (2012) and Lu et al. (2014) provide different theoretical explanations for the existence of Chinese pure exporters. In Lu (2010) pure exporters have a comparative advantage in the foreign market. In Defever and Riaño (2012), most

of Chinese pure exporters are located in the special economic zones and are entitled to a preferential tax scheme. Therefore in their model, pure exporters sacrifice the domestic market in return for the tax advantage. However, there are still 5.22% of the pure exporters that fall out of the scheme, as shown in Table 2.2. Moreover, a large portion of pure exporters exist in a wide range of countries. Our model is not relying on the tax scheme, and thus can apply to other countries. In Lu (2010) pure exporters have a comparative advantage in the foreign market. Lu et al. (2014) explain pure exporters as the exporters with large foreign demand corresponding to large foreign demand shock in our model. There is a rich literature on productivity of exporters and non-exporters indicating that exporters are more productive than non-exporters. See Bernard and Jensen (1999), Bernard et al. (2003), De Loecker (2007), Lileeva and Trefler (2010) and Bustos (2011). However, using Chinese firm-level data, Lu (2010) and Dai et al. (2011) find that productivity of exporters is lower than productivity of non-exporters while Ma et al. (2014) find the same pattern in terms of capital labor ratio. These findings are compatible with our analysis where the average productivity of exporters compared with the average productivity of non-exporters depends on the portion of pure exporters.

Table 2.2: Composition of pure exporters

percentage of pure exporters among all exporters			
	PTE	FIE	Neither	All
In a FTZ	52.63	34.67	22.49	36.04
Outside	35.56	27.85	16.85	21.93
ALL	51.62	33.74	20.79	33.58
percentage of firms among pure exporters			
	PTE	FIE	Neither	All
In a FTZ	35.47	36.95	16.13	88.55
Outside	1.54	4.69	5.22	11.45
ALL	37.01	41.64	21.35	100

This table is derived according to Defever and Riaño (2012), where pure exporter is defined as exporter that exports more than 90% output abroad. PTE means processing trade enterprises, FIE means foreign invested enterprises and FTZ is free trade zone. From the table, 51.6% of processing trade enterprises are pure exporters and 37.0% of pure exporters are processing trade enterprises.

A large and established literature has documented that trade forces the least productive firms exit markets and the overall productivity is increased consequently (e.g. Pavcnik, 2002; Melitz, 2003; Trefler, 2004; Bernard et al., 2011; Melitz and Ottaviano, 2008; Mayer et al., 2014). The finding is compatible with our model provided the distribution of shocks results in a small portion of (or no) pure exporters. In addition we find that the low productive firms with low demand-adjusted foreign entry cost can survive by solely

serving the foreign market.

The rest of this chapter is organized as follows. Section 2 is the set up of the model. In section 3 we describe the properties of the equilibrium. In section 4 we explore the effects of trade liberalization. In section 5 we study the effects of innovation. Section 6 is the conclusion.

2.2   Set Up

We consider an economy with two identical countries. The two countries have the same labor and wage. Labor is the only input factor of firms and fixed in both countries. Consumers and firms face domestic and foreign market. Firms pay entry cost whereby they learn their characteristics. Based on these characteristics they choose to serve the domestic market, foreign market or both markets. Firms have to pay entry costs to enter domestic and foreign market. There are demand shocks in both markets. At every date a portion of the firms die but the same amount of new firms successfully enter. There is a dynamic process of firm entry and exit to keep the distribution of firms stationary. Therefore profits are zero in the equilibrium.

2.2.1   Commodities

There are labor and a continuum of goods. Let Ω be the set of goods with $\omega \in \Omega$. The price of labor (wage) is normalized to one.

2.2.2   Consumers

There is a continuum of identical consumers with mass one in both countries. Every consumer has one unit of labour, that is supplied inelastically, and a CES utility function:

$$U((q(\omega))_{\omega \in \Omega}) = \left(\int_{\omega \in \Omega} [A(\omega)q(\omega)]^\rho \, d\omega \right)^{\frac{1}{\rho}}$$

with $0 < \rho < 1$. For every good ω all consumers in a country have the same taste shock $A(\omega)$, but consumers in different countries can have different taste shocks. In addition consumers have shares in firms. However, since there is free entry, average profit of firms is zero so ownership of firms can be disregarded. The problem of a consumer is to maximize utility subject to the budget constraint.

Let $\sigma = 1/(1-\rho)$ so $\sigma > 1$ because $0 < \rho < 1$. The price index P and the quantity index Q are defined as follows:

$$P = \left(\int_{\omega \in \Omega} [\frac{p(\omega)}{A(\omega)}]^{1-\sigma} \, d\omega \right)^{\frac{1}{1-\sigma}} \text{ and } Q = \left(\int_{\omega \in \Omega} [A(\omega)q(\omega)]^\rho \, d\omega \right)^{\frac{1}{\rho}}.$$

The solution to the consumer problem derives the aggregate demand $(q(\omega))_{\omega \in \Omega}$:

$$q(\omega) = A(\omega)^{\sigma-1} Q \left(\frac{p(\omega)}{P} \right)^{-\sigma}. \tag{2.1}$$

Let $r(\omega) = p(\omega)q(\omega)$ for all ω and $R = PQ = \int_{\omega \in \Omega} r(\omega) \, d\omega$.

2.2.3 Firms

Firm ω uses labor to produce good ω. Firms face identical entry cost $F_e > 0$. If a firm enters, then its cost parameters and demand shocks are revealed. The cost parameters and demand shocks are $(\varphi, F_d, F_x, A_d, A_x)$ where: φ is the productivity; F_d the domestic entry cost; F_x the foreign entry cost; A_d demand in the domestic market; and A_x demand in the foreign market. Therefore a firm is characterized by its productivity, market entry costs and demands $(\varphi, F_d, F_x, A_d, A_x)$. We assume that the parameters are drawn from a common probability distribution with density $\xi : \mathbb{R}_+^5 \to \mathbb{R}_{++}$ and cumulative distribution $\Xi : \mathbb{R}_+^5 \to [0, 1]$.

There is a continuum of active firms. Let Ω be the set of active firms with $\omega \in \Omega$.

Production

Every firm has probability $\delta > 0$ of dying at every date. Let $f_d = \delta F_d$ and $f_x = \delta F_x$ be the amortized per date market entry costs. In the sequel we use amortized per date market entry costs and calculate profit per date rather than market entry costs and expected lifetime profit. Clearly the density $\lambda : \mathbb{R}_+^5 \to \mathbb{R}_{++}$ on productivity, amortized entry costs and demand shocks is defined by $\lambda(\varphi, f_d, f_x, A_d, A_x) = \xi(\varphi, f_d/\delta, f_x/\delta, A_d, A_x)$ with cumulative distribution $\Lambda(\varphi, f_d, f_x, A_d, A_x) = \Xi(\varphi, f_d/\delta, f_x/\delta, A_d, A_x)$.

In order to supply $q > 0$ units of good ω to the domestic market the firm uses $f_d + q/\varphi$ units of labor. There is a variable export cost $\tau \geq 1$, so in order to supply $q > 0$ units of the good to the export market the firm uses $f_x + q\tau/\varphi$ units of labor.

There is monopolistic competition in both countries. Therefore for given price and quantity indices, every firm faces the demand function described in (4.5). A firm supplying the domestic market maximizes its profit on that market:

$$\max_p \; p A_d^{\sigma-1} Q \left(\frac{p}{P} \right)^{-\sigma} - \frac{1}{\varphi} A_d^{\sigma-1} Q \left(\frac{p}{P} \right)^{-\sigma}$$

The solution is $p_d(\varphi) = 1/(\rho\varphi)$, the total revenue is $r_d(P, \varphi, A_d) = R(PA_d\rho\varphi)^{\sigma-1}$ and the profit is $\pi_d(P, \varphi, f_d, A_d) = r_d(P, \varphi, A_d)/\sigma - f_d$. A firm supplying the foreign market maximizes its profit on that market:

$$\max_p \; p A_x^{\sigma-1} Q \left(\frac{p}{P} \right)^{-\sigma} - \frac{\tau}{\varphi} A_x^{\sigma-1} Q \left(\frac{p}{P} \right)^{-\sigma}$$

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The solution is $p_x(\varphi) = \tau/(\rho\varphi)$, the total revenue is $r_x(P,\varphi,A_x) = R(PA_x\rho\varphi/\tau)^{\sigma-1}$ and the profit is $\pi_x(P,\varphi,f_x,A_x) = r_x(P,\varphi,A_x)/\sigma - f_x$.

Behavior

Firms can be: non-active firms; non-exporters; ordinary exporters; or, pure exporters. For every combination of market entry cost and demand shocks (f_i,A_i), there is a pair of cut-off productivities $\varphi_i^*(P,f_i,A_i)$ with $i \in \{d,x\}$ such that a firm is active in market i if and only if $\varphi \geq \varphi_i^*(P,f_i,A_i)$. The cut-off productivities are determined by $\pi_i(P,\varphi_i^*,f_i,A_i) = 0$. Therefore for $\Theta = (\sigma/R)^{1/(\sigma-1)}/\rho$ the cut-off productivities are:

$$\begin{cases} \varphi_d^*(P,f_d,A_d) & = & \dfrac{\Theta}{P} \dfrac{f_d^{1/(\sigma-1)}}{A_d} \\[3mm] \varphi_x^*(P,f_x,A_x) & = & \dfrac{\tau\Theta}{P} \dfrac{f_x^{1/(\sigma-1)}}{A_x}. \end{cases} \tag{2.2}$$

Hence the behavior of a firm $(\varphi,f_d,f_x,A_d,A_x)$ can be characterized as follows:

Non-active firm: A firm is non-active provided

$$\varphi < \varphi_d^*(P,f_d,A_d) \text{ and } \varphi < \varphi_x^*(P,f_x,A_x).$$

Non-exporter: A firm is a non-exporter provided

$$\varphi_d^*(P,f_d,A_d) < \varphi < \varphi_x^*(P,f_x,A_x).$$

Ordinary exporter: A firm is an ordinary exporter provided

$$\varphi > \varphi_d^*(P,f_d,A_d) \text{ and } \varphi > \varphi_x^*(P,f_x,A_x).$$

Pure exporter: A firm is a pure exporter provided

$$\varphi_x^*(P,f_x,A_x) < \varphi < \varphi_d^*(P,f_d,A_d).$$

Equation (2.2) shows that cut-off productivities are linear in demand-adjusted market entry costs $z_i = f_i^{1/(\sigma-1)}/A_i$ with $i \in \{d,x\}$. Fig 2.2 illustrates the different kinds of behavior in the demand-adjusted market entry costs and productivity space. There are two hyperplanes of cut-off productivities defined by $\varphi = \varphi_d^*(P,f_d,A_d)$ and $\varphi = \varphi_x^*(P,f_x,A_x)$ as in equation (2.2). The two planes divide the space into four parts: non-exporters (NE), ordinary exporters (OE), pure exporters (PE) and non-active firms (N).

Behavior is illustrated in Fig 2.3 for given demand-adjusted market entry costs: in Fig 2.3.a for given demand-adjusted domestic entry cost; and in Fig 2.3.b for given demand-

$$\varphi_x^*(P, f_x, A_x) = \frac{\tau\Theta}{P} \frac{f_x^{1/(\sigma-1)}}{A_x}$$

$$\varphi_d^*(P, f_d, A_d) = \frac{\Theta}{P} \frac{f_d^{1/(\sigma-1)}}{A_d}$$

OE

NE

PE

N

$$\frac{f_d^{1/(\sigma-1)}}{A_d} = \tau \frac{f_x^{1/(\sigma-1)}}{A_x}$$

$$\frac{f_x^{1/(\sigma-1)}}{A_x}$$

$$\frac{f_d^{1/(\sigma-1)}}{A_d}$$
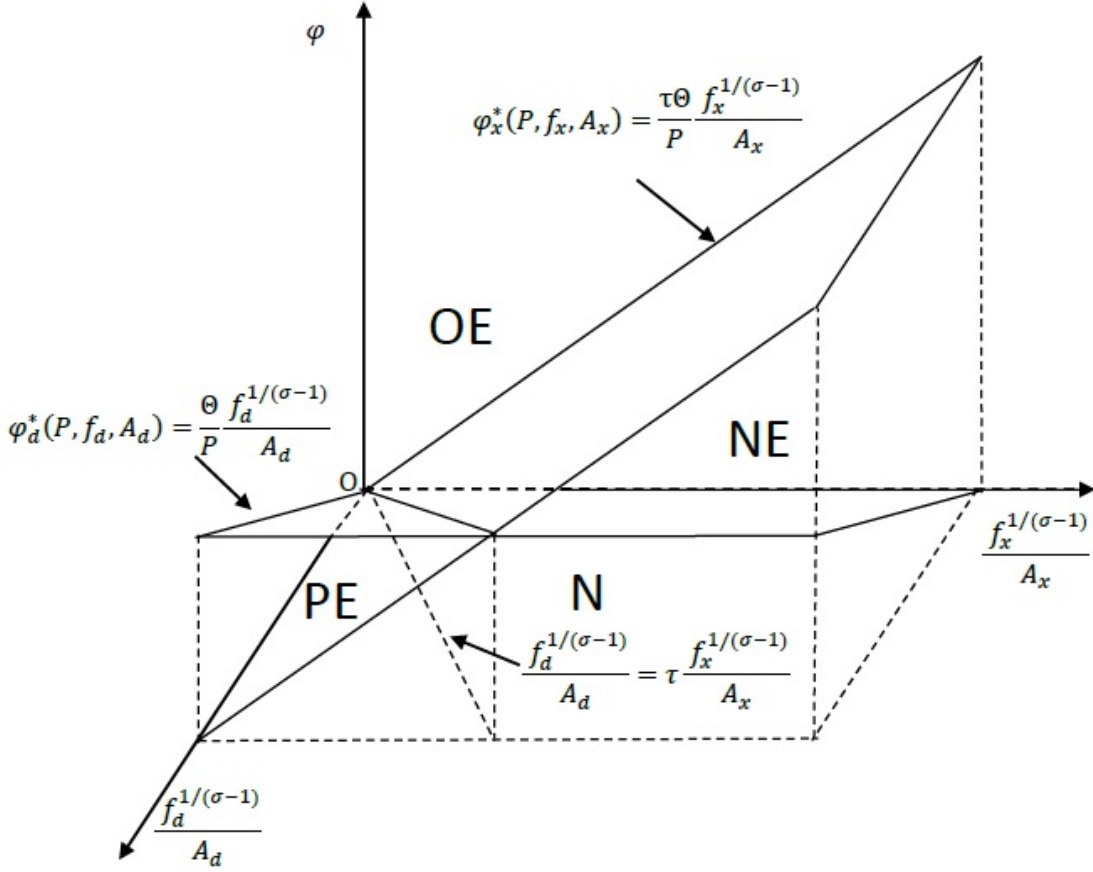
Fig 2.2: Firm behavior based on market entry costs and demand shocks

adjusted foreign entry cost. For given demand-adjusted domestic entry cost, pure exporters are characterized by low productivity and low demand-adjusted foreign entry cost. Indeed pure exporters have lower productivity than non-exporters. For given demand-adjusted foreign entry cost, pure exporters are characterized by higher productivity and demand-adjusted domestic entry cost than non-exporters.

Firm Entry and Exit

At every date a fraction δ of firms die, making the expected profit of entry positive. New firms enter until the last entrant earns zero profit. Since there is an unlimited amount of potential entrants, the dead firms are replaced by new firms. Therefore entry and exit do not affect the distribution of firms.

2.2.4 Stationary Equilibrium

We consider a stationary equilibrium where all aggregate variables are constant over time. In equilibrium consumers maximize their utilities, firms maximize their profits and mar-
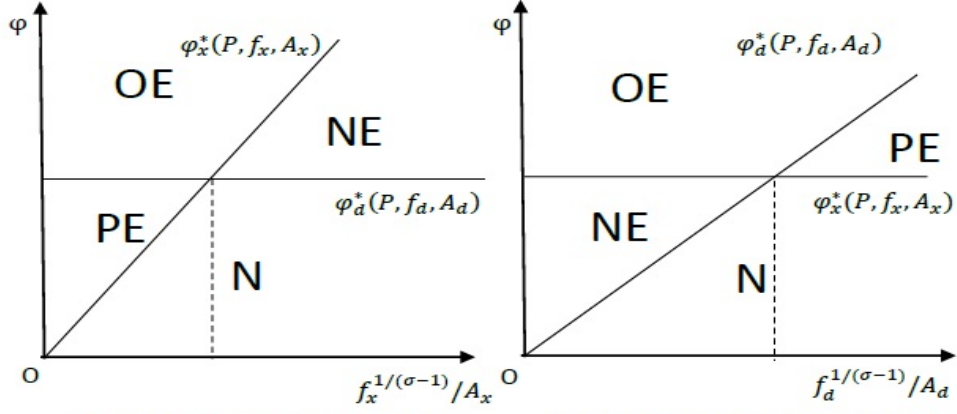
Fig 2.3.a Given demand-adjusted
domestic entry cost

Fig 2.3.b Given demand-adjusted
foreign entry cost

Fig 2.3: Firm behavior for given demand-adjusted market entry cost

kets clear. Since there is free entry, the expected lifetime profit of firms is equal to the entry cost. Let Π be the expected profit per date, then the *zero profit condition* is:

$$\frac{\Pi}{\delta} = F_e. \tag{2.3}$$

2.3 Equilibrium

There is a unique equilibrium in which all aggregate variables are constant over time.

Theorem 1 *There is a unique equilibrium.*

Proof: Let $\eta = (f_d, f_x, A_d, A_x)$ to ease notation. For price index P and parameters (φ, η) let $\pi(P, \varphi, \eta)$ be the profit per date. Then the expected profit per date is:

$$\Pi(P) = \int_{\varphi, \eta} \pi(P, \varphi, \eta) \lambda(\varphi, \eta) \, d(\varphi, \eta) = \int_{\eta} \pi(P|\eta) \lambda(\eta) \, d\eta \tag{2.4}$$

where $\lambda(\eta) = \int_{\varphi} \lambda(\varphi, \eta) \, d\varphi$ is the marginal density of η and $\pi(P|\eta) = \int_{\varphi} \pi(P, \varphi, \eta) \lambda(\varphi|\eta) \, d\varphi$ is expected profit conditional on η. $\lambda(\varphi|\eta) = \lambda(\varphi, \eta)/\lambda(\eta)$ is the distribution of productivity conditional on η. The profit $\pi(P, \varphi, \eta)$ consists of profit from the domestic market $\pi_d(P, \varphi, f_d, A_d)$ and profit from the foreign market $\pi_x(P, \varphi, f_x, A_x)$:

$$\pi(P|\eta) = \int_{\varphi_d^*(P, f_d, A_d)}^{\infty} \pi_d(P, \varphi, f_d, A_d) \lambda(\varphi|\eta) \, d\varphi + \int_{\varphi_x^*(P, f_x, A_x)}^{\infty} \pi_x(P, \varphi, f_x, A_x) \lambda(\varphi|\eta) \, d\varphi \tag{2.5}$$

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Therefore for $\Phi : \mathbb{R}_+ \to \mathbb{R}_+$ and $k : \mathbb{R}_+ \to \mathbb{R}_+$ defined by

$$\Phi(x) = \left(\frac{1}{1 - \Lambda(x \mid \eta)} \int_x^\infty \varphi^{\sigma-1} \lambda(\varphi \mid \eta) \, \mathrm{d}\varphi \right)^{\frac{1}{\sigma-1}} \tag{2.6}$$

$$k(x) = (1 - \Lambda(x \mid \eta)) \left(\left(\frac{\Phi(x)}{x} \right)^{\sigma-1} - 1 \right) \tag{2.7}$$

where $\Lambda(x \mid \eta)$ is conditional cumulative distribution, the expected profit conditional on η is

$$\pi(P \mid \eta) = f_d k(\varphi_d^*(P, f_d, A_d)) + f_x k(\varphi_x^*(P, f_x, A_x)) \tag{2.8}$$

Finally we prove that $\Pi(P)$ is an increasing function of P. From equation (2.6) and (2.7), $k'(x) = (1 - \sigma) \int_x^\infty \varphi^{\sigma-1} \lambda(\varphi \mid \eta) \, \mathrm{d}\varphi / x^\sigma < 0$. According to Equation (2.2), the derivatives of the cut-off productivities with respect to P are negative, i.e. $\partial \varphi_d^*(P, f_d, A_d) / \partial P < 0$ and $\partial \varphi_x^*(P, f_x, A_x) / \partial P < 0$. Hence $\pi'(P \mid \eta) > 0$ so $\Pi'(P) > 0$. Moreover $\lim_{P \to 0} \Pi(P) = 0$ and $\lim_{P \to \infty} \Pi(P) = \infty$. Thus there is a unique P such that Equation (2.3) is satisfied. $\square$

Corollary 1 *In equilibrium non-exporters, pure exporters and ordinary exporters co-exist.*

Given the distribution $\lambda(\varphi, \eta)$ where $\eta = (f_d, f_x, A_d, A_x)$, the firms which can afford both demand-adjusted domestic and foreign entry costs will become ordinary exporters. The firms that can only cover demand-adjusted domestic entry cost will become non-exporters, while those that are only able to cover demand-adjusted foreign entry cost will be pure exporters. Pure exporters present due to either relatively lower foreign entry cost than domestic entry cost and (or) higher foreign demand than domestic demand. Fig 1 has illustrated all the combinations of parameters for different firm behavior.

Clearly all endogenous variables, including the portion of non-exporters, ordinary exporters and pure exporters are determined in equilibrium (See Appendix A.1 for full details). The profit earned by incumbents is equal to the entry cost of the entrants, therefore the total revenue is equal to the total labor $R = L$. The total revenue is fixed as the total labor.

Fig 2.2 shows that some pure exporters have lower productivity than non-exporters. Whether the average productivity of exporters is higher or lower than the average productivity of non-exporters depends on the portion of pure exporters, which is further determined by the distribution of firms. In Theorem 2 we show by use of an example that the average productivity of exporters can be lower than the average productivity of non-exporters.

Theorem 2 *Average productivity of exporters consisting of ordinary exporters and pure exporters can be lower than average productivity of non-exporters.*

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Proof: To quantitatively see that the average productivity of exporters can be lower than non-exporters, we simplify the calculation by using a specific form of the distribution as an example. Given a distribution $\lambda(\varphi, \eta)$ such that 1) marginal density distribution of productivity φ is $g(\varphi)$, 2) demand-adjusted foreign entry cost z_x is under distribution $\gamma(z_x)$ and 3) demand-adjusted domestic entry cost z_d is under distribution $\psi(z_d)$.

As widely used, productivity distribution is Pareto distribution on $(\underline{\varphi}, \infty)$, with density distribution $g(\varphi) = \theta \underline{\varphi}^\theta \varphi^{-\theta-1}$ and cumulative distribution $G(\varphi)$, where $\underline{\varphi}$ is assumed very small and $\theta > 1$. We also assume that distribution $\psi(z_d) = \beta Z_d^\alpha z_d^{-\alpha-1}$ with support on (Z_d, ∞) and $\gamma(z_x) = \beta Z_x^\beta z_x^{-\beta-1}$ with support on (Z_x, ∞), $\alpha > 1$ and $\beta > 1$. These distributions tend to give a high portion of pure exporters, thereby more likely giving lower average productivity of exporters than non-exporters. Then in the equilibrium, average productivity of exporters and non-exporters are (see Appendix A.2 for proof):

$$\Psi_e = \frac{\theta}{\theta-1} \frac{\theta+\beta}{\theta+\beta-1} \frac{\Theta}{P} \tau Z_x$$

$$\Psi_{ne} = \frac{\theta+\beta}{\theta+\beta-1} \frac{\theta+\beta+\alpha}{\theta+\beta+\alpha-1} \cdot \frac{\Theta}{P} Z_d$$

Therefore, the ratio between average productivity of exporters and non-exporters is:

$$\frac{\Psi_e}{\Psi_{ne}} = \frac{\theta}{\theta-1} \cdot \frac{\theta+\beta+\alpha-1}{\theta+\beta+\alpha} \cdot \frac{\tau Z_x}{Z_d}.$$

The ratio is an increasing function with $\tau Z_x / Z_d$. And we can see:

$$\frac{\Psi_e}{\Psi_{ne}} < 1 \text{ provided } \frac{\tau Z_x}{Z_d} < \frac{1+(\beta+\alpha)/\theta}{1+(\beta+\alpha)/(\theta-1)} < 1.$$

The portion of pure exporters is a decreasing function of the ratio Z_x/Z_d. Therefore there are distributions such that average productivity of exporters is lower than average productivity of non-exporters. □

2.4 Trade Liberalization

2.4.1 From Autarky to Trade

In autarky, all firms are non-exporters by definition, therefore foreign entry cost and foreign demand play no role on firms' profit and cut-off productivity. In order to do comparative study between autarky and trade, we firstly prove a unique equilibrium in autarky and lower price index with trade than in autarky. To see that, the average profit of firms

conditional on η in autarky is determined as:

$$\pi(P_a \,|\, \eta) = \int_{\varphi_d^*(P_a, f_d, A_d)}^{\infty} \pi_d(P_a, \varphi, f_d, A_d) \lambda(\varphi \,|\, \eta) \,\mathrm{d}\varphi = f_d k(\varphi_d^*(P_a, f_d, A_d))$$

where P_a is the price level in autarky. The expected profit in autarky $\Pi(P_a)$ is :

$$\Pi(P_a) = \int_\eta f_d k(\varphi_d^*(P_a, f_d, A_d)) \lambda(\eta) \mathrm{d}\eta \qquad (2.9)$$

Since $k'(\cdot) < 0$ and $\varphi_d^*(P_a, f_d, A_d)$ is monotonically decreasing with P_a, $\Pi(P_a)$ is an increasing function. $\lim_{P_a \to 0} \Pi(P_a) = 0$ and $\lim_{P_a \to \infty} \Pi(P_a) = \infty$. Therefore according to equilibrium equation (2.3), there is a unique price level P_a.

The expected profit in autarky $\Pi(P_a)$ in equation (2.9) is less than the expected profit with trade $\Pi(P)$ determined by equations (2.4) and (2.5). Since $\Pi(\cdot)$ is a monotonically increasing function, we have $P < P_a$.

Because $P < P_a$, the cut-off productivity for the domestic market in equation (2.2) become higher with trade than in autarky. Therefore the plane $\varphi_d^*(P_a, f_d, A_d)$ is underneath the plane $\varphi_d^*(P, f_d, A_d)$ shown as Fig 2.4. From Fig 2.4, we see trade not only forces some low productive firms with relatively high demand-adjusted foreign entry cost ($\tau z_x > z_d$) out of the market, as shown in O space, but also induces some less productive firms with relatively low demand-adjusted foreign entry cost ($\tau z_x < z_d$) into the market as pure exporters, shown as in PE space. The effect of trade on average productivity can be positive or negative.

Theorem 3 *Moving from autarky to trade can lower average productivity.*

Proof: Using the same distributions of productivity and demand-adjusted market entry costs as in the proof in Theorem 2, the average productivities in autarky and trade are (see Appendix A.3 for proof):

$$\Psi_a = \frac{\theta}{\theta - 1} \cdot \frac{\theta + \alpha}{\theta + \alpha - 1} \cdot \frac{\Theta}{P_a} \cdot Z_d$$

$$\Psi = \frac{\theta}{\theta - 1} \cdot \frac{\theta + \beta}{\theta + \beta - 1} \cdot \frac{\frac{\alpha(\theta - 1)}{\theta + \beta + \alpha - 1} Z_d \left(\frac{\tau Z_x}{Z_d}\right)^{\theta + \beta} + \beta \tau Z_x}{\frac{\alpha \theta}{\theta + \beta + \alpha} \left(\frac{\tau Z_x}{Z_d}\right)^{\theta + \beta} + \beta} \cdot \frac{\Theta}{P}$$

Therefore the ratio between overall productivity after trade and autarky is:

$$\frac{\Psi}{\Psi_a} = \frac{\theta + \beta}{\theta + \beta - 1} \frac{\theta + \alpha - 1}{\theta + \alpha} \frac{\frac{\alpha(\theta - 1)}{\theta + \beta + \alpha - 1} \left(\frac{\tau Z_x}{Z_d}\right)^{\theta + \beta} + \beta \left(\frac{\tau Z_x}{Z_d}\right)}{\frac{\alpha \theta}{\theta + \beta + \alpha} \left(\frac{\tau Z_x}{Z_d}\right)^{\theta + \beta} + \beta} \cdot \frac{P_a}{P}$$

It is straightforward that

$$\lim_{\tau Z_x / Z_d \to 0} \frac{\Psi}{\Psi_a} = 0$$

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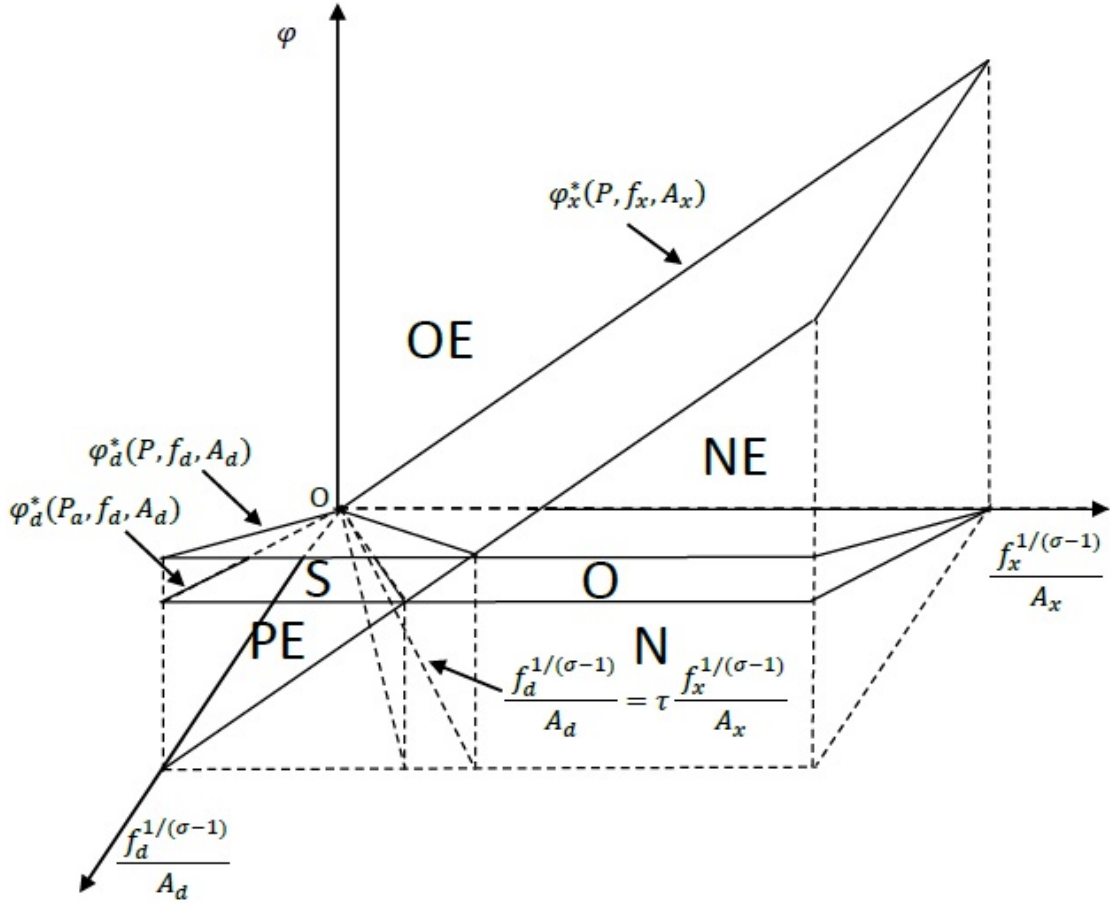
Fig 2.4: Firm behavior from autarky to trade

As $\tau Z_x / Z_d$ becomes lower, there are higher portion of pure exporters, leading to lower overall productivity with trade than in autarky. Because P_a/P is larger than 1, average productivity after trade can easily be higher than in autarky as the portion of pure exporters decreases. □

With trade the competition for labor is more intensive than in autarky. Therefore the real wage is higher with trade than in autarky. As shown in Fig 2.4, medium productive firms can afford the new wage and will serve the domestic market solely (NE). High productive firms will serve both markets (OE). Low productive firms cannot afford demand-adjusted domestic entry cost because of the high wage. Hence part of them are pushed out of the market (O), while rest of them are pushed to become pure-exporters because of low demand-adjusted foreign entry cost (S). Furthermore, some non-active firms with low demand-adjusted foreign entry cost are induced into the market as pure-exporters (PE). The effect of moving from autarky to trade on productivity is ambiguous. The outcome depends on distribution $\lambda(\varphi, \eta)$, which determines the portfolio of firms that are pushed out of and induced into the market.

Theorem 4 *Moving from autarky to trade leads to higher welfare.*

Proof: Welfare, equal to utility, is defined as:

$$W = \frac{R}{PL} = \frac{1}{P}$$

Welfare in autarky W_a and with trade W are:

$$W_a = \frac{1}{P_a} \text{ and } W = \frac{1}{P} \tag{2.10}$$

From the inequality $P < P_a$, it follows that $W_a < W$. $\qquad\square$

The effect of trade on the average productivity can be positive or negative, but the welfare gains from trade is positive. This indicates that the dominant source of trade gains here is the access to more varieties.

2.4.2 A Decrease in Foreign Entry Cost

Trade liberalization in form of lower foreign entry cost can be interpreted as a change of the conditional distribution of foreign entry cost. An example is the enlargement of EU in 2004 that standardized the regulatory environment for a lot of European firms leading to lower foreign entry cost. Fig 2.5.a illustrates a possible decrease in foreign entry cost.

Fig 2.5.a A decrease in foreign entry cost   Fig 2.5.b Innovation
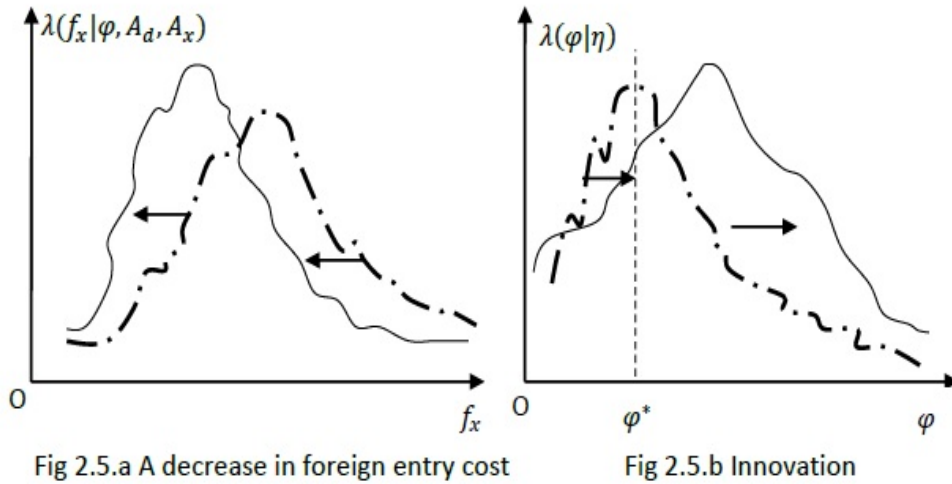
Fig 2.5: Shift of distributions

In order to analyse the effects of a decrease in foreign entry cost, we assume that for two distributions of characteristics, the conditional distributions of foreign entry cost f_x of the marginal distributions on (φ, f_x, A_d, A_x) can be ranked by first-order stochastic dominance:

Lower Foreign Entry Cost (LFEC) *For two distributions of characteristics λ and λ', λ*

has lower foreign entry cost than λ' provided $\Lambda(f_x | \varphi, A_d, A_x) \geq \Lambda'(f_x | \varphi, A_d, A_x)$ for all (φ, η).

Suppose that for two distributions of characteristics, the conditional distributions of foreign entry cost f_x can be ranked by first-order stochastic dominance. Then the conditional distributions of foreign entry cost of the marginal distributions on (φ, f_x, A_d, A_x) can be ranked by first-order stochastic dominance too. Anyway with LFEC, the effects of a decrease in foreign entry cost are summarized as in following theorem.

Theorem 5 *Suppose LFEC is satisfied. Then lower foreign entry cost pushes some pure exporters and non-exporters out of the market and some ordinary exporters to become pure exporters or non-exporters.*

Proof: Instead of cut-off productivities $\varphi_i^*(P, f_i, A_i)$, $\pi_i(P, \varphi, f_i, A_i) = 0$ can alternatively determine cut-off market entry costs $f_i^*(P, \varphi, A_i)$, $i \in \{d, x\}$. In particular, $f_d^*(P, \varphi, A_d) = (PA_d\varphi/\Theta)^{\sigma-1}$ and $f_x^*(P, \varphi, A_x) = (PA_x\varphi/(\Theta\tau))^{\sigma-1}$. Then the firms with market entry cost lower than the cut-off will serve the markets. The profit in the domestic and foreign market are $\pi_d(P, \varphi, f_d, A_d) = f_d^*(P, \varphi, A_d) - f_d$ and $\pi_x(P, \varphi, f_x, A_x) = f_x^*(P, \varphi, A_x) - f_x$ respectively.

Let $\lambda(\varphi, A_d, A_x) = \int_{f_d, f_x} \lambda(\varphi, \eta) d(f_d, f_x)$ be the marginal distribution and $\pi(P | \varphi, A_d, A_x)$ conditional profit on (φ, A_d, A_x), then the expected profit determined as in equation (2.4) can be expressed alternatively as

$$\Pi(P) = \int_{\varphi, A_d, A_x} \pi(P | \varphi, A_d, A_x) \lambda(\varphi, A_d, A_x) d(\varphi, A_d, A_x)$$

Let $\lambda(f_d | \varphi, A_d, A_x) = \int_{f_x} \lambda(\varphi, \eta) df_x / \lambda(\varphi, A_d, A_x)$ be the conditional distribution of domestic entry cost on (φ, A_d, A_x) and $\lambda(f_x | \varphi, A_d, A_x) = \int_{f_d} \lambda(\varphi, \eta) df_d / \lambda(\varphi, A_d, A_x)$ conditional distribution of market entry cost.

$$\begin{aligned} \pi(P | \varphi, A_d, A_x) &= \int_0^{f_d^*(P, \varphi, A_d)} (f_d^*(P, \varphi, A_d) - f_d) \lambda(f_d | \varphi, A_d, A_x) df_d \\ &+ \int_0^{f_x^*(P, \varphi, A_x)} (f_x^*(P, \varphi, A_x) - f_x) \lambda(f_x | \varphi, A_d, A_x) df_x \end{aligned}$$

Here a decrease in foreign entry cost will shift conditional distribution $\lambda(f_x | \varphi, A_d, A_x)$ while leaving $\lambda(f_d | \varphi, A_d, A_x)$ and $\lambda(\varphi, A_d, A_x)$ unchanged. With property LFEC, the decrease of foreign entry cost will increase the conditional profit $\pi(P | \varphi, A_d, A_x)$ (See Appendix A.4). As a result, $\Pi(P)$ is higher. We have shown that $\Pi(P)$ is an monotonically increasing function. Therefore price level P is decreased, leading to higher cut-off productivity for both domestic and foreign market. As shown in Fig 2.6, among firms for any given combination of demand-adjusted domestic and foreign entry cost, the least produc-

tive firms (pure exporters or non-exporters) are pushed out of the market, while the least productive ordinary exporters become pure exporters or non-exporters. □

A decrease in foreign entry cost across firms raises average profit and intensifies the competition for labor. Hence real wage is increased. As a result, some low productive non-exporters and pure exporters are forced out of the market and some ordinary exporters are pushed out of the non-profitable market. After a decrease in foreign entry cost, average productivity is increased as some low productive firms are pushed out of the market. Meanwhile, according to equation (2.10), welfare is improved because price level P is decreased.
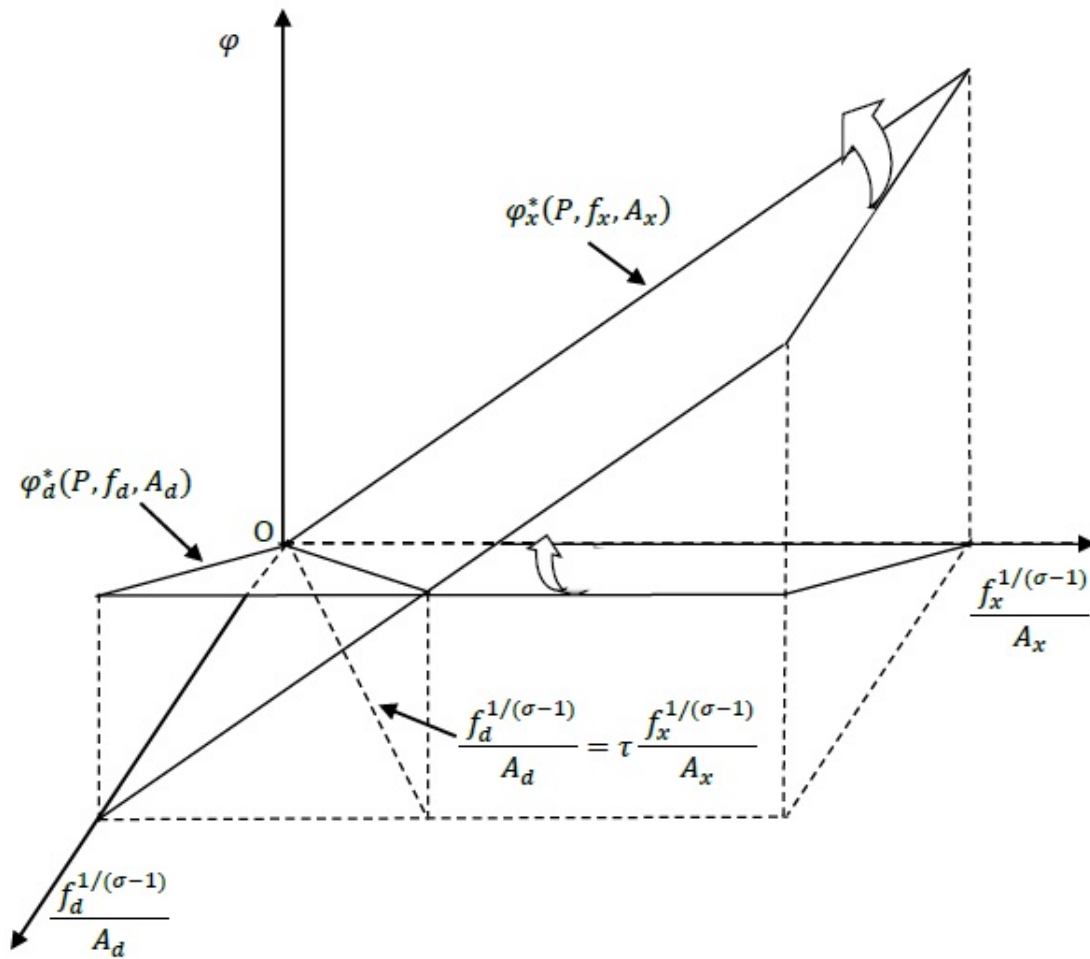
Fig 2.6: A decrease in foreign entry cost

2.4.3 A Decrease in Variable Export Cost

In this part, we study the effects of a decrease in variable export cost. The effects are summarized in the following theorem.

Theorem 6 *A decrease in variable export cost τ pushes some non-exporters out of the market or to become ordinary exporters, some non-active firms and ordinary exporters to become pure exporters.*

Proof: As variable export cost τ is decreased, the profit from the foreign market $\pi_x(P, \varphi, f_x, A_x)$ is increased. Therefore conditional profit $\pi(P|\eta)$ in equation (2.5) is increased. It is followed that $\Pi(P)$ is increased. We have shown that $\Pi(P)$ is an monotonically increasing function. Hence price index is decreased. This raises cut-off productivity in the domestic market to pushes some non-exporters out of the market and some ordinary exporters to become pure exporters.

To see the effect of τ on cut-off productivity of the foreign market, we assume $r = P/\tau$, equation (2.2) becomes $\varphi_d^*(P, f_d, A_d) = \varphi_d^*(r, f_d, A_d) = \Theta/(r\tau) \cdot f_d^{1/(\sigma-1)}/A_d$ and $\varphi_x^*(P, f_x, A_x) = \varphi_x^*(r, f_x, A_x) = \Theta/r \cdot f_x^{1/(\sigma-1)}/A_x$. Equilibrium determination (2.3) can be written as $\Pi(r, \tau) = F_e\delta$. Hence we have $dr/d\tau = -(\partial\Pi(r, \tau)/\partial\tau)/(\partial\Pi(r, \tau)/\partial r)$.

Equation (2.8) becomes a function of r, $\pi(P|\eta) = \pi(r, \tau|\eta)$. Therefore, we have

$$
\begin{aligned}
\frac{\partial\pi(r, \tau|\eta)}{\partial\tau} &= f_d k'(\cdot)\frac{\partial\varphi_d^*(r, f_d, A_d)}{\partial\tau} > 0 \\
\frac{\partial\pi(r, \tau|\eta)}{\partial r} &= f_d k'(\cdot)\frac{\partial\varphi_d^*(r, f_d, A_d)}{\partial r} + f_x k'(\cdot)\frac{\partial\varphi_x^*(r, f_x, A_x)}{\partial r} > 0
\end{aligned}
$$

Hence $\partial\Pi(r, \tau)/\partial\tau > 0$ and $\partial\Pi(r, \tau)/\partial r > 0$. We have $dr/d\tau < 0$. Therefore, the cut-off productivity of the foreign market is decreased by a decrease in variable export cost, pushing some non-active firms to be pure exporters and some non-exporters to be ordinary exporters. $\square$

A decrease in variable export cost will make firms that serve the foreign market get more profit, thereby increasing the demand for labor. The real wage will be higher. As shown in Fig 2.7, the plane of cut-off productivity for the domestic market is shifted up. Therefore, some low productive non-exporters are pushed out of the market and become non-active. Low productive ordinary exporters with relative low demand-adjusted foreign entry cost become pure exporters. However, even though the real wage is higher, the exporters still benefit from a lower variable export cost. The plane of cut-off productivity to export becomes lower to induce more firms to export. In particular, the low productive firms with relative low demand-adjusted foreign entry cost, which are otherwise non-active, will become pure exporters.

2.5 Innovation

Innovation in form of higher productivity can be interpreted as a change of the conditional distribution of productivity. An example is the digitalization starting in the 1980s. Fig
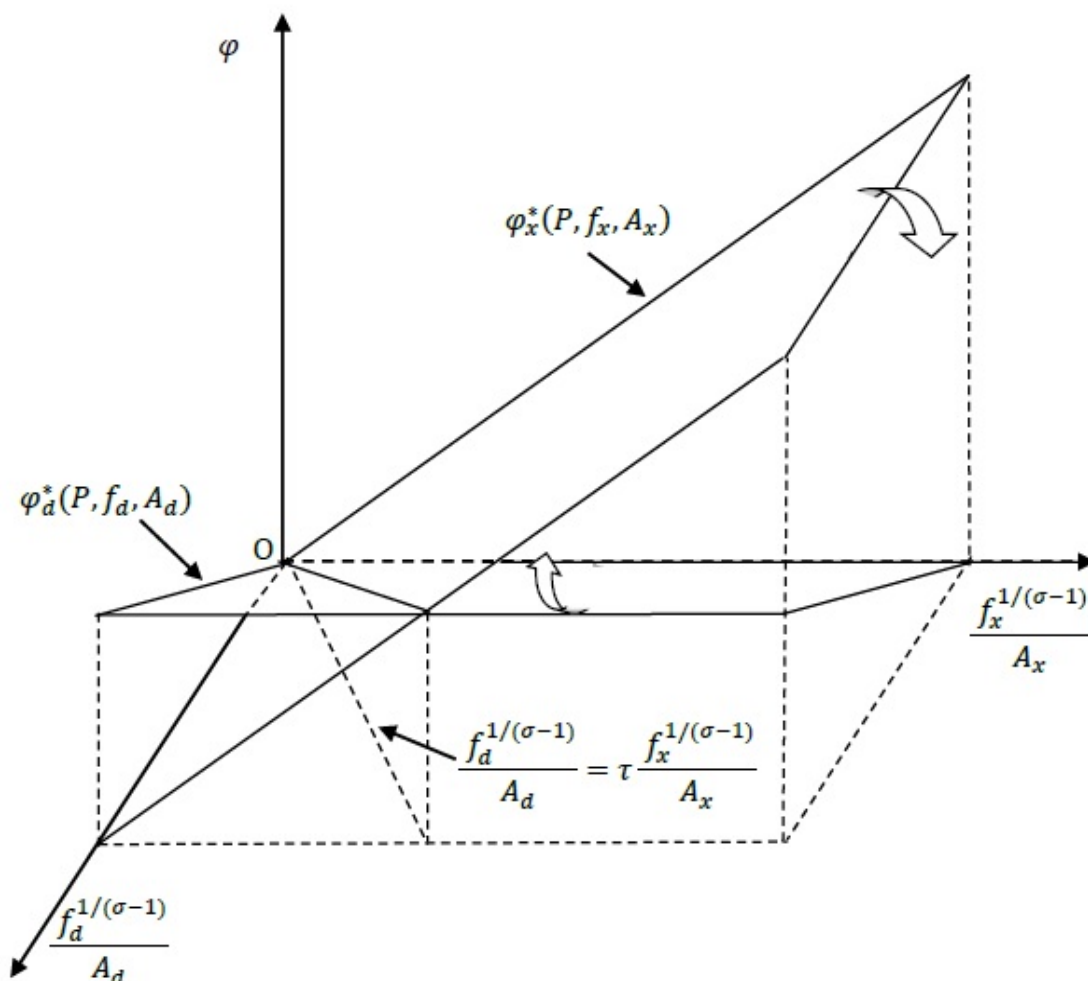
Fig 2.7: A decrease in variable export cost

2.5.b illustrates a possible increase in productivity. In order to analyse the effects of an increase in productivity, we assume that for two distributions of characteristics, the conditional distributions of productivity φ can ranked by first-order stochastic dominance:

Higher Productivity (HP) *For two distributions of characteristics λ and λ', λ has higher productivity than λ' provided $\Lambda(\varphi \,|\, \eta) \leq \Lambda'(\varphi \,|\, \eta)$ for all (φ, η).*

With HP, the effects of an innovation can be summarized in the following theorem.

Theorem 7 *Suppose HP is satisfied. Then innovation pushes some pure exporters and non-exporters out of the market and some ordinary exporters to become pure exporters or non-exporters.*

Proof: Rearrange equation (2.7) to get:

$$k(x) = \int_x^\infty \left(\left(\frac{\varphi}{x} \right)^{\sigma-1} - 1 \right) \lambda(\varphi \,|\, \eta) \mathrm{d}\varphi$$

With property HP innovation will increase $k(x)$ (See Appendix A.5), i.e. $k(\varphi_d^*(P, f_d, A_d))$ and $k(\varphi_x^*(P, f_x, A_x))$ become higher. According to equation (2.8), $\pi(P, \varphi \mid \eta)$ becomes higher, so does the expected profit $\Pi(P)$. Therefore, price level is decreased, leading to the same effects as a decrease of foreign entry cost in Theorem 5. $\qquad \square$

Innovation will increase the average productivity of incumbents and increase the average profit, thereby intensifying the competition for labor. Real wage is increased. Some low productive pure exporters and non-exporters will be forced out of the market, while some low productive ordinary exporters will become pure exporters or non-exporters. The effects of innovation are channelled through active firms. The distribution of non-active firms, i.e. firms with productivity lower than $\varphi_d^*(P, f_d, A_d)$ and $\varphi_x^*(P, f_x, A_x)$, makes no difference to the results.

2.6 Conclusion

In the present chapter we have studied what pushes firms to become pure exporters, ordinary exporters and non-exporters as well how trade liberalization and innovation push firms to change the markets they serve (Theorems 5, 6 and 7). Two important finding were that given a large portion of pure exporters, the average productivity of exporters consisting of pure exporters and ordinary exporters can be lower than productivity of non-exporters (Theorem 2) and that moving from autarky to trade can lower average productivity (Theorem 3). Despite the ambiguous effect of moving from autarky to trade on productivity, such a move leads to higher welfare because the variety of goods goes up (Theorem 4).

In the chapter there are no processing firms producing inputs or goods for other firms and there is monopolistic competition between firms. In order to enrich our understanding of pure exporters or exporters with high export intensity, it would be interesting to allow firms to become processing plants for other firms, thereby lowering their market entry cost in possibly more competitive markets.

Chapter 3

Multi-product Firms, Pure Exported Products and Extensive Margin of Export

The present chapter develops a general equilibrium model of heterogeneous multi-product firms in international trade. The model allows for heterogeneity in productivity and fixed export cost across products within a firm. Firms endogenously choose the number of products sold domestically and exported. High productive firms can manage more products in foreign market than in domestic market due to pure exported products. Exposure to trade induces reallocation across firms and within firms: least productive firms exit; least productive products are dropped from domestic market, but high productive firms switch some (or all) of them to pure exported products; the most productive firms introduce new products as pure exported products. This chapter also explores the effects of trade liberalization. In particular, more firms manage pure exported products and low productive firms reduce the number of products but high productive firms manage more products.

3.1   Introduction

Multi-product firms are of growing interest of both empirical and theoretical research in international trade. Existing theoretical literature concludes that a portion of firms export a subset of their products (e.g. Bernard *et. al.*, 2011). This implies that the extensive margin (number of products) of export is lower than the extensive margin of domestic market. In fact, there are exporters which export the full set of their products and there are also exporters which manage more products in foreign market than in domestic market. On the other hand, in current literature assumption that products within a firm only differ in productivity ignores the 'learning-by-exporting' effect. Indeed firms benefit from existing exported products to export a new product. This chapter develops a general equilibrium

model of multi-product firms, which allows for heterogeneity in productivity and fixed export cost across products within a firm. The chapter takes into account 'learning-by-exporting' effect by assuming a continually decreased fixed export cost across exported products. We find that high productive firms export, while low productive firms serve domestic market only. Across exporters, low productive firms export a subset of their domestic products while high productive firms export all their domestic products and introduce new products as pure exported products. The extensive margin of export is higher than of the margin domestic market for high productive exporters.

This chapter examines the reallocation across firms and within firms from autarky to trade. Exposure to trade forces the least productive firms out of the market, and induces high productive firms to export. All firms drop the least productive products from domestic market under trade. Across exporters, low productive exporters export a subset of the left products. Medium productive exporters export all left products and export the dropped products as pure exported products. All these firms manage less products after exposure to trade. However, high productive exporters export all left products and dropped products and introduce new products as pure exported products. High productive exporters manage more products from autarky to trade. In general, international trade decreases the number of products managed by low productive firms but increases the number of products managed by high productive firms.

This chapter explores the impacts of trade liberalization in terms of decreasing fixed and variable export cost on the number of products produced and exported. Decreasing fixed and variable export cost have the same effects. Least productive firms are forced out of the market while more firms are induced to export. More firms manage pure exported products, which means more firms have higher extensive margin of export than the margin of domestic market. For low productive firms trade liberalization decreases the number of products managed while for high productive firms it increases the number of products.

This chapter contributes to the theoretical studies on multi-product firms in international trade. We introduce heterogeneity of products within a firm and firms are differentiated by productivity. Baldwin and Gu (2009) develop a multiproduct model to analyse the impacts of trade on firm diversification, but their model assumes that firms are homogeneous and products are identical within a firm. Alternatively, Feenstra and Ma (2007) and Nocke and Yeaple (2006, 2008) develop models with heterogeneous firms, but their models assume the products within a firm are homogeneous. This is not consistent with the empirical findings about the prevalence of product churning within firms (e.g. Goldberg *et. al.*, 2008; Bernard *et. al.*, 2010; Iacovone and Javorcik, 2010). This assumption ignores the novelty of multi-product firms that they can reallocate resources across products within firms. To acknowledge the heterogeneity of products within a firm, Eckel and Neary (2010) build a model, where the products are differentiated by productivity. The product that use the core competence of the firm has the highest productivity, the products

that are further away have lower productivity [1]. However their framework assumes that the firms are homogeneous[2].

In terms of simultaneous heterogeneity of firms and products within a firm, Arkolakis and Muendler (2010), Bernard *et. al.* (2006,2011) and Mayer *et. al.* (2014) are close to ours. However, Arkolakis and Muendler (2010) focus on the partial equilibrium with export market without considering the domestic market. In Bernard *et. al.*(2011), products are assumed stochastic and continuous in 'expertise', while in Mayer *et. al.* (2014) products are ranked by the productivity. In these two papers, exporters export a subset of products. To include the pure exported products, we also introduce a heterogeneity of fixed export cost in addition to productivity across products within a firm. We show that high productive exporters export all their products and even export more products than in domestic market due to pure exported products.

The present chapter shows a positive relationship between intensive margin (output per product) and extensive margin (number of products) of export, which is also shown in other studies (Arkolakis and Muendler (2010), Bernard *et. al.* (2006,2011) and Mayer *et. al.* (2014)). However, this relationship is negative in Feenstra and Ma (2007), Nocke and Yeaple (2006, 2008) and Eckel and Neary (2010). In Feenstra and Ma (2007), adding a product decreases the aggregate price level and decreases the demand of other products; while in Eckel and Neary (2010), there are cannibalization effects to add a new product. In the setting of Nocke and Yeaple (2006, 2008), the more products a firm manages, marginal cost is higher for all the products and consequently output is smaller.

This chapter is also related to chapter 2 on pure exporters. In chapter 2, we introduce heterogeneity in productivity, entry cost and demand in both domestic and foreign market to show how firms choose to be pure exporters. A pure exporter faces lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost, and its productivity allows it to earn profit in the foreign market, but its productivity is not high enough for it to earn profit in the domestic market. In this chapter, we apply this finding into products within a firm. There are two dimensions of heterogeneity across products within a firm: productivity and fixed export cost. If firms can decrease the fixed export cost, some products will have the combination of low productivity and low fixed export cost (lower than domestic fixed cost). These products cannot earn profit in domestic market. However they can realize positive profit in foreign market and become pure exported products.

The rest of this chapter is organized as follows. Section 2 is the set up of the model. In section 3 we describes equilibrium of closed economy. In section 4 we study the open economy. In section 5 we discuss the impact of trade liberalization. Section 6 is the

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[1]Eckel *et. al.* (2015) considers a multiproduct firms that products within a firm may differ in quality. Higher quality need higher cost produce, therefore the core competence means biggest marginal cost and lowest productivity.

[2]They also assume that there is no free entry of firm. Though they can relax both assumptions, they do not give an equilibrium with both assumptions relaxed.

concluding remarks.

3.2 The Model

In our model, a firm randomly draws a marginal cost (in terms of productivity) when entering the market and then select to exit, manage one product or multi products. Products within firms are heterogeneous in terms of marginal cost and fixed export cost. Free entry and exit drives overall profit to zero.

3.2.1 Consumers

There are a continuum of products which are normalized to the interval $[0,1]$. For each product, there is a continuum of firms produce differentiated varieties of the product. The utility form is:

$$U = \left(\int_0^1 \int_{\omega \varepsilon \Omega} q(\omega)^\rho \, \mathrm{d}\omega \mathrm{d}i \right)^{\frac{1}{\rho}}$$

where i indexes products, ω indexes varieties and Ω is the set of varieties. The elasticity of substitution between any two varieties is denoted by $\sigma = 1/(1-\rho)$, and $\sigma > 1$ since $0 < \rho < 1$. Wage is normalized to one. Consumers maximize utility under limited budget. The aggregate quantity index and price index are denoted as:

$$Q = \left(\int_0^1 \int_{\omega \varepsilon \Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} \, \mathrm{d}\omega \mathrm{d}i \right)^{\frac{\sigma}{\sigma-1}} \qquad P = \left(\int_0^1 \int_{\omega \varepsilon \Omega} p(\omega)^{1-\sigma} \, \mathrm{d}\omega \mathrm{d}i \right)^{\frac{1}{1-\sigma}}$$

The demand is denoted as:

$$q(\omega) = Q \left(\frac{p(\omega)}{P} \right)^{-\sigma} \tag{3.1}$$

The total expenditure R is determined by $R = PQ = \int_0^1 \int_{\omega \varepsilon \Omega} q(\omega) p(\omega) \mathrm{d}\omega \mathrm{d}i$.

3.2.2 Firms

The dynamics of firm entry and exit follows Melitz (2003). Prior to entry, firms are identical. A firm pays an entry cost f_e to enter the market and draws productivity φ from a common cumulative distribution $G(\varphi)$ for the production of the first product. If the firm cannot get profit from this first product, it exits the market; otherwise the firm stays in the market and tries to add the second product. The firm will not produce the second product if it cannot generate profit; otherwise the firm produces the second product and tries to add the third product. Every firm proceeds this product ladder until it cannot get

profit from adding a new product. I assume that the first product uses the firm's core competence, so the first product has the highest productivity. The second product has a lower productivity. The further way the added product is from the core product, the lower productivity it has. For each product, firms pay identical fixed cost f to sell. Labor is the only input factor.

Product Ladder

In closed economy, the fixed cost to sell in domestic market is denoted as f_d. The output of the first product is denoted as:

$$l_1(\varphi) = f_d + q/\varphi$$

where l_1 is labor used for the first product. With demand from equation (4.5), in order to maximize the profit the price of first product is:

$$p_1(\varphi) = \frac{1}{\rho\varphi}$$

The revenue and the profit for the first product are denoted as:

$$r_1(\varphi) = \frac{R}{(\rho P)^{1-\sigma}}\varphi^{\sigma-1} \qquad \pi_1(\varphi) = \frac{r(\varphi)}{\sigma} - f_d$$

Above equation shows that the ratio of revenue for any two varieties is solely determined by their relative productivity:

$$\frac{r(\varphi)}{r(\varphi')} = \left(\frac{\varphi}{\varphi'}\right)^{\sigma-1}$$

If $\pi_1(\varphi) < 0$, the firm exits from the market immediately; otherwise firm is active and tries to add the second product with lower productivity φ_2. The output of second product is determined as $l_2(\varphi) = f_d + q/\varphi_2$. The price of second product is $p_2(\varphi) = \frac{1}{\rho\varphi_2}$. So the profit of second product is denoted as:

$$\pi_2(\varphi) = \frac{r(\varphi_2)}{\sigma} - f_d = \frac{\varphi_2{}^{\sigma-1}}{\varphi^{\sigma-1}}\frac{r_1(\varphi)}{\sigma} - f_d$$

If $\pi(\varphi_2) < 0$, firm will not produce the second product; otherwise firm produces the second product and tries to add the third product with productivity φ_3. Firm proceeds this product ladder until it cannot get profit for the added product. To simplify the situation, we assume that the ratio of productivity for two neighbour products is fixed as α, :

$$\alpha = \frac{\varphi_{i+1}}{\varphi_i}$$

where $\alpha < 1$. The profit for the $i - th$ product is determined as:

$$\pi_i(\varphi) = \frac{r(\varphi_i)}{\sigma} - f_d = \beta^{i-1}\frac{r_1(\varphi)}{\sigma} - f_d$$

where $\beta = \alpha^{\sigma-1}$. The profit is decreasing as the number increases. The higher productivity first drawn is, the more products can the firm manage. The number of products $N_d(\varphi)$ is determined as:

$$N_d(\varphi) = \begin{cases} 0 & \text{if } \pi_1(\varphi) < 0 \\ max\{i|\pi_i(\varphi) \geq 0 \quad and \quad \pi_{i+1}(\varphi) < 0\} & \text{if } \pi_1(\varphi) \geq 0 \end{cases} \quad (3.2)$$

The cut-off productivity φ^* is determined by $\pi_1(\varphi) = 0$ (So φ^* also can be denoted as φ_1^*, hereafter $\varphi^* = \varphi_1^*$). If the firm draws a productivity lower than φ^*, they immediately exit. The cut-off productivity for $i - products$ firm φ_i^* is determined by $\pi_i(\varphi) = 0$. As we know $\pi_1(\varphi^*) = 0$, so $r_1(\varphi^*) = \sigma f_d$. $\pi_i(\varphi_i^*) = 0$, so $r_1(\varphi_i^*) = \frac{\sigma f_d}{\beta^{i-1}}$. So the relationship between cut-off productivity for $i - products$ ($i \geq 2$) firms and cut-off productivity is denoted as:

$$\frac{\varphi_i^*}{\varphi^*} = \left(\frac{1}{\beta^{i-1}}\right)^{\frac{1}{\sigma-1}} = \alpha^{1-i} \quad (3.3)$$

Fig 3.1 gives an example of the product ladder and how the number of products is determined. If a firm draws a productivity φ_0 between φ_5^* and φ_6^*, it will produce 5 products. The firm produces the first product with productivity φ_0 and produces the fifth product with productivity $\beta^4\varphi_0$.

Aggregate Output and Profit

Firms choose the number of products based on the productivity. The total output of the firm with the productivity φ can be denoted as:

$$l(\varphi) = \sum_{j=1}^{i}(f_d + \frac{q_j}{\varphi_j}) = if_d + \frac{(\sum_{j=1}^{i}q_j^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}}}{(\sum_{j=1}^{i}\beta^{j-1})^{\frac{1}{\sigma-1}}\varphi} \qquad \varphi \in [\varphi_i^*, \varphi_{i+1}^*)$$

If the output of the first product is assumed as q, $(\sum_{j=1}^{i}q_j^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}} = (\sum_{j=1}^{i}\beta^{j-1})^{\frac{\sigma}{\sigma-1}}q$. So the firm with the productivity φ managing i products can be represented by the firm with 'representative productivity' $\tilde{\varphi}(\varphi) = (\sum_{j=1}^{i}\beta^{j-1})^{\frac{1}{\sigma-1}}\varphi$ producing a single product with i times of fixed domestic cost f_d.

The total profit by a firm with the productivity $\varphi \in [\varphi_i^*, \varphi_{i+1}^*)$ is denoted as $\pi(\tilde{\varphi}) =$

38
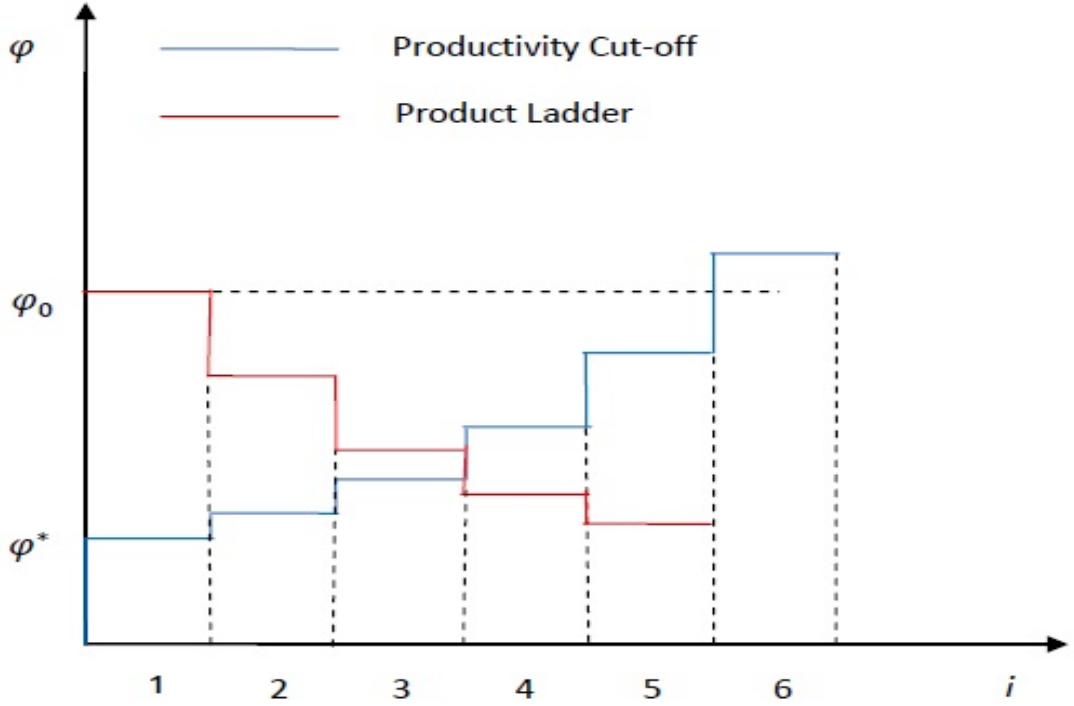
Fig 3.1: The number of products and product ladder

$\frac{r(\tilde{\varphi})}{\sigma} - i f_d = (\frac{\tilde{\varphi}}{\varphi^*})^{\sigma-1} \frac{r(\varphi^*)}{\sigma} - i f_d$. So the total profit by a firm is determined by:

$$\pi(\varphi) = \begin{cases} 0 & \text{if } \varphi < \varphi^* \\ \left(\sum_{j=1}^{i} \beta^{j-1} k(\varphi) - i\right) f_d & \text{if } \varphi \in [\varphi_i^*, \varphi_{i+1}^*) \end{cases} \qquad (3.4)$$

where $k(\varphi) = (\varphi/\varphi^*)^{\sigma-1}$.

Free entry

We assume that there is a probability δ that active firms are forced out of the market due to external shocks. The average profit conditional on successful entry is denoted as $\overline{\pi}$, so

$$\overline{\pi} = \frac{1}{1 - G(\varphi^*)} \sum_{i=1}^{\infty} \int_{\varphi_i^*}^{\varphi_{i+1}^*} \pi(\varphi) g(\varphi) \mathrm{d}\varphi \qquad (3.5)$$

The expected value of entry v_e is determined as:

$$v_e = \frac{1 - G(\varphi^*)}{\delta} \overline{\pi} \qquad (3.6)$$

where $G(*)$ is the cumulative function of $g(\varphi)$ and $1 - G(\varphi^*)$ is the ex ante probability of successful entry. Under free entry, the expected value of entry equals the entry cost, such

that profit is zero.

$$v_e = f_e \tag{3.7}$$

3.3 Closed Economy Equilibrium

Equilibrium of closed economy is solely described as the set $\{\varphi^*, \varphi_i^*\}$. φ_i^* is functions of φ^* and all other variables are functions of the vector of these elements. With equations (3.4), (3.5), (3.6) and (3.7), we can determine the equilibrium.

Theorem 8 *There exists a unique equilibrium.*

Proof: : see Appendix B.1. ■

The average revenue $\bar{r}$ is determined as:

$$\bar{r} = \frac{f_d/\sigma}{1 - G(\varphi^*)} \sum_{i=1}^{\infty} \int_{\varphi_i^*}^{\varphi_{i+1}^*} \sum_{j=1}^{i} \beta^{j-1} k(\varphi) g(\varphi) \mathrm{d}\varphi$$

So the number of incumbent firms M is determined by $M = R/\bar{r} = L/\bar{r}$, where L is the total labor in the market. If we assume the number of entrants is M_e, in equilibrium, the number of firms exit equals the number of successful entrants as $\delta M = (1 - G(\varphi^*))M_e$. The labor used by the incumbent firms is assumed as L_p and labor used by the entrants as L_e.

$$L_e = M_e f_e = \frac{\delta M}{1 - G(\varphi^*)} f_e = M\bar{\pi} = \Pi$$

Therefore labor market clears because $L = R = L_p + L_e = L_p + \Pi$.

3.4 The Open Economy

In this section, I explore the multi-products firms in open economy within a framework of two symmetric countries. As literature has assumed, there is a fixed cost and an iceberg variable cost to export. The variable export cost τ is assumed to be identical across firms and products, where $\tau > 1$ units are shipped but only one unit arrives at destination. Fixed export cost f_x for the first product is assumed to be identical across firms. However, within a firm fixed export cost is heterogeneous across products. This is due to the fact that firms can learn from export or simply share export distribution channel to decrease the fixed export cost of added products.

3.4.1 Product Ladder for Export

With the demand equation (4.5) in order to maximise the export profit, firms set the price of the first product for export as:

$$p_{1,x}(\varphi) = \tau p_{1,d}(\varphi) = \frac{\tau}{\rho \varphi}$$

where subscript x denotes 'export' and d denotes 'domestic'. Firms export from the core product to fringe product. If $\pi_{1,x}(\varphi) < 0$, firms will not export; otherwise firms will export the first product and try to export the second product. Firms proceed the product ladder until they cannot get extra profit from exporting the new product. Fixed export cost of added product is decreasing due to. I assume fixed export cost for $i-th$ product is:

$$f_{i,x} = \begin{cases} f_x & \text{if } i = 1 \\ (\beta^{i-1} + \gamma) f_x & \text{if } i \geq 2 \end{cases} \tag{3.8}$$

where $\beta + \gamma < 1$. The boundary of fixed export cost is γf_x. The profit from export of the $i-th$ product is:

$$\pi_{i,x}(\varphi) = \begin{cases} \dfrac{r_{1,x}(\varphi)}{\sigma} - f_x & \text{if } i = 1 \\ \dfrac{r_{i,x}(\alpha^{i-1}\varphi)}{\sigma} - \beta^{i-1} f_x - \gamma f_x = \beta^{i-1}\pi_{1,x}(\varphi) - \gamma f_x & \text{if } i \geq 2 \end{cases}$$

If $\pi_{i,x}(\varphi) \geq 0$, the $i-th$ product is exported. The number of products exported is determined as:

$$N_x(\varphi) = \begin{cases} 0 & \text{if } \pi_{1,x}(\varphi) < 0 \\ max\left\{i|\pi_{i,x}(\varphi) \geq 0 \, and \, \pi_{i+1,x}(\varphi) < 0\right\} & \text{if } \pi_{1,x}(\varphi) \geq 0 \end{cases} \tag{3.9}$$

The cut-off productivity for export is assumed as φ_x^* (also can be denoted as $\varphi_{1,x}^*$, hereafter $\varphi_{1,x}^* = \varphi_x^*$), and the cut-off productivity for exporting i product is assumed as $\varphi_{i,x}^*$. φ_x^* is determined by:

$$\pi_{1,x}(\varphi_x^*) = \frac{r_{1,x}(\varphi_x^*)}{\sigma} - f_x = \tau^{1-\sigma}\frac{r_{1,d}(\varphi_x^*)}{\sigma} - f_x = 0$$

The cut-off productivity for domestic is still determined by $\frac{r_{1,d}(\varphi^*)}{\sigma} - f_d = 0$. So the relationship between the cut-off productivity for domestic market and export is denoted as:

$$\frac{\varphi_x^*}{\varphi^*} = \tau\left(\frac{f_x}{f_d}\right)^{\frac{1}{\sigma-1}} \tag{3.10}$$

We assume $f_x > \tau^{1-\sigma}f_d$ as Melitz (2003) to assure that $\varphi_x^* > \varphi^*$. There must be a

cut-off productivity for domestic market φ_{λ}^{*} to allow $\varphi_{x}^{*} \in [\varphi_{\lambda}^{*}, \varphi_{\lambda+1}^{*})$.

$$\lambda = int\left(1 + \frac{ln(\tau^{1-\sigma} f_d / f_x)}{ln\beta}\right)$$

The firms that draw productivity lower than φ_{x}^{*} do not export and can produce λ products at most. $\varphi_{i,x}^{*}$ $(i \geq 2)$ is determined by:

$$\pi_{i,x}(\varphi_{i,x}^{*}) = \beta^{i-1}\pi_{1,x}(\varphi_{i,x}^{*}) - \gamma f_x = \beta^{i-1}\tau^{1-\sigma}\frac{r_{1,d}(\varphi_{i,x}^{*})}{\sigma} - \beta^{i-1}f_x - \gamma f_x = 0$$

The relationship between cut-off productivity for export $i - products$ $(i \geq 2)$ firms and cut-off productivity for export is denoted as:

$$\frac{\varphi_{i,x}^{*}}{\varphi_{x}^{*}} = \left(\frac{\gamma + \beta^{i-1}}{\beta^{i-1}}\right)^{\frac{1}{\sigma-1}} \tag{3.11}$$

Pure Exported Products

Firms can export added product with a lower fixed export cost than existing products. If a firm first draws a high productivity and manges a big number of products, the fixed export cost of some products may even lower than fixed cost to sell in domestic market. For these products, firm cannot get profit from domestic market but can get profit in foreign market. From equations (3.3), (3.10) and (3.11), we can get:

$$\frac{\varphi_{i,x}^{*}}{\varphi_{i}^{*}} = (\gamma + \beta^{i-1})^{\frac{1}{\sigma-1}} \tau \left(\frac{f_x}{f_d}\right)^{\frac{1}{\sigma-1}} \tag{3.12}$$

There exists the number θ, such that $\varphi_{\theta,x}^{*} \geq \varphi_{\theta}^{*}$ and $\varphi_{\theta+1,x}^{*} < \varphi_{\theta+1}^{*}$:

$$\theta = int\left(1 + \frac{ln(\tau^{1-\sigma} f_d / f_x - \gamma)}{ln\beta}\right)$$

If firms first draw productivity higher than φ_{θ}^{*}, the number of exported products is no less than number of products sold in domestic market ($N_x \geq N_d$), otherwise $N_x \leq N_d$. There are firms that export all their products ($N_x = N_d$), which need the conditions:

$$\varphi_{\xi}^{*} < \varphi_{\xi,x}^{*} < \varphi_{\xi+1}^{*} \quad \text{if } \xi < \theta$$
$$or \quad \varphi_{\zeta,x}^{*} < \varphi_{\zeta}^{*} < \varphi_{\zeta+1,x}^{*} \quad \text{if } \zeta \geq \theta$$

The firms which draw productivity between $\varphi_{\xi,x}^{*}$ and $\varphi_{\xi+1}^{*}$ or between φ_{ζ}^{*} and $\varphi_{\zeta+1,x}^{*}$ export all their products as $N_x = N_d$. With equation (3.12), we can get $\theta_1 \leq \xi < \theta$ and

$\theta \leq \zeta \leq \theta_2$, where:

$$\theta_1 = int\left(1 + \frac{ln(\tau^{1-\sigma}f_d/f_x - \gamma\beta)}{ln\beta}\right)$$

$$\theta_2 = int\left(1 + \frac{ln(\tau^{1-\sigma}f_d/f_x - \gamma/\beta)}{ln\beta}\right)$$

We assume $\gamma/\beta < \tau^{1-\sigma}f_d/f_x$ to assure θ, θ_1 and θ_2 all exist.

The firms which draw productivity lower than φ^* exit. The firms which draw productivity between φ^* and φ_x^* only serve the domestic market and can produce λ products at most. The firms draw a productivity higher φ_x^* export. Across exporters, low productive exporters export only a subset of their products while high productive exporters manage pure exported products, thereby managing more products in export than in domestic market. Fig 3.2 gives how the number of products produced and exported are determined.

Aggregate Profit

A firm that draws productivity $\varphi \in [\varphi_{i,x}^*, \varphi_{i+1,x}^*)$ can export i products. The total profit by a firm from export is determined as:

$$\pi_x(\varphi) = \begin{cases} 0 & \text{if } \varphi < \varphi_x^* \\ \left(\sum_{j=1}^{i}\beta^{j-1}k_x(\varphi) - (i-1)\gamma\right)f_x & \text{if } \varphi \in [\varphi_{i,x}^*, \varphi_{i+1,x}^*) \end{cases} \tag{3.13}$$

where $k_x(\varphi) = (\varphi/\varphi_x^*)^{\sigma-1} - 1$. The average profit for export is denoted as:

$$\overline{\pi}_x = \frac{1}{1 - G(\varphi_x^*)}\sum_{i=1}^{\infty}\int_{\varphi_{i,x}^*}^{\varphi_{i+1,x}^*}\pi_x(\varphi)g(\varphi)\mathrm{d}\varphi \tag{3.14}$$

If the average profit from domestic market is denoted as $\overline{\pi}_d$, which is determined by equation (3.4)and (3.5), the combined average profit from domestic market and export is determined as:

$$\overline{\pi} = \overline{\pi}_d + p_x\overline{\pi}_x \tag{3.15}$$

where $p_x = \frac{1-G(\varphi_x^*)}{1-G(\varphi^*)}$ is ex-post probability that active firms export, and it is also the fraction of export firms out of all active firms.

3.4.2 Equilibrium

In open economy, equilibrium is solely described as the set $\{\varphi^*, \varphi_i^*, \varphi_x^*, \varphi_{i,x}^*,\}$. φ_i^* is functions of φ^* and $\varphi_{i,x}^*$ is functions of φ_x^*. All other variables are functions of the vector of these elements. With equations (3.6), (3.7), (3.13), (3.14) and (3.15), we can determine the equilibrium.

Theorem 9 *There exists a unique equilibrium in open economy.*
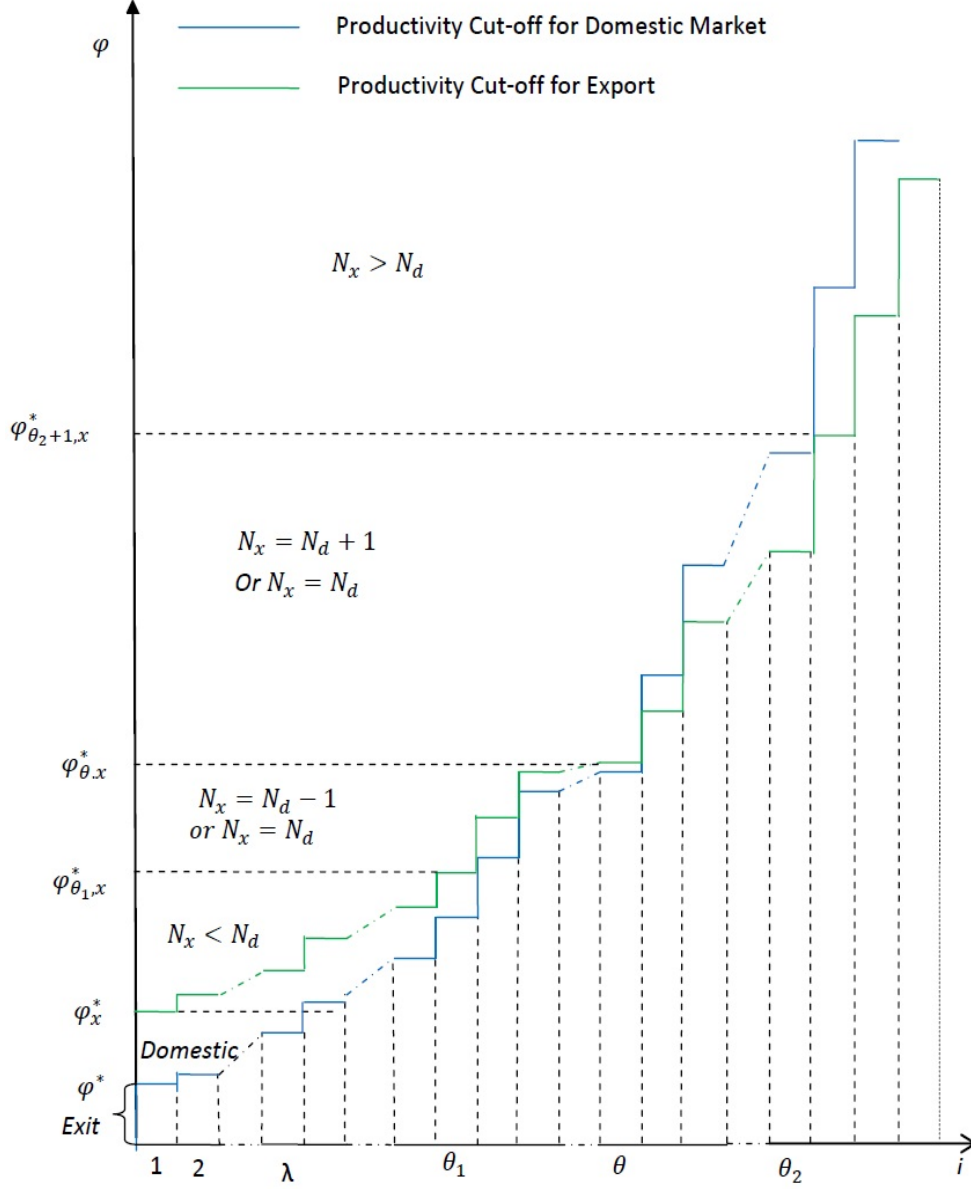
Fig 3.2: The number of products exported and product ladder

Proof: : See Appendix B.2. ∎

The average revenue $\bar{r}$ is determined as:

$$\bar{r} = \frac{f_d/\sigma}{1-G(\varphi^*)} \sum_{i=1}^{\infty} \int_{\varphi_i^*}^{\varphi_{i+1}^*} \sum_{j=1}^{i} \beta^{j-1} k(\varphi) g(\varphi) d\varphi$$

$$+ \frac{f_x/\sigma}{1-G(\varphi^*)} \sum_{i=1}^{\infty} \int_{\varphi_{i,x}^*}^{\varphi_{i+1,x}^*} \sum_{j=1}^{i} \beta^{j-1} (k_x(\varphi)+1) g(\varphi) d\varphi$$

So the number of incumbent firms M is determined by $M = R/\bar{r} = L/\bar{r}$. The number of export firms is $M_x = p_x M$. In equilibrium, the number of firms that exit the market equals the number of successful entrants. $\delta M = (1 - G(\varphi^*)) M_e$. Labor market clears as

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$L = R = L_p + L_e = L_p + \Pi.$

Theorem 10 *There is a positive relationship between intensive and extensive margins of export.*

This argument follows Bernard *et. al.* (2011). The more productive firms are larger exporters, not only because they can produce more in a given product but also because they can expand along extensive margin to export more products.

3.5 Trade Liberalization

3.5.1 From Autarky to Trade

Exposure to trade drives up cut-off the productivity (see Appendix B.3 for proof), thereby leading to: least productive firms exit from the market; low productive firms serve domestic market only, they drop least productive products and manage less products; high productive firms become exporters. However the effects are heterogeneous across exporters, which are stated in the following theorem.

Theorem 11 *Under trade, low productive exporters export a subset of products, high productive exporters manage pure exported products.*

Low productive exporters export a subset of the left products and manage less products. Medium productive exporters export all left products and switch products that are dropped from domestic market to pure exported products. High productive exporters export all left products, switch all domestic-dropped products to pure exported products, and introduce new products as pure exported products. Therefore, under trade, low productive firms manage less products while high productive firms manage more products.

To simply and clearly show the effect from auturky to trade, we draw Fig 3.3 to depict all the above arguments. The curves N_d, N_d' and N_x denote the number of products sold in domestic market in autarky, the number of products sold in domestic market after trade and the number of products exported after trade. The interaction circles denote the overlapping area as shown in Fig 3.2 between $\varphi^*_{\theta_1,x}$ and $\varphi^*_{\theta_2+1,x}$. The bold black curve depicts the number of products managed in autarky. The bold red curve depicts the number of products under trade.

Exposure to trade gives an extra profit opportunity for high productive firms and increases the competition of labor market. The real wage rate is pushed up to force least productive firms out of market (A area). The higher real wage rate also force the least productive products exit from domestic market, shown as $N_d > N_d'$.. So low productive firms (B area) cannot afford the fixed export cost and serve domestic market only. All firms with productivity higher than φ^*_x become exporters. Low productive exporters (C

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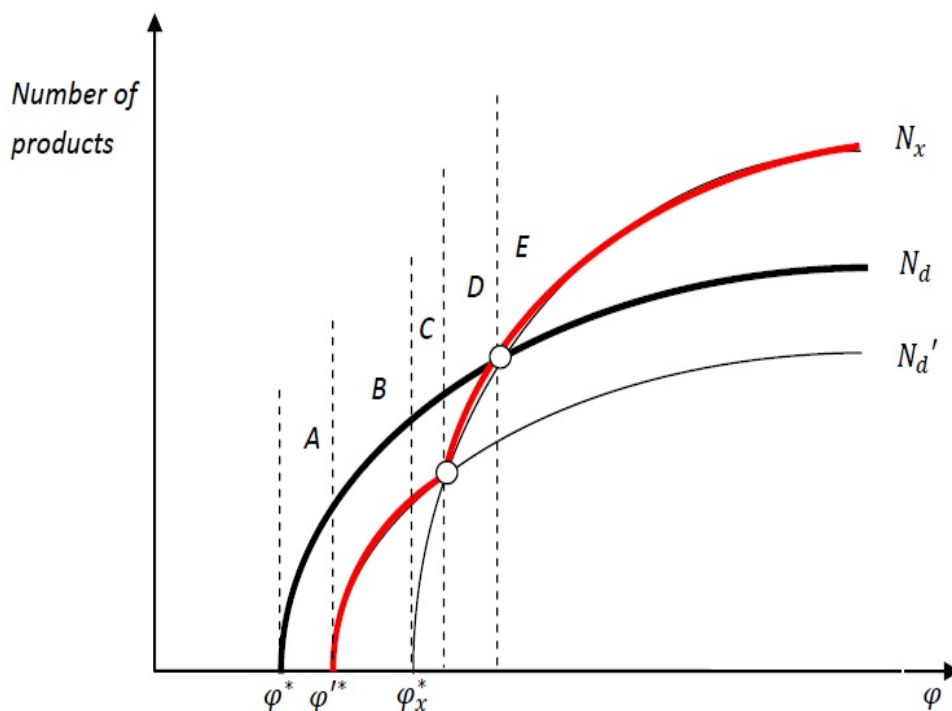
Fig 3.3: The extensive margins of firms

area) drop least productive products from domestic market and export a subset of left products, shown as $N_d > N_d' > N_x$. Middle productive exporters (D area) drop the least productive products from domestic but some of these domestic-dropped products are exported. These middle productive exporters manage pure exported products and have a higher extensive margin of export than of domestic market, shown as $N_d > N_x > N_d'$. This is because that after trade firms can decrease the fixed export cost for added products. The fringe products of these middle productive exporters have a lower fixed export cost than fixed cost to sell in domestic market. High productive exporters (E area) drop least productive products from domestic market, but all of these domestic-dropped products are exported. These exporters even introduce new products as pure exported products, shown as $N_x > N_d > N_d'$. High productive exporters can manage more products and can have a lower fixed export cost for the added fringe products. These products can not be sold in domestic market but only be exported. After trade, high productive exporters manage more products while other low productive firms manage less products, as shown by the bold black and red curves.

3.5.2 Decrease in Export Cost

In this subsection, we try to study the impact of trade liberalization on extensive margin of export and of domestic market. Two channels of trade liberalization are investigated:

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decrease in variable export cost τ and decrease in fixed export cost f_x. Both channels have similar effects on extensive margin of export.

Decease in fixed or variable export cost drives up cut-off productivity for domestic market and reduces the cut-off productivity for export (see Appendix B.4 for proof). Therefore least productive firms exit and least productive products are dropped from domestic market. Meanwhile, trade liberalization induces firms to export more products. As a result, some products that are dropped in domestic market become pure exported products. Moreover, if the firms have high productivity, they can introduce new exported products. This leads to the following theorem.

Theorem 12 *Trade liberalization makes more exporters manage pure exported products and increase the extensive margin of exporters.*

Because the least productive products are dropped from the domestic market, the low productive firms that solely serve domestic market will manage less products. However, because the high productive firms can introduce new pure exported products, they manage more products. This leads to the following theorem.

Theorem 13 *Trade liberalization makes low productive firms manage less products and high productive firms manage more products.*

I use prime to denote the variables after decrease in fixed or variable export cost. Fig 3.4 depicts how the number of products in the equilibrium changes. N_d denotes the number of products exported and N_x denotes the number of products sold in domestic market. The black and red bold curves are the number of managed products.

Due to opportunity for more profit from foreign market, the increased competition for labor drives up the real wage rate. The cut-off productivity for domestic market goes up from φ^* to φ'^*, forcing firms with productivity between φ^* and φ'^* out of market. The higher real wage rate make firms sell less in domestic market and force firms drop the least productive products from domestic market (curve N_d' is below N_d). For exporters, even though real wage rate is higher, they can still benefit from decreased fixed or variable export cost. The cut-off productivity for export is lower, inducing more firms into export. Exporters export more of a given product and export more products (curve N_x' is above N_x).

Before trade liberalization, the exporters with productivity higher than $\overline{\varphi}$ manage pure exported products ($N_x > N_d$). After trade liberalization, the lower productive exporters with productivity between $\overline{\varphi}'$ and $\overline{\varphi}$ can manage pure exported products. Similar to the effect from autarky to trade, some of domestic-dropped products are switched to pure exported products for firms with productivity from $\overline{\varphi}'$ to $\overline{\overline{\varphi}}$. All firms with productivity lower than $\overline{\overline{\varphi}}$ manage less products due to trade liberalization. For the exporters with productivity higher than $\overline{\overline{\varphi}}$, they switch all the domestic-dropped products to pure exported
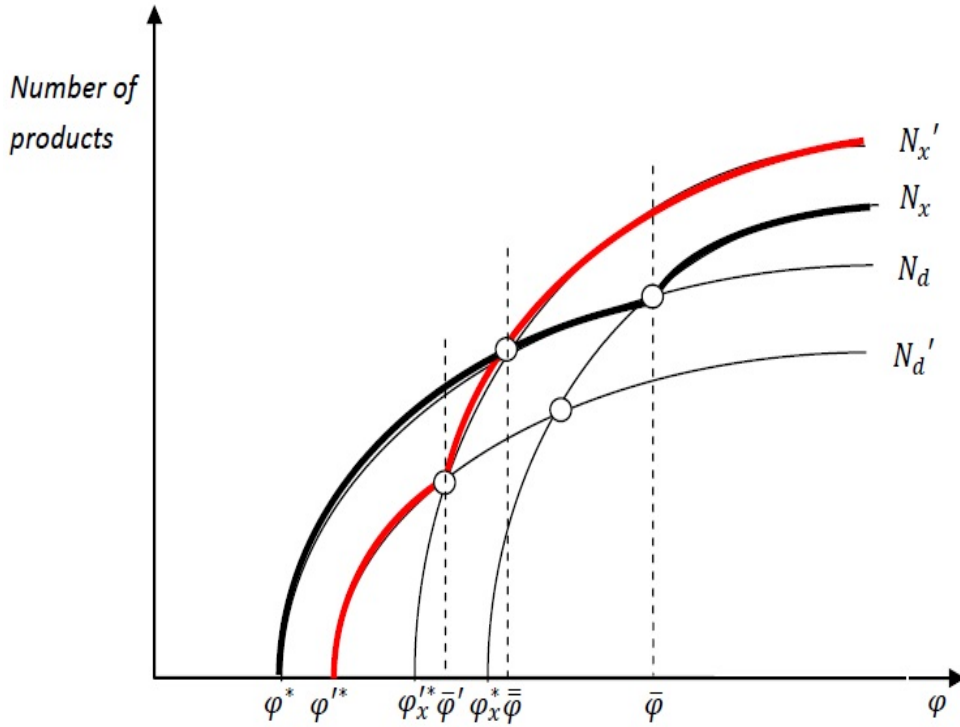
Fig 3.4: Decrease in trade cost

products, and introduce new pure exported products. These firms manage more products after trade liberalization. This argument is quite different from the previous literatures, which is derived from the assumption of decreasing fixed export cost for added products.

3.6 Conclusion

Multi-product firms are getting more and more attention in international trade. This chapter builds a general equilibrium model to allow for heterogeneity in productivity and fixed export cost. The model takes account 'learning-by-exporting' effect with the decreasing fixed export cost across products. Firms add a new product with a lower productivity and export a new product with a lower fixed export cost. The model captures pure exported products, managed by high productive exporters which has great potential to expand the product ladder and decrease fixed export cost. The pure exported products are relevant especially in developing countries but not explained theoretically in trade under framework of multi-product firms.

The model provides some interesting and even surprising results. Transition from autarky to trade makes low productive exporters export a subset of products and high productive exporters manage pure exported products. Trade liberalization makes more exporters manage pure exported products and increase the extensive margin of exporters. Moreover trade liberalization makes low productive firms manage less products and high

productive firms manage more products.

Our framework where firms endogenously decide the number of products produced and exported is highly tractable. One further extension might be to introduce multiple countries with different fixed export cost, which would add another export margin for firms to adjust under exposure to trade and trade liberalization. Another extension might be to introduce a increasing productivity across products to include 'quality ladder' within firms. Multi-product firms climb quality ladder from low productive product to high productive product, which would be a novelty in research of trade.

Chapter 4

Export Quality, Price and Income Distribution

This chapter develops a general equilibrium model with non-homothetic preference over product quality. The model delivers a one to one relationship between income of consumers and quality they buy. This income-quality relationship is subject to income distribution. The chapter further studies how qualities are specialized between the poor country and the rich country in international trade, and finds a quality specialization pattern that follows the home market effect. In particular, the low (high) qualities are completely specialized in the poor (rich) country, while medium qualities are incompletely specialized, i.e. produced by both countries and exported to each other. Furthermore, the model shows that export price distribution is related to destination income distribution, and provides the empirical evidence.

4.1 Introduction

Literature has associated quality differentiation, mostly inferred with price variation, across countries of exporters and importers to the income per capita (e.g. Schott, 2004; Hallak, 2006; Verhoogen, 2008; Bastos and Silva, 2010; Manova and Zhang, 2012). This suggests the demand-side factor is non-trivial in shaping the trade pattern on quality. Unfortunately, relatively little is known on the quality specialization between countries (e.g. Made in China vs Made in Germany) driven by demand. This chapter applies the income distribution to shed light on quality differentiation within a country and quality specialization between countries, on which to use income per capita for each country is silent. We find a one to one relationship between income of consumers and quality they buy that is subject to income distribution. Moreover we find a quality specialization pattern between countries that follows the home market effect.

    This paper develops a general equilibrium model with non-homothetic preference over

product quality. The model incorporates both horizontal differentiation and vertical differentiation by quality. Within each quality, there is a continuum of horizontally differentiated varieties, which are consumed as a composite. A consumer chooses one quality and consumes one unit of the composite. Therefore, rich consumers buy high quality. Given a continuum of qualities, the model gives a one to one relationship between income of consumers and the quality they buy. Another interesting property of this income-quality relationship is that it is subject to income distribution. Given a different distribution, the number of consumers that choose a quality is different, leading to different number of firms producing this quality. Consequently, the reprieved price of composite of this quality is different. Therefore consumers will adjust the quality they buy. Our income-quality relationship on the one hand departures from the one in Fajgelbaum *et al.* (2011), i.e. consumers with higher income have higher probability to buy higher quality; on the other hand is different from the one in Choi *et al.* (2009), which is not subject to income distribution.

Firms are under monopolistic competition. There is fixed cost to produce. The firms producing the varieties of the same quality share identical marginal cost and set identical prices. In the open economy, every firm incurs variable cost to export. However, we do not assume fixed export cost, as we are not aiming to explain the selection of firms into export. In order to focus sharply on quality specialization driven by demand, we assume both countries have the same cost to produce every quality, i.e. no comparative advantage. Therefore, in this model the countries are differentiated only by total labor supply and income distribution. We consider two countries, a poor country and a rich country. We assume that the ratio of number of consumers that choose a quality in the rich country to the poor country, i.e. the relative demand of a quality, is increasing with quality.

We find a quality specialization pattern between countries that follows the home market effect, the quality is specialized in the country with relatively large demand. In particular, If the relative demand is very high (low) compared with the trade cost across all qualities, all qualities are completely specialized in the rich (poor) country, i.e produced in the rich (poor) country and exported to the other. If the relative demand is neither high enough nor low enough across all qualities, all qualities are incompletely specialized, i.e. produced in both countries and exported to each other. If the relative demand is increasing from low enough to high enough, there is a mixed specialization. That is, low (high) qualities are completely specialized in the poor (rich) country, while medium qualities are incompletely specialized. This quality specialization pattern is purely demand-driven, and consistent with supply-side explanations, e.g. rich countries have comparative advantage in high qualities (e.g. Flam and Helpman, 1987; Bergstrand, 1990; Stokey, 1991; and Matsuyama, 2000). Furthermore, besides the quality specialization pattern, which qualities are specialized in which country is also revealed in the model.

This model shows that export price distribution and destination income distribution are strongly related. The reason is twofold. On the one hand, income distribution affects affects income-quality relationship, and consequently affects the number consumers that pay a certain price. On the other hand, under mixed quality specialization, the export qualities are consumed by a part of consumers in the destination from the truncated income distribution. For example, the high qualities are completely specialized in rich country, therefore the qualities exported from the poor country to the rich country are bought by the consumers who are not the richest.

In the empirical part, this chapter provides two pieces of supporting evidence. The first evidence is that rich people do choose high quality and pay high price. It is not observable which consumers choose which products in the trade data, however the pattern can be investigated with domestic survey. The chapter uses UK Living Cost and Food Survey, which maps the expenditure and consumption to the household income. It is found that indeed richer people pay higher price for bread and wine. This result is robust when controlling the quantity of consumption, expenditure on potential substitutes and potential measurement on prices. The second evidence is that export price distribution is strongly related to destination income distribution. This chapter applies quantile regression and show that Chinese export distribution to EU countries is significantly affected by destination income distribution. In particular, when income is shifted from the rich (poor) people to the poor (rich) people, export prices of low (high) quantiles are increased (decreased) while export prices of high quantiles decreased.

This chapter relates to research that studies the roles of income distribution on international trade, e.g. on firms' quality selection into different markets (Garcia-Marin, 2014), on bilateral trade (e.g. Eppinger and Felbermayr, 2015) and on trade pattern on quality (Fajgelbaum *et al.*, 2011). This chapter is also related to research that explains trade pattern with demands (e.g. Mitra and Trindade, 2005; Foellmi, Hepenstrick, and Zweimuller, 2010; Auer, 2010; Fajgelbaum *et al.*, 2012). Fajgelbaum *et al.*(2012) provides a similar trade pattern to this chapter, i.e. the rich country is the net exporter of high quality while the poor country is net exporter of low quality. Most of the dynamics in their paper builds on the case where there is only two qualities, i.e low and high. Therefore, coexistence of complete specialization and incomplete specialization of qualities is not studied. Moreover, because there is no income-quality relationship, the model provides very limited support for the relationship between export price distribution and income distribution.

This chapter also relates to the literatures on the relationship between export prices and moments of income distribution, including income per capita (e.g. Schott, 2004; Hallak, 2006; Bastos and Silva, 2010; Gorg et al. 2010; Manova and Zhang, 2012, 2013), income inequality (Bekkers *et al.*, 2012; Latzer and Mayneris, 2012; and Flach and Janeba, 2016) and income distribution similarity (Choi *et al.*, 2009). The effect of income per capita on export price is positive while effect of income inequality is not conclusive.

Bekkers *et al.*(2012) find a negative relationship between export price and destination income inequality while Mayneris (2012) and Flach and Janeba (2016) find a positive relationship. The present chapter shows that income-quality relationship and consequently export prices to different countries are affected by destination income distributions, but how income inequality affects export prices is ambiguous. Choi *et al.*(2009) also have a income-quality relationship under perfect competition and zero trade cost. Their income-quality relationship is not subject to income distribution. Furthermore, absence of trade cost makes their paper silent on the trade pattern. Choi *et al.* (2009) also give some empirical evidence that export price and destination income distribution are related. They find that the pairs of importers whose income distributions look more similar have more similar import price distributions.

The rest of this chapter is organized as follows. The model and its equilibrium in closed economy is described in section 2 while the open economy is studied in section 3. Some empirical evidence are provided in section 4. Section 5 is the conclusion of the chapter.

4.2   The model

4.2.1   Consumers

There are a homogeneous product and mass of differentiated products in the market. Differentiated products are vertically differentiated by a continuum of qualities. For each quality, there are a continuum of horizontally differentiated products. The consumer makes discrete choice from a continuum of qualities while the homogeneous product can be consumed in any positive amount. Similar to Garcia-Marin(2014), horizontally differentiated products with the same quality can only be consumed as a composite. And the composite of differentiated products gives utility for the first unit. This is similar to the spirit that consumer only consumes one unit of quality-differentiated product (e.g. see Shaked and Sutton, 1982; Flam and Helpman, 1987; Flach and Janeba, 2014; and Fajgelbaum *et al.*, 2012).

Utility of consuming *z* units of homogeneous products and a continuum of differentiated products with quality *q* is given as:

$$U = q \cdot z \tag{4.1}$$

Utility (4.1) features complementarity between quantity of homogeneous product and quality of differentiated product (e.g. see Shaked and Sutton(1982), Flam and Helpman(1987), Fajgelbaum *et al.* (2012) and Garcia-Marin(2014)). With this form, consumers' marginal utility of quality is increasing with quantity of homogeneous products,

i.e., consumers with higher income value higher quality products. This generates a non-homothetic aggregate demand.

The composite of differentiated products with quality q is defined as:

$$X_q = \left[\int_{\omega \in \Omega_q} x(\omega)^{(\sigma-1)/\sigma} d\omega \right]^{\sigma/(\sigma-1)}$$

where $\Omega_q > 1$ denotes the set of products with quality q and $\sigma > 1$ is elasticity of substitution between products. Let $p(\omega)$ denote the price of the product ω, and the price of homogeneous product is normalized to one. The problem of the consumer with income w is solved by:

$$\max_{q,x(\omega),z} U$$
$$\text{s.t.} \int_{\omega \in \Omega_q} p(\omega)x(\omega)d\omega + z = w$$
$$X_q = 1.$$

To solve the first order conditions, the consumer with income w will choose the quality that:

$$P_q + qP_q' = w \tag{4.2}$$

where $P_q = \left[\int_{\omega \in \Omega_q} p(\omega)^{(1-\sigma)} d\omega \right]^{1/(1-\sigma)}$ is the aggregate price index of quality q. Here we assume the price index is continuous and differentiable. After choosing the quality, the demand is $x(\omega) = P_q^{\sigma} p(\omega)^{-\sigma}$. Consumer will then buy $z = qP_q'$ units of homogeneous products, therefore price index must be a increasing function, i.e. $P_q' > 0$. To ensure that the optimality is the maximum, second order condition has to be met. Therefore the condition is

$$2P_q' + qP_q'' > 0 \qquad P_q' > 0 \tag{4.3}$$

Price index is endogenously determined in equilibrium, and then we will verify this condition. Equation (2) determines a function between income and quality, i.e. income-quality relationship, which is equivalent to:

$$w(q) = (qP_q)' \tag{4.4}$$

And equation (3) is then equivalent to:

$$w'(q) > 0$$

The total labor in the country is L. Wage is normalized to one, therefore the income of each labor is the efficient labor she can supply. The density distribution of income is denoted as $\phi(w)$ over $[w_{min}, w_{max}]$ while cumulative distribution $\Phi(w)$. w_{min} can be zero while w_{max} can be infinity. We will discuss the type of income distributions as follows:

Income distribuion distribution: There is one point $w = w^*$ that $\phi'(w^*) = 0$. If $\phi(w_{min}) \neq 0$ and(/or) $\phi(w_{max}) \neq 0$, $\phi(w)$ is continuous and differentiable around w_{min} and(/or) w_{max}.

Examples of the type of distribution include lognormal, gamma, beta, Weibull, and etc. Uniform distribution and Pareto distribution are not of this type. We put the analysis of these two types of distributions in the Appendix (See C.3 and C.4). Pareto distribution fits well in the wealthy part of consumers, while across all levels of income, gamma distribution fits better than lognormal (Salem and Mount, 1974).

We know that each consumer with income w will spend P_q on one unit of composite of differentiated products and left income (qP_q') on homogeneous product. Therefore, the aggregate quantity index of quality q is the number of consumers that choose this quality, $Q_q = L\phi(w(q))$. The aggregate expenditure on quality q is then total income of these consumers, $E_q = P_q \cdot Q_q = L\phi(w(q))P_q$. The demand of the product ω with quality q is

$$x(\omega, q) = L\phi(w(q)) \cdot \left(\frac{p(\omega)}{P_q}\right)^{-\sigma} \tag{4.5}$$

The demand is strongly related to the income distribution.

4.2.2 Firms

There is no cost for firms to choose qualities, but firms producing products with same quality share identical marginal cost. The larger the quality is, the higher the cost to produce. Let $c(q)$ denote the marginal cost to produce the quality q, f the fixed cost. Both cost are paid with labor. The Output is denoted as $y(q)$, so

$$l(q) = f + c(q)y(q)$$

Firms are under monopolistic competition. With the demand from equation (4.5), the firm producing any product ω with the quality q will set the following price to maximize the profit:

$$p(q) = \frac{\sigma \cdot c(q)}{\sigma - 1}$$

The profit of the firm is:

$$\pi(q) = \frac{c(q)}{\sigma - 1} \cdot y(q) - f$$

4.2.3 Equilibrium

Free entry and exit drive firm profit to zero, thus the output of the firm is:

$$y(q) = \frac{f \cdot (\sigma - 1)}{c(q)} \tag{4.6}$$

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The product market clearing pins down the number of firms for each quality. Labor market clears automatically within each quality. Market clearing means $x(q) = y(q)$. Combine the equation (4.5) and (4.6), we have:

$$L\phi(w(q)) \cdot \left(\frac{p(q)}{P_q}\right)^{-\sigma} = \frac{f \cdot (\sigma - 1)}{c(q)} \tag{4.7}$$

Let $\delta = \left(\frac{(\sigma-1)^{\sigma-1}}{f}\right)^{\frac{1}{\sigma}}$. According to equation (4.4), the above equation can be rearranged to get the **income-quality differential equation**:

$$w'(q) = \frac{\phi(w(q))}{q\phi'(w(q))}\left(\sigma + (\sigma - 1)\frac{qc'(q)}{c(q)} - \frac{\delta w(q)(L\phi(w(q)))^{\frac{1}{\sigma}}}{c(q)^{\frac{\sigma-1}{\sigma}}}\right) \tag{4.8}$$

if $\phi'(w(q)) \neq 0$. This is a first order differential equation of income-quality relationship: $w'(q) = F(q, w(q))$. The existence of solution with a certain initial value is provide by Picard's existence theorem (See Appendix C.1). A necessary condition to have a solution is that both $w'(q)$ and $\frac{w'(q)}{\partial w}$ are continuous functions defined around the initial value. However, only the solutions that meet the condition (4.3) are feasible. It is very hard to verify this condition as there is no reduced form of solutions $w(q)$ for general forms of the income distribution and the marginal cost. However, if using Pareto distribution and cost structure $c(q) = \varphi q^\theta$, $\theta > 0$, there will be many solutions that meet the condition. For general forms of distribution and cost, this chapter assumes:

Assumption 1 *Given $\phi(w)$ and $c(q)$, there is a non-null set O such that a initial value from set O gives a solution to income differential equation that meet the conditions $P_q' > 0$ and $w'(q) > 0$.*

In the remain of this chapter we do the analysis given that assumption is satisfied. Moreover, wherever I use certain initial value to find a solution to a differential equation, this initial value is assumed to belong to this set O.

Theorem 14 *There exists a unique equilibrium. And in the equilibrium, quality consumed by consumer with income w^*, denoted as q^*, is pined down as*

$$\delta w^*(L\phi(w^*))^{\frac{1}{\sigma}} = \left(\sigma + (\sigma - 1)\frac{q^*c'(q^*)}{c(q^*)}\right)c(q^*)^{\frac{\sigma-1}{\sigma}}$$

Proof: See Appendix C.2 ∎

Because $\phi'(w^*) = 0$, both $w'(q)$ and $\frac{w'(q)}{\partial w}$ will be continuous functions only if quality chosen by the consumers with income w^* is q^*. Therefore, (q^*, w^*) serves as the initial value of the differential equation (4.8). With assumption 1 satisfied, this initial value

guarantees the existence of solution to equation (4.8) that meets the condition $P_q' > 0$ and $w'(q) > 0$.

With the solution to income differential equation $w(q)$, the price level P_q is determined by equation (4.7), then the number of firms producing quality q is determined as $n_q = \left(\frac{(\sigma-1)P_q}{\sigma c(q)} \right)^{1-\sigma}$. The labor used in differentiated products of quality q is then $L\phi(w(q))P_q$. The labor used in homogeneous products that are consumed by consumers choosing quality q is $L\phi(w(q))(w(q) - P_q)$. Therefore labor market clears. The equilibrium is completely characterized.

4.2.4 Price Distribution

The quality consumed by consumers with income $q(w)$ is a reverse function of $w(q)$, which is related to income distribution. The price paid by consumers is then determined as $p(w) = \frac{\sigma c(q(w))}{\sigma-1}$. Therefore this model predicts that the consumers with same income choose a different quality and pay a different price under a different income distribution. The price distribution is then derived as:

$$\Upsilon(p) = \Phi(w(p))$$

where $w(p)$ is the reverse function of $p(w)$. The model predicts that the price distribution is strongly related to income distribution.

4.3 The Open Economy

Instead of comparative advantage, i.e. cost difference across countries, this chapter aims to study the roles of income distribution in international trade. Therefore, this chapter assumes the same cost $c(q)$ across countries. The countries are differentiated by total labor and income distribution. That is to say, this chapter focuses sharply on international trade driven by demand-side difference rather than supply side difference. For simplicity, there are two countries in the world, the poor country (P) and the rich country (R). The preferences are identical in both countries. There is additional cost for firms to export, iceberg variable export cost $\tau > 1$. The prices for domestic market and export are:

$$p_d^z(q) = \frac{\sigma c(q)}{\sigma - 1} \qquad p_x^z(q) = \frac{\sigma \tau c(q)}{\sigma - 1}$$

where $z \in \{P, R\}$. This chapter is not aiming at explaining the selection of firms into export, therefore the chapter does not assume fixed cost to export. The wage in the two countries are driven to be the same. Total labor is denoted as L_z. Income distribution is $\phi_z(w)$ over $[0, \infty)$, and $\phi_z'(w_z^*) = 0$. This chapter defines ***Incomplete Specialization*** and

Complete Specialization as in Fajgelbaum *et al.*(2012), i.e. qualities that are produced in both country and exported to each other are under incomplete specialization while qualities that are produced in one country and exported to the other are under complete specialization.

4.3.1 Incomplete Specialization

Under incomplete specialization, the qualities are produced in both countries and exported to each other. Therefore, market clearing means:

$$L_z\phi_z(w_z(q)) \cdot \left(\frac{p_d^z(q)}{P_q^z}\right)^{-\sigma} + \tau L_{\tilde{z}}\phi_{\tilde{z}}(w_{\tilde{z}}(q)) \cdot \left(\frac{p_x^z(q)}{P_q^{\tilde{z}}}\right)^{-\sigma} = \frac{f(\sigma-1)}{c(q)}$$

where $\{z,\tilde{z}\} \in \{P,R\}$. To solve the two equations for any incompletely specialized quality, we have:

$$L_z\phi_z(w_z(q)) \cdot \left(\frac{p_d^z(q)}{P_q^z}\right)^{-\sigma} = \frac{f \cdot (\sigma-1)}{(1+\tau^{1-\sigma})c(q)} \qquad (4.9)$$

The demand in foreign country is proportional to domestic country, as in Fajgelbaum *et al.*(2012). Let the number of firms producing each quality is n_z^q, then $P_q^{z1-\sigma} = n_q^z p(q)^{1-\sigma} + n_q^{\tilde{z}}(\tau p(q))^{1-\sigma}$. To solve the number of firms:

$$n_q^z = \left(\frac{\sigma-1}{\sigma}\right)^{1-\sigma} \frac{P_q^{z1-\sigma}}{c(q)^{1-\sigma}} \left(\frac{1-(\tau P_q^{\tilde{z}}/P_q^z)^{1-\sigma}}{1-\tau^{2(1-\sigma)}}\right)$$

To have positive number of firms in both countries, we need $1/\tau < P_q^z/P_q^{\tilde{z}} < \tau$. Let $D_g^z = L_z\phi_z(w_z(q))$ and $D_g^{\tilde{z}} = L_{\tilde{z}}\phi_{\tilde{z}}(w_{\tilde{z}}(q))$ be the demand in z and $\tilde{z}$ country respectively, we have ***relative demand condition*** according to equation (4.9):

$$\tau^{-\sigma} < D_g^z/D_g^{\tilde{z}} < \tau^{\sigma} \qquad (4.10)$$

This inequality means the relative demand in two countries is neither too high nor too low.

To rearrange this equation, we have the income-quality differential equation for qualities under incomplete specialization:

$$
\begin{aligned}
w_z'(q) &= F(q,w_z(q)) \\
&= \frac{\phi_z(w_z(q))}{q\phi_z'(w_z(q))} \left(\sigma + (\sigma-1)\frac{qc'(q)}{c(q)} - \frac{\delta w_z(q)\left((1+\tau^{1-\sigma})L_z\phi_z(w_z(q))\right)^{\frac{1}{\sigma}}}{c(q)^{\frac{\sigma-1}{\sigma}}}\right)
\end{aligned}
\qquad (4.11)
$$

if $\phi_z'(w_z(q)) \neq 0$.

4.3.2 Complete Specialization

Under complete specialization, the qualities are produced by one country and exported to the other. For qualities that are specialized in country z, $P_q^{\tilde{z}} = \tau P_q^z$. Market clearing means:

$$L_z \phi_z(w_z(q)) \cdot \left(\frac{p_d^z(q)}{P_q^z} \right)^{-\sigma} + \tau L_{\tilde{z}} \phi_{\tilde{z}}(w_{\tilde{z}}(q)) \cdot \left(\frac{p_x^z(q)}{\tau P_q^z} \right)^{-\sigma} = \frac{f(\sigma - 1)}{c(q)}$$

To rearrange this equation, we have:

$$(L_z \phi_z(w_z(q)) + \tau L_{\tilde{z}} \phi_{\tilde{z}}(w_{\tilde{z}}(q))) \cdot \left(\frac{p_d^z(q)}{P_q^z} \right)^{-\sigma} = \frac{f \cdot (\sigma - 1)}{c(q)} \tag{4.12}$$

We assume both countries want to produce heterogeneous products and trade with each other. Therefore, if the relative demand condition holds, quality will be incompletely specialized. However, if the relative demand condition is violated, i.e. $D_g^z / D_g^{\tilde{z}} > \tau^\sigma$ or $D_g^z / D_g^{\tilde{z}} < \tau^{-\sigma}$, the quality will be under complete specialization. It can be shown that P_q^z and $P_g^{\tilde{z}}$ are smaller under incomplete specialization in z ($\tilde{z}$) country than in $\tilde{z}$ (z) country or in if relative demand $D_g^z / D_g^{\tilde{z}} > \tau^\sigma (< \tau^{-\sigma})$. Therefore the quality will be completely specialized in the country with large relative demand.

Because $w_z(q) = (qP_q^z)'$, $w_{\tilde{z}}(q) = \tau w_z(q)$ if the qualities are completely specialized in z country. The above equation gives income-quality differential equation:

$$w_z'(q) = \frac{f_z(w(q))}{q(L_z \phi_z'(w_z(q)) + \tau^2 L_{\tilde{z}} \phi_{\tilde{z}}'(w_{\tilde{z}}(q)))} \left(\sigma + (\sigma - 1) \frac{qc'(q)}{c(q)} - \frac{\delta w_z(q) f_z(w(q))^{\frac{1}{\sigma}}}{c(q)^{\frac{\sigma - 1}{\sigma}}} \right) \tag{4.13}$$

if $L_z \phi_z'(w) + \tau^2 L_{\tilde{z}} \phi_{\tilde{z}}'(\tau w) \neq 0$ where $f_z(w(q)) = L_z \phi_z(w_z(q)) + \tau L_{\tilde{z}} \phi_{\tilde{z}}(w_{\tilde{z}}(q))$.

4.3.3 Equilibrium in the Open Economy

We can now characterize the equilibrium in the open economy. Suppose that there is mixed specialization, i.e. some qualities are under complete specialization and some qualities are under incomplete specialization. As quality varies, quality specialization can switch from complete specialization in one country to incomplete specialization and vice versa. However, quality specialization cannot switch from complete specialization in one country to complete specialization in the other country, because the continuity of price indices in both countries cannot allow the ratio of price index jump from τ to $1/\tau$ or from $1/\tau$ to τ. We assume that

Assumption 2 $\frac{\phi_R(\tau w)}{\phi_P(w)}$ and $\frac{\phi_R(w/\tau)}{\phi_P(w)}$ are increasing functions of w.

Assumption 2 means that the relative demand of the rich country than the poor country D_q^R / D_q^P is increasing for the qualities under complete specialization regardless of which

country it is specialized. For example, if the qualities are specialized in the rich country, $w_R(q) = w_P(q)/\tau$, then the relative demand $D_q^R/D_q^P = L_R\phi_R(w_p(q)/\tau)/L_P\phi_P(w_p(q))$ is increasing with quality. Likewise if the qualities are specialized in the poor country, relative demand is increasing as well. Provided that assumption 2 is satisfied, there are at most three intervals of qualities $(0,\underline{q})$, $(\underline{q},\overline{q})$ and $(\overline{q},\infty)$ such that quality specialization is different for each interval. Moreover, if three intervals exist, assumption 2 guarantees that qualities in $(0,\underline{q})$ are specialized in the poor country, qualities in $(\overline{q},\infty)$ are specialized in the rich country and qualities $(\underline{q},\overline{q})$ are under incomplete specialization. Next we characterize if $\underline{q}$ and $\overline{q}$ exist and how they are determined in equilibrium.

Suppose there are three intervals of qualities, there are $w_P(q)$ and $w_R(q)$ as well as corresponding P_q^P and P_q^R in each interval. In order to have a general equilibrium, P_q^P and P_q^R should be continuous and differentiable across the whole range of qualities. According to equation (4.9) and (4.12), we can find P_q^P and P_q^R for each interval. Take P_q^P as an example,

$$
P_q^P = \begin{cases} \dfrac{\sigma}{\delta}\left(\dfrac{c(q)^{\sigma-1}}{L_P\phi_P(w_P(q)) + \tau L_R\phi_R(w_R(q))}\right)^{\frac{1}{\sigma}} & \text{if } q \in (0,\underline{q}) \\[3ex] \dfrac{\sigma}{\delta}\left(\dfrac{c(q)^{\sigma-1}}{(1+\tau^{1-\sigma})L_P\phi_P(w_P(q))}\right)^{\frac{1}{\sigma}} & \text{if } q \in [\underline{q},\overline{q}] \\[3ex] \dfrac{\sigma}{\delta}\left(\dfrac{\tau^\sigma c(q)^{\sigma-1}}{L_R\phi_R(w_R(q)) + \tau L_P\phi_P(w_P(q))}\right)^{\frac{1}{\sigma}} & \text{if } q \in (\overline{q},\infty) \end{cases}
$$

P_q^P, $w_P(q)$ and $w_R(q)$ are continuous in each interval, therefore P_q^P is differentiable as well in each interval because $P_q^{P'} = (w_P(q) - P_q^P)/q$. At $q = \underline{q}$ and $q = \overline{q}$, $\frac{L_{\tilde{z}}\phi_{\tilde{z}}(w_{\tilde{z}}(q))}{L_z\phi_z(w_z(q))} = \tau^{-\sigma}$ and τ^σ respectively. Let the income of consumers that choose qualities $\underline{q}$ and $\overline{q}$ be $\underline{w}_P$, $\overline{w}_P$ in poor country and $\underline{w}_R$, $\overline{w}_R$ in rich country. In order to make P_q^P and P_q^R continuous and differentiable at $q = \underline{q}$ and $q = \overline{q}$, $w_P(q)$ and $w_R(q)$ should be continuous. This will pins down the income levels at $q = \underline{q}$ and $q = \overline{q}$ by the following two sets of equations:

$$
\begin{cases} \dfrac{L_R\phi_R(\underline{w}_R)}{L_P\phi_P(\underline{w}_P)} = \tau^{-\sigma} \\[2ex] \underline{w}_R = \tau\underline{w}_P \end{cases} \qquad \begin{cases} \dfrac{L_R\phi_R(\overline{w}_R)}{L_P\phi_P(\overline{w}_P)} = \tau^\sigma \\[2ex] \overline{w}_P = \tau\overline{w}_R \end{cases} \tag{4.14}
$$

Under assumption 2, there will be at most one solution to each set of equations. Depend on the existence of solutions, there exists different quality specialization in the equilibrium.

Case I: Neither sets has a solution. In this case, there are no values $\underline{q}$ and $\overline{q}$. Therefore, there is no mixed specialization, i.e. all qualities are under complete specialization in poor country or rich country, or all qualities are under incomplete specialization. If the first set does not have a solution, $L_R\phi_R(\tau w)/L_P\phi_P(w) < \tau^{-\sigma}$ or $L_R\phi_R(\tau w)/L_P\phi_P(w) > \tau^{-\sigma}$ across all income levels. Likewise, if the second set does not have a solution,

$L_R\phi_R(w/\tau)/L_P\phi_P(w) < \tau^\sigma$ or $L_R\phi_R(w/\tau)L_P\phi_P(w) > \tau^\sigma$ across all income levels. Given the income distributions described in section 2 for both countries, $\phi_R(w/\tau) < \phi_R(\tau w)$ for low income levels and $\phi_R(w/\tau) > \phi_R(\tau w)$ for high income levels.

Therefore, $L_R\phi_R(\tau w)/L_P\phi_P(w) < \tau^{-\sigma}$ across all income levels means that $\underline{q}$ determined by the first set of equations tends to infinity. Thus all qualities are specialized in the poor country. If $L_R\phi_R(\tau w)/L_P\phi_P(w) < \tau^{-\sigma}$ across all income levels, the relative demand in poor country country to rich country is too large so that all qualities are completely specialized in poor country. If $L_R\phi_R(w/\tau)/L_P\phi_P(w) > \tau^\sigma$ across all income levels, alternatively $L_P\phi_P(\tau w)/L_R\phi_R(w) < \tau^{-\sigma}$ across all income levels, $\overline{q}$ determined by the second set of equations tends to be zero. As a result, all qualities are specialized in the rich country. In this case, the relative demand in rich country country to poor country is too large so that all qualities are completely specialized in rich country.

The income-quality relationship can be solved by income-quality differential equation (4.13). To solve the equation (4.13), we assume

Assumption 3 $L_z\phi_z'(w) + \tau^2 L_{\tilde{z}}\phi_{\tilde{z}}'(\tau w) \neq 0$ *across all income levels, where* $\{z,\tilde{z}\} \in \{P,R\}$.

Supposed assumption 3 is satisfied, there is no feasible initial value to the differential equation. Hence, a Pareto superior equilibrium shown in Appendix C.4 is determined as there is no feasible initial values. This leads to the following theorem.

Theorem 15 *Suppose* $L_{\tilde{z}}\phi_{\tilde{z}}(\tau w)/L_z\phi_z(w) < \tau^{-\sigma}$ *across all income levels. Then there is an Pareto superior equilibrium that all qualities are completely specialized in z country.*

Proof: With differential equation (4.13), there are different solutions give different initial values. Under assumption 2, there are some feasible solutions. According to proof used in Appendix C.4, there is a Pareto superior equilibrium among these feasible solutions. ∎

If $L_R\phi_R(\tau w)/L_P\phi_P(w) > \tau^{-\sigma}$ across all income levels, $\underline{q}$ determined by the first set of equations tends to be zero. If $L_R\phi_R(w/\tau)/L_P\phi_P(w) < \tau^\sigma$ across all income levels, $\overline{q}$ tends to be infinity. Thus all qualities are incompletely specialized in both countries. In this situation, the relative demand in rich country to poor country is neither too high nor too low, and then all qualities are under incomplete specialization. The income-quality relationship can be solved by income-quality differential equation (4.11). According to theorem 2, there is a solution $w_z(q)$ with initial value (q_z^*, w_z^*), where $\delta(1+\tau^{1+\sigma})w_z^*(L_z\phi(w_z^*))^{\frac{1}{\sigma}} = \left(\sigma + (\sigma-1)\frac{q_z^* c'(q_z^*)}{c(q_z^*)}\right) c(q_z^*)^{\frac{\sigma-1}{\sigma}}$. This is summarized as:

Theorem 16 *Suppose* $L_{\tilde{z}}\phi_{\tilde{z}}(\tau w)/L_z\phi_z(w) < \tau^{-\sigma}$ *across all income levels for both countries* $\{z,\tilde{z}\} \in \{P,R\}$. *Then there is a unique equilibrium that all qualities are under incomplete specialization.*

Case II: Every set has a solution. In this case, $\underline{q}$ and $\overline{q}$ exist. To see how they are endogenously determined. this chapter assumes that:

Assumption 4 $\underline{w}_z > w_z^*, z \in \{P,R\}$ *and* $\underline{w}_R > \tau^2 \underline{w}_P$.

This assumption guarantees that $\underline{w}_R > \underline{w}_P$ and $\overline{w}_R > \overline{w}_P$. Moreover, this assumption guarantees that (q_z^*, w_z^*) will not be a initial value to income-quality differential equation (4.11). Therefore $w_z(q)$ for qualities under incomplete specialization varies with the chosen initial values. However, according to Lemma 1, there is a unique solution $w_z(q)$ with initial value $(\underline{q}, \underline{w}_z)$. And $w_z(q)$ can be denoted as:

$$w_z(q) = \underline{w}_z + \int_{\underline{q}}^q F(q, w_z(q)) \mathrm{d}q$$

where $F(q, w_z(q))$ is the function shown in equation (4.11). To substitute $(\overline{q}, \overline{w}_z)$ into above equation,

$$\overline{w}_z = \underline{w}_z + \int_{\underline{q}}^{\overline{q}} F(q, w_z(q)) \mathrm{d}q \tag{4.15}$$

To substitute the solved $\underline{w}_P$, $\overline{w}_P$, $\underline{w}_R$ and $\overline{w}_R$ into equation (4.15), we have a set of two equations with two unknowns $\underline{q}$ and $\overline{q}$:

$$\begin{cases} \overline{w}_P &= \underline{w}_P + \int_{\underline{q}}^{\overline{q}} F(q, w_P(q)) \mathrm{d}q \\ \overline{w}_R &= \underline{w}_R + \int_{\underline{q}}^{\overline{q}} F(q, w_R(q)) \mathrm{d}q \end{cases}$$

where $F(q, w_P(q))$ and $F(q, w_R(q))$ have been shown in equation (4.11). After solving the equations, we have the values $\underline{q}$, $\overline{q}$ as well as $w_P(q)$ and $w_R(q)$ for qualities $q \in [\underline{q}, \overline{q}]$. Take $(\overline{q}, \overline{w}_R)$ as initial value, we can solve for $w_R(q)$ for qualities $q \in (\overline{q}, \infty)$ with differential equation (4.13), and corresponding $w_P(q)$ is equal to $\tau w_R(q)$. Likewise, use $(\underline{q}, \underline{w}_P)$ as initial value, we can solve for $w_P(q)$ for qualities $q \in (0, \underline{q})$, and $w_R(q) = \tau w_P(q)$. Therefore we will have an equilibrium with mixed specialization for case II:

Theorem 17 *Suppose there is one solution to each set of equations, there is an equilibrium with mixed specialization. Low qualities are completely specialized in poor country, medium qualities are under incomplete specialization, high qualities are completely specialized in rich country.*

As shown in Fig 4.1, the qualities $q \in (0, \underline{q})$ are specialized in poor country and exported to rich country, while the qualities $q \in (\overline{q}, \infty)$ are specialized in rich country and exported to poor country. These qualities are specialized in the country with relative large demand. The medium qualities $q \in [\underline{q}, \overline{q}]$ are incompletely specialized, i.e. produced by both countries and exported to each other.

Consider distributions with bounded income w_{min}^z and w_{max}^z, and let q_{min}^z and q_{max}^z denote the minimal and maximum qualities in the two countries. If $w_{min}^R > \tau w_{min}^P$, $q_{min}^P <$
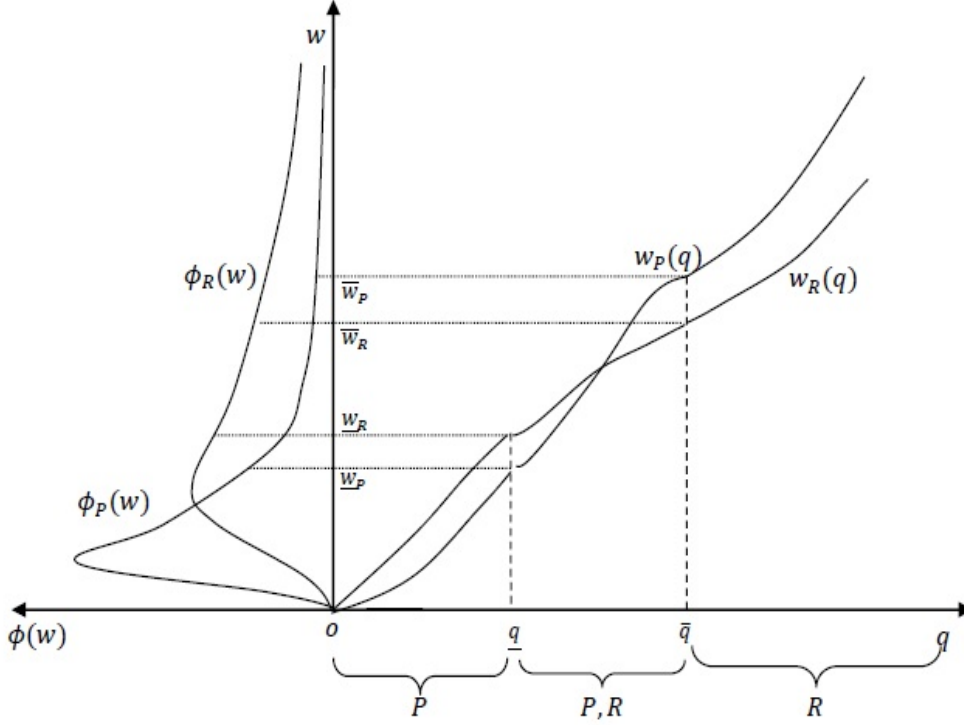
Fig 4.1: Equilibrium in open economy

q^R_{min}. The lowest qualities in poor country does not have demand in rich country, therefore they are non-exported. Likewise, there are non-exported qualities in rich country if $w^R_{max} > \tau w^P_{max}$. This leads to following corollary:

Corollary 2 *Given distributions that $w^R_{min} > \tau w^P_{min}$ and $w^R_{max} > w^P_{max}/\tau$, there is an equilibrium of which the lowest qualities are demanded in poor country, and the highest qualities are demanded in rich country if $\phi_R(w^R_{min}) = 0$ and $\phi_P(w^P_{max}) = 0$.*

Proof: Market clearing is denoted as equation (4.7) for non-exported qualities. In order to make P^P_q continuous and differentiable at $q = q^P_{min}$, $\phi_R(w^R_{min})$ should be zero and $w_P(q)$ should be continuous at $q = q^P_{min}$. The income of consumers that choose quality q^R_{min} in poor country is w^R_{min}/τ. We can solve income differential equation (4.8) for poor country with the initial value $(q^R_{min}, w^P_{min}/\tau)$ to get $w_P(q)$ for non-exported qualities, and then $w_P(q)$ is continuous at $q = q^R_{min}$. Likewise, we can solve $w_R(q)$ for non-exported qualities in rich country to make $w_R(q)$ continuous at $q = q^P_{max}$. ∎

As shown in Fig 4.2, the lowest qualities $q \in [q^P_{min}, q^R_{min}]$ are non-exported qualities of poor country, while the highest qualities $q \in [q^P_{max}, q^R_{max}]$ are non-exported qualities of rich country. There are no demand of these qualities in the other country.

Case III: There is a solution to only one set of equations. If only the first set has a solution $\underline{w}_P$ and $\underline{w}_R$, low qualities are completely specialized in poor countries while all

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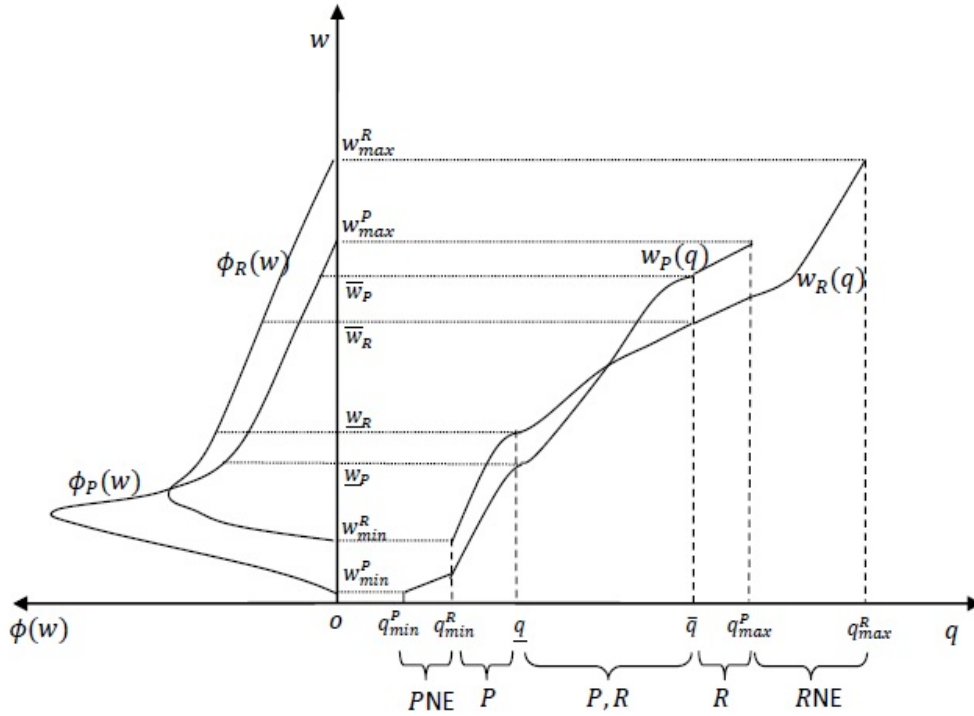
Fig 4.2: Equilibrium in open economy

high qualities are under incomplete specialization. If it is the second set that has a solution $\overline{w}_P$ and $\overline{w}_R$, all low qualities are under incomplete specialization while high qualites are completely specialized in rich country. The cutoff quality Q can be identified if $\underline{w}_P > w_P^*$ or $\overline{w}_P < w^*$. Take the solution to first set as an example, with initial value $(Q, \underline{w}_P)$, we can solve $w_P(q)$ for qualities that are completely specialized in poor country and under incomplete specialization respectively. Similarly, we can solve $w_R(q)$ for these qualities with initial value $(Q, \underline{w}_R)$. Any two solutions with different Q do not cross, therefore Q is value that gives the Pareto superior equilibrium.

In any case described above, after we identify the $w_z(q)$, $z \in \{P, R\}$, we can solve P_q^z and n_q^z depending on quality specialization. Labor market automatically clears within each quality.

4.3.4 Export Price Distribution

With $w_z(q)$ $z \in \{P, R\}$, the reversal function gives the quality chosen by consumers with income w in both country $q_z(w)$. $q_P(w)$ and $q_R(w)$ are different because of different income distributions. This means the consumers with the same income level will buy different qualities in different countries. The export price and income are then linked by the quality. The f.o.b export price from z country to $\tilde{z}$ country paid by consumers with

income *w* is:

$$p_{z\tilde{z}}(w) = \frac{\sigma c(q_{\tilde{z}}(w))}{\sigma - 1}$$

There is a clear relationship between export price and income, and this relationship is governed by income distributions. Let the reverse function of $p_{z\tilde{z}}(w)$ be $w(p_{z\tilde{z}})$, that is the income of consumes in country that pay f.o.b price $p_{z\tilde{z}}$ for imported products from z country. The export price distribution from z country to $\tilde{z}$ country is then:

$$\Upsilon_{z\tilde{z}}(p) = \Phi(w(p_{z\tilde{z}}))$$

The export price distribution is strongly related to income distributions. For mixed specialization, exported qualities serve a truncated distribution of consumers. For example, as shown in Fig 4.1, export qualities from poor country to rich country is $(0, \overline{q})$. Therefore these export qualities only serve consumers with income $(0, \overline{w}_R)$, so the export price distribution from poor country to rich country is adjusted by a truncated income distribution:

$$\Upsilon_{PR}(p) = \frac{\Phi_R(w(p_{z\tilde{z}}))}{\Phi_R(\overline{w}_R)}$$

We have documented that export price and price distribution are related to income distributions of both countries, and the channel they are related is quality. However, reduced form between them is absent because of the solution to income differential equation cannot be tractably solved, even given some specific forms of income distribution and cost. I will leave this part to a empirical study.

4.4   Empirical Study

In this section, I provide some empirical evidence of the model. Firstly, the model builds on the non-homothetic preference over quality that leads to the income-quality relationship: consumers with high income choose high quality and pay high price. Though it is not observable that which consumers buy which imported products in the export data, it is possible to test with domestic survey on household expenditure and income. Therefore the first proposition tested in this section is:

Income-quality relationship *Consumers with high income choose high quality and pay high price.*

Secondly, the model predicts that export price distribution is strongly related to the destination income distribution. Though the mapping between consumer income and price paid is not observable in the export data, export price distribution and some moments of income distribution, e.g income per capita, Gini coefficient and income shares for certain quantiles are observable. Therefore the second proposition tested in this section

is:

Export price distribution and income distribution *Export price distribution is strongly related to the destination income distribution.*

4.4.1 Evidence of Income-quality relationship

To test income-quality relationship proposition, I use UK Living Cost and Food Surveys (LCF)[1]. LCF is constructed mainly through household questionnaire, individual questionnaire and Expenditure and Food Survey (EFS) diary. The household questionnaire includes questions on a range of subjects including family members and relationships, employment details, expenditure that typically made by the whole households, e.g. council tax, and some infrequently expenditure such as vehicles, holidays and housing. Individual questionnaire covers information on the income of household member from various source, e.g. employment, benefits and assets, and forms the household level income. In EFS diary, each individual aged 16 years and over in the household is asked to keep diary records of daily expenditure for two weeks, including quantity of the purchase.

The advantage of this data is twofold. Firstly, the expenditure is quite disaggregated. It is more disaggregated than Classification of Individual Consumption according to Purpose (COICOP). For example, in COICOP, the most disaggregated category about bread is "bread and cereals", but in LCF, there are sub categories as "white bread", "brown bread", "wholemeal bread" and etc. Another advantage is that the data provide the purchased quantity as well as the expenditure. This allows to calculate the price (unit value) of the product purchased by each household. As widely used, this section will use unit values to proxy the quality. Therefore, this section can show direct evidence on the relationship between income and price (quality). However, one might be concerned by the measurement error on the quantity information, because expenditure is clearly stated in the receipt but quantity might not in some cases. As a robust check, I use expenditure and household composition to see if consumers with high income spend more on a product given that the quantity is controlled.

Expenditure on food, though purchased by individuals, is household level. Therefore, I use household income to test the relationship between price and income. However, household income is not comparable across households because the household composition is different. Fortunately, LCF has already provided the OECD-modified equivalence scale to adjust income for each household. OECD-modified equivalence scale is used

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[1]EU Household Budget Surveys (HBSs) provides the expenditure and income of households. The Statistical Office of the European Union (Eurostat) releases the household consumption expenditure by income quintile at 3 digital level for all EU countries according to Classification of Individual Consumption according to Purpose (COICOP), and more disaggregated data is given only for Italy of year 1995 and Norway of year 2010. However, a disadvantage of the released Eurostat data is that it does not release the corresponding household size and purchasing quantity information.

widely across Europe. To calculate the scale, single adult households are taken as the reference group and are given a scale value of one. For larger households, each additional adult children aged 14 and over are given a smaller value of 0.5 while children under the age of 14 are given a value of 0.3. This is to reflect the effect of economies of scale on reducing living costs per person, when larger households share resources such as water and electricity. To compare the household incomes, normal disposable income divided by OECD scale, i.e. equivalised disposable income is used.

Results

In this section, we focus on two narrowly defined products, bread and wine. They have a large range of qualities in the market. And household of all income levels will buy these products. For bread, there are several sub products. Therefore quantity is calculated as the total quantity of all sub products and price is calculated by total expenditure divided by quantity. In the analysis, I will control the expenditure on substitutes of bread, including rice, cereals, cakes, puddings and etc, as well as substitutes of wine, e.g. beers, lagers, ciders, champagne, spirits, fortified wine and etc. (See Appendix Table AC.5 for the source of variables and how they are constructed). Table 4.1 presents the descriptive results of the variables.

Table 4.1: Description of the data

Variable	# obs.	Mean	Std. Dev.	Min	Max
Household					
Disposable income (£)	5,144	578.68	373.46	-348.08	1566.13
OECD scale	5,144	1.59	0.53	1	4.2
Equivalised disposable income	5,144	256.70	0.66	-232.05	2028.44
Bread					
Expenditure (£)	4,873	2.99	2.23	0.1	20.62
Equivalised expenditure	4,873	1.84	1.22	0.07	10.73
Equivalised expenditure of substitutes	4,873	4.77	3.27	0	25.97
Price (p/g)	4,846	0.20	0.09	0.03	1.92
Equivalised quantity (g)	4,846	923.61	585.17	21.67	5,520
Wine					
Expenditure (£)	1,711	10.98	14.63	0.30	182.99
Equivalised expenditure	1,711	6.99	9.69	0.12	121.99
Equivalised expenditure of substitutes	1711	4.29	7.18	0	90
Price (p/ml)	1,698	0.69	0.26	0.05	4.00
Equivalised quantity (ml)	1,698	1,030.73	1,224.41	25.71	12,500

The measurement unit of income and expenditure is pound. There are two households that have less than zero disposable income and 11 households that have zero disposable income. "income", "expenditure" and "quantity" are weekly numbers.

Fig 4.3 plots the price of bread and wine with deciles of equivalised household disposable income. As income increases, the price of the consumption product is increasing.

That is, richer people pay higher price for a given product than poor people, which also means richer people buy higher quality.
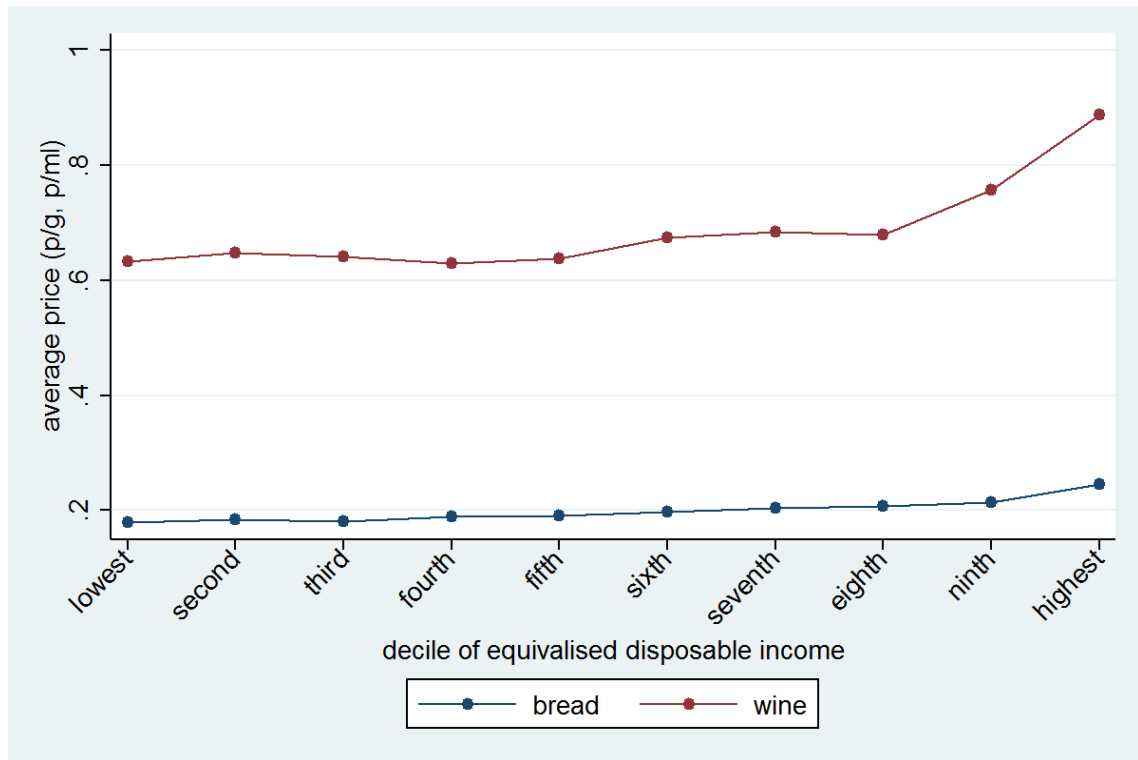
Note: Price of bread is pence per gram and price of wine is pence per ml.

Fig 4.3: Price and income

Next I run regressions between price (ln *price*) and equivalised income (ln inc_{eq}). The results are shown in Table 4.2. As shown in column 1 and 4, for both bread and wine, the coefficients of equivalised income are positive and significant. I control the equivalised expenditure on substitutes (ln ex_{sub}) in column 2 and 5, the coefficients of equivalised income are still positive and significant. Moreover, as shown in column 3 and 6, when controlling quantity (ln $quan_{eq}$) and the expenditure on substitutes, price is still positively related to income. Richer people are willing to pay more for each unit given the same quantity consumed and expenditure on substitutes. This is direct evidence that rich people choose high quality and pay high price.

Alternative robustness

There might be potential measurement error on the quantity information, because expenditure is clearly stated in the receipts but quantity might not in some cases. As a robust check, I use expenditure and household composition to see if consumers with higher income spend more on a product when controlling the purchased quantity.

In Fig 4.4, we plot the deciles of equivalised household disposable income and average expenditure for bread. As income increases, the expenditure is increasing. However, this

Table 4.2: Price and disposable income

	Bread			Wine		
	ln *price*	ln *price*	ln *price*	ln *price*	ln *price*	ln *price*
	(1)	(2)	(3)	(4)	(5)	(6)
ln inc_{eq}	0.125	0.118	0.101	0.129	0.144	0.153
	(0.008) ***	(0.008)***	(0.008)***	(0.013)***	(0.018)***	(0.018)***
ln ex_{sub}		0.040	0.074		0.004	0.016
		(0.007)***	(0.007)***		(0.010)	(0.010)
ln $quan_{eq}$			-0.180			-0.050
			(0.007)***			(0.011)***
_cons	-2.410	-2.421	-1.054	-1.196	-1.302	-1.013
	(0.047)***	(0.047)***	(0.071)***	(0.080) ***	(0.106)***	(0.122)***
# obs.	4,836	4,729	4,729	1,697	1,017	1,017
adj. R^2	0.047	0.053	0.163	0.052	0.061	0.080

Standard errors are stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

relationship could be driven by the household size. The larger household spends more given the same income. We also plot the deciles of equivalised household disposable income and the equivalised expenditure. As income increases, the equivalised expenditure is increasing as well. In Table 4.3, I run regressions of expenditure (ln *exp*) and income (ln *inc*) controlling for various household composition from column 1 to 4, e.g. household size (hs), number of children aged over 16 (N_c) number of adults aged under 45 (N_a), household composition (hc)[2]. The positive relationship between expenditure and income holds.

As shown in column 1 in Table 4.4, this pattern still holds when using equivalised expenditure. Richer people spend more on a product, and this is not because of less consumption of substitutes (column 2). This is the evidence that rich spend more for a given product because they choose high quality and pay high price. I use bread rather than wine to show the alternative evidence, because income might affect the purchased quantity for wine but plausibly do not affect the purchased quantity for for bread. This could be tested by regressing equivalised quantity purchased between equivalised income, shown in column 3 and 4 in Table 4.4. Income does not significantly affect quantity of bread, but richer people drink more given that the price is controlled.

The model builds on the non-homothetic preference over quality and gives a one to one relationship between income and quality, consequently relationship between income and price, i.e stated in income-quality relationship proposition. In this part, it is shown

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[2]There are 30 compositions, e.g. one man, one woman, one man and one woman, one man and one woman plus one child, etc.
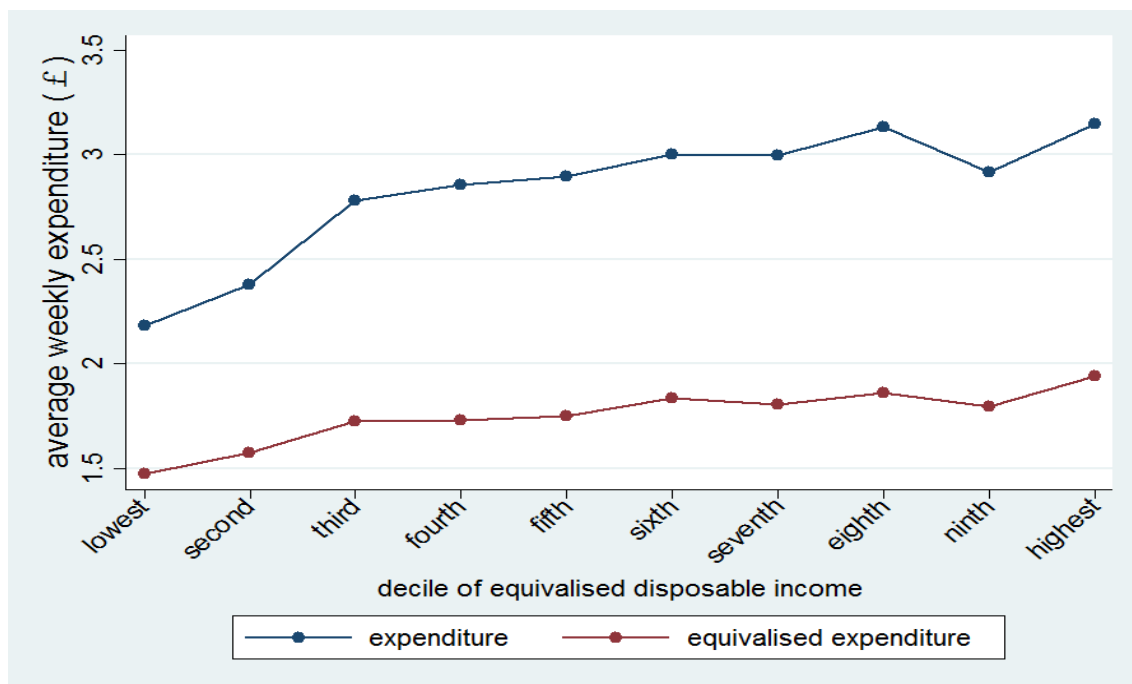
Fig 4.4: Weekly expenditure of bread and income

that rich consumers choose high quality and pay high price. The results are consistent with Bils and Klenow (2001) that rich people consume better goods and Faber and Fally (2015) that richer households source their consumption from significantly larger firms and high quality products.

4.4.2 Evidence of Export Price Distribution and Income Distribution

In this part, we will use quantile regression to test proposition on the relationship between export price distribution and income distribution.

As commonly used in literatures (e.g. Schott, 2000; Hallak, 2006; Manova and Zhang, 2012), export price is proxied as unit value. Export value and quantity are from Chinese Customs Trade Database (Previous literatures using this database include Manova and Zhang (2009, 2012), Ahn *et al.* (2011), Wang and Yu (2012) Upward *et al.* (2013)). This database reports all Chinese export and import transactional records, and each record has information on value and quantity by product, firm and export destination/import origin. With these data, we have product-level export price distribution to each destination. Note that the model is built on a two-country basis. Therefore to test the model in a multi-country world, this section will choose the product whose export from China has a relatively large share in world export.

This section will use quantile regression to study export price distributions across countries. Therefore the chapter will select a product to construct the sample[3]. The prod-

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[3]Though fixed effects quantile regression is developed (Canay, 2011; Powell, 2014), it has not been

Table 4.3: Household expenditure of bread

	$\ln exp$ (1)	$\ln exp$ (2)	$\ln exp$ (3)	$\ln exp$ (4)
$\ln inc$	0.313 (0.015)***	0.148 (0.016) ***	0.265 (0.015) ***	0.136 (0.016)***
hs		0.214 (0.009) ***		
N_c			0.342*** (0.042)	
N_a			0.0881***	
hc				0.046 (0.002)***
_cons	-1.109 (0.091) ***	-0.604 (0.088)***	-0.900 (0.092)***	-0.379 (0.093)***
# obs.	4,863	4,863	4,863	4,863
adj. R^2	0.086	0.184	0.109	0.170

Standard errors are stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

Table 4.4: equivalised household expenditure and disposable income

	Bread			Wine
	$\ln exp_{eq}$ (1)	$\ln exp_{eq}$ (2)	$\ln quan_{eq}$ (3)	$\ln quan_{eq}$ (4)
$\ln inc_{eq}$	0.093 (0.015)***	0.051 (0.015)***	0.017 (0.015)	0.237 (0.053)***
$\ln ex_{sub}$		0.238 (0.013)***	0.216 (0.013)***	0.238 (0.028)***
$\ln price$			-0.649 (0.026)***	-0.420 (0.090)***
_cons	-0.144 (0.089)	-0.208 (0.087)**	6.024 (0.105)***	5.282 (0.327)***
	4,863	4,753	4,729	1,017
	0.007	0.074	0.156	0.094

Standard errors are stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

widely used.

uct chosen for this analysis has to be the product whose export from China has a relatively large share in world export. Moreover, it should be 1) a final consumption product, as intermediate or capital products are not necessarily related to the income of consumers; 2)a product that is consumed by consumers with all levels of income, i.e. not substitutable as income of consumers increases or decreases; 3) a product with large variations of export prices within each destination, which makes export price distributions more reliable. Based on these requirements, this chapter selects the product from textile and clothing, "Jerseys, pullovers, cardigans, waist-coats and similar articles, knitted or crocheted" coded as $HS6110$ in the version of 2002 HS code. Jerseys, pullovers, cardigans, waist-coats and similar articles are substitutable to some extent, thereby being defined as one product[4]. Within this product category, there are some sub categories according to the materials that the product is made of, e.g. of wool(611011), Kashmir(611012), cotton (611020), man-made fibres(611030) and other materials (611090). Thus, for different sub categories, they are essentially the same product. Therefore, price variations within the product, i.e. $HS6110$, can be plausibly considered as quality differences.

Moreover, we choose the destinations from European Union to construct the sample. The main reason is that the consumer patterns in EU are similar across countries. Secondly the currency for most countries are Euro, excluding the impacts of exchange rate on country demand for imported products. Income data of EU countries are from Statistical Office of the European Union (Eurostat), including Gini coefficients, income share by income quantiles. Other gravity-related data, e.g. GDP per capita, population, distance and remoteness[5] are from CEPII database. In the regression, we will limit the sample to the countries that have more than 100 number of varieties, to allow the enough range of quality differentiation within each country (see Appendix A C.6 for details of the country sample and number of varieties).

Model

In order to see the relationship between export price distribution and income distribution, quantile regression is applied:

$$\mathbb{Q}_\eta(p_{pd}|I_d, X_d) = \alpha_\eta^1 I_d^1 + \alpha_\eta^2 s_{middle} + \gamma_\eta + \beta_\eta X_d, \quad I_d^1 \in \{s_{poor}, s_{rich}\} \tag{4.16}$$

η is quantile of price distribution, and distribution of price is weighted by quantity. p is the product and d denotes the destination. I_d is the set of income distribution variables. X_d is the set of gravity related control variables, including population, distance to China and remoteness. When estimating the price distribution, export quantity is used as the

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[4]The narrower the product is defined, the more preference bias can be avoid. However, the narrower the product is defined, the less observations are for the distribution estimation. Meanwhile, for textile and clothing, a big portion of products are classified by sex, which are appropriate for this analysis.

[5]Remote of a country is GDP weighted distance across all other countires.

frequency weight. $s_{poor} + s_{middle} + s_{rich} = 1$. This will give the effect of income distribution shift. For example, if s_{poor} and s_{middle} are included, the coefficient of s_{poor} will tell the effect of shifting one percentage point of income from the rich to the poor, while coefficient of s_{middle} the effect of shifting one percentage point of income from the rich to the middle. Table 4.5 shows the description of the data.

Table 4.5: Description of the data

Variable	Obs	Mean	Std. Dev.	Min	Max
			price and quantity		
Quantity	32,522	7,204.60	22,838	1	1,075,844
Price	32,522	10.61	10.63	0.18	305.00
			Income of EU countries		
Income per capital	20	31,721.43	16,886.73	4,052.00	66,739.18
Income share of					
the poor(%)	20	8.16	1.42	4.4	10.1
the middle (%)	20	53.25	2.75	45.6	57.3
the rich (%)	20	38.59	4.01	33.4	50

Note: Income per capital is in terms of 2005 constant US$. We have exclude the countries that have no data on income share in 2006 and countries that have less than 100 varieties.

Results

Quantile regression of equation (4.16) shows the effects of income distribution shift that comes from income shift from the rich to the poor or from the poor to the rich. The results are reported in Table 4.6 and the coefficients of more quantiles are plotted in Fig 4.5.

A one percentage point of income shifted from the rich to the poor increases export price of quantiles from 0.1 to 0.9. And the scale of the effect is decreasing. When the poor become richer, they will choose higher qualities and pay higher prices. On the contrary, when the rich become poorer, they will choose lower qualities and pay lower prices. These results on the prices of various quantiles suggest that the export price distribution is squeezed from the both tails to the middle. This is consistent with the move of the income distribution: when income is shifted from the rich to the poor, there are less poor and less rich, therefore the income distribution is also squeezed from the both tails to the middle .

This result is confirmed by the effects of income shift from the poor to the rich. A one percentage point of income shifted from the poor to the rich decreases export price from quantile 0.1 to quantile 0.85, and the scale of effect is decreasing as well. As the income is shifted from the poor to the rich, the poor become poorer and the rich become richer. As a result, the poor will choose lower quality and pay lower price while the rich choose higher quality and pay higher price. This suggests that if we make income distribution

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Table 4.6: Export price distribution and income distribution

	Quantile 0.1	Quantile 0.25	Quantile 0.5	Quantile 0.75	Quantile 0.9
	Panel A: Income shift from the rich to the poor and the middle				
s_{poor}	0.212	0.126	0.060	0.047	-0.003
	(0.0095)***	(0.0002)***	(0.0001)***	(0.0000)***	(0.0000)***
s_{middle}	-0.073	-0.005	-0.011	0.017	0.040
	(0.0044)***	(0.0001)***	(0.0001)***	(0.0000)***	(0.00000)***
	Panel B: Income shift from the poor to the rich and the middle				
s_{rich}	-0.176	-0.110	-0.047	-0.024	0.028
	(0.0286)***	(0.00564)***	(0.00135)***	(0.00003)***	(0.00145)***
s_{middle}	-0.240	-0.111	-0.055	0.001	0.077
	(0.0397)***	(0.00783)***	(0.00188)***	(0.00005)***	(0.00202)***
# obs.	234,307,867	234,307,867	234,307,867	234,307,867	234,307,867

All regressions include income per capita and gravity related control variables: population, distance and remoteness. All regression use export quantity as the frequency weight. See Appendix C.5 for full tables. Number of observations is the total weights. Standard errors are stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

more flat, i.e. shift income from the poor to the rich, the export price distribution becomes more flat as well.

However, when income is shifted from the rich to the middle, the move of export price distribution is very similar to the result when shifting income from the poor to the middle. The potential reason is that the middle is very broadly defined, i.e. the people above bottom 20% and below the top 20%. When the income is shifted to the middle, it may be the rich part of the this group that benefit rather than the poor part. As a result, the pries of low quantiles are decreased while the prices of high quantiles are increased.

From quantile regression, we show that the shift of export price distribution is related to the shift of income distribution. In particular, if the income distribution is squeezed from both tails to the middle, export price distribution is also squeezed from both tails to the middle as well; if the income distribution becomes flat, so does the export price distribution. These are consistent with the proposition on export price distribution and income distribution, i.e. export price distribution is strongly related to income distribution.

4.5   Conclusion

This chapter develops a general equilibrium model with non-homothetic preference over a continuum of qualities. The chapter shows a one to one relationship between income of consumers and the quality they buy. This income-quality relationship is subject to income

Income shift from the rich to the poor and the middle

Income shift from the poor to the rich and the middle
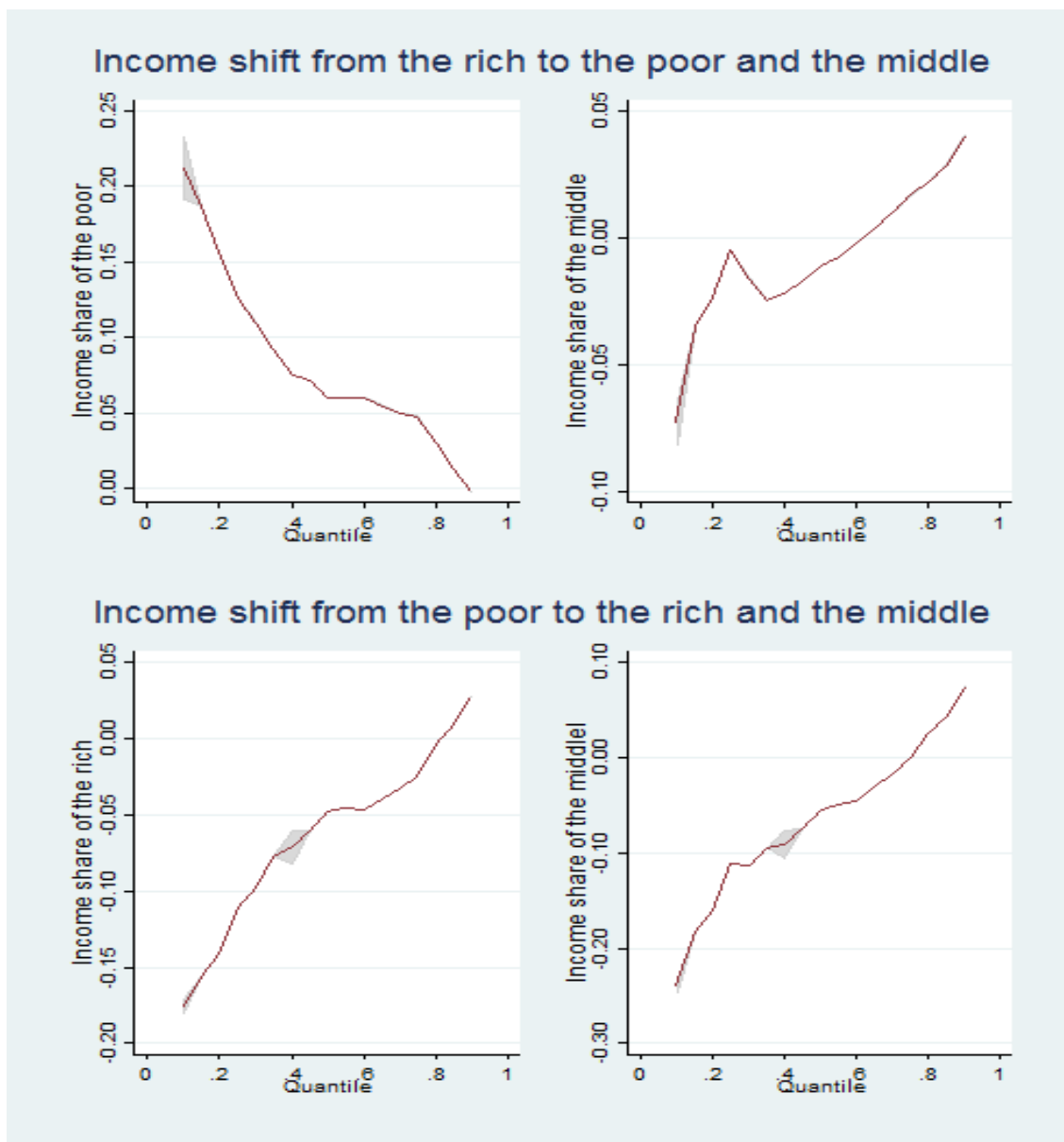
Note: The graph also includes the 95% confidence level.

Fig 4.5: Coefficients of income shift

distribution. The chapter further studies how the qualities are specialized under international trade, and finds a quality specialization pattern that follows home market effect. In particular, low (high) qualities are completely specialized in the poor (rich) country, while medium qualities are incompletely specialized, i.e. produced by both countries and exported to each other. Furthermore, the chapter shows a link between export price distribution and destination income distribution through the income-quality relationship and quality specialization, and provides the empirical evidence.

The chapter provides an alternative framework to study the interaction between vertical and horizontal differentiation of products and income distribution. Unlike nested-

logit demand, the demand in this chapter is more related to the widely used CES prefer-
ence. Therefore, this model can be applied to a wider range of trade models built on CES
preference. It is hard to have reduced form on relationship between between income of
consumers and the quality they buy under the general income distribution, and it is not
observable for the mapping between quality and income of consumers in the trade data.
However, the advantage of the present chapter to test income-quality relationship is to
link export price distribution and destination income distribution.

The chapter focus sharply on the role of demand-side difference on explaining quality
specialization pattern in international trade. However, it is straightforward to include
quality-specific cost difference, i.e. comparative advantage from supply-side difference.
Therefore, the present model can be extended to study the impact of interaction between
demand-side and supply-side difference on trade pattern, which is an interesting question
for the future study.

Chapter 5

VAT Rebates As Trade Policy: Evidence from China

Value-added tax rebates (VATRs) is a commonly used export-promoting policy. This chapter exploits China's frequent adjustments of product level VATRs and large scale data on export transactions to estimate VATRs effects on exports. Our preferred estimates, which take into account the potential endogeneity of VATRs adjustments, suggest that a one percentage point increase of VATRs does not affect export price while increasing export quantity by 1.15%. We also find that VATRs effects on exports operating through extensive margin is 2.2%. Furthermore, firm welfare is increased by 2.15%, which translates to $2.14 in revenue for a $1 additional rebate from government.

5.1 Introduction

Value-added tax rebates (VATRs) is a commonly used trade policy. Exports are exempt from VAT and input VAT for production, distribution and sales is fully or partially refunded to exporters. Feldstein and Krugman (1990) show that a partial rebate on VAT presents an export tax, which is equivalent to the difference between VAT and VATR. This gives rise to a controversial debate on VATRs because VATRs is allowed by WTO[1] while export tax is supposed to be eliminated[2]. For example, since a partial rebate on VAT generating a export tax tends to increase export price, the US Department of Commerce announced on June 19 2012 that it would deduct the non-refunded VAT from the export price to the US when calculating anti-dumping duties against China and Vietnam[3]. A natural question that follows is: does VATRs affect export price in practice?

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[1]See the footnote of Article 1.1a of the Agreement on Subsidies and Countervailing Measures of WTO.

[2]For example, please see Accession of The People's Republic of China to WTO, "China shall eliminate all taxes and charges applied to exports unless specifically provided for in Annex 6 of this Protocol or applied in conformity with the provisions of Article VIII of the GATT 1994".

[3]Federal Register Volume 77, Number 118 (Tuesday, June 19, 2012), pages 36481-36485.

In China, VATRs is used as an export-promoting tool. The total expenditure on VATRs peaked at 1.65 billion dollars in 2012. It accounted for 2% of GDP and more than 10% of government total tax revenue for the last decade[4]. It has been adjusted more than 30 times since the tax reform in 1994. However, it is unclear whether VATRs is an effective policy for promoting exports in practice. The present chapter exploits China's frequently adjustments of product-level VATRs and large scale data on export transactions to understand this question. In the spirit of Hummels and Klenow (2005), this chapter is the first study on how VATRs adjustments for a product affect export prices and quantities, i.e. the intensive margin of trade, as well as the number of firms exporting that product and the number of destinations that the product is exported to, i.e. the extensive margins of trade.

Theoretically, Feldstein and Krugman (1990) show in a pioneering piece of research that a partial rebate on VAT makes non-refunded VAT act as an export tax. This export tax is lower as VATR becomes higher. As a result, VATRs is positively related to exports.[5] However, empirically studying the VATRs effects on exports is hindered by the potential endogeneity between VATRs adjustments and exports. One potential source of the endogeneity is that VATRs could be adjusted in response to export shocks, which happened, for example, during the recent economic crisis. Another potential source is the correlation between VATRs adjustments and various unobserved factors that are likely to affect export performance, e.g. product characteristics and industry-level policies.

A few empirical studies tackle these endogeneity problems in various ways. Chandra and Long (2013) construct firm-level VATRs dividing total exports by the differential between net VAT payable and VAT calculated from value added[6]. They argue that in regions with higher fiscal deficit rates, exporters are less likely to obtain rebates and consequently have lower VATRs. Hence they use the regional fiscal deficit rate as an instrument for firms' VATRs. However, their study suffers from measurement error. On the one hand, they underestimate VATRs as they are not able to exclude the input exempted from VAT, e.g. some imported materials and exports that are not eligible for VAT rebate, such as processing trade with supplied materials; on the other hand, their indirect measure of VATRs tends to bias the estimated effects. For example, even without VATRs adjustments, in regions with higher deficit rates exporters might skew the export to the products with lower VATRs to avoid the risk of being not rebated. This adjustment of products within the firm may affect the firm exports, which inevitably contaminates the estimated VATRs effect in their paper. Gourdon *et al.* (2014) use the interaction between product-level VATRs and the share of exports eligible for VATRs to look at export quantities. The larger the share is, the larger the VATRs effects on export quantities are. They use sector-level fixed effects to control for export shocks, but they are not able to control for other unobserved

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[4]Calculated from 2012 China Statistical Year Book compiled by National Bureau of Statistics of China.

[5]The effect of VAT itself on exports is neutral in theory but negative in empirical studies (e.g. see discussions in Feldstein and Krugman (1990) and Desai and Hines (2005)).

[6]In their paper, $NetVAT\,payable = Valudeadded * 17\% - Exports * VATR$

factors that might be correlated with VATRs adjustment and export performance.

Departing from these studies, we employ a novel identification strategy to correct for the potential endogeneity of VATRs adjustments. To circumvent the potential reverse causality, we restrict our sample to the period from January 2005 to December 2006. During this period there is no relevant economic crisis in the world markets, which makes it inherently unlikely that VATRs is adjusted in response to export shocks. In fact, the VATRs adjustments during this period were aimed at upgrading China's economy structure, optimizing resource consumption and reducing environmental pollution. Consequently, these adjustments were mainly reductions of VATRs for "high energy-consuming, high polluting and resource-based products" ("Liang Gao Yi Zi" in Chinese)[7] and increasing the VATRs for high-tech equipment and IT products. Additionally, we use sector-destination-time fixed effect to control for possible export shocks to the disaggregated 4-digit HS sectors. Our multi-dimensional data, i.e. firm-product-destination-month level export transactions, also allows us to use various further fixed effects to correct for the potential endogeneity arising from other unobserved factors at the firm or product level. Therefore, VATRs adjustments for our analysis are plausibly exogenous.

We provide a simple model to show how the VATRs may affect firm export price and quantity. On the one hand, VATRs makes the non-refunded VAT act as an export tax, which affects how much the firms earn for each unit of export, i.e tax-exclusive price; on the other hand, VATRs affects the perceived price of the input that are exempted from VAT because the expenditure on these input should be excluded from exports when calculating the rebates. Therefore, VATRs is more than just a regular export tax for the firms that use input exempted from VAT. The model shows that if all the input a firm uses are exempted from VAT, i.e. the firm has not paid any input VAT, the effects of VATRs would be zero. On the contrary, if a firm uses smaller portion of input exempted from VAT, the effects would be larger. Motivated by our model, we estimate VATRs effects on export price and quantity in reduced forms. We construct export prices as unit values, i.e. export revenue divided by export quantity, which are commonly used in the literature (e.g. Schott, 2004; Hallak, 2006; Manova and Zhang, 2012). Our estimates suggest that VATRs adjustment does not affect export price significantly. This result questions the US Department of Commerce about the changes on anti-dumping duties against China. However, we find that a one percentage point increase of VATRs increases export quantity by 1.15%. It is not clear why consumers would want to buy more of a product following a higher VATRs for the producers if this did not adjust prices. One potential reason could be that firms use these higher rebates to upgrade the products, so that consumers receive higher quality for the same price. Combine the effects on export price and quantity, we can find the total

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[7]For example, see Fa Gai Jing Mao[2005] 1482 Hao and 2595 Hao, Circular No 1482 and 2595 jointly issued by National Development and Reform Commission, Ministry of Finance, Ministry of Commerce, Ministry of Land and Resources, General Administration of Customs, State Administration of Taxation and Ministry of Environmental Protection

VATRs effect on exports of the affected product through intensive margin. That is 1.15% increase of export value of the product by a given firm to a given destination with a one percentage point increase of VATRs.

Our disaggregated data allows us to explore VATRs effects operating on the extensive margins, i.e. the number of firms exporting the product to a given destination and the number of destinations the product is exported to by a given firm. The estimates on extensive margins show that with one percentage point increase of VATRs 1.43% more firms are induced to export the affected product to a given destination. Additionally, the number of destinations that the product is exported to by a given firm is increased by 0.77%. To find the total VATRs effect on exports of the affected product through extensive margins, we can add up these two semi-elasticities. This means that a one percentage point increase of VATRs increases exports by 2.2% through extensive margins, which is larger than VATRs effect through intensive margin. Combine with the effect through intensive margin, a one percentage point increase of VATRs contributes to 3.35% growth of exports of the affected product in total, which indicates that VATRs is an effective trade policy.

We also investigate the VATRs effect on tax-exclusive price of firms, which allows us to understand the VATRs effect on firm welfare. The welfare, measured as the variable profit, is proportional to revenue under monopolistic competition. We find that the tax-exclusive price is increased by 1.00% for a one percentage point increase of VATRs. Therefore, the revenue of exporting the adjusted product by a given firm to a given destination is increased by 2.15%. This translates to a \$2.14 increase in revenue with a \$1 increase of the rebate. The VATRs effects on firm welfare are heterogeneous across trade modes and ownerships. In particular, private-owned firms have the largest benefit while foreign-owned firms have the lowest benefit. The reason is that foreign-owned firms use input exempted from VAT more intensively than private-owned firms. This result is consistent with our model.

This chapter contributes to the wider literature on trade policy that aims to promote exports by refunding exporters, typically import duty drawback (IDD) and VATRs. IDD refers to the refund of duty on imported inputs used for exporting products and has been studied in various aspects, e.g. its impacts on tariff reforms, trade and welfare (e.g. Panagariya, 1992; Chao *et al.*, 2001; Chen *et al.*, 2006; Cadot *et al.*, 2003; Ianchovichina, 2004; Athukorala, 2006; Chao *et al.*, 2006; Mah, 2007). There are also some studies on VATRs that do not rely on firm level data: Chao *et al.* (2006) simulate a simple general equilibrium model with a rise of IDD and VATRs (although the VATRs in their paper is the refund of VAT paid on imported intermediate inputs). The results show positive effects between exports and IDD as well as VATRs. Chen *et al.* (2006) find VATRs is positively correlated with exports by use of Chinese country-level data. There are some literature on the motivations of adoption and adjustments of VATRs as well, e.g. environmental con-

cern (Eisenbarth, 2014; Gourdon *et al.*, 2015) and subsidization of downstream sectors (Garred, 2015; Gourdon *et al.*, 2015).

This chapter contributes to the literature on explaining Chinese export growth (e.g. Rodrik, 2006 and Girma *et al.*, 2009). This chapter also contributes to a wide range of studies of effects of various trade policy on international trade, e.g. free trade agreements (Baier and Bergstrand, 2007, 2009), anti-dumping (Lu *et al.*, 2013), economic integration agreements (Baier *et al.*, 2014), tariffs (Debaere and Mostashari, 2010; Buono and Lalanne, 2012) and WTO accession (Dutt *et al.*, 2013). In particular, some literature dissect the effects of trade policy into different margins. Lu *et al.* (2013) find trade-dampening effect of anti dumping is mainly operating on extensive margins and Dutt *et al.* (2013) show that the impact of the WTO on trade is almost exclusively through extensive margins. However, Baier *et al.* (2014) find effects of deeper economic integration agreements are larger through intensive margin and Buono and Lalanne (2012) find the same pattern on effects of tariff reduction.

The rest of this chapter is organized as follows. In section 2 we introduce the history and implementation of China's export VATRs. In section 3 we present the empirical models. In section 4 we describe how to construct data. In section 5 and 6 we report the empirical results and some robustness checks. Section 7 is the conclusion.

5.2 China's Export VATRs

Countries often tax imported goods to ensure an equal competitiveness between them and domestic counterparts. VATRs is adopted to let exported products enter foreign markets at tax-excluded prices. This policy is allowed by the World Trade Organization as long as the tax rebate does not exceed the tax levied. In this section, we briefly introduce the history and implementation of China's VATRs.

5.2.1 A Brief History

China's export VATRs was introduced in 1985, and was based on *industrial and commercial standard tax* ("Gong Shang Tong Yi Shui" in Chinese).[8] In 1994, China reformed its tax system with VAT becoming a major tax since then. At the same time, exports were exempt from output VAT and input VAT was fully refunded.[9] The current VATRs system stems from this reform but has experienced a number of adjustments over the years.

In 1994, the rebate from the government increased by 150 percent to 75 billion yuan

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[8]Exported goods were exempt from industrial and commercial standard tax, See Cai Shui Di 91 Hao (1988), i.e. Circular No. 91 (1988) jointly issued by Ministry of Finance and State Administration of Taxation.

[9]See Guo Wu Yuan Ling Di 134 Hao, "Provisional Regulations on Value-added Tax of People's Republic Of China" issued by State Council.

with 30 billion yuan being deferred to 1995 due to the state's budget constraint (Cui, 2003). At the same time VATRs fraud was considered to be a serious problem. To relieve the heavy fiscal burden and solve the fraud problem, VATRs for products with 17% VAT was decreased from 17% to 14% in July 1995 with a further reduction to 10% in January 1996, while VATRs for products with 13% VAT was decreased to 10% in July 1995 and subsequently to 6% in January 1996.[10]

China's export dropped after these adjustments and became even lower after the shock of the 1997 Asian Financial Crisis. Rather than depreciating its currency, the Yuan, the government chose to increase VATRs to help stabilize exports. From January 1998 to December 1999, VATRs was adjusted more than 10 times[11]. During this period, textile and clothing products were the main product categories affected by adjustments, with VATRs initially increased to 11%, subsequently to 13% and finally to 17%. Electronic products and machinery equipment also received higher VATRs. There was a pervasive adjustment in July 1999, with VATRs increasing from 13% or 11% to 15% and from 9% to 13% for products with a VAT of 17%, and with VATRs increasing to 13% for non-agricultural products whose VATRs was less than 13% and VAT was 13%.

From 2003 to 2007, China's VATRs experienced adjustments more than 10 times. During this period, the main aim of these adjustments was to upgrade the economy structure, to optimize resource consumption and to reduce environmental pollution[12]. VATRs was increased for agricultural products, high-tech equipment and IT products. All the remaining adjustments were to reduce or cancel VATRs for high energy-consuming and polluting products (e.g., steel products, pesticide, chlorine and other chemical products), resource-based products (e.g. rare earth metals, silicon, wooden products) and products causing trade frictions (e.g. textile, clothing, toys).

During 2008 and 2009, China's export was influenced by the global financial crisis. Consequently, VATRs for the products whose exports were significantly affected were increased, which included textiles, clothing, furniture, toys and electromechanical products. For example, VATRs for textile and clothing products was increased 4 times, from 11% to 13%, then to 14%, subsequently to 15% and finally to 16%. Furniture and electromechanical products also experienced three adjustments of their VATRs.

Since 2010, even though the European debt crisis had a negative impact on China's exports, VATRs has not been increased by much. There are two possible explanations

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[10]See Guo Fa Ming Dian [1995] 3 Hao, Circular No.3 [1995] issued by State Council on "Reducing Rate and Strengthening management of Export Tax Rebate" and Guo Fa [1995] 29 Hao, Circular No. 29 [1995] issued by State Council on "Reducing Rate of Export Tax Rebate".

[11]Hereafter we do not denote the relevant circulars of adjustments. All our collected circulars can be found in appendix D.

[12]For example, see Fa Gai Jing Mao[2005] 1482 Hao and 2595 Hao, Circular No 1482 and 2595 jointly issued by National Development and Reform Commission, Ministry of Finance, Ministry of Commerce, Ministry of Land and Resources, General Administration of Customs, State Administration of Taxation and Ministry of Environmental Protection

for this lack of activity. Firstly, the adjustments after the global financial crisis were quite substantial and left less room to increase VATRs further. Secondly, China shifted attention to boosting domestic consumption in recent years and might have simply accelerated this process under the pressure of slowing export growth.

To sum up, China's initial adoption of VATRs was to promote exports. After these increases in exports were achieved, further adjustments of VATRs were primarily aimed at upgrading the economy structure and responding to external export shocks. As we are investigating the effects of VATRs on exports in this chapter, it is important to avoid adjustments that happened in response to (negative) export shocks. Consequently, we select adjustments of VATRs from January 2005 to December 2006, i.e., the time period where VATRs was primarily changed to upgrade China's economic structure.

5.2.2   Implementation

For sales in the domestic market, VAT is ultimately borne by consumers. However, VAT cannot be collected for exported products that are bought by final consumers outside of China, effectively exempting them from VAT. However, exporters had to pay VAT on inputs used in the production process. As exporters cannot collect output VAT from foreign importers to recover input VAT, the government refunds input VAT fully or partially. There are three implementations of VATRs in practice:

The first implementation is no eligibility for VATRs. The firms have no eligibility if they do not pay any input VAT, which can be the case if their only inputs are, for example, tax-exempted goods purchased from local farmers or fishermen, bonded materials or supplied materials for export processing firms, or where the paid input VAT is not entitled to refunds, for example, if purchased from small-scale taxpayers who cannot provide VAT invoices.

The second implementation is called exemption-refund. Exports are exempted from VAT and input VAT is partially or fully refunded. Firms that are not active in domestic markets, e.g. export intermediaries and some processing trade firms, are usually using this implementation.

The third implementation is exemption-credit-refund. This implementation applies to firms that have sales in both the domestic market and foreign markets. In this model, exports are exempted from VAT and VAT paid on input materials purchased for the production of export goods is offset against the output VAT collected on domestic sales. After the offsetting, any excess amount of input VAT is refundable to the exporter.

According to *Circular No. 7 cai shui [2002]*, the net VAT payable for eligible firms is:

$$NetVAT\,payable = (Exports - BM) * (VAT - VATRs) + Domestic\,sales * VAT - Input * VAT$$

where *BM* denotes the input which are exempt from VAT, typically the bonded materials, entering China without payments of duty and VAT, to be reshipped out of China after being stored, processed or assembled. If the net VAT payable is positive, firms need to pay VAT; otherwise, firms are refunded by the government.

5.3 Identification and Empirical Models

5.3.1 A Simple Model

Input VAT for domestic sales is effectively covered by domestic consumers, while input VAT for foreign importers is partially or fully refunded by the government. For simplicity, we assume firms separately organize production for export from domestic sales. Production of exports depends on labor l, input with VAT I_l (typically the input from domestic market), and input exempted from VAT I_b (typically the imported bonded materials). The wage, price for input with VAT and price for input exempted from VAT are exogenously given as w, p_l and p_b respectively. There is a fixed cost f_x for the export market. The paid input VAT is $p_l I_l \cdot VAT$. Therefore, combining the net VAT payable in section 2, the profit of the firm from exporting y units of output with f.o.b. export price p is:

$$\pi = py - (wl + p_l I_l + p_b I_b) - f_x - \underbrace{(p_l I_l \cdot VAT + ((py - p_b I_b) \cdot (VAT - VATRs) - p_l I_l \cdot VAT))}_{\text{VAT Cost}}$$

There is a VAT cost to exporters if input VAT is only partially refunded. VAT cost is decreasing as VATRs becomes higher. Also, if more input is exempted from VAT, VAT cost is lower leading to a smaller expected effects of VATRs adjustment. Rearranging the above equation, we get:

$$\pi = (1 - VAT + VATRs)py - (wl + p_l I_l) - (1 - VAT + VATRs)p_b I_b - f_x$$

On the one hand, VATRs adjustment affects how much the firm earns for each unit of export, given by the tax-exclusive price $p^s = p(1 - VAT + VATRs)$; on the other hand, VATRs adjustment affects the perceived price of input exempted from VAT, $p_b(1 - VAT + VATRs)$.

Suppose firms operate in international market under monopolistic competition and assume that the output of exports comes from a Cobb-Douglas production function:

$$y = \varphi \cdot l^\alpha \left(I_l^\beta I_b^{1-\beta} \right)^\gamma$$

where φ is the productivity parameter, $0 < \beta < 1$, $\alpha > 0$, $\gamma > 0$ and $\alpha + \gamma = 1$. The firm's problem is to maximize the profit by choosing labor l, inputs I_l and I_b. In the optimum,

the marginal cost is:

$$mc = k \cdot (1 - VAT + VATRs)^{(1-\beta)\gamma}$$

where $k = \frac{w^\alpha p_l^{\beta\gamma} p_b^{(1-\beta)\gamma}}{\varphi \alpha^\alpha (\beta\gamma)^{\beta\gamma}[(1-\beta)\gamma]^{(1-\beta)\gamma}} > 0$ and $0 < (1-\beta)\gamma < 1$. The marginal cost is constant as output varies, but it is increasing as VATRs becomes higher. Now assume a demand system $x = A(\tau p)^{-\sigma}$ where A is a demand parameter and τ is variable export cost, then the demand elasticity is σ. Therefore, the tax-exclusive price and f.o.b. export price are:

$$p^s = \frac{k \cdot (1 - VAT + VATRs)^{(1-\beta)\gamma}}{1 - 1/\sigma} \quad \text{and} \quad p = \frac{k \cdot (1 - VAT + VATRs)^{(1-\beta)\gamma - 1}}{1 - 1/\sigma}$$

Note that VATRs adjustments may also affect prices through k and σ. For example, as the perceived price of the input exempted from VAT becomes higher, firms may change the ratio between them and the other inputs, i.e. $1 - \beta$. With different marginal cost and input structure, the elasticity σ, markup and demand may become different. With this in mind, we refrain from placing more structure onto the model and focus on investigating the effects of VATRs adjustment on export price and quantity in a reduced form.
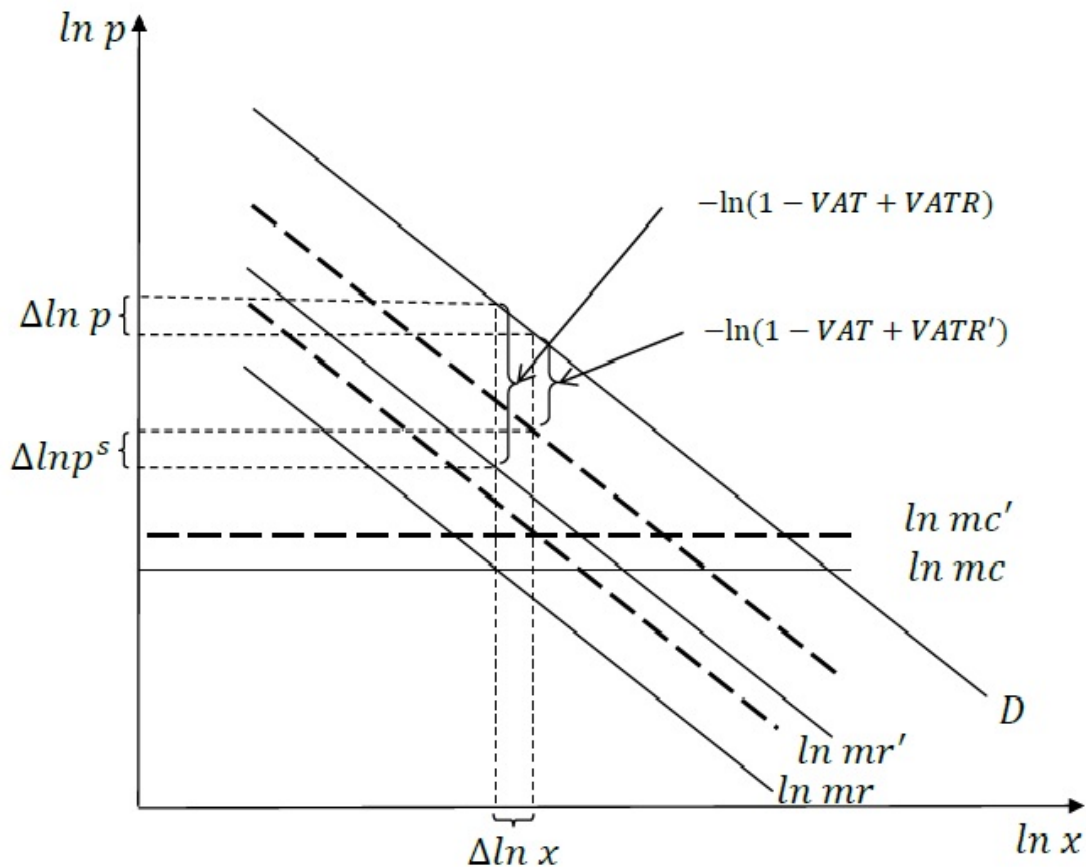
Fig 5.1: VATRs adjustments under monopolistic competition

Fig 5.1 illustrates an example where demand has a constant elasticity and demand is

not affected by the VATRs adjustment. The increase in VATRs will shift up marginal cost ($\ln mc$). The tax-exclusive price is increased, therefore marginal revenue ($\ln mr$) of the firm is increased as well. Note that the higher the share of input exempted from VAT in total input is, i.e. the higher $(1-\beta)\gamma$ is, the shift of the marginal cost curve is closer to the shift of marginal revenue, leading to lower effects on export price, quantity and tax-exclusive price.

5.3.2 Empirical Implementation

Export Price and Quantity

To explore the VATRs effects on export price and quantity, we consider the following reduced form equations:

$$\ln p_{i \in k j d t} = \delta VATRs_{it} + \varsigma_{ij} + \varsigma_{kdt} + \varepsilon_{i \in k j d t} \tag{5.1}$$

$$\ln y_{i \in k j d t} = \rho VATRs_{it} + \varsigma_{ij} + \varsigma_{kdt} + \varepsilon_{i \in k j d t} \tag{5.2}$$

where $\ln p_{ij \in k d t}$ is the logarithm of export price of product i of sector k exported by firm j to destination d at time t from China and $\ln y_{ij \in k d t}$ the logarithm of export quantity.

ς_{ij} is product-firm fixed effect. The presence is motivated by the fact that in the model, the price is affected by firm productivity φ, cost share of labor and input materials α and γ, as well as wage w, input prices p_l and p_b. These factors can be considered as time-invariant within a firm in a short period (e.g. two years in our sample). Therefore their effects can be controlled by product-firm fixed effect. The export price is also influenced by demand elasticity, markup and consumers' willingness to pay for quality, which may vary across time, sectors and destinations (e.g. quality differentiation across countries as in Schott (2004), Hummels and Klenow (2005), Hallak(2006), Bastos and Silva (2010), Baldwin and Harrigan (2011), and Manova and Zhang (2012)). We use sector-destination-time fixed effects ς_{kdt} to control for these effects. ς_{kdt} can also control for the demand parameter A and variable export cost τ in the estimation of export quantity.

To empirically study VATRs effects on export is hindered by the potential endogeneity of VATRs adjustments. The first source is that VATRs adjustments may be responses to export shocks. For example, China experienced frequent VATRs adjustments during Asian economic crisis or global financial crisis. This source of endogeneity should be fairly minor in our sample due to our focus on the period from January 2005 to December 2006, a period without a relevant economic crisis in the world market and during which VATRs adjustments were aimed at upgrading the economy structure, optimizing resource consumption and reducing environmental pollution. In addition, sector-destination-time fixed effect ς_{kdt} will control for all export shocks at 4-digit HS sector level, even when the export shocks vary cross countries and time.

Another source of endogeneity is the correlation between VATRs adjustments and various factors which are likely to affect export performance. For example, there is a possibility mentioned by Chandra and Long (2013) that officials may adjust those products with better potential export performance. Another example is that VATRs is based on VAT and VAT itself affects export (e.g. see Desai and Hines (2005)). Product-firm fixed effect ς_{ij} can control for these factors, as well as all other time-invariant firm, product and industry characteristics that are related to VATRs adjustment and export performance. However, we cannot control for the time-variant product level policies, e.g. import or export tariff. We believe this bias is very small as tariff is less frequently adjusted than VATRs and currently available annual tariff data cannot allow monthly variation within each year. Moreover, sector-destination-time fixed effect ς_{kdt} can control for the economic conditions of foreign markets that are correlated with VATRs adjustments, e.g. exchange rate fluctuations, aggregate expenditure and competition in the foreign markets.

Our main interest is in estimating the VATRs effects on export price and quantity, δ and ρ respectively. However, the export value of product i of sector k exported by firm j to destination d at time t from China is:

$$\ln ev_{i_{\in k}jdt} = \ln p_{i_{\in k}jdt} + \ln y_{i_{\in k}jdt}$$

Therefore we can get the VATs effect on export value as $\delta + \rho$ if δ and ρ are significant. $\delta + \rho$ is also VATRs effect on export through intensive margin.

Export Extensive Margins

There are two possible extensive margins of trade that could be influenced by VATRs, namely the number of firms exporting the product to a given destination, $N_{i^{\in k}dt}$ and the number of destinations that the product is exported to by a given firm, $M_{i^{\in k}jt}$. We study the effects of VATRs adjustment on export extensive margins with the following estimating equations:

$$\ln N_{i_{\in k}dt} = \mu VATRs_{it} + \varsigma_i + \varsigma_{kdt} + \varepsilon_{idt} \tag{5.3}$$

$$\ln M_{i_{\in k}jt} = \kappa VATRs_{it} + \varsigma_{ij} + \varsigma_{kt} + \varepsilon_{ijt} \tag{5.4}$$

Let $\overline{ev}_{i_{\in k}jdt}$ be the average export value of product i of sector k exported at time t across firms and destinations, then the export value of product i of sector k exported at time t from China:

$$\ln ev_{i_{\in k}t} = \ln \overline{ev}_{i_{\in k}jdt} + \ln N_{i_{\in k}dt} + \ln M_{i_{\in k}jt}$$

If μ and κ are both significant, we can find the total effect on extensive margins, i.e. $\mu + \kappa$. Note that the effect of VATRs on average export value $\overline{ev}_{i_{\in k}jdt}$ is also denoted as $\delta + \rho$. Therefore the overall VATRs effect on export value of the adjusted product is $\delta + \rho + \mu + \kappa$, as in Hummels and Klenow (2005). By analogy, the total VATRs effect on

export quantity of the adjusted product is given $\rho + \mu + \kappa$.

Firm Welfare

Since the products are exported, we analyse the (domestic) welfare effect on firms. We define the firm welfare as the variable profit for exporting the product, i.e. the net profit plus the fixed cost as in Melitz (2003). Because the marginal cost is constant, the variable profit is proportional to revenue.

$$W = \frac{p^s y}{\sigma}$$

Given that the demand elasticity σ is not changed by VATRs adjustments, firm welfare is affected only through the tax-exclusive price and the export quantity. Equation (2) tells us the effect of VATRs adjustment on export quantity, ρ. Likewise, we use the following equation to estimate the effect on the tax-exclusive price:

$$\ln p^s_{i \in k j d t} = \lambda VATRs_{it} + \varsigma_{ij} + \varsigma_{kdt} + \varepsilon_{i \in k j d t} \tag{5.5}$$

Therefore the effect on the firm welfare ($\ln W$) is approximately given as $\rho + \lambda$.

5.4 Data

In this section we describe how we construct data and report some descriptive characteristics of our data. Our data involves two sources. One is product-level data on VATRss, the other is transaction-level data on exports from the Chinese Customs Trade Database. We link the two data sets on the product level for the purpose of our empirical study.

5.4.1 VATRs

There is no public database recording all the product-level VATRs in monthly or yearly frequency [13]. The VATRs of all products after the last adjustment (included in our sample) in September 2006 are available on some websites, e.g. China's Export Tax Rebate Consulting Website[14]. We supplements this by collecting all the circulars on adjustments of VATRs between January 2005 and December 2006 in SAT Taxation Law Database[15]. In our analysis, products are defined as 8-digit HS products. For very few 8-digit HS products, the adjustments affect subcategories of product at the 10 or 11-digit level. Because our data on exports is at 8-digit product-level, we drop the products where sub-10

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[13]The State Administration of Taxation (SAT, http://www.chinatax.gov.cn) provides the latest product-level VATRs, recorded by HS code.

[14]http://www.taxrefund.com.cn, or http://cws.mofcom.gov.cn/accessory/200703/1174376723900.xls accessed on 12 February 2016.

[15]See Appendix Table A D.1 for details.

(or 11)-digit HS products have different VATRs or are affected differently by VATRs adjustments. This exercise provides us with monthly VATRs information for 7,308 8-digit HS products, covering the years 2005 and 2006. Table 5.1 reports the descriptive statistics of adjustments.

Table 5.1: Descriptive statistics of adjustments on VATRs

Time	Percentage points of adjustments	Number of adjusted products
April 2005	-13	17
	-11	3
May 2005	-13	6
	-8	2
	-5	45
	-3	11
	-2	25
August 2005	-13	1
September 2005	-13	1
	-11	1
January 2006	-13	67
	-8	16
	-5	27
	-3	19
	+11	1
	+13	1
March 2006	-13	1
	-11	1
September 2006	-13	136
	-11	30
	-8	64
	-5	210
	-4	2
	-2	881
	+2	2
	+4	140
	+8	32
At least adjusted once		1,692

Note: "-" means that VATRs is reduced and "+" means that VATRs is increased.

Between 2005 and 2006, VATRs is adjusted 7 times. The adjustments in May 2005, January 2006 and September 2006 involve 89 products, 131 products and 1,497 products respectively. 1,692 products (23% of all products) are adjusted at least once. The scale of adjustments varies from 2% to 13%. Taking into account that the maximum VATRs is 17%, the scale of these adjustments is fairly substantial.

A potential worry is that firms adjust exports in anticipation of future VATRs adjust-

ments. Fortunately, during our observation period, the time between announcement of VATRs and them coming into effect are very close, ranging from one day to ten days (see Table A D.1), which makes potential anticipation effects highly unlikely.

5.4.2   Transaction-level Exports

Our transactional export quantities and prices are from Chinese Customs Trade Database collected by the General Administration of Customs of China[16]. This database reports export (and import) transactional values and quantities by product-firm-destination (source country for imports) at a monthly frequency. We use the unit values, i.e. export value divided by quantity, to approximate prices, which is a common approach used in the literature (e.g. Schott, 2004; Hallak, 2006; Manova and Zhang, 2012).

The database also reports registry information of firms, including identifier, name, ownership and the region the firm is situated in. These are time invariant and are captured by the product-firm fixed effects. For every transaction, this database also reports the trade mode. There are 18 possible trade modes, but more than 90 percent of exports are under "ordinary trade (OT)", "processing trade with purchased materials (PTPM)" or "processing trade with supplied materials (PTSM)". PTPM, also known as import-assembly trade, refers to "business activities in which the operating enterprise imports materials/parts by paying foreign exchange for their processing and exports finished processed products for sale abroad". PTSM, also known as pure assembly trade, refers to "the business activities in which the imported materials are supplied by the overseas enterprise, and the operating enterprise need not pay foreign exchange for the import, but just carries out processing or assembling in accordance with the requirements of the overseas enterprise, and charges for the processing, with the finished products being marketed by the overseas enterprise"[17]. Both PTPM and PTSM are eligible for some preferential tariff and tax policies, while OT refers to trade under normal tariff regimes. Regarding VATRs, there is a substantial difference between PTPM and PTSM. Under PTSM, operating enterprises only get assembly fees and do not pay any input VAT, thus products exported under PTSM are not eligible for VATRs. By contrast, under PTPM, operating enterprises purchase materials from abroad and/or from the domestic market, and have to pay input VAT, thus the products under PTPM are eligible for VATRs. Therefore we only use exports under OT and PTPM. The database also records the modes of shipment, including by air, highway, railway, sea and post. We aggregate the data across shipment modes and trade modes, constructing a product-firm-destination-time level sample.

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[16]Previous literatures exploiting this database include Manova and Zhang (2012) and Ahn *et al.* (2011).

[17]The definitions of PTPM and PTSM come from Order No.113 of the General Administration of Customs of the People's Republic of China "Measures of the Customs of the Republic of China on the Supervision of Processing Trade Goods".

5.4.3 Merged Data

We link the two data sources at the product-month level and delete observations with missing values to construct our final sample. Table 5.2 reports descriptive statistics of our final data.

Table 5.2: Descriptive statistics of data

Variable	Observations	Mean	Std. Dev.	Min	Max
ln price	19,425,067	1.12	1.94	-11.33	18.08
ln quantity	19,425,067	7.82	2.60	0	21.92
ln tax-exclusive price	19,411,053	1.08	1.94	-11.42	18.08
VATRs(%)	19,448,390	12.50	2.66	0	17
VAT(%)	19,434,262	16.91	0.61	13	17
# Products		6,952			
# Products at least adjusted once		1,581			
# Firms		178,102			
# Product-firm pairs		3,490,009			
# Product-firm-destination pairs		7,615,698			

In the final sample, we have more than 19 million observations on export price, quantity, tax-exclusive price, VATRs and VAT. The merged sample covers 6,952 products, with 1,581 products for which VATRs are adjusted at least once. These products are exported by 178,102 firms, leading to more than 3 million product-firm pairs and more than 7 million product-firm-destination pairs.

5.5 Empirical Results

5.5.1 Export Price and Quantity

We begin by looking at the effects of VATRs on export price and quantity. The results are shown in Table 5.3.

Changes to VATRs do not significantly affect export price. The point estimate is also small at 0.09 and precisely estimated, suggesting a negligible impact of VATRs on prices. However, export quantity increases significantly with a rise of VATRs: A one percentage point increase of VATRs, leads to an increase in export quantity by 1.15%. Together these results imply that the firms export higher quantities at the same price after an increase in VATRs. This indicates that demand for the product becomes larger. This overall effect is of the expected direction. However, it is not clear why consumers would want to buy more of a product following a higher VATRs for the producers if this was not used to adjust prices. One potential reason could be that firms use these higher products to upgrade products, so that consumers receive higher quality for the same price, or that they engage in more aggressive marketing activities. This means the firms are potentially

Table 5.3: VATRs effects on export price and quantity

	Export price: $\ln p$	Export quantity: $\ln y$
VATRs(%)	-0.09	1.15
	(0.15)	(0.54)**
product-firm	√	√
sector-destination-time	√	√
#product-firm pairs	1,732,336	
# clusters	6,533	
# observations	17,659,758	

Standard errors are clustered at the product level and stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

credit constrained. With the increase of VATRs, the firms become less constrained and then invest in quality upgrading or marketing activities. This is consistent with the studies that document the presence of credit constraints of Chinese firms (e.g. Poncet *et.al.*, 2010) and, more specifically, exporters (e.g. Manova and Yu, 2016).

Combining the effects on export price and quantity, export value increases by 1.15% (the effect on export price is treated as zero as it is not significant). This is total effect on exports through the intensive margin. We will assess the overall effects of VATRs adjustment on exports after discussing the effects on the extensive margins.

5.5.2 Extensive Margins

Table 5.4 presents the estimation results for the extensive margins, measured as the number of firms exporting the product to a given destination and the number of destinations that the product is exported to by a given firm.

Table 5.4: Effects of VATRs adjustments on extensive margins

	Number of Firms: $\ln N$		Number of destinations: $\ln M$	
VATRs(%)	1.43	1.42	0.77	0.78
	(0.24)***	(0.25)***	(0.21)***	(0.21)***
product	√	√		
sector-destination-time	√	√		
product-firm			√	√
sector-time			√	√
Products	all products	continuously exported	all products	continuously exported
# clusters	6,773	4,977	6,575	4,977
# observations	3,337,687	3,260,803	10,185,366	9,994,870

Standard errors are clustered at the product level and stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

The effects of VATRs adjustment on the number of firms are reported in the first two columns while the effects on number of destinations in the last two columns. In order to avoid potential biases due to the development of new product and the cessation of production of products, we also estimate both effects using only those products that are continuously exported throughout the whole period. As shown in Table 5.4, the effects in both specifications are practically identical.

We find that the effects of VATRs adjustment on extensive margins are significant. If the VATRs of a product is increased, it will be exported by more firms to a given destinations and it will be exported to more destinations by a given firm as well. In particular, a one percentage point rise of VATRs increases the number of firms exporting this product by 1.43% while the number of destinations that the product is exported to is increased by 0.77%. By adding these two semi-elasticities, the total VATRs effect on exports through extensive margins is then 2.2%. This effect is attributed to the entry of new firms into the product market and then entry of new destinations of the product.

5.5.3   VATRs effects on Exports

We have estimated the VATRs effects on export price, quantity and extensive margins. A one percentage point increase of VATRs increases export by 1.15 % along intensive margin and by 2.2% along extensive margins. It is straightforward that extensive margins play a larger role for VATRs to adjust export. Indeed the effects through extensive margins are almost twice of the effects through intensive margin. In total, export of the product is increased by 3.35%. According to statistics from World Bank, the average growth rate of export for China is 23.5% in 2005 and 2006. That is to say, one percentage point increase of VATRs can contribute one seventh of the growth. Moreover, the average growth rate for East Asia and Pacific countries, Europe and central Asia countries and OECD countries are 12.4%, 7.57% and 7.32% respectively. In this sense, VATRs is a fairly effective trade policy to adjust export.

In our analysis, because the VATRs effect on export price is negligible, a one percentage point increase of VATRs increases export quantity by 3.35%. Using product-level data, Gourdon *et. al* (2014) estimate VATRs effect on export quantity by use of interaction term between VATRs and share of eligible export for VATRs in total exports, as well as interaction term between VATRs and share of non-eligible export. The coefficient of interaction term between VATRs and share of eligible export is around 7%. They argue that this is the effect of VATRs on export quantity. Indeed this is the upper bound of the VATRs effect, when the share of eligible export is one. However the share is less than one, thus VATRs effect on export quantity should be smaller. Moreover, their estimates could is biased because their data is not as disaggregated as ours, making it impossible to control for firm-level and destination-level factors that are correlated to VATRs adjustments

and export performance.

Chandra and Long (2013) construct firm level VATRs dividing total exports by the differential between net VAT payable and VAT calculated from value added. They argue that in regions with high deficit rate exporters are less likely to obtain rebate and have lower VATRs. Hence they use regional fiscal deficit rate as an instrument of firm VATRs and find a one percentage point increase of VATRs raises firm export value by 13%. In our analysis, the export value of the adjusted product by a given firm is increased by 1.92% (i.e. 1.15%+0.77%). The reason that their effect is much larger is twofold. Firstly, their study suffers from measurement error. On the one hand, they underestimate VATRs by including the input exempted from VAT and the non-eligible export for VAT rebate in the total export; on the other hand, their indirect measure of VATRs tends to bias the estimated effects. For example, even without VATRs adjustments, in regions with higher deficit rates exporters might skew the export to the products with lower VATRs to avoid the risk of being not rebated. This adjustment of products within the firm may affect the firm exports, which inevitably contaminates the estimated VATRs effect. Secondly, our analysis cannot capture the effects that a firm exports multiple products that are adjusted or that the firm may add products.

5.5.4 Firm Welfare

To investigate the effect of VATRs on the change in firm welfare arising from exporting a given product, we first estimate equation (5) to get the VATRs effect on the tax-exclusive price. The results are shown in the first column of Table 5.5. A one percentage point increase of VATRs raises the tax-exclusive price by 1.00%. As noted in section 3, firm welfare measured as the variable profit is proportional to export revenue under monopolistic competition. Therefore, combined with the effect on export quantity 1.15%, a one percentage point increase of VATRs raises firm welfare by 2.15%.

As shown in section 3, the rebate from the government to the firm exporting the product is $-((py - p_b I_b)(VAT - VATRs) - p_l I_l VAT)$. In order to approximately quantify the change of revenue for a \$1 rebate, we assume there is no input exempted from VAT I_b. Let the export value and VATRs before adjustment be $ev_0 = p_0 y_0$ and $VATRs_0$ respectively. The export value is increased by 1.15%. Ignore the change of input that are entitled VAT I_l, then change of VATRs refunded by government with one percentage point increase of VATRs:

$$ev_0 \times (VAT - VATRs_0) - ev_0 \times (1 + 1.15\%) \times (VAT - VATRs_0 - 1\%)$$

The firm revenue $r_0 = p_0^s y_0 = ev_0(1 - VAT + VATRs)$ is increased by 2.15%:

$$ev_0(1 - VAT + VATRs) \times 2.15\%$$

Taking the average rates of VAT and VATRs, 16.9% and 12.5% respectively, into the above equations, we can calculate the ratio between change in revenue and rebate, which is 2.14. This means on average a one percentage point increase of VATRs translates to a $2.14 increase in revenue of the adjusted product with a $1 additional rebate from the government.

The VATRs effects on firm welfare vary across trade modes and ownerships, as shown in other columns in Table 5.5. The effect on firms that export under OT is almost three times larger than the effect on firms that export under PTPM. The effect on private-owned firms is the largest while the effect on foreign-owned firms is the smallest. The reason is that input exempted from VAT are more prevalent in PTPM than OT, and also more dominant in foreign-owned firms than in private- and state-owned firms. These heterogeneity are consistent with the results derived in section 3, i.e. the higher the share of input exempted from VAT is, the smaller is the effect of VATRs adjustment.

Table 5.5: VATRs effects on firm welfare

	Overall	OT	PTPM	State-owned	Private-owned	Foreign-owned
			Export quantity: $\ln x$			
VATRs(%)	1.15	1.00	0.66	0.91	1.59	0.68
	(0.54)**	(0.51)*	(0.65)	(0.49)*	(0.81)**	(0.55)
			Tax-exclusive price: $\ln p^s$			
VATRs(%)	1.00	1.08	0.76	0.90	0.99	0.95
	(0.15)***	(0.13)***	(0.21)***	(0.18)***	(0.19)***	(0.14)***
			Firm welfare: $\ln W$			
$\rho+\lambda$	2.15	2.08	0.76	1.81	2.54	0.95
# product-firm pairs	1,732,336	1,690,766	142,675	364,019	914,604	218,226
# clusters	6,533	6,487	4,478	6,058	6,004	5,235
# observations	17,659,758	16,194,058	3,317,578	4,353,200	6,800,285	3,294,646

"OT" means ordinary trade, while "PTPM" means processing trade with purchased materials. All regressions include firm-product and sector-destination-time fixed effects. Standard errors are clustered at the product level and stated in parentheses below point estimates. If the ρ or λ is not significant, it is treated as zero when adding ρ and λ. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

5.6 Robustness Check

One potential concern is that the data in monthly frequency does not allow time for firms to react to VATRs adjustment. We use the lagged VATRs by 3 months as a robustness check. The results are shown in the first column in Table 5.6. The effects are quite consistent with previous results.

Table 5.6: Robustness check

	Export price: $\ln p$		
VATRs(%)	0.08	0.20	0.24
	(0.15)	(0.36)	(0.27)
	Export quantity: $\ln x$		
VATRs(%)	0.98	0.89	0.87
	(0.41)**	(1.00)	(0.87)
	Tax-exclusive price: $\ln p^s$		
VATRs(%)	0.85	1.24	0.94
	(0.12)***	(0.36)***	(0.27)***
	Firm welfare: $\ln W$		
$\rho + \lambda$	1.83	1.24	0.94
	Number of firms: $\ln N$		
VATRs(%)	1.53	1.33	1.54
	(0.26)***	(0.47)***	(0.49)***
	Number of destinations: $\ln M$		
VATRs(%)	0.77	0.95	1.00
	(0.19)***	(0.18)***	(0.20)***
lagged $VATRs_{t-3}$	$\checkmark$		$\checkmark$
6-digit sector		$\checkmark$	$\checkmark$

Standard errors are clustered at the product level and stated in parentheses below point estimates. All regressions include firm-product and sector-destination-time fixed effects. If the ρ or λ is not significant, it is treated as zero when adding ρ and λ. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

Given that VATRs adjustments are in 8-digit HS product level, we have used 4 digit HS sectors to control export demand shocks. To allow strict control on export shocks, we also report the results using 6 digit HS sectors as a robustness check in the second and third column. The effect on export quantity disappears. However, it is not clear that this specification is actually preferable: Though more disaggregated sectors allow for stricter control of export demand shocks, it also soaks up more of the variation in the data, which might lead to attenuation bias .

5.7   Conclusion

This chapter exploits China's frequent adjustments of product level VATRs and large scale data on export transactions to estimate VATRs effects on exports. Based on corrections for the potential endogeneity of VATRs adjustment, this chapter finds non-trivial VATRs effects on export, with the effects along extensive margins larger than the effects along intensive margin. We find that the export price is not affected by VATRs adjustment. This result suggests that to deduct the non-refunded VAT from the export price to the US when calculating anti-dumping duties against China might not be justified. Moreover, export quantity is increased with higher VATRs. This indicates that an increase of VATRs may push firms to upgrade the quality of exports.

We also find the tax-exclusive price is increased by an increase of VATRs. Consequently the firm welfare is increased as well. On average VATRs effect on firm welfare translates into a \$2.14 increase in revenue of the adjusted product with a \$1 additional rebate from the government. This means an increase of VATRs will benefit the society as a whole.

VATRs effects on firm welfare are heterogeneous across trade modes and ownerships. In particular, the effect on firms that export under OT is larger than the effect on firms that export under PTPM, while the effect on private-owned firms is larger than the effects on state-owned and foreign-owned firms. This suggests a possibility for the government to make best use of expenditure on rebates by choosing specific products to allocate more benefit to some groups, e.g. choosing products that are pervasively exported by specific firm ownership or under certain trade mode.

Chapter 6

Conclusion

6.1 Summary

This thesis analyses firm exporting behaviour and trade policy of export VATRs in China.

In chapter 2, pure exporters are studied in a general equilibrium model with heterogeneous firms in terms of productivity, entry cost and demand in both domestic and foreign market. Hardly surprising, a pure exporter faces lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost; and, its productivity allows it to earn profit in the foreign market, but its productivity is not high enough for it to earn profit in the domestic market. Non-exporters, pure exporters and ordinary exporters co-exist in equilibrium. For any given demand-adjusted domestic entry cost, the productivity of pure exporters is lower than productivity of non-exporters. Therefore, the presence of a large portion of pure exporters can make the average productivity of exporters lower than average productivity of non-exporters. The move from autarky to trade on the one hand pushes firms with low productivity and high demand-adjusted foreign entry cost out of the market; on the other hand induces some firms with even lower productivity and low demand-adjusted foreign entry cost into the market as pure exporters. Therefore given a large portion of pure exporters the move from autarky to trade can result in lower average productivity. Furthermore, this chapter studies the effects of trade liberalization in terms of changes of the conditional distribution of foreign entry cost and variable export cost. Similarly the chapter studies the effects of innovation in terms of a change of the conditional distribution of productivity. A decrease in foreign entry cost raises the cut-off productivity for both domestic and foreign market. Therefore among firms with any given combination of demand-adjusted domestic and foreign entry costs, the least productive firms are pushed out of the market while the least productive ordinary exporters become pure exporters or non-exporters. A decrease in variable export cost raises the cut-off productivity to serve the domestic market and decreases the cut-off productivity to serve the foreign market. Hence some non-exporters are pushed out of the market, some non-active firms and or-

dinary exporters become pure exporters. Innovation has the same effects as an decrease in foreign entry cost. The effects of trade liberalization and innovation are channelled through labor markets, where competition for labor becomes more intensive resulting in higher real wage.

In chapter 3, pure exported products are studied a general equilibrium model with multiproduct firms, where products within a firm are heterogeneous in productivity and fixed export cost. Indeed, firms benefit from existing exported products to export a new product. In the model, firms endogenously choose the number of products produced and exported. High productive firms can manage more products in export than in domestic market due to pure exported products. This chapter then examines the reallocation across firms and within firms from autarky to trade. Exposure to trade forces the least productive firms out of the market, and induces high productive firms to export. All firms drop the least productive products from domestic market after trade. Across exporters, low productive exporters export a subset of left products. Medium productive exporters export all left products and switch domestic-dropped products to pure exported products. All these firms manage less products after exposure to trade. However, high productive exporters export all left products, switch all domestic-dropped products to pure exported products and introduce new products as pure exported products. High productive exporters manage more products from autarky to trade. In general, trade decreases the number of products managed by low productive firms but increases the number of products managed by high productive firms. This chapter also explores the impact of trade liberalization in terms of decreases in fixed and variable export cost on the number of products produced and exported. Both decreases in trade cost have similar effects. Least productive firms are forced out of the market while more firms are induced to export. Firms shrink in domestic market along both intensive margin (how much of a given product) and extensive margin, but expand in export market along both margins. More firms manage export-only products, which means more firms have higher extensive margin of export than of domestic market. Similar to the effect from autarky to trade, for low productive firms, trade liberalization decreases the number of products managed; but for high productive firms otherwise.

Chapter 4 develops a general equilibrium model with non-homothetic preference over product quality. In the model, there is a one to one income-quality relationship, which gives rise to a continuum of qualities under a general income distribution. Moreover, the quality-income relationship generates a non-homothetic demand for any product of any quality. Given a quality, the quality-income relationship reveals the income of consumers that choose this quality. Because each consumer buys one unit of composite of the quality, total units of the composite are the number of the consumers that choose this quality, which is given by income distribution and total labor in the country. Then the demand for each product within that quality is derived as in the CES preference. The income-quality relationship is subject to the income distribution, i.e. the consumers with the same

income will choose different qualities under different income distribution. In the open economy, the model considers two countries, the poor and the rich. The ratio of number of consumers that choose the same quality in the rich country to the poor country, i.e. the relative demand of a quality, is increasing with quality. When the two countries trade with each, the paper finds a quality specialization pattern between them and the pattern follows home market effect. If the relative demand is very high (low) compared with the trade cost across all qualities, all qualities are completely specialized in the rich (poor) country, i.e produced in the rich (poor) country and exported to the other. If the relative demand is neither high enough nor low enough across all qualities, all qualities are incompletely specialized, i.e. produced in both countries and exported to each other. If the relative demand is increasing from low enough to high enough, there is a mixed specialization. That is, low (high) qualities are completely specialized in the poor (rich) country, while medium qualities are incompletely specialized. This model builds a link between export price distribution and destination income distribution. This chapter further provides two evidence of the model. The first evidence is that rich people do choose high quality and pay high price. The second evidence is that export price distribution is strongly related to destination income distribution by use of quantile regression. In particular, when income is shifted from the rich (poor) people to the poor (rich) people, export prices of low (high) quantiles are increased (decreased) while export prices of high quantiles decreased.

In chapter 5, the trade policy of export VATRs is analysed. The potential endogeneity is corrected with various strategies. To circumvent the potential reverse causality, we restrict our sample to the period from January 2005 to December 2006. During this period there is no relevant economic crisis in the world markets, which makes it inherently unlikely that VATRs is adjusted in response to export shocks. In fact, the VATRs adjustments during this period were aimed at upgrading China's economy structure, optimizing resource consumption and reducing environmental pollution. Consequently, these adjustments were mainly reductions of VATRs for "high energy-consuming, high polluting and resource-based products" ("Liang Gao Yi Zi" in Chinese) and increasing the VATRs for high-tech equipment and IT products. Additionally, we use sector-destination-time fixed effect to control for possible export shocks to the disaggregated 4-digit HS sectors. Our multi-dimensional data, i.e. firm-product-destination-month level export transactions, also allows us to use various further fixed effects to correct for the potential endogeneity arising from other unobserved factors at the firm or product level. Therefore, VATRs adjustments for our analysis are plausibly exogenous. Motivated by a simple model, the estimates suggest that VATRs adjustment does not affect export price significantly. However, a one percentage point increase of VATRs increases export quantity by 1.15%. That is 1.15% increase of export value of the product by a given firm to a given destination with a one percentage point increase of VATRs. Moreover the estimates on extensive margins show that with one percentage point increase of VATRs 1.43% more firms

are induced to export the affected product to a given destination. Additionally, the number of destinations that the product is exported to by a given firm is increased by 0.77%. This means that a one percentage point increase of VATRs increases exports by 2.2% through extensive margins, which is larger than VATRs effect through intensive margin. Combine with the effect through intensive margin, a one percentage point increase of VATRs contributes to 3.35% growth of exports of the affected product in total, which indicates that VATRs is an effective trade policy. It is also found that the tax-exclusive price is increased by 1.00% for a one percentage point increase of VATRs. Therefore, the revenue of exporting the adjusted product by a given firm to a given destination is increased by 2.15%. This translates to a $2.14 increase in revenue with a $1 increase of the rebate. The VATRs effects on firm welfare are heterogeneous across trade modes and ownerships. In particular, private-owned firms have the largest benefit while foreign-owned firms have the lowest benefit. The reason is that foreign-owned firms use input exempted from VAT more intensively than private-owned firms.

6.2   Policy Implications

The analysis on pure exporters and pure exported products in chapter 2 and chapter 3 show that firms may benefit from pure exporting behaviour, especially those low productive firms with low foreign entry cost. In the traditional research, low productive firms loose from international trade because they are forced out of the market. However, if the foreign entry cost is low enough, these firms can survive in foreign markets. Moreover, some non-active firms become pure exporters under international trade and liberation of trade. This means trade policy that decrease trade barriers could lead to a positive effect on these low productive firms, acting as a "protecting" tool. In China, there exists some policy favouring pure exporting behaviour. For example, corporate income tax rates for Chinese firms is 30%, however foreign-invested enterprises that export more than 70% of their output have a lower income tax rate of 15%. Firms that located in some specific locations, e.g. free trade zone or coastal zone, will have a lower income tax rate 10% if they export more than 70% of their output (15% or 24% if they export less than 70% of their output). These policy benefit the pure exporting behaviour, however, to access the welfare of these policy is complicated. One the one hand, in chapter 2 and 3, models assume symmetric countries, which means both countries have the pure exporters. If one country has more pure exporters, it will have more pure imported products as well, then the overall varieties are increased, leading to a higher welfare. In reality, the countries are not symmetric. In particular, China purely exports to developed countries, but developed countries do not purely export to China. In this case, the policy favouring pure exporters may reduce the domestic varieties, leading to a low welfare. On the other hand, these favouring policy may distort the firm export behaviour. In the models of chapter 2 and 3,

firms self select to become pure exporters or manage pure exported products. However, given these policy on corporate tax, firms may scarify the domestic market in return of a lower tax. This distortion may reduce the number of varieties in domestic market and lead to a lower welfare. In conclusion, these policy benefit some firms, especially those low productive firms with low foreign entry cost, they may hurt domestic consumers by reducing the number of varieties.

In chapter 4, we depart from the research that have focused on the effects of supply-side factors on international trade, e.g. productivity, comparative advantage, factor endowments. These studies favour the policy that are related to productivity innovation, skilled labor training or human capital accumulation. These policy will increase the competition of export or upgrade the bundle of export. However in our analysis, we provides an alternative mechanism that quality specialization is purely driven by demand-side factor, i.e. income distribution. In order to export a product or become the net exporter of a product, the country should have larger domestic demand than foreign demand. Therefore, the policy that increases the income will nurture an industry and increase the export quality. Moreover, the policy that increases the income of all people will upgrade the quality of the export. Furthermore, the policy that redistribute the income across people, e.g. from the rich to the poor will also shift the qualities of export and increase the overall quality. Chapter 4 shows a quality specialization pattern that rich countries specialize in high qualities and poor countries specialize in poor qualities. Both countries will benefit from trade. However, if rich countries impose an importing duty on the low qualities imported from the poor country, the welfare could be worse. On the one hand, the increase of the importing price force the consumers that choose these qualities before the duty is imposed to buy lower qualities; on the other hand, this importing duty can have general equilibrium effect on consumers that choose high qualities: there would be more varieties with high quality if the employment that is occupied by producing low qualities due to the protecting duty is released to produce high qualities.

Chapter 5 studies the trade policy of export VATRs, and it is found that the policy is quite effective in promoting export, i.e. a one percentage point increase of VATRs increase the export of the affected product by 3.35%. Moreover, on average a one percentage point increase of VATRs translates to a $2.14 increase in revenue of the adjusted product with a $1 additional rebate from the government. Though the rebate from government is higher, the revenue for firms is increased by much more. This means an increase of VATRs will benefit the society as a whole. Therefore, export VATRs could be adjusted to curb or promote export. VATRs effects on firm welfare are heterogeneous across trade modes and ownerships. In particular, the effect on firms that export under OT is larger than the effect on firms that export under PTPM, while the effect on private-owned firms is larger than the effect on state-owned and foreign-owned firms. This suggests a possibility for the government to make best use of expenditure on rebates by choosing specific products

that are pervasively exported by specific firm ownerships or under certain trade modes. For example, if the government selects products for which private-owned firms have the largest export share, then private-owned firms will benefit the most. Likewise, if the government selects products for which the export share is the largest under OT, then the firms that export under OT will benefit more than firms under PTPM. Another implication of VATRs is that it may provide the credit to the firms. Those firms that are credit constrained will benefit. As shown in chapter 5, with the same price, export quantity is increased with the increase of VATRs. This result suggests that with the additional credit from VATRs firms may upgrade the quality or engage in more aggressive marketing. In China, private Chinese firms are credit constrained while state-owned firms and foreign-owned firms are not (e.g. Poncet *et.al*, 2010). This is consistent with our results that welfare of private firms are increased most. Consider the large number of private firms and their contribution to employment and economic growth, VATRs may have big impacts to the whole economy in China. VATRs effects are far more than adjusting export and are worthy of further exploration.

6.3   Future Studies

One direction of future studies is to introduce more factors into the models. Currently the models in chapter 2, 3 and 4 assume only one factor as the input of firms, i.e. labor. It is interesting to introduce two factors, e.g. labor and capital or skilled labor and unskilled labor. With two factors, the model is able to allow the effects of factor endowment and to include multi-sectors with different intensity of capital/labor ratio and skilled/unskilled. It will show the potential sector-specific effects. Moreover, to introduce two factors can also contribute to the studies of the wage premium. Especially, the skill-biased technology can be introduced into firms as another source of heterogeneity.

Another direction of future studies is to analyse quality specialization with interaction of demand-side difference and supply-side difference. The chapter 4 focus sharply on the role of demand-side difference on explaining quality specialization pattern in international trade. However, it is straightforward to include quality-specific cost difference, i.e. comparative advantage from supply-side difference. If the rich country has comparative advantage in high qualities, i.e. the marginal cost ratio between the rich and the poor country is decreasing as the quality becomes higher, this supply-side comparative advantage will reinforce our quality specialization pattern. However, if the relative demand of quality between the rich and the poor country is decreasing as the quality becomes higher, e.g. with Pareto income distribution in both countries, then the supply-side comparative advantage will offset the relative demand, and the quality specialization can even be reversed. That is, the model in chapter 4 can be extended to study the impact of interaction between demand-side and supply-side difference on trade pattern, which is an interesting

question for the future study.

The third direction of future studies is to analyse the various effects of export VATRs. In chapter 5, it is found that VATRs makes firms export more quantity with the same export price. One potential reason is that firms are upgrading the quality of export with higher rebates. This could be used to estimate the quality of exports. VATRs is product-specific, therefore the adjustments of VATRs gives the cost variations of products within a firm. This can be used to study the reallocation effects between products within a firm. We can also study the VATRs effects on employment and wage of firms. Firm-level VATRs can be constructed as exports-weighted product-level VAT rebates within the firm. As we know that the exports under processing trade with supplied materials are no eligible for VAT rebates while other exports are eligible. Thus, we have a natural treatment group and control group. Difference-in-difference can be applied to identify the effects on employment and wage, and to other interesting topics related to export VATRs.

Appendix A

Appendix of Chapter 2

A.1 All Variables in the Equilibrium

Let Υ be the probability of an entrant becoming active, then

$$\Upsilon = \int_\eta \int_{\varphi^*(\eta)} \lambda(\varphi,\eta)\,\mathrm{d}(\varphi,\eta)$$

where $\varphi^*(\eta) = \min\{\varphi_d^*(P,f_d,A_d), \varphi_x^*(P,f_x,A_x)\}$. For (f_i,A_i), $z_i = f_i^{1/(\sigma-1)}/A_i$. It follows from equation (2.2) that $\varphi^*(\eta) = \varphi_d^*(P,f_d,A_d)$ if $z_d < \tau z_x$ and $\varphi^*(\eta) = \varphi_x^*(P,f_x,A_x)$ if $z_d > \tau z_x$.

Let Π_p be the average profit earned by incumbents. In equilibrium we use Π to denote the expected profit per date, so Π should be equal to the profit earned conditional on successful entry, i.e. $\Pi = \Upsilon\Pi_p$.

Let M_e denote the amount of entrants and M the amount of incumbents. Since successful entrants will replace the dead firms, we have $M\delta = M_e\Upsilon$. Labor L is used for production by incumbents L_p and investment by entrants L_e. The labor for entrants is $L_e = M_eF_e$. With equation (2.3), we have

$$L_e = M_eF_e = \frac{\delta M}{\Upsilon}\frac{\Pi}{\delta} = M\frac{\Pi}{\Upsilon} = M\Pi_p$$

$M\Pi_p$ is the total profit eared by all incumbents, therefore we have $R = L_p + M\Pi_p = L_p + L_e = L$. Total revenue is fixed as the total labor. Let $\bar{r}$ and $\bar{f}$ be the average revenue and fixed cost of incumbents respectively. Then $\Pi_p = \bar{r}/\sigma - \bar{f}$. It follows that $\bar{r} = \sigma(\Pi_p + \bar{f}) = \sigma(\delta F_e/\Upsilon + \bar{f})$. With Υ, we can also denote the distribution of incumbents as $\lambda(\varphi,\eta)/\Upsilon$. $\bar{f}$ is the average market entry cost of incumbents,

$$\bar{f} = \int_\eta \int_{\varphi_d^*(P,f_d,A_d)} f_d \frac{\lambda(\varphi,\eta)}{\Upsilon}\,\mathrm{d}(\varphi,\eta) + \int_\eta \int_{\varphi_x^*(P,f_x,A_x)} f_x \frac{\lambda(\varphi,\eta)}{\Upsilon}\,\mathrm{d}(\varphi,\eta)$$

In equilibrium, we have found the price index and cut-off productivities. So Υ and $\bar{f}$ are known. Then the amount of incumbents M can be determined by:

$$M = \frac{R}{\bar{r}} = \frac{L}{\sigma(\delta F_e/\Upsilon + \bar{f})}$$

Appendix 1.1 contains an alternative route to above equation using labor market.

Let the S_d denote the area $\{\eta \,|\, z_d < \tau z_x\}$ and S_x the area $\{\eta \,|\, z_d > \tau z_x\}$. Non-exporters are located in the S_d area and the amount is determined by:

$$M_{ne} = M \int_{S_d} \int_{\varphi_d^*(P,f_d,A_d)}^{\varphi_x^*(P,f_x,A_x)} \frac{\lambda(\varphi,\eta)}{\Upsilon} \, \mathrm{d}(\varphi,\eta)$$

Pure exporters are located in S_x area and amount of pure exporters is determined by:

$$M_{pe} = M \int_{S_x} \int_{\varphi_x^*(P,f_x,A_x)}^{\varphi_d^*(P,f_d,A_d)} \frac{\lambda(\varphi,\eta)}{\Upsilon} \, \mathrm{d}(\varphi,\eta)$$

An alternative way to find number of incumbents

For a firm $(\varphi, f_d, f_x, A_d, A_x)$, let q be the output in the domestic market, labor used to serve the domestic market is $f_d + q/\varphi = f_d + \rho p(\varphi)q = f_d + \sigma\rho(\pi_d(P,\varphi,f_d,A_d) + f_d) = (\sigma - 1)\pi_d(P,\varphi,f_d,A_d) + \sigma f_d$. By analogy, the labor used to export is $(\sigma - 1)\pi_x(P,\varphi,f_x,A_x) + \sigma f_x$.

With Υ, the distribution of incumbents is $\lambda(\varphi,\eta)/\Upsilon$. Then the total labor for incumbents L_p is

$$
\begin{aligned}
L_p = {} & M \int_\eta \int_{\varphi_d^*(P,f_d,A_d)}^{\infty} ((\sigma - 1)\pi_d(P,\varphi,f_d,A_d) + \sigma f_d) \frac{\lambda(\varphi,\eta)}{\Upsilon} \, \mathrm{d}(\varphi,\eta) \\
& + M \int_\eta \int_{\varphi_x^*(P,f_x,A_x)}^{\infty} ((\sigma - 1)\pi_x(P,\varphi,f_x,A_x) + \sigma f_x) \frac{\lambda(\varphi,\eta)}{\Upsilon} \, \mathrm{d}(\varphi,\eta)
\end{aligned}
$$

Combine with equation (2.4) and (2.5), we get

$$L_p = \frac{M}{\Upsilon} \cdot ((\sigma - 1)\Pi + \sigma \Upsilon \bar{f})$$

where $\bar{f}$ has been shown in Appendix A.1. The labor for entrants L_e is:

$$Le = M_e \cdot F_e = \frac{\delta M}{\Upsilon} \cdot \frac{\Pi}{\delta} = \frac{M\Pi}{\Upsilon}$$

Then total labor L is:

$$L = L_p + L_e = \frac{M}{\Upsilon} \cdot (\sigma\Pi + \sigma \Upsilon \bar{f})$$

With equation (2.3), we have the number of incumbents:

$$M = \frac{R}{\bar{r}} = \frac{L}{\sigma(\delta F_e/\Upsilon + \bar{f})}$$

This equation has been shown in Appendix A.1.

A.2   Average Productivity of Exporters and Non-exporters

Let $\varphi_d^*(z_d) = \varphi_d^*(P, f_d, A_d)$ and $\varphi_x^*(z_x) = \varphi_x^*(P, f_x, A_x)$ denote the cut-off productivities. Let $\varphi^*(z_d, z_x) = \min\{\varphi_d^*(z_d), \varphi_x^*(z_x)\}$. Then the probability of an entrant becoming active Υ is determined as:

$$\Upsilon = \int_{z_d,z_x} \int_{\varphi^*(z_d,z_x)} g(\varphi)\gamma(z_x)\psi(z_d)\,\mathrm{d}(\varphi,z_d,z_x)$$

According to equation (2.2), $\varphi^*(z_d, z_x) = \varphi_d^*(z_d)$ if $z_d < \tau z_x$ and $\varphi^*(z_x, z_d) = \varphi_x^*(z_x)$ if $z_d > \tau z_x$. The distribution of incumbents is then $g(\varphi)\gamma(z_x)\psi(z_d)/\Upsilon$.

Therefore the average productivity of exporters can be denoted as:

$$
\begin{aligned}
\Psi_e &= \frac{\displaystyle\int_{z_d,z_x}\int_{\varphi_x^*(z_x)}^{\infty} \varphi\frac{g(\varphi)\gamma(z_x)\psi(z_d)}{\Upsilon}M\,\mathrm{d}(\varphi,z_d,z_x)}{\displaystyle\int_{z_d,z_x}\int_{\varphi_x^*(z_x)}^{\infty} \frac{g(\varphi)\gamma(z_x)\psi(z_d)}{\Upsilon}M\,\mathrm{d}(\varphi,z_d,z_x)} \\[2ex]
&= \frac{\displaystyle\int_{z_d}\int_{z_x}\int_{\varphi_x^*(z_x)}^{\infty} \varphi g(\varphi)\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\,\mathrm{d}z_x\,\mathrm{d}z_d}{\displaystyle\int_{z_d}\int_{z_x}(1 - G(\varphi_x^*(z_x)))\gamma(z_x)\psi(z_d)\,\mathrm{d}z_x\,\mathrm{d}z_d}
\end{aligned}
$$

In equilibrium, P is determined. Together with equation (2.2), we can get:

$$
\begin{aligned}
\Psi_e &= \frac{\theta}{\theta - 1} \cdot \frac{\displaystyle\int_{z_x} \varphi_x^*(z_x)^{1-\theta}\gamma(z_x)\,\mathrm{d}z_x}{\displaystyle\int_{z_x} \varphi_x^*(z_x)^{-\theta}\gamma(z_x)\,\mathrm{d}z_x} \\[2ex]
&= \frac{\theta}{\theta - 1} \cdot \frac{\theta + \beta}{\theta + \beta - 1} \cdot \frac{\Theta}{P} \cdot \tau Z_x
\end{aligned}
$$

Let S_d denote the area $\{(z_d, z_x)\,|\,z_d < \tau z_x\}$ and S_x the area $\{(z_d, z_x)\,|\,z_d > \tau z_x\}$. Average

productivity of non-exporters is :

$$
\begin{aligned}
\Psi_{ne} &= \frac{\int_{S_d}\int_{\varphi_d^*(z_d)}^{\varphi_x^*(z_x)} \varphi \dfrac{g(\varphi)\gamma(z_x)\psi(z_d)}{\Upsilon} M\,\mathrm{d}(\varphi,z_d,z_x)}{\int_{S_d}\int_{\varphi_d^*(z_d)}^{\varphi_x^*(z_x)} \dfrac{g(\varphi)\gamma(z_x)\psi(z_d)}{\Upsilon} M\,\mathrm{d}(\varphi,z_d,z_x)} \\
&= \frac{\int_{z_d}\int_{z_d/\tau}^{\infty}\int_{\varphi_d^*(z_d)}^{\varphi_x^*(z_x)} \varphi g(\varphi)\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_x\mathrm{d}z_d}{\int_{z_d}\int_{z_d/\tau}^{\infty} (G(\varphi_x^*(z_x))-G(\varphi_d^*(z_d)))\gamma(z_x)\psi(z_d)\,\mathrm{d}z_x\mathrm{d}z_d}
\end{aligned}
$$

In equilibrium, P is determined. Together with equation (2.2), we can get:

$$
\begin{aligned}
\Psi_{ne} &= \frac{\theta}{\theta-1}\cdot\frac{\int_{z_d}\int_{z_d/\tau}^{\infty}(\varphi_d^*(z_d)^{1-\theta}-\varphi_x^*(z_x)^{1-\theta})\gamma(z_x)\psi(z_d)\,\mathrm{d}z_x\mathrm{d}z_d}{\int_{z_d}\int_{z_d/\tau}^{\infty}(\varphi_d^{*-\theta}-\varphi_x^{*-\theta})\gamma(z_x)\psi(z_d)\,\mathrm{d}z_x\mathrm{d}z_d} \\
&= \frac{\theta+\beta}{\theta+\beta-1}\frac{\theta+\beta+\alpha}{\theta+\beta+\alpha-1}\cdot\frac{\Theta}{P}\cdot Z_d
\end{aligned}
$$

A.3 Average Productivity in Autarky and under Trade

In autarky, the probability of an entrant becoming active Υ_a is determined as:

$$
\Upsilon_a = \int_{z_d}\int_{\varphi_d^*(z_d)} g(\varphi)\psi(z_d)\,\mathrm{d}(\varphi,z_d)
$$

The average productivity in autarky is:

$$
\begin{aligned}
\Psi_a &= \frac{\int_{z_d}\int_{\varphi_d^*(z_d)}^{\infty} \varphi \dfrac{g(\varphi)\psi(z_d)}{\Upsilon_a} M\,\mathrm{d}(\varphi,z_d)}{M} \\
&= \frac{\int_{z_d}\int_{\varphi_d^*(z_d)}^{\infty} \varphi g(\varphi)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_d}{\int_{z_d}(1-G(\varphi_d^*(z_d)))\psi(z_d)\,\mathrm{d}z_d} \\
&= \frac{\theta}{\theta-1}\cdot\frac{\theta+\alpha}{\theta+\alpha-1}\cdot\frac{\Theta}{P_a}\cdot Z_d
\end{aligned}
$$

With trade the average productivity after trade can be expressed as:

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$$\Psi = \frac{\int_{z_x,z_d}\int_{\varphi^*(z_d,z_x)}^{\infty}\varphi\frac{g(\varphi)\gamma(z_x)\psi(z_d)}{\Upsilon}M\,\mathrm{d}(\varphi,z_d,z_x)}{M}$$

$$= \frac{\int_{S_d}\int_{\varphi_d^*(z_d)}^{\infty}\varphi g(\varphi)\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_x\mathrm{d}z_d + \int_{S_x}\int_{\varphi_x^*(z_x)}^{\infty}\varphi g(\varphi)\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_x\mathrm{d}z_d}{\int_{S_d}(1-G(\varphi_d^*(z_d)))\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_x\mathrm{d}z_d + \int_{S_x}(1-G(\varphi_x^*(z_x)))\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_x\mathrm{d}z_d}$$

$$= \frac{\theta}{\theta-1}\cdot\frac{\int_{Z_d}\int_{z_d/\tau}^{\infty}\varphi_d^*(z_d)^{1-\theta}\gamma(z_x)\psi(z_d)\,\mathrm{d}z_x\mathrm{d}z_d + \int_{Z_d}\int_{Z_x}^{z_d/\tau}\varphi_x^*(z_x)^{1-\theta}\gamma(z_x)\psi(z_d)\,\mathrm{d}z_x\mathrm{d}z_d}{\int_{Z_d}\int_{z_d/\tau}^{\infty}\varphi_d^*(z_d)^{-\theta}\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_x\mathrm{d}z_d + \int_{Z_d}\int_{Z_x}^{z_d/\tau}\varphi_x^*(z_x)^{-\theta}\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_x\mathrm{d}z_d}$$

$$= \frac{\theta}{\theta-1}\cdot\frac{\theta+\beta}{\theta+\beta-1}\cdot\frac{\frac{\alpha(\theta-1)}{\theta+\beta+\alpha-1}Z_d\left(\frac{\tau Z_x}{Z_d}\right)^{\theta+\beta}+\beta\tau Z_x}{\frac{\alpha\theta}{\theta+\beta+\alpha}\left(\frac{\tau Z_x}{Z_d}\right)^{\theta+\beta}+\beta}\cdot\frac{\Theta}{P}$$

A.4 A Decrease in Foreign Entry Cost

$\lambda'(f_x\,|\,\varphi,A_d,A_x)$ is the conditional distribution of foreign entry cost, and $\lambda(f_x\,|\,\varphi,A_d,A_x)$ is the conditional distribution with a decrease of foreign entry cost. $\Lambda'(f_x\,|\,\varphi,A_d,A_x)$ and $\Lambda(f_x\,|\,\varphi,A_d,A_x)$ are the corresponding cumulative distributions. The change of conditional profit $\Delta\pi(P\,|\,\varphi,A_d,A_x)$ is then:

$$\Delta\pi(P\,|\,\varphi,A_d,A_x) = \int_0^{f_x^*(P,\varphi,A_x)}(f_x^*(P,\varphi,A_x)-f_x)(\lambda(f_x\,|\,\varphi,A_d,A_x)-\lambda'(f_x\,|\,\varphi,A_d,A_x))\mathrm{d}f_x$$

$$= (f_x^*(P,\varphi,A_x)-f_x)(\Lambda(f_x\,|\,\varphi,A_d,A_x)-\Lambda'(f_x\,|\,\varphi,A_d,A_x))\Big|_0^{f_x^*(P,\varphi,A_x)}$$

$$\quad -\int_0^{f_x^*(P,\varphi,A_x)}(-1)(\Lambda(f_x\,|\,\varphi,A_d,A_x)-\Lambda'(f_x\,|\,\varphi,A_d,A_x))\mathrm{d}f_x$$

$$= \int_0^{f_x^*(P,\varphi,A_x)}(\Lambda(f_x\,|\,\varphi,A_d,A_x)-\Lambda'(f_x\,|\,\varphi,A_d,A_x))\mathrm{d}f_x$$

With property of LEFC, i.e. $\Lambda(f_x\,|\,\varphi,A_d,A_x)\geq\Lambda'(f_x\,|\,\varphi,A_d,A_x)$, $\Delta\pi(P\,|\,\varphi,A_d,A_x)\geq 0$. Therefore $\pi(P\,|\,\varphi,A_d,A_x)$ becomes higher.

A.5 Innovation

$\lambda'(\varphi\,|\,\eta)$ denotes the conditional distribution of productivity and $\lambda(\varphi\,|\,\eta)$ denotes the conditional distribution with innovation. $\Lambda'(\varphi\,|\,\eta)$ and $\Lambda(\varphi\,|\,\eta)$ are the corresponding

cumulative distributions. The change of $k(x)$ is:

$$
\begin{aligned}
\Delta k(x) &= \int_x^\infty \left((\frac{\varphi}{x})^{\sigma-1} - 1 \right) \left(\lambda(\varphi \,|\, \eta) - \lambda'(\varphi \,|\, \eta) \right) \mathrm{d}\varphi \\
&= \left((\frac{\varphi}{x})^{\sigma-1} - 1 \right) \left(\Lambda(\varphi \,|\, \eta) - \Lambda'(\varphi \,|\, \eta) \right) |_x^\infty - \int_x^\infty \frac{(\sigma-1)\varphi^{\sigma-2}}{x^{\sigma-1}} (\Lambda(\varphi \,|\, \eta) - \Lambda'(\varphi \,|\, \eta)) \mathrm{d}\varphi \\
&= -\int_x^\infty \frac{(\sigma-1)\varphi^{\sigma-2}}{x^{\sigma-1}} (\Lambda(\varphi \,|\, \eta) - \Lambda'(\varphi \,|\, \eta)) \mathrm{d}\varphi
\end{aligned}
$$

With property of HP, i.e. $\Lambda(\varphi \,|\, \eta) \leq \Lambda'(\varphi \,|\, \eta)$, $\Delta k(x) \geq 0$. Therefore $k(x)$ is increased.

Appendix B

Appendix of Chapter 3

B.1 Existence of Closed Economy Equilibrium

With equations (3.4), (3.5), (3.6) and (3.7),we define a function $f(\varphi^*)$ such that equilibrium is determined by $f(\varphi^*) = \frac{\delta f_e}{f_d}$, where

$$f(\varphi^*) = \sum_{i=1}^{\infty} \int_{\varphi_i^*}^{\varphi_{i+1}^*} \left(\sum_{j=1}^{i} \beta^{j-1} k(\varphi) - i \right) g(\varphi) d\varphi$$

We prove the existence of equilibrium by showing that $f(\varphi^*)$ is monotonically decreasing from infinity to zero as φ^* approaches to infinity from zero. The derivative of $f(\varphi^*)$ is:

$$f'(\varphi^*) = \sum_{i=1}^{\infty} \int_{\varphi_i^*}^{\varphi_{i+1}^*} \sum_{j=1}^{i} \beta^{j-1} \frac{dk(\varphi)}{d\varphi^*} g(\varphi) d\varphi +$$
$$\sum_{i=1}^{\infty} \left\{ \left(\sum_{j=1}^{i} \beta^{j-1} k(\varphi_{i+1}^*) - i \right) g(\varphi_{i+1}^*) \frac{d\varphi_{i+1}^*}{d\varphi^*} - \left(\sum_{j=1}^{i} \beta^{j-1} k(\varphi_i^*) - i \right) g(\varphi_i^*) \frac{d\varphi_i^*}{d\varphi^*} \right\}$$

To rewrite the above equation, we can get:

$$f'(\varphi^*) = \sum_{i=1}^{\infty} \int_{\varphi_i^*}^{\varphi_{i+1}^*} \sum_{j=1}^{i} \beta^{j-1} \frac{dk(\varphi)}{d\varphi^*} g(\varphi) d\varphi + \sum_{i=1}^{\infty} \left(1 - \beta^{i-1} k(\varphi_i^*) \right) g(\varphi_i^*) \frac{d\varphi_i^*}{d\varphi^*}$$

where $\beta^{j-1} k(\varphi_i^*) = \beta^{j-1} \left(\frac{\varphi_i^*}{\varphi^*} \right)^{\sigma-1} = 1$. So The derivative of $f(\varphi^*)$ is:

$$f'(\varphi^*) = \sum_{i=1}^{\infty} \int_{\varphi_i^*}^{\varphi_{i+1}^*} \sum_{j=1}^{i} \beta^{j-1} \frac{dk(\varphi)}{d\varphi^*} g(\varphi) d\varphi$$

where $\frac{dk(\varphi)}{d\varphi^*} < 0$. So $f'(\varphi^*) < 0$. As φ^* approaches to zero (infinity), $k(\varphi)$ approaches to infinity (zero), as a result $f(\varphi^*)$ approaches to infinity (zero). $f(\varphi^*)$ is monotonically

decreasing from infinity to zero. There must be a unique φ^* such that:

$$f(\varphi^*) = \frac{\delta f_e}{f_d}$$

There exists a unique equilibrium in closed economy.

B.2   Existence of Open Economy Equilibrium

With equations (3.6), (3.7), (3.13), (3.14) and (3.15), we assume a function $f(\varphi^*)$ such that equilibrium is determined by $f(\varphi^*) = \delta f_e$, where:

$$f(\varphi^*) = f_1(\varphi^*) + f_2(\varphi_x^*)$$

where

$$f_1(\varphi^*) = f_d \sum_{i=1}^{\infty} \int_{\varphi_i^*}^{\varphi_{i+1}^*} \left(\sum_{j=1}^{i} \beta^{j-1} k(\varphi) - i \right) g(\varphi) d\varphi$$

$$f_2(\varphi_x^*) = f_x \sum_{i=1}^{\infty} \int_{\varphi_{i,x}^*}^{\varphi_{i+1,x}^*} \left(\sum_{j=1}^{i} \beta^{j-1} k_x(\varphi) - (i-1)\gamma \right) g(\varphi) d\varphi$$

We prove the existence of equilibrium by showing that $f(\varphi^*)$ is monotonically decreasing from infinity to zero as φ^* approaches to infinity from zero. According to appendix on the existence of closed economy, $f_1'(\varphi^*) < 0$. The derivative of $f_2(\varphi_x^*)$ is:

$$f_2'(\varphi_x^*) = \sum_{i=1}^{\infty} \int_{\varphi_{i,x}^*}^{\varphi_{i+1,x}^*} \sum_{j=1}^{i} \beta^{j-1} \frac{dk_x(\varphi)}{d\varphi^*} g(\varphi) d\varphi +$$

$$\sum_{i=1}^{\infty} \left\{ \left(\sum_{j=1}^{i} \beta^{j-1} k_x(\varphi_{i+1,x}^*) - (i-1)\gamma \right) g(\varphi_{i+1,x}^*) \frac{d\varphi_{i+1,x}^*}{d\varphi^*} - \left(\sum_{j=1}^{i} \beta^{j-1} k(\varphi_{i,x}^*) - (i-1)\gamma \right) g(\varphi_{i,x}^*) \frac{d\varphi_{i,x}^*}{d\varphi^*} \right\}$$

To rewrite the above equation, we can get:

$$f_2'(\varphi_x^*) = \sum_{i=1}^{\infty} \int_{\varphi_{i,x}^*}^{\varphi_{i+1,x}^*} \sum_{j=1}^{i} \beta^{j-1} \frac{dk_x(\varphi)}{d\varphi^*} g(\varphi) d\varphi - k_x(\varphi_x^*) g(\varphi_x^*) \frac{dk_x(\varphi_x^*)}{d\varphi^*} +$$

$$\sum_{i=2}^{\infty} \left(\gamma - \beta^{i-1} k(\varphi_{i,x}^*) \right) g(\varphi_{i,x}^*) \frac{d\varphi_{i,x}^*}{d\varphi^*}$$

where $\frac{dk_x(\varphi_x^*)}{d\varphi^*} < 0$, $k_x(\varphi_x^*) = 0$, $\gamma - \beta^{i-1} k(\varphi_{i,x}^*) = (\gamma + \beta^{i-1})(1 - f_x/\tau^{1-\sigma} f_d) < 0$ and $\frac{d\varphi_{i,x}^*}{d\varphi^*} > 0$. So we can get $f_2'(\varphi_x^*) < 0$. Therefore:

$$f'(\varphi^*) < 0$$

As φ^* approaches to zero (infinity), $k(\varphi)$ approaches to infinity (zero), as a result $f(\varphi^*)$ approaches to infinity (zero). $f(\varphi^*)$ is monotonically decreasing from infinity to zero. There must be a unique φ^* such that:

$$f(\varphi^*) = \delta f_e$$

There exists a unique equilibrium in open economy.

B.3   From Autarky to Trade

We use prime to denote the state after exposure to trade. φ^* and φ_i^* denote cut-off productivity in autarky, and φ'^* and $\varphi_i'^*$ denote cut-off productivity for domestic in open economy. According to appendix on the existence of equilibrium in closed economy and open economy, v_e and v_e' are decreasing functions and $v_e' > v_e$. The curve v_e is below e v_e'. So in equilibrium, $\varphi'^* > \varphi^*$ and $\varphi_i'^* > \varphi_i^*$.

B.4   Trade liberalization

We use prime to denote the state after trade liberalization. As for decrease in variable export cost, according to appendix on existence of open economy equilibrium, φ^* is determined by $F(\varphi^*, \tau) = f_1(\varphi^*) + f_2(\varphi_x^*) = \delta f_e$. So:

$$\frac{d\varphi^*}{d\tau} = -\frac{\partial F(\varphi^*, \tau)/\partial \tau}{\partial F(\varphi^*, \tau)/\partial \varphi^*}$$

From appendix on existence of open economy equilibrium, we can get

$$\frac{\partial F(\varphi^*, \tau)}{\partial \tau} = \sum_{i=1}^{\infty} \int_{\varphi_{i,x}^*}^{\varphi_{i+1,x}^*} \sum_{j=1}^{i} \beta^{j-1} \frac{dk_x(\varphi)}{d\tau} g(\varphi) d\varphi + \sum_{i=2}^{\infty} \left(\gamma - \beta^{i-1} k(\varphi_{i,x}^*)\right) g(\varphi_{i,x}^*) \frac{d\varphi_{i,x}^*}{d\tau}$$

where $\frac{dk_x(\varphi_x^*)}{d\tau}$ and $\frac{d\varphi_{i,x}^*}{d\tau}$ are partial derivatives in respect to τ. So $\frac{dk_x(\varphi_x^*)}{d\tau} < 0$ and $\frac{d\varphi_{i,x}^*}{d\tau} < 0$. We can get $\frac{\partial F(\varphi^*, \tau)}{\partial \tau} < 0$. $\frac{\partial F(\varphi^*, \tau)}{\partial \varphi^*} < 0$ as shown in appendix on existence of open economy equilibrium. Therefore, we have

$$\frac{d\varphi^*}{d\tau} < 0$$

As variable export cost decreases, φ^* and φ_i^* increase.

φ_x^* is determined by $\Gamma(\varphi_x^*, \tau) = f_1(\varphi^*) + f_2(\varphi_x^*) = \delta f_e$. So:

$$\frac{d\varphi_x^*}{d\tau} = -\frac{\partial \Gamma(\varphi_x^*, \tau)/\partial \tau}{\partial \Gamma(\varphi_x^*, \tau)/\partial \varphi_x^*}$$

From appendix on the existence of closed economy equilibrium, we can get

$$\frac{\partial \Gamma(\varphi_x^*, \tau)}{\partial \tau} = \sum_{i=1}^{\infty} \int_{\varphi_i^*}^{\varphi_{i+1}^*} \sum_{j=1}^{i} \beta^{j-1} \frac{dk(\varphi)}{d\tau} g(\varphi) d\varphi$$

where $\frac{dk(\varphi)}{d\tau}$ is partial derivative in respect to τ. Partial derivative $\frac{dk(\varphi)}{d\tau} > 0$. So $\frac{\partial \Gamma(\varphi_x^*, \tau)}{\partial \tau} > 0$. $\frac{\partial F(\varphi_x^*, \tau)}{\partial \varphi_x^*} < 0$. So

$$\frac{d\varphi_x^*}{d\tau} > 0$$

As variable export cost decreases, φ_x^* and $\varphi_{i,x}^*$ decrease.

As for the decrease in fixed export cost, the proof is similar. The result is:

$$\frac{d\varphi^*}{df_x} < 0 \qquad \frac{d\varphi_x^*}{df_x} > 0$$

As variable export cost decreases, φ^* and φ_i^* increase while φ_x^* and $\varphi_{i,x}^*$ decrease.

Appendix C

Appendix of Chapter 4

C.1 Existence of Solutions with Initial Value

Firstly I describe the theorem on existence and uniqueness of solution to first order differential equation. Given a general first order differential equation:

$$y' = F(x,y) \quad \text{with an initial value} \quad (x_0, y_0) \qquad (*)$$

Suppose a region R:

$$R = \{(x,y)|x_0 - a \leq x \leq x_0 + a, y_0 - b \leq y \leq y_0 + b\}$$

contains (x_0, y_0).

Picard's Existence Theorem Suppose that both $F(x,y)$ and $\frac{\partial F}{\partial y}$ are continuous functions defined in the region R, then there is a positive number $\varepsilon \leq a$ so that a unique solution to $(*)$ exists for the $x_0 - \varepsilon < x < x_0 + \varepsilon$.

Secondly I prove the existence of the solution to income-quality differential equaiton. Differential equation is $w' = F(q,w)$, where

$$F(q,w) = \frac{\phi(w)}{q\phi'(w)}\left(\sigma + (\sigma-1)\frac{qc'(q)}{c(q)} - \frac{\delta w(L\phi(w))^{\frac{1}{\sigma}}}{c(q)^{\frac{\sigma-1}{\sigma}}}\right)$$

and

$$\frac{\partial F(q,w)}{\partial w} = \frac{\sigma}{q} + \frac{(\sigma-1)c'(q)}{c(q)} - (1+\frac{1}{\sigma})\frac{\delta w(L\phi(w))^{\frac{1}{\sigma}}}{qc(q)^{\frac{\sigma-1}{\sigma}}} - \frac{\phi(w)}{q}f(q,w)$$

where

$$f(q,w) = \frac{\phi''(w)\left(\sigma + (\sigma-1)\frac{qc'(q)}{c(q)}\right) + \frac{\delta L^{\frac{1}{\sigma}}}{c(q)^{\frac{\sigma-1}{\sigma}}}\left(\phi(w)^{\frac{1}{\sigma}}\phi'(w) - w\phi(w)^{\frac{1}{\sigma}}\phi''(w)\right)}{\phi'(w)^2}$$

According to Picard's existence theorem, for any given initial value (q_0, w_0) where $q_0 > 0$ and $w_0 \in [w_{min}, w_{max}]$, there is a positive number ε_2 that a unique solution to (*) exists in the open interval $(w_0 - \varepsilon_2, w_0 + \varepsilon_2)$. Here $w(q)$ should be continuous across qualities, so we assume ε_2 is as large as $[w_{min}, w_{max}] \in (w_0 - \varepsilon_2, w_0 + \varepsilon_2)$. That is, there is a unique solution across $[w_{min}, w_{max}]$.

If $\phi(w)$ is not continuous around w_{max} but $\phi(w_{max}) = 0$, there still is a unique solution across $[w_{min}, w_{max})$. Because there are no consumers with income w_{max}, this solution on $[w_{min}, w_{max})$ is feasible.

C.2 Equilibrium of Closed Economy

Because $\phi'(w^*) = 0$, In order to let $F(q, w)$ be continuous at w^*. The quality consumed by consumer with income w^*, denoted as q^*, is determined as:

$$\delta w^* (L\phi(w^*))^{\frac{1}{\sigma}} = \left(\sigma + (\sigma - 1)\frac{q^* c'(q^*)}{c(q^*)} \right) c(q^*)^{\frac{\sigma-1}{\sigma}}$$

In this case,

$$\lim_{w \to w^*} F(q, w) = - \lim_{w \to w^*} \frac{\phi(w)\delta L^{\frac{1}{\sigma}}}{q\phi''(w)} \cdot \left(\frac{\phi(w)^{\frac{1}{\sigma}} + \phi(w)^{\frac{1}{\sigma}-1}\phi'(w)w/\sigma}{c(q)^{\frac{\sigma-1}{\sigma}}} \right)$$

As long as $\phi''(w) \neq 0$,

$$\lim_{w \to w^*} F(q, w) = -\frac{\delta L^{\frac{1}{\sigma}}\phi(w^*)^{\frac{1}{\sigma}+1}}{\phi''(w^*)q^* c(q^*)^{\frac{\sigma-1}{\sigma}}}$$

Therefore, we asset the point (q^*, w^*) into the function $F(q, w)$ and

$$F(q, w) = \begin{cases} \dfrac{\phi(w(q))}{q\phi'(w(q))} \left(\sigma + (\sigma - 1)\dfrac{qc'(q)}{c(q)} - \dfrac{\delta w(q)(L\phi(w(q)))^{\frac{1}{\sigma}}}{c(q)^{\frac{\sigma-1}{\sigma}}} \right) & \text{if} \quad w \neq w^* \\ -\dfrac{\delta L^{\frac{1}{\sigma}}\phi(w^*)^{\frac{1}{\sigma}+1}}{\phi''(w^*)q^* c(q^*)^{\frac{\sigma-1}{\sigma}}} & \text{if} \quad w = w^* \end{cases}$$

is continuous. And $\dfrac{\partial F(q, w)}{\partial w}$ is continuous because

$$\lim_{w \to w^*} \frac{\partial F(q, w)}{\partial w} = \frac{\delta w^* (L\phi(w^*))^{\frac{1}{\sigma}}}{2q^*} \left(\frac{\phi'''(w^*)\phi(w^*)}{w^*\phi''(w^*)^2} - \frac{1}{\sigma c(q^*)^{\frac{\sigma-1}{\sigma}}} \right) \neq \pm\infty$$

Therefore $F(q, w)$ and $\partial F(q, w)/\partial w$ are continuous for $w \in [w_{min}, w_{max}]$. According to Appendix C.1, there exists a unique equilibrium with the initial value (q^*, w^*).

C.3   Uniform Distribution

The Closed Economy

Suppose the income distribution density is $\phi(w) = 1/(w_{max} - w_{min})$.

Theorem 18 *Given a uniform distribution, there is a unique equilibrium in closed economy.*

Proof: With uniform distribution,

$$P_q = \frac{\sigma}{\delta} \left(\frac{W_{max} - W_{min}}{L} \right)^{\frac{1}{\sigma}} c(q)^{\frac{\sigma-1}{\sigma}}$$

With equation (4.4), we can find the income-quality relationship $w(q)$. Then then the number of firms producing quality q is determined as $n_q = \left(\frac{(\sigma-1)P_q}{\sigma c(q)} \right)^{1-\sigma}$. The labor used in differentiated products of quality q is then $LP_q/(w_{max} - w_{min})$. The labor used in homogeneous products that are consumed by consumers choosing quality q is $L(w(q) - P_q)/(w_{max} - w_{min})$. Therefore labor market clears.

The Open Economy

With uniform distribution, we can solve equation (4.9) and get the price index for qualities under incomplete specialization:

$$P_q^z = \frac{\sigma}{\delta} \left(\frac{W_{max}^z - W_{min}^z}{L^z(1 + \tau^{1-\sigma})} \right)^{\frac{1}{\sigma}} c(q)^{\frac{\sigma-1}{\sigma}}$$

The relative demand between country z and country $\tilde{z}$ for all qualities under incomplete specialization is $\rho = \frac{L^z(W_{max}^{\tilde{z}} - W_{min}^{\tilde{z}})}{L^{\tilde{z}}(W_{max}^z - W_{min}^z)}$. Therefore, all qualities are under incomplete specialization if $\tau^{-\sigma} < \rho < \tau^\sigma$ and all qualities are completely specialized in $z(\tilde{z})$ country if $\rho > \tau^\sigma (< \tau^{-\sigma})$. The price index is then determined as in equation (4.12), e.g. under complete specialization in z country:

$$P_q^z = \frac{\sigma}{\delta} \left(\frac{L^z}{W_{max}^z - W_{min}^z} + \frac{\tau L^{\tilde{z}}}{W_{max}^{\tilde{z}} - W_{min}^{\tilde{z}}} \right)^{-\frac{1}{\sigma}} c(q)^{\frac{\sigma-1}{\sigma}}$$

There cannot exist the **mixed specialization**, i.e. some qualities are under complete specialization and some qualities are under incomplete specialization.

C.4   Pareto Distribution

The Closed Economy

A family of distribution: $\phi'(w) < 0$ for all $w \in [w_{min}, w_{max}]$. $\phi(w_{min}) > 0$, $\phi(w)$ is continuous and differentiable around w_{min}. $\phi(w_{max}) \geq 0$ and if $\phi(w_{max}) \neq 0$, $\phi(w)$ is continuous and differentiable around w_{max}.

Examples of distributions of this family include Pareto, truncated Pareto and exponential distributions. Given a distribution $\phi(w)$ of the family, according to C.1 and assumption 1, there exists a unique solution $w(q)$ that meets the conditions $P'_q > 0$ and $w'(q) > 0$ for any given initial value (q_0, w_0) that belongs to set O. For different initial values that belong to set o, there are different solutions. However, they can be ranked by all consumers. Only one solution of them is preferred by consumers of all income levels than all the others, and the equilibrium with this solution is ***Pareto Superior equilibrium***.

Theorem 19 *Given a distribution of the family described above, there is a Pareto Superior equilibrium.*

Proof: Any two solutions to equation (4.8) do not cross. This means solutions can be ranked. The solution which determines the largest quality consumed by any given $w \in [w_{min}, w_{max}]$ is Pareto superior. ■

Example 1 *Pareto distribution $\phi(w) = \lambda w_m^\lambda / w^{\lambda+1}$, where $\lambda + 1 < \sigma$. $c(q) = \varphi q^\theta$, $\theta > 0$.*

Let $\kappa = 1 + \frac{\theta(\sigma-1)}{\alpha(\sigma-\lambda-1)}$ and $\Xi = \frac{\sigma^\sigma \varphi^{\sigma-1}}{L\delta^\sigma \lambda w_m^\lambda}$, the solution to the income-quality differential equation is:

$$P_q = \frac{\left(\Xi\kappa^{\lambda+1}\right)^{\frac{1}{\sigma-\lambda-1}} q^{\frac{\theta(\sigma-1)}{\sigma-\lambda-1}}}{\left(1 + \gamma q^{\frac{\alpha(\sigma-\lambda-1)+\theta(\sigma-1)}{\lambda+1}}\right)^{\frac{\lambda+1}{\sigma-\lambda-1}}}$$

where γ is an constant. Different values of γ mean different initial values. This corresponds to the Lemma 1 that for each value γ there is a solution. However, only the values of γ that satisfy conditions $P'_q > 0$ and $w'(q) > 0$ are feasible. Given a maximum quality $\overline{q}$ that consumers can choose, the condition of γ is that $\gamma < \frac{\theta(\sigma-1)(\lambda+1)}{(\alpha\sigma+\theta(\sigma-1))(\sigma-\lambda-1)} \overline{q}^{\frac{-\alpha(\sigma-\lambda-1)-\theta(\sigma-1)}{\lambda+1}}$. Therefore there exists a set of initial values that correspond to the feasible values of γ to satisfy Assumption 1.

As a matter of utility of consumers, the lower price level is, the higher utility for consumers. Therefore there is a γ that all consumers prefer, i.e. the largest feasible γ, which determines the Pareto superior equilibrium. Because income is not upper bounded

in Pareto income distribution, possible highest quality is infinity. Therefore the pareto superior γ is zero. The price index is then

$$P_q = (\Xi \kappa^{\lambda+1})^{\frac{1}{\sigma-\lambda-1}} q^{\frac{\theta(\sigma-1)}{\sigma-\lambda-1}}$$

The Open Economy

With Pareto distribution, it will be Case I or Case III. Firstly consider the situation $\lambda_P = \lambda_R = \lambda$, assumption 2 is not satisfied, which means the relative demand is not increasing but fixed. However we can still apply Case I. According to Theorem 15, if $L_R \phi_R w_m^{R\lambda}/(L_P w_m^{P\lambda}) \leq \tau^{\lambda+1-\sigma}(L_R \phi_R w_m^{R\lambda}/(L_P w_m^{P\lambda}) \geq \tau^{\sigma-\lambda-1})$ (here we add the relationship of equality, it is straightforward to verify this), all qualities are completely specialized in poor (rich) country. The price index of the country z that all qualities are specialized is determined by the differential equation (4.12):

$$P_q^z = \frac{\left(\Xi_z^c \kappa^{\lambda+1}/(1+\tau^{1-\sigma})\right)^{\frac{1}{\sigma-\lambda-1}} \cdot q^{\frac{\theta(\sigma-1)}{\sigma-\lambda-1}}}{\left(1+\gamma_z q^{\frac{\alpha(\sigma-\lambda-1)+\theta(\sigma-1)}{\lambda+1}}\right)^{\frac{\lambda+1}{\sigma-\lambda-1}}}$$

where where $\Xi_z^c = \frac{\sigma^\sigma \varphi_z^{\sigma-1}}{(L_z \varpi_z^\lambda + \tau_{\bar{z}}^{-\lambda} L_{\bar{z}} \varpi_{\bar{z}}^\lambda)\lambda \delta^\sigma}$ and γ_z is determined as

$$\gamma_z = \frac{\theta(\sigma-1)(\lambda+1)}{(\alpha\sigma+\theta(\sigma-1))(\sigma-\lambda-1)} \bar{q}^{\frac{-\alpha(\sigma-\lambda-1)-\theta(\sigma-1)}{\lambda+1}}$$

and $\bar{q}$ is the maximum quality under incomplete specialization. According to income-quality relationship (4.2) and above price index, under complete specialization, the quality chosen by the consumers with infinite income is infinity, i.e. $\lim_{w\to\infty} q(w) = \infty$. That is, the maximum quality in both countries are infinite, i.e. $\bar{q} = \infty$. Therefore according to Lemma 1, the Pareto superior γ_z is zero. The price index is then

$$P_q^z = (\Xi_z^c \kappa^{\lambda+1})^{\frac{1}{\sigma-\lambda-1}} q^{\frac{\theta(\sigma-1)}{\sigma-\lambda-1}}$$

The price index in the other country is then $P_q = \tau P_q^z$. The condition (4.3) is satisfied in both countries given the above price index. However according to Theorem 16, if $\tau^{\lambda+1-\sigma} < L_R \phi_R w_m^{R\lambda}/(L_P w_m^{P\lambda}) < \tau^{\sigma-\lambda-1}$, all qualities are under incomplete specialization. To solve the differential equation (4.12), we have

$$P_q^z = \frac{\left(\Xi_z \kappa^{\lambda+1}/(1+\tau^{1-\sigma})\right)^{\frac{1}{\sigma-\lambda-1}} \cdot q^{\frac{\theta(\sigma-1)}{\sigma-\lambda-1}}}{\left(1+\gamma_z q^{\frac{\alpha(\sigma-\lambda-1)+\theta(\sigma-1)}{\lambda+1}}\right)^{\frac{\lambda+1}{\sigma-\lambda-1}}}$$

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where $\Xi_c = \frac{\sigma^\sigma \varphi^{\sigma-1}}{L_z \delta^\sigma \lambda w_m^{z\lambda}}$. And by analogy, $\overline{q} = \infty$ and $\gamma_z = 0$. The price index is then

$$P_q^z = \left(\Xi_z \kappa_z^{\lambda+1}\right)^{\frac{1}{\sigma-\lambda-1}} q^{\frac{\theta(\sigma-1)}{\sigma-\lambda-1}}$$

The condition (4.3) is satisfied in both countries given the above price index.

Now consider the situation $\lambda_P \neq \lambda_R$, it will be the Case III. Then there is one value q^* that $P_q^{\tilde{z}}/P_q^z = \tau_{\tilde{z}}$ where P_q^z and $P_q^{\tilde{z}}$ are determined as in equation (4.12) and $\{z, \tilde{z}\} \in \{P, R\}$. Now I denote the price index under incomplete specialization in equation (**??**) as $P_q^z(\gamma_z^i)$ and $P_q^{\tilde{z}}(\gamma_{\tilde{z}}^i)$. Under complete specialization in z country, I denote price index in z country as $P_q^z(\gamma_z^c)$ and price index in $\tilde{z}$ country as $\tau_{\tilde{z}}P_q^z(\gamma_z^c)$. If $P_q^{\tilde{z}}/P_q^z = \tau_{\tilde{z}}$ at q^*, there is a change between incomplete specialization and complete specialization in z country. Because price index should be continuous and differentiable in both countries, we have

$$
\begin{cases}
P_{q^*}^{\tilde{z}}(\gamma_{\tilde{z}}^i)/P_{q^*}^z(\gamma_z^i) &=& \tau_{\tilde{z}} \\
P_{q^*}^z(\gamma_z^i) &=& P_{q^*}^z(\gamma_z^c) \\
P_q^{z\prime}(\gamma_z^i)|_{q=q^*} &=& P_q^{z\prime}(\gamma_z^c)|_{q=q^*} \\
P_q^{\tilde{z}\prime}(\gamma_{\tilde{z}}^i)|_{q=q^*} &=& \tau_{\tilde{z}}P_q^{z\prime}(\gamma_z^c)|_{q=q^*}
\end{cases}
$$

We have four equations four unknowns q^*, γ_z^i, $\gamma_{\tilde{z}}^i$ and γ_z^c. After solving the equations, we can know which interval of quality is specialized P country, R country or both countries.

C.5 Other Tables

Table C.1: Variables and description

Variable	Code	Source and description
		Household
Disposable income	P389p	Derived household characteristics data: 2013_dvhh_ukanon
OECD scale	OECDSc	Derived household characteristics data: 2013_dvhh_ukanon
Equivalised disposable income	EqIncDOp	Derived household characteristics data: 2013_dvhh_ukanon
		Bread
Expenditure	C11121t	Derived household characteristics data: 2013_dvhh_ukanon
Equivalised expenditure		C11121t/OECDSc
Equivalised expenditure of substitutes		Derived household characteristics data: 2013_dvhh_ukanon; Includes expenditure on Rice (C11111t), Buns, crisp bread and biscuits (C11122t) Pasta products (C11131t), Cakes and Puddings (C11141t),Pastry(C11142t) and Other breads and cereals(C11151t); then divided by OECD scale
Equivalised quantity		LCF food diary: restricted_familyfood2013; Include quantity of White bread, standard, unsliced (20102), White bread, standard,sliced (25202), White bread, premium, sliced and unsliced (25701), White bread, soft grain, sliced and unsliced (25801), Brown bread, sliced and unsliced (25901), Wholemeal and granary bread, sliced and unsliced (26001), Rolls - white, brown or wholemeal(26302), Malt bread and fruit loaves (26303), Vienna and French bread (26304), Starch reduced bread and rolls (26305) and Other breads(26308); then divided by OECD scale
Price		Expenditure of above products divided by quantity of above products
		Wine
Expenditure	C21211t	Derived household characteristics data: 2013_dvhh_ukanon
Equivalised expenditure		C21211t/OECDSc
Equivalised expenditure of substitutes		Derived household characteristics data: 2013_dvhh_ukanon; Includes expenditure on Spirits and liqueurs (C21111t), Fortified wine (C21212t), Ciders and Perry (C21213t), Alcopops (C21214t), Champagne and sparkling wines (C21221t), Beer and lager (C21311t); then divided by OECD scale
Equivalised quantity	38403	LCF food diary: restricted_familyfood2013; quantity of 38403 divided by OECD scale
Price	38403	Expenditure of 38403 divided by quantity

Table C.2: Country samples and number of varieties

Country	number	Percent	Cum.
Germany	5,377	14.51	14.51
France	4,288	11.57	26.08
Italy	4,107	11.08	37.16
United Kingdom	3,642	9.83	46.99
Romania	3,369	9.09	56.08
Norway	2,906	7.84	63.92
Spain	1,973	5.32	69.25
Netherlands	1,828	4.93	74.18
Denmark	1,647	4.44	78.63
Sweden	1,294	3.49	82.12
Bulgaria	1,027	2.77	84.89
Belgium	942	2.54	87.43
Turkey	872	2.35	89.78
Croatia	807	2.18	91.96
Poland	706	1.91	93.87
Finland	464	1.25	95.12
Austria	372	1.00	96.12
Greece	261	0.70	96.83
Ireland	261	0.70	97.53
Czech Republic	231	0.62	98.15
Portugal	215	0.58	98.73
Hungary	109	0.29	99.03
Latvia	98	0.26	99.29
Slovenia	41	0.11	99.40
Malta	39	0.11	99.51
Estonia	35	0.09	99.60
Slovak Republic	34	0.09	99.70
Lithuania	33	0.09	99.78
Luxembourg	30	0.08	99.87
Iceland	28	0.08	99.94
Cyprus	22	0.06	100.00

Table C.3: Income shift from the rich to the poor and middle

	Quantile 0.1	Quantile 0.25	Quantile 0.5	Quantile 0.75	Quantile 0.9
s_{poor}	0.212	0.126	0.060	0.047	-0.003
	(0.0095)***	(0.0002)***	(0.0001)***	(0.0000)***	(0.0000)***
s_{middle}	-0.073	-0.005	-0.011	0.017	0.040
	(0.0044)***	(0.0001)***	(0.0001)***	(0.0000)***	(0.00000)***
$\ln ipc$	0.034	0.243	0.076	-0.029	-0.096
	(0.0106)***	(0.0002)***	(0.0001)***	(0.0001)***	(0.0000)***
$\ln pop$	0.116	0.087	0.106	0.107	0.147
	(0.0057)***	(0.0001)***	(0.0001)***	(0.0000)***	(0.0000)***
$\ln dist$	3.099	1.395	0.042	-0.013	0.529
	(0.0818)***	(0.0014)***	(0.0010)***	(0.0004)***	(0.0001)***
$\ln rem$	2.475	1.653	1.483	2.166	1.153
	(0.226)***	(0.0040)***	(0.0029)***	(0.0011)***	(0.0002)***
_cons	-92.60	-60.31	-40.15	-57.55	-36.21
	(5.977)***	(0.105)***	(0.0758)***	(0.0283)***	(0.0051)***
# obs.	234,307,867	234,307,867	234,307,867	234,307,867	234,307,867

Standard errors are stated in parentheses below point estimates. ***, ** and * mean
1%, 5% and 10% significance levels respectively.

Table C.4: Income shift from the poor to the rich and middle

	Quantile 0.1	Quantile 0.25	Quantile 0.5	Quantile 0.75	Quantile 0.9
rich	-0.176	-0.110	-0.047	-0.024	0.028
	(0.0004)***	(0.0001)***	(0.0014)***	(0.0000)***	(0.0055)***
middle	-0.240	-0.111	-0.055	0.001	0.076
	(0.0006)***	(0.0002)***	(0.0019)***	(0.0000)***	(0.0076)***
$\ln ipc$	0.182	0.241	0.076	-0.027	-0.094
	(0.0005)***	(0.0002)***	(0.0016)***	(0.0000)***	(0.0065)***
$\ln pop$	0.044	0.085	0.105	0.107	0.143
	(0.0003)***	(0.0001)***	(0.0009)***	(0.0000)***	(0.0035)***
$\ln dist$	2.347	1.422	0.058	0.018	0.521
	(0.0041)***	(0.0013)***	(0.0125)***	(0.0003)***	(0.0504)***
$\ln rem$	2.686	1.504	1.359	2.055	1.029
	(0.0111)***	(0.0035)***	(0.0338)***	(0.0008)***	(0.137)***
_cons	-74.15	-44.84	-32.33	-52.72	-35.81
	(0.277)***	(0.0872)***	(0.844)***	(0.0204)***	(3.419)***
# obs.	234,307,867	234,307,867	234,307,867	234,307,867	234,307,867

Standard errors are stated in parentheses below point estimates. ***, ** and * mean
1%, 5% and 10% significance levels respectively.

Table C.5: Export price distribution and income distribution

	Quantile 0.1	Quantile 0.25	Quantile 0.5	Quantile 0.75	Quantile 0.9
		Panel A: Income per capita			
$\ln ipc$	0.268	0.347	0.161	-0.016	-0.063
	(0.0164)***	(0.0002)***	(0.0001)***	(0.0107)	(0.0001)***
		Panel B: Gini coefficient			
Gini	0.014	-0.006	0.009	-0.016	-0.027
	(0.0086)***	(0.0005)***	(0.0001)***	(0.0004)***	(0.0000)***
# obs.	40,6515,124	406,515,124	406,515,124	406,515,124	406,515,124

All regressions include gravity related control variables: population, distance and remoteness. All regression use export quantity as the frequency weight. See Appendix C for full tables. Standard errors are stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.
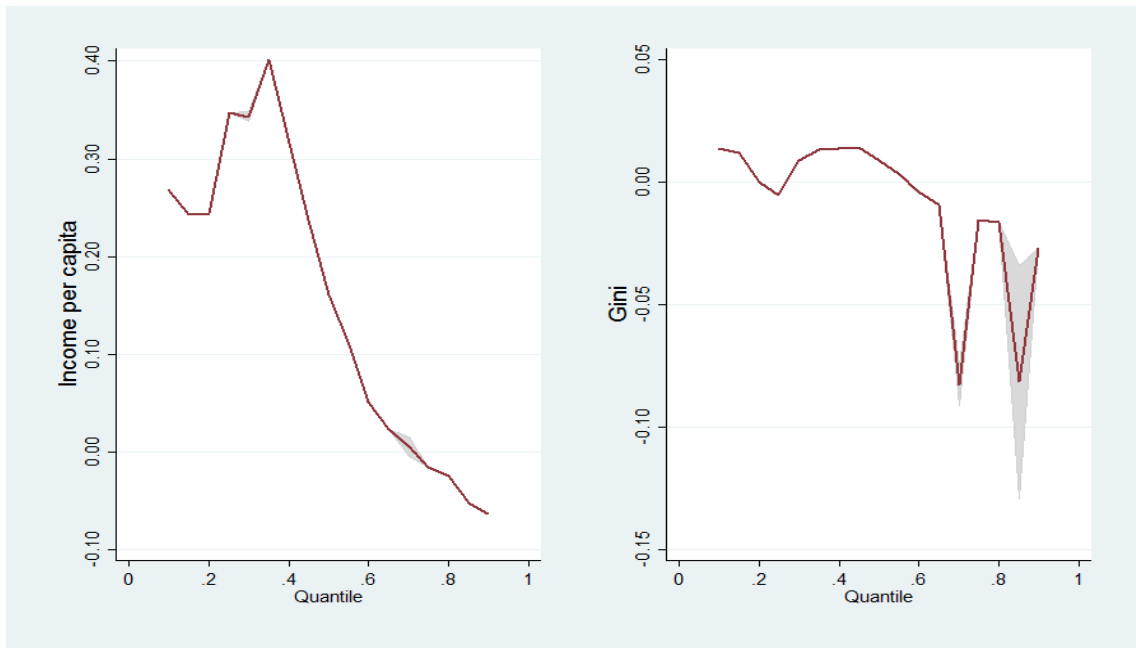
Note: The graph also includes the 95% confidence level.

Fig C.1: Coefficients of income per capita and Gini

Table C.6: Export price distribution and income per capita

	Quantile 0.1	Quantile 0.25	Quantile 0.5	Quantile 0.75	Quantile 0.9
ln ipc	0.268	0.347	0.161	-0.016	-0.063
	(0.0164)***	(0.0002)***	(0.0001)***	(0.0107)	(0.0001)***
ln pop	0.109	0.199	0.220	0.142	0.138
	(0.0097)***	(0.0001)***	(0.0001)***	(0.0063)***	(0.0001)***
ln $dist$	1.671	0.246	-0.929	-0.184	0.602
	(0.145)***	(0.0014)***	(0.0010)***	(0.0947)*	(0.0011)***
ln rem	2.430	1.096	1.056	0.521	-0.002
	(0.292)***	(0.0029)***	(0.0021)***	(0.190)**	(0.0023)
_cons	-83.03	-36.75	-23.06	-12.14	-4.56
	(7.791)***	(0.077)***	(0.055)***	(5.087)*	(0.061)***
N	406,515,124	406,515,124	406,515,124	406,515,124	406,515,124

Standard errors are stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

Table C.7: Export price distribution and Gini coefficient

	Quantile 0.1	Quantile 0.25	Quantile 0.5	Quantile 0.75	Quantile 0.9
Gini	0.014	-0.006	0.009	-0.016	-0.027
	(0.0086)***	(0.0005)***	(0.0001)***	(0.0004)***	(0.0000)***
ln pop	0.150	0.240	0.214	0.168	0.172
	(0.0283)***	(0.0017)***	(0.0004)***	(0.0012)***	(0.0001)***
ln $dist$	2.776	1.796	-0.150	-0.398	0.280
	(0.345)***	(0.0209)***	(0.0044)***	(0.0149)***	(0.0008)***
ln rem	-1.863	-3.702	-2.015	1.846	2.762
	(0.729)**	(0.0441)***	(0.0092)***	(0.0315)***	(0.0017)***
_cons	21.61	76.89	52.23	-45.25	-74.83
	(19.71)***	(1.193)***	(0.249)***	(0.853)***	(0.0466)***
N	406,515,124	406,515,124	406,515,124	406,515,124	406,515,124

Standard errors are stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

Appendix D

Appendix of Chapter 5

D.1   Circulars of VATRs Adjustments

Circulars in 1998 and 1999:

Guo Shui Ming Dian[1998] 004 Hao issued by State Administration of Taxation; Cai Shui Zi [1998] 28 Hao, Cai Shui [1998] 102 Hao and Cai Shui [1998] 107 Hao issued jointly by Ministry of Finance and State Administration of Taxation; Guo Shui Fa [1998] 118 Hao issued by State Administration of Taxation; Cai Shui Ming Dian [1998] 2 Hao issued by Ministry of Finance; Guo Shui Fa [1998] 152 and [1998] 207 issued by State Administration of Taxation; Cai Shui [1999] 17 Hao, Cai Shui [1999] 225 Hao, Cai Shui Zi [1999] 200 Hao, Cai Shui Zi [1999] 227 Hao and Cai Shui Zi [1999] 289 Hao issued jointly by Ministry of Finance and State Administration of Taxation.

Circulars from 2003 to 2007:

Cai Shui [2003] 222 Hao, Cai Shui Ming Dian [2004] 1 Hao, Cai Shui Ming Dian [2004] 2 Hao, Cai Shui Ming Dian [2004] 3 Hao, Cai Shui [2004] 200 Hao, Cai Shui [2004] 201 Hao, Cai Shui [2004] 214 Hao, Cai Shui [2004] 224 Hao, Cai Shui [2005] 51 Hao, Cai Shui [2005] 57 Hao, Cai Shui [2005] 75 Hao, Cai Shui [2005] 93 Hao, Cai Shui [2005] 119 Hao, Cai Shui [2005] 133 Hao, Cai Shui [2005] 184 Hao, Cai Shui [2006] 6 Hao, Cai Shui [2006] 42 Hao, Cai Shui [2006] 139 Hao, Cai Shui [2006] 145 Hao, Cai Shui [2006] 1263 Hao, Cai Shui [2007] 39 Hao, Cai Shui [2007] 64 Hao, Cai Shui [2007] 90 Hao and Cai Shui [2007] 97 Hao jointly issued by Ministry of Finance and State Administration of Taxation for details.

Circulars from 2008 to 2009:

Cai Shui [2008] 111 Hao, Cai Shui [2008] 138 Hao, Cai Shui [2008] 144 Hao, Cai Shui [2008] 177 Hao, Cai Shui [2009] 14 Hao, Cai Shui [2009] 43 Hao and Cai Shui [2009] 88 hao jointly issued by Ministry of Finance and State Administration of Taxation.

D.2 Adjustments Details

Table D.1: Adjustments on Export Tax Rebate in 2005 and 2006

Circular Title	Release at Effective from	Adjustments
Cai Shui [2005] 57 Hao	28/03/2005 01/04/2005	Cancel VATRs of steel primary products (HS code: 7203-,7205,7206-,7207-,7218- and 7224-)
Cai Shui [2005] 75 Hao	29/04/2005 01/05/2005	Reduce VATRs of Coal products, Tungsten, Tin, Zinc, Antimony and their processed products and so on to 8%; Cancel VATRs of fuel wood, Silicon,Rare earth metals, Magnesium,Natural steatite, Natural fluorine minerals and so on
Cai Shui [2005] 119 Hao	21/07/2005 01/08/2005	Cancel VATRs of Manganese, articles thereof, waste or scrap (HS code 81110010)
Cai Shui [2005] 133 Hao	25/08/2005 01/09/2005	Cancel VATRs of Aviation spirit (HS code 27101110 and 27101120) until 31st December 2005
Cai Shui [2005] 184 Hao	23/12/2005 01/01/2006	Reduce VATRs of 25 kind of pesticide, Tungsten, Tin, Zinc, Antimony and their processed products and so on to 5%; Cancel VATRs of raw hides and skins,raw furskins, tar from coal, lignite or peat, other mineral tars and so on
Cai Shui [2006] 42 Hao	21/03/2006 14/03/2006	Cancel VATRs of Aviation spirit (HS code 27101110 and 27101120)
Cai Shui [2006] 139 Hao	14/09/2006 15/09/2006	Cancel VATRs of 25 kind of pesticide, coal, gas, paraffin, silicon, non-ferrous metals, primary wood products and so on; Reduce VATRs of steel products from 11% to 8%; Reduce VATRs of ceramic, cement, glass products and so on from 13% to 11% or 8%; Reduce VATRs of some non-ferrous metal materials from 13% to 11%, 8% or 5%; Reduce VATRs of extiles, furniture, plastics, lighters, a few wood products from 13% to 11%; Reduce VATRs of non-mechanical vehicles and their intermediary inputs from 17% to 13%; Increase VATRs of major technical equipment, bio-pharmaceutical products, some IT products, supported high-tech products and so on from 13% to 17%; Increase VATRs of processed products with agricultural goods from 5% or 11% to 13%

Source: The Taxation Law Database of State Administration of Taxation, http://www.chinatax.gov.cn

Reference

Ahn, J., Khandelwal, A.K., and Wei, S., 2011. "The role of intermediaries in facilitating trade." *Journal of International Economics*, 84(1), pp.73-85.

Arkolakis, C., 2010. "Market penetration costs and the new consumers margin in international trade", *Journal of Political Economy*, 118(6), pp.1151-1199.

Arkolakis, C., Muendler, M., 2010. "The extensive margin of exporting products: A firm-level analysis." *CESifo Working Paper NO. 3309.*

Athukorala, P., 2006. "Trade policy reforms and the structure of protection in Vietnam." *The World Economy*, 29(2), pp.161-87.

Auer, R.A., 2010. "Consumer heterogeneity and the impact of trade liberalization: How representative is the representative agent framework?", *Swiss National Bank Working Paper no. 2010-13.*

Baier, S.L., and Bergstrand, J.H., 2007. "Do free trade agreements actually increase members' international trade?" *Journal of International Economics*, 71(1), pp.72-95.

Baier, S.L., and Bergstrand, J.H., 2009. "Estimating the effects of free trade agreements on international trade flows using matching econometrics." *Journal of International Economics*, 77(1), pp.63-76.

Baier, S.L., Bergstrand, J.H., and Feng. M., 2014. "Economic integration agreements and the margins of international trade." *Journal of International Economics*, 93(2), pp.339-350.

Baldwin, J., and Gu, W., 2009. "The impact of trade on plant scale, production-run length and diversification." *In producer dynamics: New Evidence from micro data (pp. 557-592). University of Chicago Press.*

Baldwin, R., and Harrigan, J., 2011. "Zeros, quality, and space: Trade theory and trade evidence." *American Economic Journal: Microeconomics*, 3(2), pp.60-88.

Bastos, P., and Silva, J., 2010. "The quality of a firm's exports: Where you export to matters." *Journal of International Economics*, 82(2), pp.99-111.

Bekkers, E., Francois, J., and Manchin, M., 2012. "Import prices, income, and inequality", *European Economic Review*, 56(4), 848-869.

Bergstrand, J.H., 1990. "The Heckscher-Ohlin-Samuelson model, the Linder hypothesis and the determinants of bilateral intra-industry trade", *Economic Journal*, 100(403), pp.1216-1129.

Bernard, A.B., Eaton, J., Jensen, J.B., and Kortum, S., 2003. "Plants and productivity in international trade", *American Economic Review*, 93(4), pp.1268-1290.

Bernard, A.B., and Jensen, J.B., 1999. "Exceptional exporter performance: cause, effect, or both?" *Journal of International Economics*, 47(1), pp.1-25.

Bernard, A.B., Redding, S.J., and Schott, P.K., 2006. "Multiproduct firms and trade liberalization." *NBER Working Paper 12782*

Bernard, A.B., Redding, S.J., and Schott, P.K., 2010. "Multiple-product firms and product switching." *American Economic Review,* 100(1), pp.70-79

Bernard, A.B., Redding, S.J. and Schott, P.K., 2011. "Multi-product firms and trade liberalization ", *Quarterly Journal of Economics*, 126(3), pp.1271-1318.

Bils, M., and Klenow, P.J., 2001. "Quantifying quality growth?, *The American Economic Review*, 91(4), pp.1006-1030.

Buono, I., and Lalanne, G., 2012. "The effect of the Uruguay round on the intensive and extensive margins of trade." *Journal of International Economics*, 86(2), pp. 269-283.

Bustos, P., 2011. "Trade liberalization, exports, and technology upgrading: Evidence on the impact of MERCOSUR on Argentinian firms", *American Economic Review*, 101(1), pp.304-340.

Cadot, O., De Melo, J., and Olarreaga, M., 2003. "The protectionist bias of duty drawbacks: Evidence from Mercosur." *Journal of International Economics*, 59(1), pp.161-182.

Chandra, P., and Long, C., 2013. "VAT rebates and export performance in China: Firm-level evidence." *Journal of Public Economics*, 102, pp.13-22.

Chao, C., Chou, W., and Yu, E.SH., 2001. "Export duty rebates and export performance: Theory and China's experience." *Journal of Comparative Economics*, 29(2), pp.314-326.

Chao, C., Yu, E.SH., and Yu, W., 2006. "China's import duty drawback and VAT rebate policies: A general equilibrium analysis." *China Economic Review*, 17 (4), pp.432-448.

Chen, C., Mai, C., and Yu, H., 2006. "The effect of export tax rebates on export performance: Theory and evidence from China." *China Economic Review*, 17(2), pp.226-235.

Choi, Y.C., Hummels, D., and Xiang, C., 2009. "Explaining import quality: the role of the income distribution", *Journal of International Economics* 78(2), pp.265-276.

Cui, Z., 2003. "China's export tax rebate policy." *China: An International Journal*, 1(2), pp.339-349.

Dai, M., Maitra, M., and Yu, M., 2011. "Unexceptional exporter performance in China? The role of processing trade", Available at SSRN1963652.

Das, S., Roberts, M.J., and Tybout, J.R., 2007. "Market entry costs, producer heterogeneity and export dynamics", *Econometrica*, 75(3), pp.837-873.

De Loecker, J., 2007. "Do exports generate higher productivity? Evidence from Slovenia", *Journal of International Economics*, 73(1), 69-98.

Debaere, P., and Mostashari, S., 2010. "Do tariffs matter for the extensive margin of international trade? An empirical analysis." *Journal of International Economics*, 81(2), pp.163-169.

Defever, F., and Riaño, A., 2012. "China's pure exporter subsidies", *CESifo Working Paper Series No. 4054*.

Desai, M.A., and Hines, J., 2005. "Value added taxes and international trade: the evidence." *Unpublished Manuscript*.

Dutt, P., Mihov, I., and Van Zandt, T., 2013. "The effect of WTO on the extensive and the intensive margins of trade." *Journal of international Economics*, 91(2), pp.204-219.

Eaton, J., Kortum, S., and Kramarz, F., 2011. "An anatomy of international trade: Evidence from French firms", *Econometrica*, 79(5), pp.1453-1498.

Eckel, C., Iacovone, L., Javorcik, B., and Neary, J.P., 2015. "Multi-product firms at home and away: Cost-versus quality-based competence." *Journal of International Economics*, 95(2), pp.216-232.

Eckel, C., and Neary, P.J., 2010. "Multi-product firms and flexible manufacturing in the global economy." *Review of Economic Studies,* 77, pp.188-217

Eisenbarth, S., 2014. "Is Chinese trade policy motivated by environmental concerns?" *European Trade Study Group Conference*.

Eppinger, P.S., and Felbermayr, G.J., 2015. "Bilateral trade and similarity of income distributions: The role of second moments", *Economics Letters*, 126, pp.159-162.

Faber, B., and Thibault, F., 2015. "Firm heterogeneity in consumption baskets: Evidence from home and store scanner data", mimo.

Fajgelbaum, P., Grossman, G.M., and Helpman, E., 2011. "Income distribution, product quality, and international trade." *Journal of Political Economy*, 119(4), pp.721-765.

Fan, H., Li, Y.A., and Yeaple, S.R., 2015. "Trade liberalization, quality, and export prices", *Review of Economics and Statistics*, 97(5), pp.1033-1051.

Feenstra, R., and Ma, H., 2007. "Optimal choice of product scope for multiproduct firms under monopolistic competition." *NBER Working Paper 13703*.

Feldstein, M.S., and Krugman, P.R., 1990. "International trade effects of value-added taxation." In *Taxation in the Global Economy*, University of Chicago Press, pp.263-82.

Flach, L., and Janeba E., 2016. "Income inequality and export prices across countries", *Canadian Journal of Economics,* forthcoming.

Flam, H., and Helpman, E., 1987. "Vertical product differentiation and North-South trade", *The American Economic Review*, 77(5), pp.810-822.

Foellmi, R., Hepenstrick, C., and Zweimüller, J., 2010. "Non-homothetic preferences, parallel imports and the extensive margin of international trade", *University of Zurich Institute for Empirical Research in Economics Working Paper 497*.

Garcia-Marin, A., 2014. "Income distribution, quality sorting and trade", *mimo*.

Garred, J., 2015. "Capturing the value chain: The persistence of trade policy in China after WTO accession." *Unpublished*.

Girma, S., Gong, Y., Görg, H., and Yu, Z., 2009. "Can production subsidies explain China's export performance? Evidence from firm-level data." *Scandinavian Journal of Economics*, 111(4), pp.863-891.

Goldberg, P., Khandelwal, A., Pavcnik, N., and Topalova, P., 2010. "Multiproduct firms and product turnover in the developing world: Evidence from India." *The Review of Economics and Statistics,* 92(4), pp.1042-1049

Gorg, H., Halpern, L., and Murakozy, B., 2010. "Why do within firm-product export prices differ across markets",*mimo*.

Gourdon, J., Monjon, S., and Poncet, S., 2014. " Incomplete VAT rebates to exporters: How do they affect China's export performance?" *CEPII Working Paper No.2014-05*.

Gourdon, J., Monjon, S., and Poncet, S., 2015. " Trade policy and industrial policy in China: What motivates public authorities to apply restrictions on exports?" *CEPII Working Paper No.2015-05*.

Hallak, J.C., 2006. "Product quality and the direction of trade." *Journal of International Economics*, 68(1), pp.238-265.

Hallak, J.C., and Schott, P.K., 2011. "Estimating cross-country differences in product quality", *Quarterly Journal of Economics*, 126(1), pp.417-474.

Hummels, D., and Klenow, P.J., 2005. "The variety and quality of a nation's exports." *American Economic Review*, 95(2), pp.704-723.

Iacovone, L., and Javorcik, B.S., 2008. "Multi-product exporters: Diversification and micro-level dynamics." *World Bank Policy Research Working Paper 4723*.

Iacovone, L., and Javorcik, B.S., 2010. "Multi-Product exporters: Product churning, uncertainty and export discoveries." *Economic Journal,* 120(544), pp.481-499;

Ianchovichina, E., 2004. "Trade policy analysis in the presence of duty drawbacks," *Journal of Policy Modeling*, 26(3), pp.353-371.

Jørgensen, J.G., and Schröder, P.J., 2006. "Tariffs and firm-level heterogeneous fixed export costs", *Contributions to Economic Analysis and Policy*, 5(1), pp.1-17.

Jørgensen, J.G., and Schröder, P.J., 2008. "Fixed export cost heterogeneity, trade and welfare", *European Economic Review*, 52(7), pp.1256-1274.

Kasahara, H., and Lapham, B., 2013. "Productivity and the decision to import and export: Theory and evidence", *Journal of International Economics*, 89(2), pp.297-316.

Krautheim, S., 2012. "Heterogeneous firms, exporter networks and the effect of distance on international trade", *Journal of International Economics*, 87(1), pp.27-35.

Latzer, H., and Mayneris, F., 2012. "Income distribution and vertical comparative advantage: Theory and evidence", *Discussion Papers (IRES-Institut de Recherches Economiques et Sociales) 2012018*.

Lileeva, A., and Trefler, D., 2010. "Improved access to foreign markets raises plant-Level productivity... for some plants", *Quarterly Journal of Economics*, 125(3), pp.1051-1099.

Lin, J.Y., and Li, Y., 2003. "Export and economic growth in China: A demand-oriented analysis." *China Economic Quarterly*, 2(4), pp.779-794 (Chinese)

Lu, D., 2010. "Exceptional exporter performance? Evidence from Chinese manufacturing firms", *Manuscript*, University of Chicago.

Lu, J., Lu, Y., and Tao, Z., 2014. "Pure exporter: theory and evidence from China", *The World Economy*, 37(9), pp.1219-1236.

Lu, Y, Tao, Z., and Zhang, Y., 2013. "How do exporters respond to antidumping investigations?." *Journal of International Economics*, 91(2), pp.290-300.

Ma, Y., Tang, H., and Zhang, y., 2014. "Factor intensity, product switching, and productivity: Evidence from Chinese exporters", *Journal of International Economics*, 92(2), pp.349-362.

Mah, J.S., 2007. "The effect of duty drawback on export promotion: The case of Korea." *Journal of Asian Economics*, 18(6), pp.967-973.

Manova, K., and Yu, Z., 2016. "How firms export: Processing vs. ordinary trade with financial frictions" *Journal of International economics*, forthcoming.

Manova, K., and Zhang, Z., 2009. "China's exporters and importers: firms, products and trade partners." *NBER Working Paper w15249*.

Manova, K., and Zhang, Z., 2012. "Export prices across firms and destinations." *Quarterly Journal of Economics*, 127(1), pp.379-436.

Matsuyama, K., 2000. "A Ricardian model with a continuum of goods under nonhomothetic preferences: Demand complementaries, income distribution, and North-South trade",*Journal of Political Economy*, 108(6), pp.1093-1120.

Mayer, T., Melitz, M.J., and Ottaviano, G.IP., 2014. "Market size, competition, and the product mix of exporters", *American Economic Review*, 104(2), pp.495-536.

McFadden, D., 1978. "Modelling the choice of residential location", *Institute of Transportation Studies* University of California.

Melitz, M.J., 2003. "The impact of trade on intra-industry reallocations and aggregate industry productivity", *Econometrica*, 71(6), pp.1695-1725.

Melitz, Ma.J., and Ottaviano, G.IP., 2008. "Market size, trade, and productivity", *Review of Economic Studies*, 75(1), pp.295-316.

Mitra, D., and Trindade, V., 2005. "Inequality and trade", *Canadian Journal of Economics*, 38(4), pp.1253-1271.

Nocke, V., and Yeaple, S., 2006. "Globalization and endogenous firm scope." *NBER Working Paper 12322*

Nocke, V., and Yeaple, S., 2008. "Globalization and the size distribution of multiproduct firms." *CEPR Discussion Paper No. DP6948*

Panagariya, A., 1992. "Input tariffs, duty drawbacks, and tariff reforms." *Journal of International Economics*, 32(1), pp.131-147.

Pavcnik, N., 2002. "Trade liberalization, exit, and productivity improvements: Evidence from Chilean plants", *Review of Economic Studies*, 69(1), pp.245-276.

Poncet, S., Steingress, W. and Vandenbussche, H., 2010. "Financial constraints in China: firm-level evidence", *China Economic Review*, 21(3), pp.411-422.

Powell, D., 2014. "Quantile regression with nonadditive fixed effects", *mimo*.

Pula, G. and Santabárbara, D., 2012. "Is China climbing up the quality ladder?", *BOFIT Discussion Papers 23*.

Rodrik, D., 2006. "What's so special about China's exports?." *China & World Economy*, 14(5), pp.1-19.

Schmitt, N., and Yu, Z., 2001. "Economics of scale and the volume of intra-industry trade", *Economics Letters*, 74(1), pp.127-32.

Schott, P.K., 2004. "Across-product versus within-product specialization in international trade", *Quarterly Journal of Economics*, 119(2), pp.647-678.

Schott, P.K., 2008. "The relative sophistication of Chinese exports", *Economic policy*, 23(53), pp.6-49.

Shaked, A., and Sutton, J., 1982. "Relaxing price competition through product differentiation", *Review of Economic Studies*, 49(1), pp.3-14.

Stokey, N.L., 1991. "The volume and composition of trade between rich and poor countries", *Review of Economic Studies*, 58 (1), pp.63-80.

Trefler, D., 2004. "The long and short of the Canada-U.S. free trade agreement", *American Economic Review*, 94(4), pp.870-95.

Upward, R., Wang Z., and Zheng, J., 2013. "Weighing China's export basket: The domestic content and technology intensity of Chinese exports." *Journal of Comparative Economics*, 41(2), pp.527-543.

Verhoogen, E.A., 2008. "Trade, quality upgrading, and wage inequality in the Mexican manufacturing sector", *Quarterly Journal of Economics*, 123(2), pp.489-530.

Wang, Z., and Yu, Z., 2012. "Trading partners, traded products, and firm performance: Evidence from China's exporter-importers." *The World Economy*, 35(12), pp.1795-1824.

Young, A., 2000. "The Razor's edge: Distortions and incremental reform in the People's Republic of China", *Quarterly Journal of Economics*, 115(4), pp.1091-1135.