THE EFFECT OF CHINA'S EXPORT VAT REBATE ON INTERMEDIATE INPUT IMPORTS

by

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ABSTRACT

This dissertation studies empirically and theoretically the effects of China's export value-added tax (VAT) policy on its firm-level and aggregate exports and imports. Between 2004 and 2007, China sharply reduced the export VAT rebate given to exporters, raising the effective export VAT rate by about six percentage points. In the empirical chapter, using firm-product-level data, I assess the effects on the intensive and extensive margins of firm-product-level imports. I find that a higher export VAT significantly decreases big firms' extensive and intensive margins of imports. In addition, I document that most of the change in import growth at the aggregate level occurred at the extensive margin. In the theoretical chapter, to better understand the findings from the empirical part, as well as examine the welfare consequences, I develop a multi-country heterogeneous-firm model of imported input sourcing and exporting. In the model, monopolistically competitive firms choose their export destinations, as well as their import sources, with both subject to variable and fixed costs. To validate my model, I conduct a simulation of a higher export VAT. I find that the results for imports and exports at the firm-level and in the aggregate are consistent with my empirical findings.

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Chapter 1

Introduction

China's manufacturing firms have significantly increased their international market shares during the last four decades, and China has emerged as the world's largest exporter and the second-largest importer. Surprisingly, unlike China's persistent growth in global trade share, its export and import shares of GDP declined after joining the World Trade Organization (WTO). Figure 1.1 depicts China's export and import shares of GDP from 1994 to 2018. As the figure shows, the import share of GDP peaked at 28.4% in 2004 and subsequently declined to 15.7% by 2018. Similarly, the export share of GDP peaked at 36% in 2006 and declined to 18.3% by 2018. For China, the vast majority of imports was from imported intermediate goods,[1] so this downturn reflected a growth decline in the demand of imported inputs for Chinese production.[2] Given the important role of intermediate input imports in explaining economic growth in developing countries, investigating the decline in the import share of GDP is important in understanding the evolution of China's economy in the future.

At the time when China's import share of GDP started to decline, the Chinese government cut the VAT rebate rate for exporters and raised China's average effective export VAT rate from 3% to 9%.[3] The export VAT clearly affected firm-level incentives to export, with consequences, as well, for their inputs, including imported inputs. To what extent

[1]Using BEC codes to classify imports shows that more than 75% of China's imports are intermediate inputs during the period 2000–2009.

[2]More details of trade shares of GDP can be found in Appendix A.1.

[3]Details of the time variation in the export VAT are documented in the next section.

did changes in the export VAT rate shape the growth change in imported inputs? What were the welfare consequences of the export VAT rebate rate change? Little research has been done to answer these questions. This dissertation will investigate the effects of the change in export VAT as well as quantify its welfare implications.

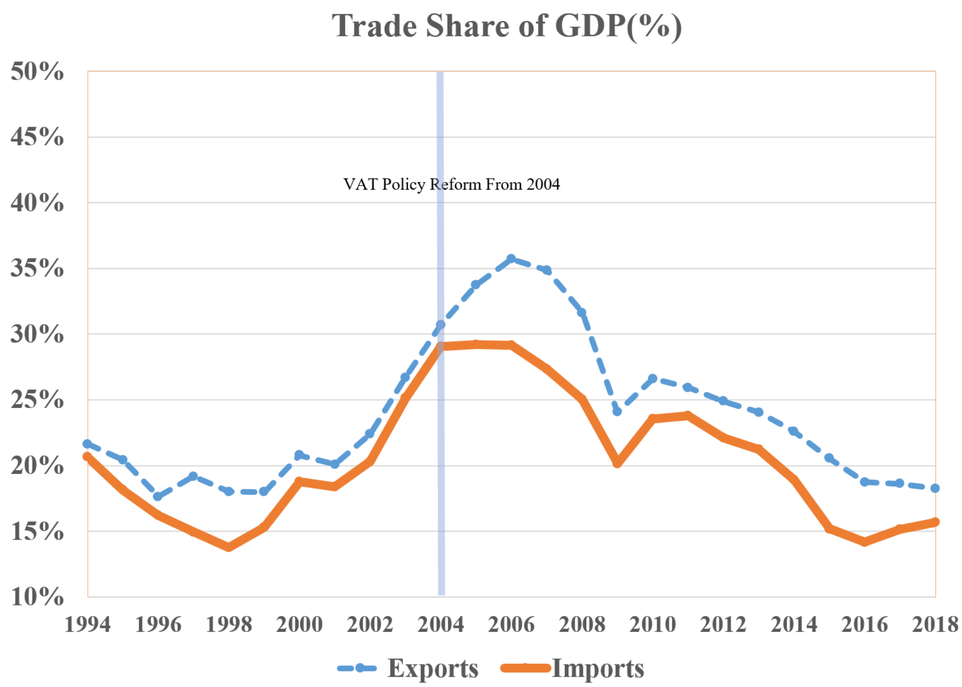
In this dissertation, I study empirically and theoretically the effects of the change in China's export VAT policy for its exporters on its imported inputs. I make two empirical contributions. First, I decompose the growth in imports and document the contributions from the extensive and intensive margins. The results point to the importance of the extensive margin in understanding the change in China's imported inputs. Second, I estimate the effects of the export VAT on firm-product-level imports and show that the export VAT is strongly associated with the change in such imports. Motivated by these empirical findings and the insights from previous research,[4] I extend the model of Antras, Fort, and Tintelnot (2017) to allow for trade in final goods and to allow for a VAT and an export VAT rebate. The model has a wedge between the domestic VAT and export VAT, and it implies an interdependence between exporting and imported input sources. These features allow me to quantify the effects of the change in the export VAT on firms' import decisions through joint import and export decisions. Then I conduct some numerical exercises to validate my model with these new features by comparing them with China's trade facts.

In the empirical part, using the increasingly available trade and production data of China, I look at the change in import growth and estimate the effects of the export VAT at a more disaggregated level. I first investigate how the growth of imported inputs changed from 2000 to 2009. I document two facts about the time variation in aggregated imports. First, the extensive margin of product and location choices contributed to most of the change in import growth during the period 2000–2009. By decomposing import growth into the intensive margin and the extensive margins, I find that the extensive

[4]See Romer (1994); Melitz (2003); Bernard, Jensen, Redding, and Schott (2009).

[4]Calculated based on "*China Trade and External Economic Statistical Yearbook*."

Figure 1.1: China's Trade Share of GDP,1994–2018



margin contributed to 86% of China's import growth. In addition, I did another the decomposition to confirm that the extensive margin was also the main source of the change in the imported input share in total inputs over time. These two facts show the importance of the extensive margin in explaining the patterns in imported inputs and input intensity in the years before and after 2004.

After documenting the importance of the extensive margin in explaining import growth, I estimate the effect of the change in China's export VAT on its manufacturing imported inputs.[5] I estimate the average impact of the export VAT on firm-product-level imports using a double-log regression with fixed effects. I use a non-parametric selection model to control for selection effects. The estimation results confirm the significant impact of the export VAT on imports. For large firms, whose imports are more than 70% of the total sample, the impact of the export VAT is significantly negative.

[5] Gourdon, Hering, Monjon, and Poncet (2020) find that the export VAT contributes to the decline in exports. By using more aggregated data. I estimate the effects of the export VAT on firms' exports of specific products.

To test the impact of the export VAT on firms' extensive margin, I estimate the impact of the export VAT on the number of export destinations and import sources. For both, the export VAT has a significant impact on large firms.

For the theoretical part, motivated by the empirical findings, I develop a heterogeneous multi-country model to study the effect of the export VAT on firm-level and aggregate exports and imports. The model allows firms to select into export destinations and import sources simultaneously before they start producing. Hence, a firm's global trade strategy includes the choices of both export destinations and import sources.[6] After firms choose their trade strategy, they produce final goods by using both labor and imported inputs from countries included in their outsourcing countries (including the home country). Then, firms export to their destinations, and they pay the export VAT on their value added. By showing the duality that firms' optimal location choices in equilibrium can be solved by solving a sequence of minimum productivity requirements for entry, I solve the equilibrium in Antras et al. (2017) through dynamic programming.

I conduct a numerical exercise with a three-country version of the model in which one country has an increase in the export VAT. The exercise yields three main results: First, when the export VAT changes, the distribution of firms' outsourcing and export decisions will change. The distribution change is caused by the direct effect of the change in the export VAT, as well as general equilibrium effects on the wage. The direct effect leads exporters to select less often into exporting and outsourcing on both the intensive and extensive margins. The general equilibrium effect of the real wage leads to be easier for non-exporters to stay in the market and outsource more because exporters now make less profit. Second, at the aggregate level, I find that exports and imports both fall, but exports fall by more. They both fall because an increase in the export VAT means that fewer entrants will choose to enter the market. Exports fall by more than imports

[6] In Antras et al. (2017), they call the location choices of intermediate inputs as outsourcing, I use the term *trade strategy* to refer to the joint location choices for exporting and importing.

because a higher export VAT favors firms that do not export. Hence, they expand and import more inputs. This effect partially offsets the reduction in imports by the exporters. Finally, an increase in the export VAT leads to a welfare loss, not only because few firms stay in the market and productive exporters produce less, but also because exporters now face a higher marginal cost of intermediate inputs as they outsource fewer inputs from the international market.

Related Literature This dissertation relates to several areas of research. First, it contributes to a growing literature on the trade performance of Chinese manufacturing firms. Kee and Tang (2016) analyze the increase in domestic value added to Chinese company exports, demonstrating that a domestic price decline caused domestic material substitution for imported goods. In my paper, I emphasize the effects of a policy change in exports on firms' demand for imported inputs through the link between firms' import and export decisions. Ma (2006) shows the spillover effects of foreign countries' export activities on Chinese exporters' export location choices. Based on their empirical results, my model applies the idea that firms will jointly select into export destinations. Amiti, Dai, Feenstra, and Romalis (2020) document the contribution of China's export growth. My paper documents the main contribution of the extensive margins to China's import growth change as well as its import intensity change. These results improve our understanding of the change in China's import growth.

Second, this dissertation contributes to the literature on the effects of trade policy and trade costs. Previous researchers have shown that lower input tariffs increase total firm productivity (Amiti & Konings, 2007; Goldberg, Khandelwal, Pavcnik, & Topalova, 2010; Yu, 2015; Dai, Maitra, & Yu, 2016). Khandelwal, Schott, and Wei (2013) focus on the effects of changing specific quotas. Johnson and Noguera (2012) assert that the Chinese VAT rebate system typified a primary industrial policy affecting its exports. Manova and Yu (2016) illuminate how financial frictions affected institutional export performance across processing and ordinary trade treatments. Gourdon et al. (2020) estimates the impact of the export VAT on China's city-product level exports. They show the negative impact of the export VAT on China's exports. Unlike these researchers, I emphasize the effects of the export VAT on firms' imported inputs through the linkage between exports and imports. Garred (2018) shows the persistence of China's trade policy after China joined the WTO. I use his export VAT data matched with micro-level production and trade data to analyze the impact of the export VAT on firms' decisions. Wang (2020) investigates the impact of corporation taxation on multinational firms' export performance. My model shows the impact of the export decision on the import decision.

Finally, this dissertation contributes to the literature in analyzing firms' trade performance by connecting imported inputs with exports. Blaum et al. (2018) shows that through the link between firms' import and export decisions, devaluation will lead exporters, who are also import-intense firms, to expand their market share so that the aggregate import intensity increases as well. Similar to his idea, my paper shows that an increase in the export VAT discouraged firms' import on both the intensive and extensive margins. Previous researchers, for example, Amiti, Itskhoki, and Konings (2014), highlight the effect of the intermediate input price on exporter pricing decisions, linking imports and exports. Other research looks at the relationship between intermediate input imports and exports from imports to exports. Bas (2012); Feng, Li, and Swenson (2016) look at the TFP increase caused by importing intermediate inputs and its impact on the export decision. I focus on the relationship between firms' export and import decisions, especially the joint decisions of exporting and outsourcing locations. My model is built on Antras et al. (2017), extending it by including a joint exporting and importing strategy with discrete location choices. In this model, the endogenous choices of both export destinations and outsourcing sources allow export decisions to directly affect firms' extensive margins of outsourcing.[7]

Road Map The rest of the dissertation is structured as follows. In chapter 2, I introduce China's VAT system, the change in China's export VAT rebate policy, and the two different trade regimes which are undertaking different tariff treatments. In chapter 3, I will show the main empirical findings. I first describe the data I used, then decompose China's time variation of imports and import intensity. In the third section of chapter 3, I empirically analyze the impact of the export VAT on Chinese company imports. In the end of chapter 3, I will conclude my empirical findings. In chapter 4, I first present the framework of my model. Then I will do an numeric exercise and discuss the numeric exercise results. At the end of this chapter, I will conclude the main implications of my model.

[7]To solve this optimal discrete choice problem, see also (Jia, 2008; Arkolakis & Eckert, 2017; Hu & Shi, 2019).

Chapter 2

Background of China's Trade Policy

This chapter briefly introduces China's VAT system, explains and illustrates how the VAT payable is calculated and finally documents the history of the export VAT rebate rate change from 2003 to 2007. Finally, as two important trade treatments in understanding China's trade facts, processing trade and ordinary trade are very different. I will introduce them in the final part of this chapter.

2.1 China's VAT and Export VAT Rebate

China's system of export VAT rebates is considered an important instrument of China's industrial policy in influencing its trade performance. As one of the indirect taxes, it has been China's most important source of tax revenue. Before 2018, the VAT rate is 17% for non-agricultural products (13% for agricultural products). This standard VAT rate applies to most manufacturing firms and is levied on domestic sales, imported goods, and on repair, replacement, and processing services. Furthermore, it exhibits very little variation during the time period I am interested in. The export VAT rebate rates, however, changed a lot during this period and the change in these rebate rates generated most of the variation of effective export VAT change. Three treatments are available for the export VAT rebate (Chan, 2008) : tax-exempt, pay first and refund later, and exempt offset rebate.

Tax-exempt treatment. A small subset of products are classified as being exempt from taxes, which means that they pay no output VAT on exports, but their input VAT is not reimbursed.

Pay first and refund later treatment. The pay-first-and-refund-later method is used in export refunds for commercial enterprises. In that connection, firms pay VAT on export sales first and apply for a VAT refund later.

Exempt-offset-rebate treatment. This payment method is similar to pay first and refund later treatment while it is widely used in all production-type enterprises. The difference is that commercial firms use purchase for exports to calculate the VAT rebate while production enterprises use input VAT to calculate the VAT rebate part. In this paper, I focus on the impact of VAT on manufacturing firms, so my following analysis will focus on this treatment.

The official formula to calculate VAT is as follows:

$$\begin{aligned}\text{VAT} \quad \text{Payable} = & \underbrace{\text{Domestic Sales} * \text{VAT Rate}}_{\text{Output VAT}} \\ & - \underbrace{\text{All Inputs} * \text{VAT Rate}}_{\text{Input VAT Withholdings}} \\ & + \underbrace{(\text{Exports} - \text{Duty-Free Imports}) * (\text{VAT} - \text{VAT Rebate})}_{\text{Export VAT}}.\end{aligned} \tag{2.1}$$

The output VAT is collected on domestic sales, and the input VAT is the VAT paid on inputs subject to the VAT. The input VAT applies to all inputs, whether they are domestically sourced or imported. One exception is the bonded duty-free imported inputs (for commercial firms, the input VAT is the VAT paid on the purchases for exporting.). The export VAT, strictly speaking, is a kind of disallowed credit, which is the amount of the input VAT that is neither exempted from the VAT nor credited against the output VAT. The disallowed credit should be deducted from the input VAT paid on the locally purchased materials for the current period. If exports are fully rebated for VAT, VAT = VAT rebate, and there is no VAT burden from exports. However, unlike many other countries, China does not fully rebate the VAT for exports, and rebate rates are adjusted in response to concerns about countries' export levels. The rebate rate has seven levels which are 17%, 15%, 13%, 11%, 9%, 5%, and 0 before 2018.

2.2 Illustration of VAT and Export VAT

The following example illustrates how the VAT works and how the partial rebated export VAT works with a rebate rate change.

Suppose there is a bicycle producer. The standard VAT rate is 17% and VAT rebate rate is 17% (fully rebated).

How VAT Works. This producer sells goods only in the domestic market, and the pre-VAT cost of the bicycle is as follows:

$$\underbrace{\$217}_{\text{Total Cost}} = \underbrace{\$100}_{\text{Total Wage}} + \underbrace{\$117}_{\text{Input Purchase}}.$$

Here, the value added part is from labor, so the VAT is

$$\$100 \times 17\% = \$17.$$

The bicycle producer sells a bicycle at

$$\text{After-VAT Price} = \underbrace{\$217}_{Cost} + \underbrace{\$17}_{VAT} = \$234.$$

In practice, based on equation (2.1), we have

$$\text{Output VAT} = \underbrace{\$234}_{\text{Domestic sales}} \times \frac{\%17}{1+\%17} = \$34.$$

The value of the input purchase is measured at the *after-tax* price, and it includes domestic inputs or imported inputs (I assume that no input is bonded duty-free). Now we have

$$\text{Input VAT} = \$117 \times \frac{\%17}{1+\%17} = \$17,$$

$$\text{Export VAT} = 0 \times (17\% - 17\%)/(1+17\%) = 0,$$

$$\begin{aligned}\text{VAT payable} &= \text{Output VAT} - \text{Input VAT} \; + \text{Export VAT} \\ &= \$34 - \$17 + \$0 \\ &= \underbrace{\$100}_{wage} \times \%17.\end{aligned}$$

Here, the wage payment equals the value added, and only the value added part is taxed.

Exports with Different Levels of Rebate. Now, I suppose this bicycle firm only exports (holding the value of sales fixed, so domestic sales are 0), and the export VAT rebate rate varies from 17% to 5%. Table 2.1 shows the implications of different levels

Table 2.1: VAT with Different Levels of Rebate for Exporters

	Export VAT	VAT Payable
VAT rebate rate 17%	$\$\ 234 \times \frac{17\%-17\%}{1+17\%} = \$0$	$\$0\text{-}\$\ 117 \times \frac{17\%}{1+\%17} + \text{Export VAT} = -\$17$
VAT rebate rate 5%	$\$\ 234 \times \frac{17\%-5\%}{1+17\%} = \$24$	$\$0\text{-}\$117 \times \frac{17\%}{1+\%17} + \text{Export VAT} = \$7$

Notes: The VAT rebate in column (1) refers to the export VAT rebate rate, for local inputs, the rebate rate is always 17%.

of VAT rebates for exporters. If the VAT payable is negative, it means a debit balance. If the VAT payable is positive, it means a VAT liability.

2.3 History of VAT Policy Change, 2000–2007

This section gives a brief introduction of the change in China's export VAT from 2000 to 2007. This time period is what I am focusing on to investigate the potential relationship between the export VAT reform and the decline in China's import share. After joining the WTO, China's high growth rate in exports led the export VAT rebate to become an excessive fiscal obligation for its central government. With the goal of also accelerating the structural transformation of its economy, China started from a reform of the VAT and reduced rebates for exports until the global crisis hit.[1] This section describes the timeline of the export VAT rate change from 2004 to 2007 based on a report from the U.S. International Trade Commission.[2]

In October 2003, the State Council issued the "Decision to Reform the Existing Regime of Tax Rebate for Exports," effective on 1 January 2004. For many goods, the tax rebate rate lowered by 4% to 6%.[3]

In September 2006, China canceled the VAT export rebate for certain nonmetallic products, metallic ceramics, certain pesticides, leather, certain batteries, and other miscellaneous products; and reduced the export VAT rebate rates on a number of metallic, ceramic, and other products.

In April 2007, China canceled the VAT export rebate for 83 steel products, reduced the rebate rate to 5% for 76 other steel products.

In June 2007, China undertook measures covering 2,831 specific commodities. These measures included (1) eliminated the export VAT rebate for 553 "high energy consuming, high polluting, and scarce resource-consuming" products, and (2) reducing the VAT export refund rate by 2% to 8% for 2,268 products that might potentially be involved in

[1] When the global financial crisis happened, China increased part of its export rebate rate. But on average, the level of export VAT is never as low as the level before 2004.

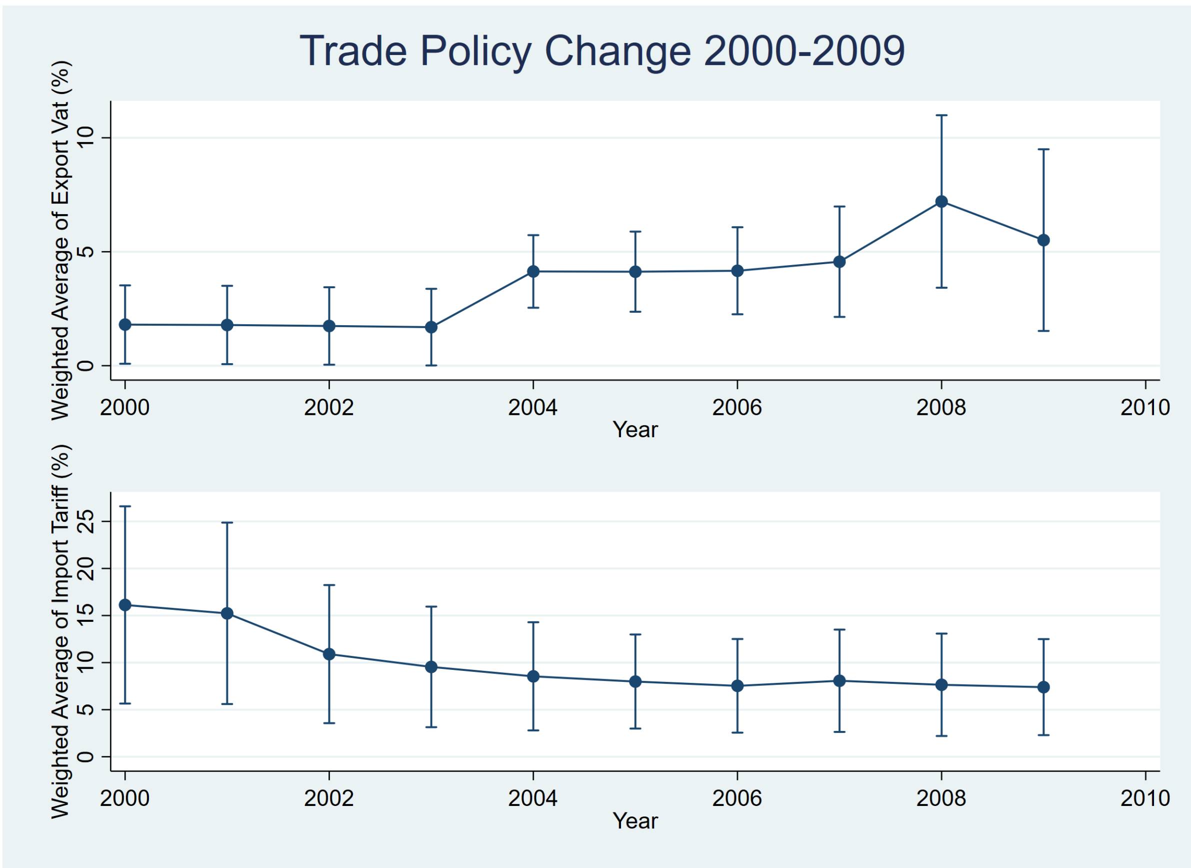
[2] See *China: Description of Selected Government Practices and Policies Affecting Decision-making in the Economy.*

[3] The decision of tax rebate reform can be found at http://www.chinatax.gov.cn (in Chinese).

trade disputes.

The change in the weighted average effective export VAT is shown in Figure 2.1. Here I also document the time trend of tariffs. The tariff policy was stable during the period 2002–2009 after China entered into the WTO.

Figure 2.1: Average Tariff and VAT of Manufacturing Firms 2000-2009



2.4 China's Two Main Trade Regimes

In China, two different trade treatments (processing trade and ordinary trade) also have significant impacts on firms' trade performance. Ordinary trade is the regular trade treatment that firms pay tariffs for importing and use their imports for whatever they want. Processing trade allows firms to purchase imported inputs with a tariff exemption. The differences between these two treatments play an important role in understanding China's trade facts, so I will distinguish these two trade treatments in my empirical work of estimation in the next chapter. This section provides a simple introduction of processing trade.

To engage in processing trade, firms need to be certified to contract with foreign companies. Once firms engage in a contract with a foreign company, the Chinese party pays for domestic inputs and labor and customizes the product to the foreign buyers. Processing firms and non-processing firms have two fundamental differences. First, processing firms have the advantage of the customs tariff. Second, firms are required to export all their production to the foreign market. Even though the treatments of tariffs are very different between processing trade and ordinary trade, their export VAT policy is similar. [4]

Each firm may legally undertake both ordinary and processing trade, in which case each of its import and export transactions is recorded and treated separately according to its specified trade treatments. According to Dai et al. (2016), those firms who are involved only in processing trade have lower wages, sales, profitability, R&D investment, and skill intensity relative to firms who are involved in both ordinary and processing trade.

Before 1996, processing trade grew rapidly and accounted for more than 55% of the share of exports during the period 1996-2004. After 2004, the share declined and was 32% by 2017. [5]

[4] One exception is processing with assembling, where a tax-exempt treatment is applied. From 2000 to 2009, the share of processing assembling in the processing trade is about 17%.

[5] Before 2008, the data source is *Statistical Yearbook of China*, and after 2008, it is from the website of custom information:http://www.haiguan.info/(in Chinese).

Chapter 3

Empirical Investigation on the Impacts of Export VAT on Firms' Imports

This chapter uses micro-level Chinese trade data to provide a broad overview of how the margins of trade contribute to variation in China's imports and to investigate the behavior of firms in response to the change in the export VAT. Section 3.1 describes the data sets I used in my analysis. Section 3.2 explains the key facts that motivate my specification. Section 3.3 demonstrates the importance of firms decisions regarding entry and product choices in contributing to the growth of firms' imports. Section 3.4 suggests a specification for estimating the impact of the export VAT on firms' imports decisions through different trade treatments across different firm sizes.

3.1 Data Description

The main database I use are the Annual Survey of China's Industrial Firms (ASIF) and transaction-level custom data of Chinese firms (2000–2009). I also use the trade policy data from Garred (2018). By matching these three data sets, I am able to use the matched sample to estimate the impact of the export VAT on firms' imported inputs.

3.1.1 Product-Level Customs Data

The disaggregated product-level trade transaction data are obtained from China's General Administration of Customs. The data record a firm's product trade flow to a specific country at the product level. The original data are recorded monthly based on an eight-digit HS code, and I aggregate these records to generate an annual six-digit HS code data set.

3.1.2 Firm-Level Production Data

The customs data do not include information about firms' ownership types,firm size, and so on. A widely used approach for obtaining information that supports analyzing customs data is by matching customs data set with firm-level production data. For production data, research highly depends on the annual Census of China's Manufacturing Firms. Following Cai and Liu (2009) and Yu (2015), I cleaned the ASIF by dropping all firms that satisfy the following conditions.[1]

(1) Key variables such as gross output, employment, and fixed assets are not positive.

(2) Employment is less than 8.

(3) The opening month is not between 1 to 12.

3.1.3 Trade Policy Data

I use data from Jason Garred as the trade policy data.[2] This data source includes reliable export VAT data after 2002, so I use its export VAT and tariff data from 2002 to 2009 to match with ASIF and customs data. In his website, Garred also provides the

[1]After 2007, many pieces of key information, such as intermediate inputs and value-added, are no longer reported in the ASIF. Therefore, I do not use these variables to clean the data.

[2]See his website: http://web5.uottawa.ca/www5/jasongarred/index.html

trade policy data from 1994 to 2001, generated by interpolation. Since data from this period are not as reliable as those from the period after 2002, I use only part of them (2000–2001) when I illustrate the aggregate-level trends (see Figure 2.1).

3.2 Time Trends of Firms' Import Behavior in Matched Sample

In this section, I use the matched sample to check Chinese manufacturing firms' import behavior.[3] This section reports some firm-level trends in firms' import behavior to compare with the declining relative importance of imports for Chinese production at the aggregate level as described in the introduction. Here, I use firm size to capture the heterogeneity of firms' productivity and to check the time trends across different levels of firm size. The measure of firm size depends on whether a firm hires more than 300 people in the initial year. In Figure 3.1, we can see that Chinese importers' import intensity declined across different firm sizes over the period from 2000 to 2009. The ratio of imports to gross output declined before 2004 when the aggregate level import share of GDP declined.[4]

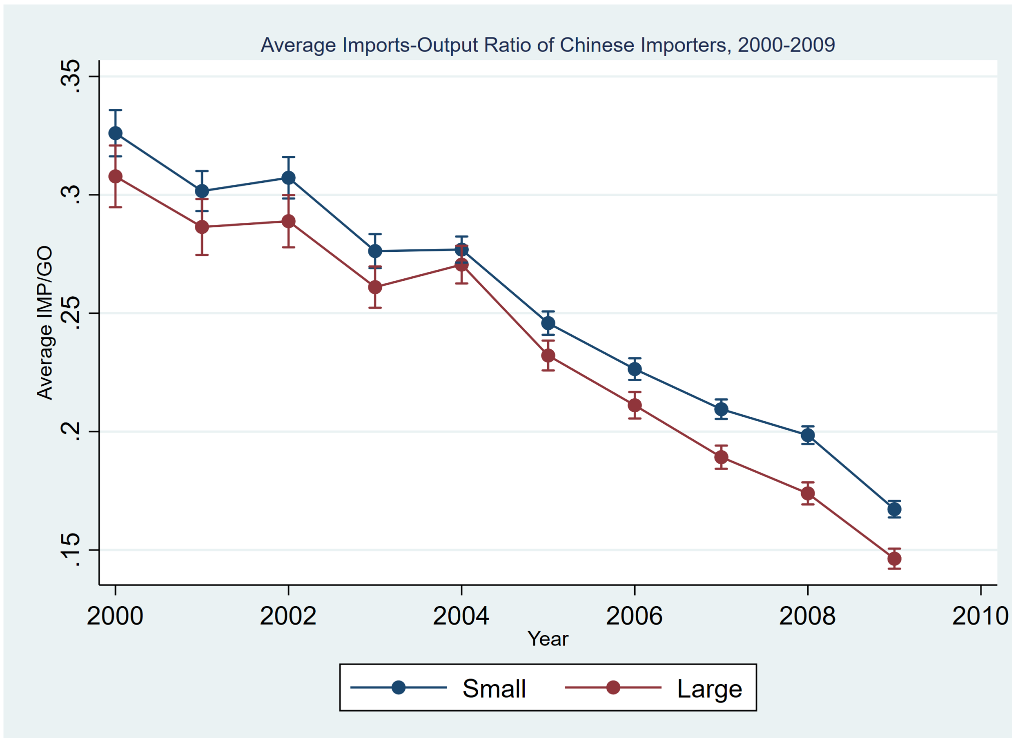
Vertical specialization is an important characteristic of China's trade, which makes the location choices and number of countries from which to outsource to be very important in understanding Chinese firms' import performance. The micro-level data provide an opportunity to check this time trend during the period I am interested in. Figure 3.2 depicts the number of countries across different firm sizes. The extensive margin in the number of importing countries from Figure 3.2 shows the trends across firm sizes over the period 2000–2009. For small firms, it continued declining after China joined

[3]The matching technique follows Yu (2015) who uses firm name and phone number and zip code to match up ASIF data set and customs data. More results of the matched sample are shown in Appendix B.1.

[4]I trim 0.5% of top and bottom outliers of the results within each year.

the WTO. For large firms, they experienced a slight growth of extensive margin before 2004, and then the growth rate declined immediately after 2004.[5]

Figure 3.1: Importers' Average Imports-Output Ratio in Matched Sample, 2000-2009



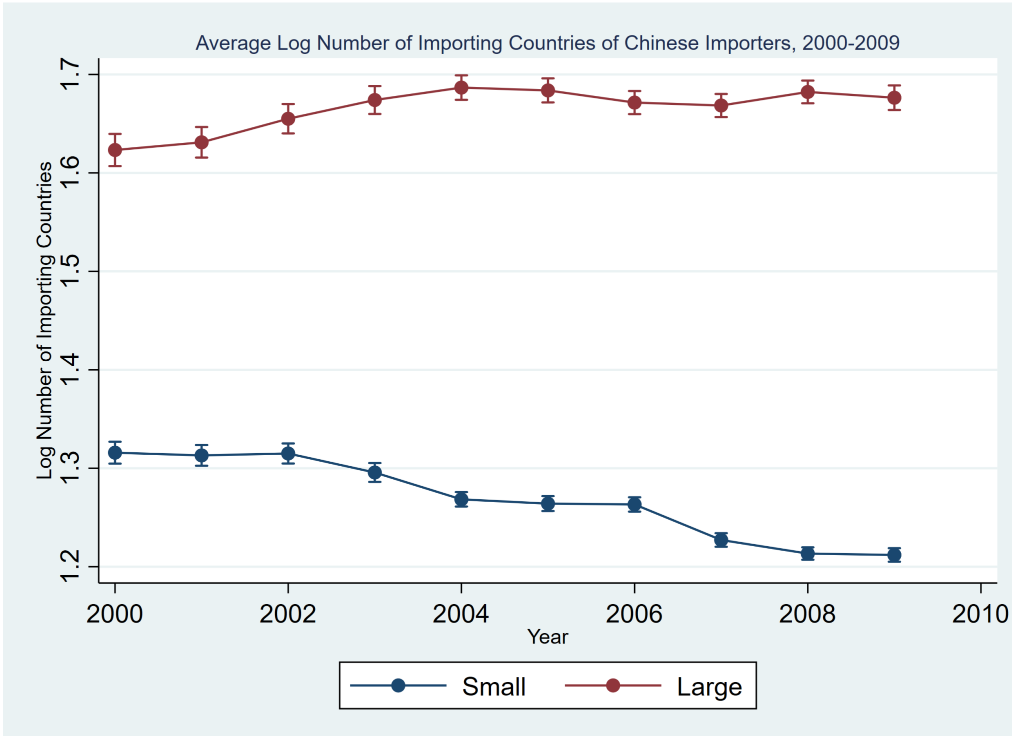
Notes: Output is measured by gross output. The bar at each point describes the 95% confidence interval.

3.3 Growth Decomposition

In this section, I first decompose imports growth at the *firm-country-product* level. As mentioned in the introduction, during the period 2000–2009, the main decline in the imports share of GDP was caused by the decline in imports growth, and imported intermediate inputs contributed to around 75% of total imports. Because most imports are imported inputs and their share of total imports is stable, I decompose the growth of imports instead of the growth of imported inputs to show the contribution of each margin to China's imported inputs variation. Then, to further confirm a decline in the

[5]The trends of exports are shown in Appendix B.1

Figure 3.2: Importers' Number of Importing Countries in Matched Sample, 2000-2009



Notes: The number of importing countries is constructed by the reported number+1. The bar at each point describes the 95% confidence interval.

importance of imported inputs in China's economy, I decompose the firm-level decline in import intensity.[6]

3.3.1 Time-Series Variation in Imports Growth

To analyze the change in imports, I construct a decomposition similar to Bernard et al. (2009). I want to test the contribution of firms' entry decisions of a specific product on the time variation of imports, so I change the decomposition by decomposing the growth into switching across the firm-product-country level. To simplify the notation, I index a country-product pair as a specific product. Here, since I only need the firms' information about trade, I use the full sample of customs data instead of the matched sample to do the decomposition. The aggregate change in China's imports based on customs data

[6]The conclusion will not change if I use BEC-classified intermediate goods to analyze; results can be found in Appendix B.2.

Δx_t between the beginning year $t = 0$ and the ending year $t = 1$ can be decomposed into three parts: The first part is the change due to net entry of importers which is the new importers in period 1 minus the old importers only imported in period 0. Second, for these importers that exist in both period 0 and 1, I note their switching from importing old products to importing new products. The third part is the change in imports for existing products for existing firms. Equation (3.1) depicts the formula of decomposition. Except for the overall time period 2000–2009 based on my data set, I also split the overall time period into two periods 2000–2004 and 2004–2009, because of the reform of the export VAT rebate rate started from 2004 (see Figure 2.1.).

$$\frac{1}{\Delta x_t}\Delta x_t = \frac{1}{\Delta x_t}\left\{\underbrace{\sum_{f\in\Omega_t} x_{ft} - \sum_{f\in\Omega_0} x_{ft}}_{\text{Net Entry}} + \underbrace{\sum_{f\in\Omega_c}\left(\sum_{p\in\omega_t} x_{fpt} - \sum_{p\in\omega_0} x_{fpt}\right)}_{\text{Net Change in Extensive Margin}} + \underbrace{\sum_{f\in\Omega_c}\sum_{p\in\omega_c}\Delta x_{fpt}}_{\text{Net Change in Intensive Margin}}.\right\} \tag{3.1}$$

Here, Ω_t represents the set of firms that imported in period t but not in period 0, Ω_0 represents the set of firms imported in the beginning year but not in the ending year. Ω_c represents the number of incumbent importers that imported in both the beginning and ending periods.ω_t represents the set of new products imported by importers in both the beginning period and ending period, and ω_0 is the set of products imported in period 0 by continuous importers. ω_c is the set of imported products in both periods for importers in both periods. The results are reported in Table 3.1.

Treating both the net entry and net switching of new products of existing importers together as the contribution from extensive margins, we can see that most of the time variation in import growth is from the extensive margin, which is consistent with the results given by Bernard et al. (2009); Amiti et al. (2020), the extensive margin contributed to most of the time variation of import. In the overall period, 2000–2009, China's imports grow by 329%. For this overall growth, 86% of the overall change is contributed by firms' entry or product switching. Furthermore, firms' net entry takes into account most of the contribution in the extensive margin. The two periods 2000–2004 and 2004–2009 confirm the slowdown in import growth (141% in the five years from 2000 to 2004 and 78% in the six years from 2004 to 2009), and the second period shows less of a contribution from the extensive margin relative to the intensive margin. Comparing with the pre 2004 period with the post 2004 period, the main growth decline is caused by the decline in the contribution of import growth from the extensive margin.

To summarize, Table 3.1 shows that most of the growth in imports over time is contributed by firms' net entry and product switching.

Table 3.1: Decomposition of Changes in China Imports Over Time

Year	Total Growth	Proportion of Annual Growth Due to		
		Net Entry and Exit	Product-Country Switching	Net Intensive Margin
2000–2004	141%	57	20	23
2004–2009	78%	54	16	30
2000–2009	329%	70	16	14

Notes: This table contains the growth decomposition of China's imports. Total growth is the growth rate over the sample period. Proportions are in percentages.

3.3.2 Time-Series Variation in Intermediate Input Share

A decomposition of the variation in import value shows the important role of the extensive margin in explaining the decline in the import growth. Furthermore, when combined with firms' production data, the growth decomposition can explore the change in technology in the view of import intensity and the resource reallocation corresponding to this technology change. Here, import intensity is measured by the share of imported inputs in the total expenditure of firms' intermediate inputs. Since intermediate input data are available by 2007, the decomposition in this section will use the matched sample over the period 2000–2007. Equation (3.2) depicts the formula of decomposition, which follows Blaum et al. (2018).

$$\Delta S_I = \underbrace{\sum_{CI} m_{i1}(s_{i2} - s_{i1})}_{within} + \underbrace{\sum_{CI}(m_{i2} - m_{i1})s_{i1}}_{between} + \underbrace{\sum_{CI}(m_{i1} - m_{i2})(s_{i2} - s_{i1})}_{covariance} + \underbrace{\sum_{New} m_{i2}s_{i2} - \sum_{Old} m_{i1}s_{i1}}_{NetEntry}, \tag{3.2}$$

Where ΔS_I is the change in import intensity (measured by the imported inputs share of total intermediate inputs), CI is number of the continuous importers in both the beginning and ending periods, m_{it} is the share of firm i in total manufacturing materials, s_{it} is the share of imported materials in the total expenditure of intermediate input, 1 represents the beginning period, and 2 represents the ending period. The term Old means the old importers who only import in period 1, and the term New means the new importers who only import in period 2. The term *within* measures the change in aggregate import intensity contributed by these continuing importers by holding their market share. The term *between* captures the change contributed by the change in market share only. The term *covariance* captures the change in the comovement of market share of import intensity. The term *NetEnty* shows the change in aggregate import intensity contributed by the net entry of firms. Table 3.2 shows the results of the decomposition.

First, a comparison of the overall change in aggregate import intensity in the pre-2004 period and post-2004 period reveals a decline in the import intensity among Chinese firms. These results confirms that China's manufacturing firms use less foreign input for production. The term *netentry* shows a significant difference in the pre-2004 period relative to the post-2004 period. In the pre-2004 period, new firms entered into the market and use more intermediate goods from foreign countries. On the other hand, these incumbents saw a significant decline in their market share because of the expansion in new entrants. In the period after 2004, there was no expansion of new entrants and the decline in the import intensity of incumbents dominates the overall change. We can also compare the period 2000–2004 with the period 2000–2007. The decline in the overall change in import intensity is mainly caused by both the decline in the import intensity of continuing firms and fewer entrants with high import intensity.

Table 3.2: Decomposition of Imported Input Share of Intermediate Inputs

Year	Overall Change(%)	Within	Between	Covariance	NetEntry
2000–2004	2.57	-1.25	-6.25	0.22	9.85
2004–2007	-5.37	-4.37	-1.47	-0.09	0.57
2000–2007	-2.8	-3.81	-6.73	1.99	5.75

Notes: Numbers refer to the change in the imported input share in percentage points. Imported inputs are measured by all reported imports

Overall, the decomposition in equation (3.2) shows that the growth rate of Chinese firms' use of foreign resources is declining not only as a result of the variation in firms' import intensity but also as a result of fewer import-intensive entrants.

To summarize, the two accounting decompositions I conducted show the importance of both the extensive and intensive margins in accounting for the changes in China's imports in the 2000s.

3.4 Empirical Analysis of Effects of Export VAT Rebate

The previous section documents the contribution of the extensive margin in explaining the decline in the China's import growth as well as the change in imported input share. Motivated by the trends from Figure 1.1 and 2.1, in this section, I test whether the reduction in China's export VAT rebates will lower firms' imports level as well as their choice of countries from which to outsource. The main regression will estimate the effect of China's export VAT rebate reductions on firms' imported inputs. We can predict that reducing China's export VAT rebate rate will increase firms' price of exporting goods and lower the demand for firms' goods. As a result, firms' demand for imported inputs for production. Moreover, previous research mentioned in the introduction and my growth decomposition in the previous section emphasize the variation driven by the extensive margin. Thus, I will assess the effects of the export VAT on both firms' intensive and extensive margins of imports.

3.4.1 The Empirical Specification of Impact on Firm's Intensive Margins

To estimate the effect of the VAT policy change on firms' import performance, the benchmark specification is

$$\ln IM_{fpt}^{R} = \beta_1 \ln v_{pt} + \beta_2 \ln v_{pt} \times Size_f + \beta_3 \ln tr_{pt} + \beta_4 \ln tr_{pt} \times Size_f + \gamma_f + \gamma_p + \gamma_t + \epsilon_{fpt} \quad . \tag{3.3}$$

The indicator IM_{fpt}^{R} is firm f's imports of product p through trade treatment R (R can be processing trade or non-processing trade) at time t. I run the regressions of these two treatments separately for the following two reasons. First, processing and non-processing trade show heterogeneity in policy and production at the product level. Second, here I use total imports to measure the imported imports for manufacturing firms; separating processing and non-processing trade allows me to control for the measurement error for processing trade in this approximation (imports through processing trade should be intermediate inputs). The indicator $Size_f$ shows whether this firm is a medium-or above-size (hereinafter called "large") firm in the initial year. I use initial year instead of current year to reduce the issue of endogeneity in firm size and imports behavior.[7] The dummy of firm size $Size_f = 1$ if employment at initial year is greater than 300. The terms γ_f,γ_t,γ_p are fixed effects of firm, time, and product. Here, the variation of VAT rebate rate is at the product level.[8] Because $\ln IM_{fpt}^{R}$ is not defined when $IM_{fpt}^{R} = 0$, we may concern the selection bias. To solve this problem, I use equation (3.5) the linear probability model to estimate the participation rate:

$$\mathbb{I}_{fpt}^{R} = \beta_1 \ln v_{pt} + \beta_2 \ln v_{pt} \times Size_f + \beta_3 \ln tr_{pt} + \beta_4 \ln tr_{pt} \times Size_f + \boldsymbol{\beta_X X_{ft}} + \gamma_f + \gamma_t + \epsilon_{fpt}. \tag{3.4}$$

[7] I also estimate the effects of the export VAT based on whether or not the firm only involve in processing trade, results can be found in Appendix B.3.

[8] I use the disaggregated firm-product-level import data and product-level vat as the following reasons: first, the VAT rate and export VAT rebate rate is officially set at product-level, which makes the variation of VAT across product exogenous. Second, the decomposition at the product-level has shown the product switching is very important to explain the decline in the import growth.

$\mathbb{I}^R_{fpt}$ is the index to indicate whether or not firm f imports product p in period t, $\mathbb{I}^R_{fpt} = 1$ if firm f imports product p in period t through trade regime R. In equation $\boldsymbol{X_{ft}}$ are additional variables that can affect firms' participation probability. They are dummy variables of firms' ownership by distinguishing firms as state-owned or foreign-owned. According to Yu (2015), these two types of firms are different from other firms in terms of their accessibility to international trade.

Once I get the estimated probability of imports $\hat{\mathscr{P}_{fpt}}$, I use the non-parametric estimation method following Das, Newey, and Vella (2003); Amiti et al. (2020)) to control for the possible selection bias.

$$\ln IM_{fpt} = \beta_1 \ln v_{pt} + \beta_2 \ln v_{pt} \times Size_f + \beta_3 \ln tr_{pt} + \beta_4 \ln tr_{pt} \times Size_f + \delta_{fpt}(\hat{\mathscr{P}_{fpt}}) + \gamma_f + \gamma_p + \gamma_t + u_{fpt}, \quad (3.5)$$

where the correction term $\delta_{fpt}(\hat{\mathscr{P}_{fpt}})$ is a forth polynomial of propensity score $\hat{\mathscr{P}_{fpt}}$:

$$\delta_{fpt}(\hat{\mathscr{P}_{fpt}}) = \alpha_0 + \alpha_1 \hat{\mathscr{P}_{fpt}} + \alpha_2 (\hat{\mathscr{P}_{fpt}})^2 + \alpha_3 (\hat{\mathscr{P}_{fpt}})^3 + \alpha_4 (\hat{\mathscr{P}_{fpt}})^4 + \eta_{fpt}. \quad (3.6)$$

Besides estimating the impact of the VAT on firms' imports, I use firms' exports as an alternative dependent variable in equation (3.3) to show the effects of the export VAT on firms' exports. In next subsection, I first show the results for firms' exports in Table 3.3, then provide the results for imports in Table 3.4.

3.4.2 Estimation Results of Impact On Intensive Margins and Explanation

Exports: I predict the export VAT affects both firms' exports and imports. Because the export VAT is directly on firms' exports, when firms make their decisions of trade, they will consider the impacts of the export VAT on their exports. For this reason, I first confirm the negative impact of an increase in the export VAT on firms' imports by running the regressions on exports. In Table 3.3, columns (1) and (4) give the OLS regressions for processing trade and non-processing trade. For processing trade, the coefficient of the VAT on firm-product-specific exports is -0.731. It represents that the average impact of the export VAT at the product level will lower the exports of small firms through processing trade by 0.731% if the product level export VAT is increased by 1%. For large firms, the coefficient of interaction is -2.44 so large firms are more sensitive to the change in the export VAT than small firms. Columns (2) and (5) represent the impact of the export VAT on firms' probability of participating in exports. For processing trade, the probability of exporting a specific product will decrease by 0.02% if the export VAT is increased by 1%. For large firms, the impact on import probability is also stronger. However, the product level selection effect is not very strong for firms' export intensity. After controlling the selection effect, both the impact of the export VAT on exports through processing and non-processing does not change significantly. Overall, the average impacts of the export VAT at the product level show a negative impact on firms' exports of the related products, and the effects are stronger for large firms than small firms. The negative and significant impacts of the export VAT is consistent with previous research (Gourdon et al., 2020). As the export VAT increased, the price of a product increased. Thus the demand for a specific product declines so that firms can export fewer goods than before. Large firms are more sensitive than small size firms in response to the change in the export VAT as they have higher export exposure than these small firms. This is how the average impact of the export VAT on firms' exports under a subheading of products. Also, firms intensive margins will be impacted through firms' extensive margins. The impact on the extensive margin is discussed in the following section 3.4.3.

Imports: In Table 3.4, column (1) is the simple OLS regression for processing trade, and it shows a negative impact of an increase in the export VAT on firms' imports. For small firms, the coefficient is –0.48. So increasing the export VAT by 1% will cause a decline in imports by 0.48%. For large firms, the response is stronger which is –1.2%. Column (2) shows the impact of the export VAT on the participation rate of importing through processing trade. Here, increasing the export VAT of a specific product will increase the probability of participating in a specific product's imports. This result may not be very intuitive. However, if we notice the following two facts, then the sign of the impact of the export VAT on the participation probability of imports makes sense. First, the v_{pt} here is for exports, and domestic sales of related products still face 17% VAT rate. Second, only for those firms that are exporting the products under a specific subheading will experience an export VAT increase. The increase in the export VAT reduces the price advantage of existing exporters in the subheading. More firms will enter into the market of

Table 3.3: Impact of Product-Level Export VAT on Exports

Trade Regime	Processing Trade			Non-Processing Trade		
Method	OLS	Nonparametric Sample Selection		OLS	Nonparametric Sample Selection	
		1st Step	2nd Step		1st Step	2nd Step
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	$\ln EX^1_{fpt}$	I^1_{EXfpt}	$\ln EX^1_{fpt}$	$\ln EX^0_{fpt}$	I^0_{EXfpt}	$\ln EX^0_{fpt}$
$\ln v_{pt}$	-0.731**	-0.019***	-1.033***	-2.124***	-0.121***	-2.615***
	(0.289)	(0.007)	(0.319)	(0.149)	(0.008)	(0.171)
$\ln v_{pt} \times Size_f$	-2.443***	-0.043***	-2.333***	-1.288***	0.020**	-1.243***
	(0.300)	(0.008)	(0.433)	(0.179)	(0.009)	(0.180)
$\ln tr_{pt}$	1.190***	0.068***	1.959***	0.686***	0.041***	0.810***
	(0.290)	(0.009)	(0.568)	(0.184)	(0.011)	(0.186)
$\ln tr_{pt} \times Size_f$	-0.871***	0.101***	-1.091	0.106	-0.055***	-0.083
	(0.168)	(0.005)	(0.744)	(0.102)	(0.006)	(0.107)
SOE_{ft}		0.001			0.007***	
		(0.001)			(0.001)	
$\mathrm{Foreign}_{ft}$		0.002***			0.015***	
		(0.001)			(0.001)	
Control Selection Effect	N		Y	N		Y
Firm,Product,Year FE	Y	Y	Y	Y	Y	Y
N	612982	5993334	612982	1637791	5993334	1637791
R^2	0.474	0.417	0.474	0.385	0.618	0.385

Notes: Standard errors in parentheses. Significant at * $p < .10$, ** $p < .05$, *** $p < .01$. The significance of VAT impacts on exports will not change if heteroskedasticity-robust standard errors clustered at the product-level.

Table 3.4: The Impact of Product-Level Export VAT on Imports

Trade Regime	Processing Trade			Non-Processing Trade		
Method	OLS	Nonparametric Sample Selection		OLS	Nonparametric Sample Selection	
		1st Step	2nd Step		1st Step	2nd Step
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	$\ln IM^1_{fpt}$	I^1_{fpt}	$\ln IM^1_{fpt}$	$\ln IM^0_{fpt}$	I^0_{fpt}	$\ln IM^0_{fpt}$
$\ln v_{pt}$	-0.482***	0.061***	-0.395***	0.320***	0.087***	0.300***
	(0.096)	(0.008)	(0.097)	(0.084)	(0.008)	(0.099)
$\ln v_{pt} \times Size_f$	-0.758***	0.144***	-0.536***	-1.378***	-0.327***	-2.587***
	(0.101)	(0.010)	(0.110)	(0.095)	(0.009)	(0.204)
$\ln tr_{pt}$	4.931***	-0.343***	4.383***	-0.658***	0.343***	-0.254
	(0.136)	(0.013)	(0.173)	(0.170)	(0.012)	(0.259)
$\ln tr_{pt} \times Size_f$	-2.145***	-0.211***	-2.646***	-0.305***	-0.013**	0.308***
	(0.075)	(0.007)	(0.106)	(0.079)	(0.006)	(0.096)
SOE_{ft}		-0.007***			-0.003**	
		(0.001)			(0.001)	
Foreign_{ft}		-0.032***			0.016***	
		(0.001)			(0.001)	
Control Selection Effect	N		Y	N		Y
Firm,Product,Year FE	Y	Y	Y	Y	Y	Y
N	2832411	6909728	2832411	2613818	6909728	2613818
R^2	0.392	0.506	0.392	0.362	0.554	0.362

Notes: Standard errors in parentheses. Significant at * $p < .10$, ** $p < .05$, *** $p < .01$. The significance will not change if heteroskedasticity-robust standard errors are clustered at the product-level.

producing a specific product to increase the probability of becoming involved in the intra-product trade and use more imported inputs from a specific subheading of product. By controlling for the selection effect, the impact of export VAT on firms' imports through processing trade is slightly smaller. On average, large firms have a stronger response to imports on VAT because at the product level, more productive firms are more exposed to exports than less productive firms.

Columns (4) – (6) in Table 3.4 show the impact of the export VAT on imports through non-processing trade. Now the signs of the impact of VAT on imports differ for the initial firm size. Column (4) gives the OLS regression results, and column (6) gives the results with selection effect control. For small-size firms, an increase in the export VAT will increase firms' intensive margin of imports on average. With controlling for selection effects, increasing 1% the export VAT will lead the import of the corresponding products increase by 0.3%. Still, more firms can access production under a specific subheading, so to use more imported inputs under this subheading—combined with the fact that firms involved in non-processing trade are less export-intense than processing firms—the average impact of VAT at the product level for small firms is dominated by the fact that more firms are involved with production under a specific subheading. Large firms' imports through non-processing trade are more sensitive to the VAT change than small firms'.

Industry-Level Export VAT: The average impact of VAT on firms' imports has been discussed earlier. By using the concordance between the HS code and CIC code, I generate the industry level export VAT and check the average impact of the *industry level* VAT on firms' imports at the product level. The product level export VAT is how VAT is levied by the government and the HS code mainly reflects the product's physical characteristics. Instead, classifying firms into different industries based on their CIC code is more related to their industrial organization. The regression is similar to equation (3.3), but the dependent variable and interaction of the export VAT is changed by using industry level export VAT. The results are shown in Table 3.5. The signs are similar to the product level export VAT. The difference in magnitude of the impact of the export VAT reflects the difference between the average impact at industry and product levels. Compared with the product level impact, the industry level shows greater differences among firms' responses based on their firm size. Considering the industry level classification

Table 3.5: The Impact of Industry-Level VAT on Imports

Trade Regime	Processing Trade			Non-Processing Trade		
Method	OLS	Nonparametric Sample Selection		OLS	Nonparametric Sample Selection	
		1st Step	2nd Step		1st Step	2nd Step
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	$\ln IM^1_{fpt}$	I^1_{fpt}	$\ln IM^1_{fpt}$	$\ln IM^0_{fpt}$	I^0_{fpt}	$\ln IM^0_{fpt}$
$\ln v_{nt}$	0.181	-0.075***	0.106	1.281***	0.034***	1.291***
	(0.161)	(0.013)	(0.163)	(0.133)	(0.012)	(0.135)
$\ln v_{nt} \times Size_f$	-1.246***	0.007	-1.314***	-1.366***	-0.095***	-1.617***
	(0.195)	(0.017)	(0.197)	(0.181)	(0.016)	(0.191)
$\ln tr_{pt}$	4.861***	-0.328***	4.376***	-0.700***	0.327***	-0.097
	(0.138)	(0.013)	(0.173)	(0.172)	(0.013)	(0.258)
$\ln tr_{pt} \times Size_f$	-2.197***	-0.219***	-2.694***	-0.370***	-0.004	-0.094
	(0.076)	(0.007)	(0.110)	(0.080)	(0.006)	(0.083)
SOE_{ft}		-0.007***			-0.003**	
		(0.001)			(0.001)	
$Foreign_{ft}$		-0.031***			0.016***	
		(0.001)			(0.001)	
Control Selection Effect	N		Y	N		Y
Firm,Product,Year FE	Y	Y	Y	Y	Y	Y
N	2778118	6730777	2778118	2537107	6730777	2537107
R^2	0.391	0.508	0.391	0.361	0.553	0.362

Notes: Standard errors in parentheses. Significant at * $p < .10$, ** $p < .05$, *** $p < .01$. The significance of VAT impacts on exports will not change if heteroskedasticity-robust standard errors clustered at the product-level.

captures more firms' characteristics of industry-organization (Pierce & Schott, 2012), it makes sense that firm size differences capture more differences within industries [9].

3.4.3 Effects of Export VAT on Extensive Margins

Based on my findings in Section 3.3 about the growth decomposition, I confirm the important role of firms' extensive margins in contributing to the time-variation of imports. Follow Romer (1994), and I treat the flexibility of location choices of varieties corresponding to the change in the export VAT as the flexibility in using technology. Thus large and more productive firms

[9] We may also consider the indirect impact of export VAT levied to downstream industries on the demand of intermediate supplied by upstream firms, so as to the demand of imported intermediate inputs. The results of estimating the indirect impacts of export VAT can be found in Appendix B.4

have more flexibility in their choices of technologies so that their choice of both exporting and outsourcing countries is more elastic than small and less productive firms. To test the flexibility in technology adjustment, I use the extensive margins measured by the number of countries of exporting or outsourcing regressed by the export VAT to check the impact of the export VAT on firms' imports on the extensive margin. The regressions are shown as equations (3.7) and equation (3.8), and results are shown in Table 3.6.

$$\ln N_{fpt}^{IM} = \beta_1 \ln v_{pt} + \beta_2 \ln v_{pt} \times Size_f + \beta_3 \ln tr_{pt} + \beta_4 \ln tr_{pt} \times Size_f + \gamma_f + \gamma_p + \gamma_t + \epsilon_{fpt} \quad , \tag{3.7}$$

$$\ln N_{fpt}^{EX} = \beta_1 \ln v_{pt} + \beta_2 \ln v_{pt} \times Size_f + \beta_3 \ln tr_{pt} + \beta_4 \ln tr_{pt} \times Size_f + \gamma_f + \gamma_p + \gamma_t + \epsilon_{fpt} \quad . \tag{3.8}$$

In equations (3.7) and (3.8), N_{fpt}^{IM} is the number of countries from which a firm will import for product p at time t, and N_{fpt}^{EX} is the number of countries to which a firm will export for product p at time t. The results are shown in Table 3.6. Here, I assume that firms also import and export specific products domestically, so N_{fpt}^{EX} is the observed number of countries export to plus 1, and similarly, for imports.

In Table 3.6, columns (1) and (2), we can see that at the product level, large firms have more flexibility in response to the change in the export VAT. For the extensive margin of exports, now the number of export platforms of a specific product for small firms decreases by 0.25% if the export VAT is increased by 1%. For large firms, it is more stronger and will decrease by 0.38%. For imports, increasing the export VAT by 1% lead the number of countries for outsourcing increase by 0.11% for small firms and decrease by 0.21% for large firms. We find that the extensive margin in terms of location choices is not very elastic with respect to the change in the export VAT. And large firms are more sensitive to the change in the export VAT in terms of location choices. More flexible means that more adjustments can be made in response to the change in the extensive margin. Large firms can stay in the market by choosing fewer importing and exporting countries in response to an increase of the export VAT while small firms can do less. Otherwise, they are not able to stay in the market.

Table 3.6: The Impact of VAT on Firms' Location Choices

	(1) $\ln N_{fpt}^{EX}$	(2) $\ln N_{fpt}^{IM}$
$\ln v_{pt}$	-0.245***	0.109***
	(0.011)	(0.007)
$\ln v_{pt} \times Size_f$	-0.130***	-0.317***
	(0.013)	(0.008)
$\ln tr_{pt}$	-0.117***	0.301***
	(0.018)	(0.012)
$\ln tr_{pt} \times Size_f$	0.250***	-0.517***
	(0.009)	(0.006)
SOE_{ft}	0.001	-0.010***
	(0.002)	(0.001)
Foreign_{ft}	-0.004***	-0.003***
	(0.001)	(0.001)
Firm,Product,Year FE	Y	Y
N	6909728	6909728
R^2	0.502	0.570

Notes: Standard errors in parentheses. Significant at * $p < .10$, ** $p < .05$, *** $p < .01$. Significance will not change if heteroskedasticity-robust standard errors clustered at the product-level.

3.5 Conclusions

This chapter empirically investigates the effects of changes in China's export VAT on its import growth decline. The growth decomposition of imports shows that firm entry and product-country switching play a key role in explaining China's growth decline in imports. At the same time, the entry effect of firms contributes to the main portion of the change in import intensity. These two facts emphasize the extensive margin's contribution to the declining relative importance of foreign materials to the Chinese economy.

Estimating the average impact of the product-level export VAT shows the overall negative and significant effects of the export VAT on both firms' intensive and extensive margins in imports, especially for those large firms. These results hold for both processing and non-processing treatments. In addition, if we generate the variation at industry-firm level, the results are similar to what we got at the product-firm level. These results show that either we consider the effects of export VAT in terms of product or industry level, we find the significant and negative impact of the increase in the export VAT on manufacturing firms, especially for large size firms.

Chapter 4

A Multi-Country Model of Exporting and Sourcing

The goal in this chapter is to show a theory that can account for the empirical findings for counterfactual analysis. Motivated by my empirical findings, selection effects and extensive margins in terms of joint location choices are emphasized in my model, which draws from a quantifiable multi-country sourcing model developed by Antras et al. (2017). I extend their framework by adding two features: First, final goods can be traded. Second, production has a value-added part, and a value-added tax will be levied on final goods producers. The VAT rate differs across domestic sales and exports, so there exists a policy wedge between domestic production and exports.

4.1 Theoretical Framework

4.1.1 Environment

Consider a world with J countries, indexed by $i \in \{1,2,...,J\}$. Each country i is exogenously endowed a mass L_i of agents that consume tradable final goods and supply labor resources. Households spend a constant share η_i of total income on manufacturing goods. As in Chaney (2008), to simplify the question, I assume each country i also has a non-manufacturing sector and its firms produce tradable non-manufacturing q_0 in a perfectly competitive and free-trade economy. It only uses labor to produce, and 1 unit of labor can produce w_i units of q_0 in the country i. The unit of q_0 is a numeraire, and its price is set as 1. Now the wage in country i is w_i, and the non-manufacturing sector is large enough to pin down the w_i so that we can treat wage w_i as exogenous in this model.

4.1.2 Households

Assume households consume all available goods in country i, and its set is Ω_i. For simplicity, I have $\sigma > 1$, which is the common elasticity of substitutes of final goods for all countries.

$$U_i = q_0^{1-\eta_i}\left(\int_{\omega\in\Omega_i} q_i(\omega)^{\frac{\sigma-1}{\sigma}} d(\omega)\right)^{\frac{\sigma}{\sigma-1}\eta_i},$$

where demand for good ω is given by

$$q_i(\omega) = E_i P_i^{\sigma-1} p_i(\omega)^{-\sigma},$$

$p_i(\omega)$ is the price of good ω in country i, P_i is the price index in country i and E_i is the aggregate expenditure in the manufacturing sector, and B_i is the measure of demand for manufacturing goods demand:

$$B_i = \frac{1}{\sigma}(\frac{\sigma}{\sigma-1})^{1-\sigma} E_i P_i^{\sigma-1}. \tag{4.1}$$

4.1.3 Final Goods Producers

A mass N_i of final good producers choose to enter the market in country i. Each producer produces a single differentiated variety in monopolistic competition. All final producers in country i are indexed by their productivity ϕ. Firms learn their productivity ϕ only after incurring an entry cost fe_i, which is in units of labor. The productivity of final goods firms ϕ is drawn from a country-specific distribution $G_i(\phi)$. The distribution is in $[\phi_{min}, \infty]$.

To produce the final good, final good producers need to use a bundle of intermediates. Intermediates can be outsourced from the home country and internationally. Each intermediate

$\nu \in [0,1]$ requires country-specific labour $a_j(\nu)$. Assume intermediates to be imperfectly substitutable with each other, with constant and symmetric elasticity of substitution equal to ρ. Final goods producers will use an intermediate bundle produced by an intermediate producer in country i. The final good producer ϕ in country i will choose intermediate ν at the lowest price across all countries among the outsourcing list. One key feature of this model is that putting one country in the list of outsourcing incurs a fixed cost f_{ji}^M. Let $\mathscr{J}_{\boldsymbol{M}} = \{0,1\}^J$ denote firm's choice set of outsourcing countries. An element of set $\mathscr{J}_{\boldsymbol{M}}$ is a $J-$ coordinate vector $I^M(\phi) = (I_1^M(\phi), I_2^M(\phi), ..., I_J^M(\phi))$, where $I_j^M(\phi) = 1$ if country j is selected by firm ϕ as one of the outsourcing country. A projection $\mathscr{P}(I^M(\phi))$ maps the choice vector to the country list set $\mathscr{J}_M(\phi)$ including all countries selected by firm ϕ as outsourcing countries (i.e, $\mathscr{J}_M(\phi) = \left\{i : I_i^M(\phi) = 1\right\}$).

At the same time, when a firm determines its outsourcing strategy, the final good producer ϕ will also determine its exporting strategy. Similar to the outsourcing strategy, I use $\mathscr{J}_{\boldsymbol{X}} = \{0,1\}^J$ to denote firm's choice set of exporting countries. Selling goods in country j incurs a fixed cost f_{ji} for firm ϕ in country i, and $\mathscr{J}_x(\phi) = \left\{i : I_i^M(\phi) = 1\right\}$ describes the exporting strategy firm ϕ chooses. Once final goods producers choose their outsourcing strategy and exporting strategy, they have a trade strategy and start to produce or exit. This setup requires the assumption that firms have a trade strategy before they start to produce for both exporting and outsourcing. [1]

As mentioned, firm ϕ will choose the lowest price of intermediate ν across the selected outsourcing countries, so the price of ν will be

$$z_i(\nu, \phi; \mathscr{J}_M(\phi)) = \min_{j \in \mathscr{J}_M(\phi)} \{\tau_{ij} w_j a_j(\nu, \phi)\},$$

where w_j is wage in country j and τ_{ij} is the iceberg cost from j to i.

Final good producers get intermediates from a perfectly competitive market, so we have the ideal price index of intermediates

$$P_i^M(\phi) = \left(\int_0^1 z_i(\nu, \phi, \mathscr{J}_M(\phi))^{1-\rho} d\nu \right)^{\frac{1}{1-\rho}}. \tag{4.2}$$

[1] Mayneris and Poncet (2015) show that Chinese firms' export decisions are both country and product-specific, which supports this assumption.

Besides intermediate goods, final goods producers also need to use labor for producing, and the production function follows a Cobb-Douglas form:

$$q = \phi l^{1-\mu} M^{\mu}. \tag{4.3}$$

Delivering one unit of final goods to market j from country i requires a total τ_{ji} units of goods (suppose $\tau_{ii} = 1$), so the marginal cost is

$$c_i(\phi) = \frac{\iota \tau_{ji}}{\phi} w_i^{1-\mu} P_i^M(\phi)^{1-\mu}, \tag{4.4}$$

where ι is a numeric factor $\iota = \mu^{-\mu}(1-\mu)^{\mu-1}$.

Intermediates are supplied by intermediate producers in country j. Following Eaton and Kortum (2002), intermediate producers draw input efficiency $\frac{1}{a_j(\nu)}$ from Frechet distribution:

$$Pr(a_j(\nu) \geq a) = e^{-T_j a^{\theta}},$$

where T_j is the parameter that captures the average technology of suppliers in country j and θ captures technology dispersion. For the extreme value distribution, I can write the price index of intermediates as

$$P_i^M(\phi) = \left(\gamma \Theta_i(\phi)\right)^{-\frac{1}{\theta}}, \tag{4.5}$$

where $\gamma = [\Gamma(\frac{\theta+1-\rho}{\theta})]^{\frac{\theta}{\rho-1}}$ is the factor of the summation of extreme value in the Frechet distribution. Following Antras et al. (2017), $\Theta_i(\phi)$ is called sourcing capability:

$$\Theta_i(\phi) = \sum_{j \in \mathscr{J}_M(\phi)} T_j (\tau_{ij} w_j)^{-\theta}.$$

Notice the sourcing capability is firm specific which depends on firm's outsourcing strategy $\mathscr{J}_M(\phi)$;

more details about a firm's decision on outsourcing will be discussed later. The imported intermediate share from country j is

$$\chi_{ij}^M(\phi) = \begin{cases} \frac{T_j(\tau_{ij}w_j)^{-\theta}}{\Theta_i(\phi)}, & j \in \mathscr{J}_M(\phi) \\ 0 & \text{Otherwise.} \end{cases} \tag{4.6}$$

4.1.4 Profits of Final Good Firms

To analyze the impact of an export VAT rebate change on a firm's imports, the price p_{ji} in country j will include a wedge, which is an effective export VAT rate equivalence. As I mentioned in the introduction of the VAT, there is no distortion in the VAT rate for firm's inputs sd they are fully rebated. Thus, I do not generate a wedge in firm's intermediate input price $P_i^M(\phi)$. Now final goods firms' profit optimization problem (without entry sun cost f_{ei}) is

$$\begin{aligned} \max_{\{l, M(\phi), \mathscr{J}_X(\phi), \mathscr{J}_M(\phi)\}} \sum_{k \in \mathscr{J}_x(\phi)} \frac{1}{1+t_{ki}} p_{ki}(\phi) q_{ji}(\phi) - w_i l - P_i^M(\phi) M_i(\phi) - w_i \sum_{k \in \mathscr{J}_x(\phi)} f_{ki} - w_i \sum_{k \in \mathscr{J}_M(\phi)} f_{ik}^M \\ s.t \quad q_{ki}(\phi) = E_k P_k^{\sigma} p_{ki}(\phi)^{-\sigma} \\ s.t \quad q_{ki}(\phi) = \frac{1}{\tau_{ki}} \phi l_{ki}(\phi)^{\mu} M_{ki}(\phi)^{1-\mu}. \end{aligned} \tag{4.7}$$

The problem can be treated as follows: given the export and import strategies, choose the optimal output level and input level from the selected exporting countries and import countries. This is a standard profit optimization problem, which gives

$$\pi\left(\phi, \mathscr{J}_M(\phi), \mathscr{J}_x(\phi)\right) = \underbrace{X_i\left(\mathscr{J}_x(\phi)\right)}_{\text{Exporting Potential}} \iota^{1-\sigma} w_i^{(1-\mu)(1-\sigma)} \underbrace{\left(\gamma \Theta_i(\mathscr{J}_m(\phi)\right)^{\frac{\mu(\sigma-1)}{\theta}}}_{\text{Sourcing Capability}} \phi^{\sigma-1} - w_i \underbrace{FX_i\left(\mathscr{J}_x(\phi), \mathscr{J}_m(\phi)\right)}_{\text{Decision Fixed Cost}}. \tag{4.8}$$

Exporting Potential: The first term in equation (4.8) represents firms' exporting potential based on their exporting strategy $\mathscr{J}_x(\phi)$ and export VAT rate and iceberg cost.

$$X_i(\mathscr{J}_x(\phi)) = \sum_{k \in \mathscr{J}_x(\phi)} (1+t_{ki})^{-\sigma} (\tau_{ki})^{1-\sigma} B_k. \tag{4.9}$$

Sourcing Capability: $\Theta_i(\mathscr{J}_m(\phi))$ is similar to the notation in equation (4.6), but now it maps the outsourcing strategy to the sourcing capability, and we also call this sourcing capability as in equation (4.6):

$$\Theta_i\left(\mathscr{J}_m(\phi)\right) = \sum_{j\in\mathscr{J}_m(\phi)} T_j(\tau_{ij}w_j)^{-\theta}.$$

Decision Fixed Cost: $FX\left(\mathscr{J}_x(\phi),\mathscr{J}_m(\phi)\right)$ gives the fixed cost combination of firm ϕ:

$$FX_i\left(\mathscr{J}_x(\phi),\mathscr{J}_m(\phi)\right) = \sum_{k\in\mathscr{J}_x(\phi)} f^X_{ki} + \sum_{k\in\mathscr{J}_m(\phi)} f^M_{ik}. \tag{4.10}$$

Besides the above notation, for simplification, I denote the wage level W_i:

$$W_i = \iota^{1-\sigma} w_i^{(1-\mu)(1-\sigma)}. \tag{4.11}$$

Now our problem of solving the optimal joint exporting and outsourcing strategy is to choose the exporting and outsourcing vector $\boldsymbol{I^M} = \left(I^M_{1i}(\phi), I^M_{2i}(\phi),...,I^M_{Ji}(\phi)\right)$ and $\boldsymbol{I^X} = \left(I^X_{1i}(\phi), I^X_{2i}(\phi),...,I^X_{Ji}(\phi)\right)$, which give the corresponding exporting strategy $\mathscr{J}_x(\phi)$ and outsourcing strategy $\mathscr{J}_m(\phi)$ to maximize firms' profit when labor and intermediate goods are chosen at the optimal level. Furthermore, I can construct a $2J-$vector to represent firms overall trade decision, which is $I = \left(I^M_{i1}, I^M_{i2},...,I^M_{iJ}, I^X_{1i}, I^X_{2i},...,I^X_{Ji}\right)$; then equation (4.8) can be written as

$$\begin{aligned}\max_{I} \quad \pi(I,\phi) = &\sum_{k=1}^{J} I^X_{ki}(1+t_{ki})^{-\sigma}(\tau_{ki})^{1-\sigma}B_k\iota^{1-\sigma}w_i^{(1-\mu)(1-\sigma)}\left(\gamma\left(\sum_{j=1}^{J} I^M_{ij}T_j(\tau_{ij}w_j)^{-\theta}\right)\right)^{\frac{\mu(\sigma-1)}{\theta}}\phi^{\sigma-1}\\ &- w_i\left(\sum_{k=1}^{J} I^X_{ki}f^X_{ki} + \sum_{j=1}^{J} I^M_{ij}f^M_{ik}\right).\end{aligned} \tag{4.12}$$

Now for each firm $\phi > 0$, I denote the optimal solution set as $\mathscr{I}^*(\phi) = \left\{I : argmax \quad \pi(I,\phi), I\in R^{2J}\right\}$.

The key features of the profit function and firm's trade strategy $\mathscr{I}^*$ are given by the following propositions:

Proposition 1 *When $\mu(\sigma-1)\geq\theta$, firms' profits $\pi(I,\phi)$ are supermodular in firms' choice of exporting and outsourcing countries vector I. (The proof can be found in Appendix C.1.1.)*

Proposition 1 guarantees the complementarity between exports and imports. Here, we need to assume $\frac{\mu(\sigma-1)}{\theta}\geq 1$. This will hold when firms' intermediate input share of total input is large enough, final goods are substitutable and the productivity dispersion of intermediate suppliers across countries are big enough. From data we know this assumption is supported by China's facts. Furthermore, I can show the supermodularity is strict. That is, if $I < I'$, then both changes S decisions described by vector I_s, we have strict inequality $\pi(I+I_s,\phi)-\pi(I,\phi) < \pi(I'+I_s,\phi)-\pi(I',\phi)$.

Proposition 2 *When $\mu(\sigma-1)\geq\theta$, firms' trade strategy $\mathscr{I}(\phi)=\{I: argmax \quad \pi(I,\phi)\}$ is increasing in ϕ. (The proof can be found in Appendix C.1.2).*

Proposition (2) describes an important feature for this model, that is, both firms' trade strategies are non-decreasing in firms' productivity. That is, if a lower productive firm puts country j in its trade strategy, all firms with higher productivity will also do so.

4.2 Equilibrium

According to Proposition 2, we know that $I(\phi)\leq I(\phi')$ when $\phi<\phi'$. We also know that the profit function is continuous in ϕ, which can be drawn from distribution in $(0,\infty)$. Therefore, there must exist a cutoff that firms will import from and export to all countries. So firms' trade strategy will include from zero countries to all countries with an increase in ϕ. In equilibrium, for each country j, firm ϕ in country i will add it to its exporting strategy when ϕ is greater or equal to a cutoff, denoted as ϕ_{xji}. Here, in the subscript xji, x means this is a cutoff for exporting. The subscripts ji have a similar meaning as mentioned before, j is the destination, and i is the exporting country. Similarly, firm ϕ will add it to its outsourcing strategy when ϕ is greater than or equal to ϕ_{mij}. Notice that a firm will stay in the market and operate only if it imports from at least one country and exports to one country (including the home country). This is the cutoff that firms will stay in the market, denote it as ϕ_i^*.

4.2.1 Zero Cutoffs

Firms' profits $\pi(I,\phi)$ are monotonic in ϕ given trade strategy I, and firms' trade strategies are increasing in ϕ. Then for a cutoff ϕ_L and its corresponding trade strategy I, firms with productivity $\phi > \phi_L$ will deviate to new strategy I' only if

$$\pi(I',\phi) - \pi(I,\phi) \geq 0.$$

A firm has the motivation to add one more country j to its exporting strategy if

$$\begin{aligned}
&X_i\left(\mathcal{J}_x(\phi)\bigcup\{j\}\right)W_i\left(\gamma\Theta_i(\mathcal{J}_m(\phi)\right)^{\frac{\mu(\sigma-1)}{\theta}} - FX_i\left(\mathcal{J}_x(\phi)\bigcup\{j\},\mathcal{J}_m(\phi)\right)\\
&-\left(X_i\left(\mathcal{J}_x(\phi)\right)W_i\left(\gamma\Theta_i(\mathcal{J}_m(\phi)\right)^{\frac{\mu(\sigma-1)}{\theta}} - FX_i\left(\mathcal{J}_x(\phi),\mathcal{J}_m(\phi)\right)\right)\\
&=(1+t_{ji})^{-\sigma}(\tau_{ji})^{1-\sigma}B_jW_i\left(\gamma\Theta_i(\mathcal{J}_m(\phi))\right)^{\frac{\mu(\sigma-1)}{\theta}}\phi^{\sigma-1} - w_if_{ji} \geq 0,
\end{aligned} \tag{4.13}$$

where $(1+t_{ji})^{-\sigma}(\tau_{ji})^{1-\sigma}B_j = X_i\left(\mathcal{J}_x(\phi)\bigcup\{j\}\right) - X_i\left(\mathcal{J}_x(\phi)\right)$ gives the change in the exporting potential when country j is added to firm's exporting strategy. Similarly, if add country j to firm's outsourcing strategy,

$$\begin{aligned}
&X_i\left(\mathcal{J}_x(\phi)\right)W_i\left(\gamma\Theta_i(\mathcal{J}_m(\phi)\bigcup\{j\}\right)^{\frac{\mu(\sigma-1)}{\theta}} - FX_i\left(\mathcal{J}_x(\phi),\mathcal{J}_m(\phi)\bigcup\{j\}\right)\\
&-\left(X_i\left(\mathcal{J}_x(\phi)\right)W_i\left(\gamma\Theta_i(\mathcal{J}_m(\phi)\right)^{\frac{\mu(\sigma-1)}{\theta}} - FX_i\left(\mathcal{J}_x(\phi),\mathcal{J}_m(\phi)\right)\right)\\
&=X_i(\mathcal{J}(\phi))W_i\left(\left(\gamma\Theta_i(\mathcal{J}_m(\phi)\bigcup\{j\}\right)^{\frac{\mu(\sigma-1)}{\theta}} - \left(\gamma\Theta_i(\mathcal{J}_m(\phi))\right)^{\frac{\mu(\sigma-1)}{\theta}}\right)\phi^{\sigma-1} - w_if^M_{ji} \geq 0.
\end{aligned} \tag{4.14}$$

The above results are derived from changing only one decision. In general, firm ϕ can change a set of choice $S = S_X \bigcup S_M$. Here, S_X is the change choice set of export and S_M is outsourcing. Now the cutoff ϕ' with the new strategy will be

$$\begin{aligned}
&\pi(I+I_s,\phi') - \pi(I,\phi') = 0 \Longrightarrow\\
&X_i(J_x(\phi)\bigcup S_x)W_i\left(\gamma\Theta_i(\mathcal{J}_m(\phi)\bigcup S_m)\right)^{\frac{\mu(\sigma-1)}{\theta}}(\phi')^{\sigma-1} - X_i(J_x(\phi))W_i\left(\gamma\Theta_i(\mathcal{J}_m(\phi))\right)^{\frac{\mu(\sigma-1)}{\theta}}(\phi')^{\sigma-1}\\
&= \sum_{k\in S_m} w_if^M_{ik} + \sum_{k\in S_x} w_if_{ki}.
\end{aligned} \tag{4.15}$$

The above equation shows a general zero cutoff condition, if there is a new trade strategy that corresponds to cutoff ϕ' add a set of country S_x to firms' exporting strategy and add S_m to firm's outsourcing strategy; the change in profit should then be zero. Also, the zero cutoff condition implies that a firm will export to one country or outsource from it when the benefit is non-negative. Here, the zero cutoff productivity ϕ' must exist because we can always lower the productivity to let the equality hold, given previous strategy I and the new one $I + I_s$. In equilibrium, all cutoffs can be described by the following proposition:

Proposition 3

(a) In equilibrium, the sequence of cutoffs $\{\phi_{i(r)}\}$ *satisfies:*

$$\phi_{i(r)}^{1-\sigma} = \max_{S_x,S_m} \frac{X_i\left(\mathscr{J}_x(\phi)\bigcup S_x\right)W_i\left(\gamma\Theta_i(\mathscr{J}_m(\phi)\bigcup S_m)\right)^{\frac{\mu(\sigma-1)}{\theta}} - X_i\left(\mathscr{J}(\phi_{i(r-1)})\right)W_i\left(\gamma\Theta_i(\mathscr{J}_m(\phi_{i(r-1)}))\right)^{\frac{\mu(\sigma-1)}{\theta}}}{\sum\limits_{S_m} w_i f_{ik}^M + \sum\limits_{S_x} w_i f_{ki}}. \tag{4.16}$$

(b) When $\frac{\mu(\sigma-1)}{\theta} \geq 1$*, each cutoff* $\phi_{i(r)}$ *in the sequence of cutoffs* $\{\phi_{i(r)}\}$ *given by part (a) has a unique corresponding trade strategy if all zero cutoff conditions hold.*

Proposition 3 guarantees that the sequence $\{\phi_{i(r)}\}$ gives an equilibrium in which firms have no motivation to change their strategy when other parameters and demand levels are given. Furthermore, when $\frac{\mu(\sigma-1)}{\theta} \geq 1$ and zero cutoff condition holds, firms' trade strategy should be unique. (The proof and more details can be found in appendix C.1.3.)

Notice the sequence $\{\phi_{i(r)}\}$ corresponding to the change sets $\{S_{x(r)}\}$ and $\{S_{m(r)}\}$. It also determines a sequence of decision vectors $\{I_{i(r)}\}$. Here, the decision vector follows

$$I_{i(r)} = I_{i(r-1)} + I_{i(s)}, \tag{4.17}$$

where $I_{i(s)}$, the first to the Jth elements are equal to 1 if the corresponding countries are in the choice set S_x and the $J+1th$ to $2Jth$ elements equal to 1 if corresponding countries are in choice set S_m. Here $I_{i(0)} = \{0,0,0,...,0\}$

Furthermore, once the decision vectors are determined, we also have a corresponding exporting potential sequence $\{X_{i(r)}\}$ and an outsourcing capability sequence $\{\Theta_{i(r)}\}$:

$$X_{i(r)} = \sum_{k\in\mathscr{J}_x(\phi_{i(r)})} (1+t_{ki})^{-\sigma}(\tau_{ki})^{1-\sigma}B_k, \tag{4.18}$$

$$\Theta_{i(r)} = \sum_{j\in\mathscr{J}_m(\phi_{i(r)})} T_j(\tau_{ij}w_j)^{-\theta}. \tag{4.19}$$

In equilibrium, for those firms that stay in the market, the J cutoffs for exporting $\{\phi_{xki}\}$ $\forall k = 1,2,3,...,J$ and the J cutoffs for outsourcing $\{\phi_{mik}\}$ $\forall k = 1,2,3,...,J$ can be obtained based on the cutoff sequence and corresponding change sets. For example, from $\phi_{i(r-1)}$ to $\phi_{i(r)}$, the strategy change set $S = S_{x(r)} \bigcup S_m$, I have $\{\phi_{xki}\} = \phi_{i(r)} \quad \forall k \in S_{x(r)}$ and $\{\phi_{mik}\} = \phi_{i(r)} \quad \forall \quad k \in S_{m(r)}$.

4.2.2 Free-Entry Condition

The expected profit should be greater than or equal to the sunk cost, so we have a free-entry condition in equilibrium: According to the new profit function (4.8), the free-entry condition is:

$$N_i \int_{\tilde{\phi}_i}^{\infty} X_i(\mathscr{J}_x(\phi)) W_i \left(\gamma \Theta_i(\mathscr{J}_m(\phi)\right)^{\frac{\mu(\sigma-1)}{\theta}} \phi^{\sigma-1} - w_i F X_i \left(\mathscr{J}_x(\phi), \mathscr{J}_m(\phi)\right) dG_i(\phi) = N_i w_i f e_i. \tag{4.20}$$

From Propositions 1,2 and 3, we know if each country $i's$ demand level B_i is given and the zero cutoff holds,there exists a sequence $\{\phi_{i(r)}\}$ that also firms' choose their optimal trade strategy and do not deviate. If the free-entry condition and all markets clear, we can solve a unique demand level vector $\{B_1, B_2, B_3, ..., B_J\}$ as well as other variables.

4.2.3 Market Equilibrium

Based on my setup, the household's total consumption of final goods should be equal to η of its total income.

$$P_i C_i = E_i = \eta(w_i L_i + \mathscr{T}_i), \tag{4.21}$$

where $\mathscr{T}_i$ is the total tax income of consumers. I assume the government obeys the budget balance policy:

$$\mathscr{T}_i = \int_{\phi_{ki}}^{\infty} N_{ei} t_i(\phi) dG_i(\phi), \tag{4.22}$$

where $t_i(\phi)$ is the tax revenue from firm ϕ:

$$t_i(\phi) = \sum_{k \in \mathscr{J}_x(\phi)} t_{ki} p_{ki}(\phi) q_{ki}(\phi). \tag{4.23}$$

According to our assumption, the expenditure share of final goods in the manufacturing sector takes into account η of people's total income and equals the total revenue of final good firms:

$$\eta(w_i L_i + \mathcal{T}_i) = \sum_{k=1}^{J} N_{ek} \int_{\phi_{xik}}^{\infty} p_{ik}(\phi) q_{ik}(\phi) dG(\phi). \tag{4.24}$$

The ideal price index in country i:

$$P_i^{1-\sigma} = \sum_{k=1}^{J} N_{ek} \int_{\phi_{xik}}^{\infty} p_{ik}(\phi)^{1-\sigma} dG(\phi). \tag{4.25}$$

Once we solve all demand levels $B_1, B_2, B_3, ..., B_k$ and all sequences $\{\phi_{i(r)}\}$ $\quad \forall i = 1,2,3,...,J$, we can solve all variables based on equations (4.1), (4.25), and (4.23) (the algorithm for model solving can be found in Appendix C.3.) Now I impose on the final good producer a wide used distribution Pareto distribution as its productivity draw. Because of its feature that a truncated distribution of Pareto distribution is still a Pareto distribution, it is widely used for modeling selection. Another feature is that I can get an analytical expression of variables in terms of cutoffs and demand level by imposing on a Pareto distribution. This is not necessary for this model though.

4.2.4 Equilibrium in Pareto Distribution

The distribution of final goods producer $G(\phi)$ also needs to be defined for solving my model. Here I impose Pareto distribution as previous research did and show the key results conditional on it.

Free Entry Condition

Notice for firms that have the same trade strategy, the ratio of their profits without fixed cost is equal to the ratio of their productivity, so for a firm with ϕ between $(\phi_{i(r)}, \phi_{i(r+1)})$,

$$X_i(\mathcal{I}_x(\phi)) W_i \left(\gamma \Theta_i(\mathcal{I}_m(\phi))\right)^{\frac{\mu(\sigma-1)}{\theta}} \phi^{\sigma-1} = X_{i(r)} W_i \left(\gamma \Theta_{i(r)}\right)^{\frac{\mu(\sigma-1)}{\theta}} \phi_{i(r)}^{\sigma-1} \left(\frac{\phi}{\phi_{i(r)}}\right)^{\sigma-1}, \tag{4.26}$$

where $X_{i(r)}$ and $\Theta_{i(r)}$ use the notation of exporting sequence (4.18) and outsourcing sequence (4.19). Based on the zero cutoff condition (4.15), the profit function uses a decision vector $I_{i(r)}$

which is the corresponding decision vector of $\phi_{i(r)}$. The total fixed cost incurred from exporting or outsourcing is a summation of all countries in the change set $S_{x(l)}$ and $S_{m(l)}$ which $l = 1,2,...,r$:

$$\pi(I_{i(r)},\phi) = X_{i(r)} W_i \left(\gamma \Theta_{i(r)}\right)^{\frac{\mu(\sigma-1)}{\theta}} \phi^{\sigma-1} - w_i \sum_{l=1}^{r} \left(\sum_{k\in S_{x(l)}} f_{ki} + \sum_{k\in S_{m(l)}} f_{ik}^{M} \right). \tag{4.27}$$

Now I can write the corresponding fixed cost for each strategy change as

$$\mathscr{F}_{i(l)} = \sum_{k\in S_{x(l)}} f_{ki} + \sum_{k\in S_{m(l)}} f_{ik}^{M}.$$

The firms' profit can be written as

$$\pi(I_{i(r)},\phi) = \sum_{l=1}^{r} \left(\frac{\phi}{\phi_{i(l)}}\right)^{\sigma-1} w_i \mathscr{F}_{i(l)} - \sum_{l=1}^{r} w_i \mathscr{F}_{i(l)}. \tag{4.28}$$

Now, the free-entry condition can be written as

$$\sum_{r=1}^{R-1} \int_{\phi_r}^{\phi_{r+1}} \sum_{l=1}^{r} \left(\frac{\phi}{\phi_{i(l)}}\right)^{\sigma-1} \mathscr{F}_{i(l)} - \sum_{l=1}^{r} \mathscr{F}_k dG(\phi) + \int_{\phi_R}^{\infty} \sum_{k=1}^{R} \left(\frac{\phi}{\phi_{i(l)}}\right)^{\sigma-1} \mathscr{F}_{i(l)} - \sum_{l=1}^{R} \mathscr{F}_{i(l)} dG(\phi) = f_e. \tag{4.29}$$

By simplifying and imposing the Pareto distribution $G(\phi) = 1 - (\frac{\phi_{min}}{\phi})^{\kappa}$, the free-entry condition in terms of cutoffs sequence is

$$\sum_{r=1}^{R} \frac{\sigma-1}{\kappa+1-\sigma} (\frac{\phi_{min}}{\phi_{i(r)}})^{\kappa} \mathscr{F}_{i(r)} = f_e.^{2} \tag{4.30}$$

Notice $\mathscr{F}_{i(r)} = \sum_{k\in S_{x(r)}} f_{ki} + \sum_{k\in S_{m(l)}} f_{ik}^{M}$, which gives the change in fixed cost when firms start to choose $I_{i(r)}$ corresponding to $\phi_{i(r)}$. Also, we know that $\phi_{xki} = \phi_{i(r)} \quad \forall k \in S_{x(r)}$, and $\phi_{mik} = \phi_{i(r)} \quad \forall k \in S_{m(r)}$. Thus, the above free-entry equation can be written as

$$\sum_{k=1}^{J} \frac{\sigma-1}{\kappa+1-\sigma} (\frac{\phi_{min}}{\phi_{xki}})^{\kappa} f_{ki} + \sum_{k=1}^{J} \frac{\sigma-1}{\kappa+1-\sigma} (\frac{\phi_{min}}{\phi_{mik}})^{\kappa} f_{ik}^{M} = f_e. \tag{4.31}$$

This expression is similar to the free entry condition in Melitz (2003) with Pareto distribution.

[2] see equation (C.19).

Price Index

Once we solve the ordered sequence $\{\phi_{i(r)}\} \quad r = 1,2,3,...,R$ and corresponding strategy vectors $\{I_{i(r)}\}$, now I impose the Pareto distribution and get

$$\begin{aligned} P_i^{1-\sigma} &= \sum_{k=1}^{J} N_{ek} \int_{\phi_{xik}}^{\infty} p_{ik}(\phi)^{1-\sigma} dG(\phi) \\ &= \sum_{k=1}^{J} N_{ek} A_{ik} \frac{\kappa \phi_{min}^{\kappa}}{\kappa+1-\sigma} \left(\sum_{r=r_{0k}}^{R_k} (\gamma \Theta_{k(r)})^{\frac{\mu(\sigma-1)}{\theta}} \left(\phi_{k(r)}^{\sigma-\kappa-1} - \phi_{k(r+1)}^{\sigma-\kappa-1} \right) \right), \end{aligned} \tag{4.32}$$

where r_{0k} is the rank of the cutoff to export to country i from country k in sequence $\{\phi_{k(r)}\}$ (I also assume $\phi_{k(R_k+1)}^{\sigma-\kappa-1} = 0$). Here, A_{ik} is

$$A_{ik} = (1+t_{ik})^{1-\sigma} \tau_{ik}^{1-\sigma} (\frac{\sigma}{\sigma-1})^{1-\sigma} W_k.$$

Tax Revenue

From equation (4.23), and also because the export VAT rebate rate and VAT in China are not country-specific, it makes a difference based on whether the goods are exported, so I suppose $t_{ji} = t_x, \forall j \neq i, t_{ii} = t_d$ and simplify a firm ϕ's tax revenue as

$$t_i(\phi) = t_x \sum_{k \in \mathscr{J}_x(\phi)} \frac{p_{ki}(\phi) q_{ki}(\phi)}{1+t_{ix}} + \bar{\omega} \frac{p_{ii}(\phi) q_{ii}(\phi)}{1+t_d}. \tag{4.33}$$

The aggregate tax revenue is

$$\begin{aligned} \mathscr{T}_i &= t_x \int_{\tilde{\phi}_i}^{\infty} N_{ei} \sum_{k \in \mathscr{J}_x(\phi)} \frac{p_{ki}(\phi) q_{ki}(\phi)}{1+t_{ik}} dG_i(\phi) + \bar{\omega} \int_{\tilde{\phi}_i}^{\infty} N_{ei} \frac{p_{ii}(\phi) q_{ii}(\phi)}{1+t_d} dG_i(\phi) \\ &= N_{ei} t_x \frac{\kappa \sigma w_i f_{ei}}{\sigma-1} + \bar{\omega} N_{ei} \sigma \sum_{r=r_{di}}^{R_i} B_i (1+t_d)^{-\sigma} \tau_{ii}^{1-\sigma} W_i \frac{\kappa \phi_{min}^{\kappa}}{\kappa+1-\sigma} \left((\gamma \Theta_{i(r)})^{\frac{\mu(\sigma-1)}{\theta}} \left(\phi_{i(r)}^{\sigma-\kappa-1} - \phi_{i(r+1)}^{\sigma-\kappa-1} \right) \right) \end{aligned}, \tag{4.34}$$

where $\bar{\omega} = t_d - t_x$ is the tax difference between the domestic and the export VAT. If there is no difference between the domestic and the export VAT, the second term in equation (4.34) will be zero. Then mass of firms will not depend on the distribution of firms, which is similar to Melitz (2003); Antras et al. (2017). However, if $\bar{\omega} \neq 0$, the distribution matters.

Final Goods Exports and Intermediate Goods Imports

First consider the imports of final goods in country i:

$$\begin{aligned} IM_{ij}^{F} &= N_{ej}\int_{\phi_{xij}}^{\infty} p_{ij}(\phi)q_{ij}(\phi)dG(\phi) \\ &= N_{ej}(1+t_{ij})^{1-\sigma}\tau_{ij}^{1-\sigma}\sigma B_i W_i \frac{\kappa\phi_{min}^{\kappa}}{\kappa+1-\sigma}\left(\sum_{r=r(0j)}^{R_j}\left(\gamma\Theta_{i(r)}\right)^{\frac{\mu(\sigma-1)}{\theta}}\left(\phi_{j(r)}^{\sigma-\kappa-1}-\phi_{j(r+1)}^{\sigma-\kappa-1}\right)\right), \end{aligned} \tag{4.35}$$

where $r(0j)$ gives order in sequence $\{\phi_{j(r)}\}$ for exporting to country i.

For aggregate intermediate goods, first consider a firm with productivity ϕ, the value of total intermediate is

$$P_{mi}(\phi)M_i(\phi) = \mu(\sigma-1)\sum_{k\in\mathscr{J}_x(\phi)}\frac{p_{ki}(\phi)q_{ki}(\phi)}{\sigma(1+t_{ki})}. \tag{4.36}$$

The import from specific country j is

$$P_{mi}(\phi)M_{ij}(\phi) = \chi_{ji}^{M}(\phi)\mu(\sigma-1)\sum_{k\in\mathscr{J}_x(\phi)}\frac{p_{ki}(\phi)q_{ki}(\phi)}{\sigma(1+t_{ki})}. \tag{4.37}$$

Notice that the demand of intermediate input between two ordered cutoff will be

$$IM_{ij}(\phi) = \mu(\sigma-1)\chi_{ij}^{M}(\phi)\left(\frac{\phi}{\phi_{i(r)}}\right)^{\sigma-1}\left(\sum_{k=1}^{r} w_i\mathscr{F}_{i(r)}\right). \tag{4.38}$$

We see that at the firm level, firms' intermediate goods imports will be affected by export directly through the level of exports, so the VAT has the direct impact on the level of export and the outsourcing strategy $\chi_{ij}^{M}(\phi)$. There is a general equilibrium effect through the cutoff $\phi_{i(r)}$. Only if $\phi \geq \phi_{i(r_j)}$ will the firm outsource from country j. Here, r_j is the order in which a firm will outsource from country j in sequence $\{\phi_{i(r)}\}$:

$$\begin{aligned} IM_{ij}^{M} &= N_{ei}\int_{\phi_i}^{\infty}\chi_{ij}^{M}(\phi)\mu(\sigma-1)\sum_{k\in\mathscr{J}_x(\phi)}\frac{p_{ki}(\phi)q_{ki}(\phi)}{\sigma(1+t_{ki})}dG(\phi) \\ &= \mu(\sigma-1)\gamma N_{ei}T_j(\tau_{ij}w_j)^{-\theta}\frac{\kappa\phi_{min}^{\kappa}}{\kappa+1-\sigma}\left(\sum_{r=r_j}^{R_i} X_{i(r)}W_i\left(\gamma\Theta_{i(r)}\right)^{\frac{\mu(\sigma-1)}{\theta}-1}\left(\phi_{i(r)}^{\sigma-\kappa-1}-\phi_{i(r+1)}^{\sigma-\kappa-1}\right)\right). \end{aligned} \tag{4.39}$$

4.3 Numerical Exercise: Effects of Change in Export VAT

In this section, I conduct a numerical exercise based on a special case to show the effects of a change in export VAT on firms' trade decisions and other aggregate endogenous variables. I employ a three-country version of the model, in which productivity of the final goods firms has a Pareto distribution. The three countries are asymmetric in that one country has an export VAT, and the other two countries are export VAT free.

In Table 4.1, I summarize the common parameters across all countries in my exercise. Here, the elasticity of final goods σ is calibrated to match my matched sample data in 2007. It is calculated based on the markup between variable cost and gross output. The intermediate input share of total inputs μ is the median value in my 2007 matched sample. The common manufacturing expenditure share η is calculated based on the manufacturing trade share in the World Bank data set.[3] The Pareto distribution shape parameter for final goods κ is from Tintelnot (2017). The Frechet distribution shape parameter θ is from Antras et al. (2017) and the Frechet distribution parameter for average productivity (i.e, T_i) is set to 1 for all countries. For the VAT rate and export VAT rate, I use 17% as the standard VAT rate for domestic sales in country 1. Thus, country 1 could be thought of as China. In the exercise, I raise the export VAT equivalent rate in country 1 from 3% to 9%. This value captures the change in the average export VAT rate from 2004 to 2008.[4] All countries are endowed one unit of labor resources L_i. The fixed cost is shown in matrices (4.40):

$$\boldsymbol{FX^X} = \begin{pmatrix} 0 & 10 & 10 \\ 1 & 0 & 10 \\ 2 & 10 & 0 \end{pmatrix} \qquad \boldsymbol{FX^M} = \begin{pmatrix} 0.1 & 10 & 10 \\ 1 & 0.1 & 10 \\ 10 & 10 & 0.1 \end{pmatrix}. \tag{4.40}$$

$\boldsymbol{FX^X}$ shows the fixed cost of exporting. Each element f_{xji} in column i row j is the fixed cost of exporting from country i to country j. $\boldsymbol{FX^M}$ shows the fixed cost of importing. Each element f_{mij}

[3] See https://data.worldbank.org/indicator/TX.VAL.MANF.ZS.UN.

[4] See Figure 2.1.

in column i row j is the fixed cost of importing from country j to country i.

The results of the numerical exercise are shown in Table 4.2. In the firm-level results part, I first report the productivity cutoffs for exporting and importing for the initial equilibrium of a 3 percent export VAT. This is shown in the left column in Table 4.2. When the export VAT is 3 percent, the productivity cutoff sequence in equilibrium is $\{1.1, 1.52, 2.1, 2.14\}$, dividing observed firms in country 1 into four groups in terms of their location choices.[5] Between 1.10 and1.52, firms do not enter into the international market. They do not import any intermediate inputs from foreign countries nor export to any foreign countries. When $\phi \in [1.52, 2.1)$, firms will import from country 2 but not export to any foreign countries. When $\phi \in [2.10, 2.14)$, firms will be productive enough to export to country 2 and import from country 3. If the firms' productivity is above 2.14, they will import from all countries in the world and export to all of them. The right column reports the cutoffs that arise when the export VAT is 9%. Now, the productivity cutoff sequence is $\{1.09, 1.51, 2.11, 2.3\}$. The productivity cutoff sequence still has four distinct values; therefore, country 1 still has four groups of firms in terms of their exporting and importing decisions. When $\phi \in (1.09, 1.51)$, firms do not enter into the international market. When $\phi \in [1.51, 2.11)$, firms start to importing from country 2 but still do not export to any foreign country. When $\phi \in [2.11, 2; 3)$, firms' optimal choice is to import from country 2 and 3 and export to country 2. In this high export VAT case, firms will export to country 3 only if $\phi \geq 2.3$.

When the export VAT increases, the demand in final goods produced by country 1 for other countries declines; so, only those firms with higher productivity will be able to earn positive profits from exporting. As a result, all cutoffs of exporting increase. Looking at the changes in aggregate variables in Table 4.2, we can see that the mass of entrants declines, and aggregate income declines while the price level increases. Therefore, labor demand and real wage decline. As the real wage declines, the cutoff for staying in the market decline, so those entrants who have relatively low productivity draw now decide to stay in the market. The same logic works for those entrants whose optimal decision does not include exporting. When $t_{j1} = 1.03$, entrants whose productivity draw is in $[1.52, 2.1)$ will choose to outsource only from country 2. When the export

[5] (1) non-traders; (2) import from country 2 only; (3) import from countries 2 and 3 and export to country 2; (4) import from all countries and export to all countries.

VAT increases to 1.09, they will not be affected by the negative demand shock caused by the export VAT increase while the benefits from the real wage decline, so the cutoff for outsourcing from country 2 declines. If entrants have a productivity draw that equals the cutoff for exporting to country 2 and outsourcing from country 3 when $t_{j1} = 1.03$ (i.e.$\phi = 2.10$), they will not outsource from country 3 when export VAT increases to 1.09. The reason is that the cutoff for exporting to country 3 increases when export VAT increases, so now firms cannot export to country 3 so that their exporting potential declines. As a result, outsourcing from country 3 is no longer profitable. This result reflects the interdependence between exporting and outsourcing decisions. I illustrate all cutoffs in Figure 4.1. In this figure, we clearly see that increasing the export VAT will make outsourcing more difficult if entrants also choose to export. [6]

Two other features of the firm-level results are worth mentioning. First, it is not necessary that the cutoff sequence has four distinct values, and the corresponding location choices do not change.[7] Second, even though the cutoff for being an importer declines in this case, a firm that stays in the market may still have a lower probability to import from country 2. This is because now those successful entrants' average productivity declines more than the cutoff for outsourcing from country 2. To summarize, the probability of outsourcing weakly decreases when export VAT increases. [8]

Table 4.2 also gives the aggregate trade shares. The ratios of both exports and imported inputs to GDP decline, and the export share declines more. Intuitively, the export share is more sensitive than import share, because all exporters are affected by export VAT change directly. This model shows the technology substitution between domestic inputs and foreign inputs in the view of the imported input share of total intermediate input. Even though this effect is not strong in this case, it will be stronger if the elasticity of final goods is smaller or there is more dispersion in the productivity draw of final goods producers.[9]

[6]Now, firms who both import and export will take more tax burden, so the requirement of making profit through exporting increases, and the cutoffs of exporting will increase.

[7]For a world with J countries, an extreme case is that there are $2J-1$ cutoffs (entrants' decisions of location never jump when ϕ is increasing. Then the optimal location choices will only add one new country to export to or import from). Another extreme case only 1 cutoff for observed firms so for all firms' who are staying in the market, the optimal choice is to export to all countries and import from all countries.

[8]Increasing the export VAT may not change the probability of importing intermediate goods, but it never decreases this probability.

[9]In the growth decomposition part in Section.3, we also can see the technology substitution is moderate

The change in the mass of importers and exporters can be decomposed into two parts. One part $\Delta\%N_E$ is caused by fewer entrants; the other part is the change in the distribution, denoted as $\Delta\%P$ (not the observed probability).[10] Now the change in mass can be approximated as: $\Delta\%N = \Delta\%N_E + \Delta\%P$. [11]In Figure 4.1, the cutoff for being an exporter increases whereas the cutoff for being an importer declines, so $\Delta\%P_x < 0 < \Delta\%P_m$ and then we have $\Delta\%N_x < \Delta\%N < \Delta\%N_m$. In this case,if I calculate the contribution of $\Delta\%N_e$ and $\Delta\%P$ based on an approximation decomposition, for exporters, $\Delta\%P$ contributes to 22% and $\Delta\%N$ contributes to 78%. For intermediate input importers, $\Delta\%N$ contributes to 161% and $\Delta\%P$ contributes to -61%. The intuition is that only for those importers who also export will undertake more tax burden as a result of increasing the export VAT. Notice the $\Delta\%P$ does not always offset the mass change in importers; all importers may undertake more tax burden if firms always choose to both import and export.

At the bottom of Table 4.2, I report the change in other aggregate variables. As mentioned before, the price will be higher if the export VAT increases because fewer firms stay in the market, leading to the price increase. The GDP decline is caused by the change in the VAT tax revenue. In this case, the demand of final goods are elastic so increasing export VAT will lead a tax revenue decline. Overall, as GDP declines and prices increase, the consumption in country 1 declines.

To further investigate the mechanism behind how the effect of an increase in the export VAT on intermediate input imports depends on the exposure of the export VAT, I conduct two other exercises. The results are shown in Table 4.3. If exports are less concentrated in a small portion of firms, the share of importers that need to undertake the negative shock of an increase in the export tax burden, so importers will be more sensitive to the export VAT rate. To check this reasoning, I change the shape of the Pareto distribution to show how the less-concentrated exporters will affect the distribution of importers. In another exercise, I increase the fixed cost of imports to show how the mass of firms will change when outsourcing becomes more difficult, and there is more overlapping between importers and exporters. According to Table 4.3, both changes support the reasoning, and their effects are strong. When κ decreases, now the change

compared to the value change in imports.

[10]P is the probability of above cutoff. For example, if the cutoff for exporting to country 2 is 2.10, then $P = (\frac{1}{2.1})^{\kappa} = 0.8\%$

[11]Ignore the interaction term $\Delta\%N_E\Delta\%P$

in the mass of importers with respect to export VAT change is -16.92%, which is much more elastic than before. In the second exercise, the change in mass of importers declines from 5.78% to 12.23%. Also, notice that if we change the shape of the distribution, both the change in the mass of importers and the change in the mass of exporters are significant. If we change the fixed cost of outsourcing, the main effect shifts the requirement for outsourcing but does not affect firms' export decisions much, so in this exercise, we find that the results for the mass change in exporters do not change a lot.

In the last part of this section, I do an exercise to investigate the welfare implications of my model, and the results are reported in Table 4.4. Now I set all the fixed costs of exporting and outsourcing in other countries to infinity (10^{12}) but hold the fixed cost of outsourcing and exporting in country 1 to what I showed in the cost matrices, but now only firms in country 1 will choose to outsource and export. Now increasing export VAT will lead the consumption decline by 3%. Then I let $f_{xj1} = 10^{12} \quad (j \neq 1)$, so no final goods trade and the equilibrium is similar to Antras et al. (2017). In this case, we find that increasing the export VAT will not change consumption. Because in this case, export is almost forbidden so no firms will choose to export and pay export VAT no matter how much the export VAT changes. In the third row, I report the case in which firms are allowed to export but not outsource. This case is close to Melitz (2003) with domestic intermediate inputs. Now consumption will decline by 0.3%. We can see that my benchmark model is most elastic with respect to an export VAT change. Because now increasing trade friction in exports will not only impact firms' decision on export but also their decision on outsourcing. Therefore increasing export VAT will lead firms to use less technology from foreign countries. As a result, the variable cost of intermediate inputs will increase compared to the case when export VAT is low. This exercise clearly shows that the interdependence between import and export decisions is important for us to understand when examining the welfare implications of trade liberalization.

Table 4.1: Model Parameters

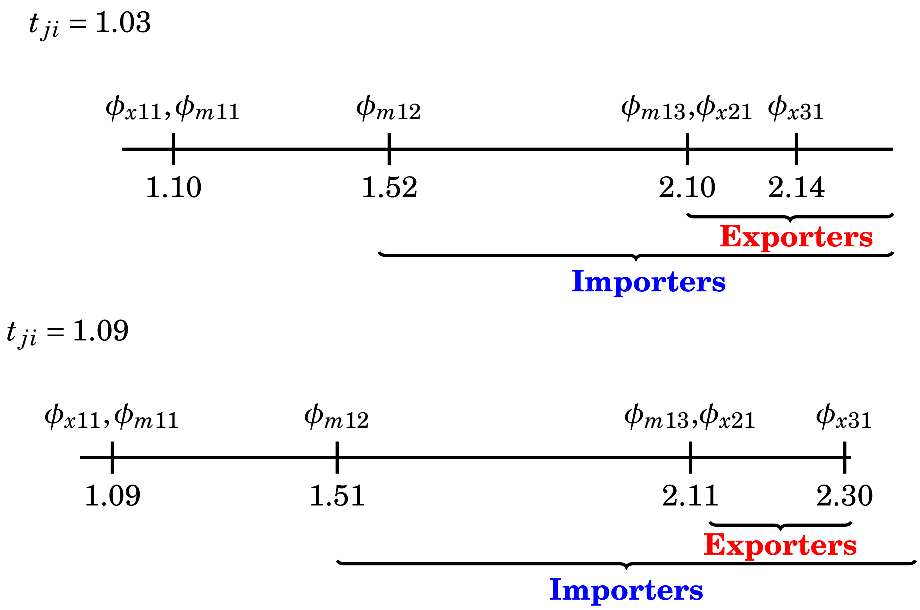
Parameter	Description	Sourcing of Parameters
$\kappa = 6.4$	Pareto shape	Tintelnot (2016)
$\phi_{min} = 1$	Minimum Productivity	
$\sigma = 6.2$	Elasticity of final goods demand	Calibrated based on mark-up in sample
$\eta = 0.69$	Expenditure share in manufacturing goods	World Bank manufacturing exports share
$\mu = 0.91$	Intermediate input share in total input	Median of intermediate Input share in sample
$\tau_{ji} = 1.5$	Iceberg cost	
$\rho = 2$	Elasticity of intermediate input	
$\theta = 1.79$	Frechet shape	Antras et.al.(2017)
$\mathrm{t}_{11} = 0.17$	Standard VAT rate	Policy
Change t_{j1} from 0.03 to 0.09	Effective export VAT rate	Policy data

Table 4.2: Effects of Increasing Export VAT in Country 1

Variable		
Firm-level	t=1.03	t=1.09
Cutoff for staying in domestic market	1.10	1.09
Cutoff for outsourcing from country 2	1.52	1.51
Cutoff for outsourcing from country 3	2.10	2.11
Cutoff for exporting to country 2	2.10	2.11
Cutoff for exporting to country 3	2.14	2.30
Probability of outsourcing from country 2	12.66%	12.66%
Probability of outsourcing from country 3	1.6%	1.5%
Probability of exporting to country 2	1.61%	1.51%
Probability of exporting to country 3	1.40%	0.87%
Trade Share	t=1.03	t=1.09
Final goods export share of GDP	5.61	3.55
Imported input share of GDP	2.79	2.47
Imported input share of total intermediate input	53.24	52.92
Other Change in country level Variables	%Change	
Mass of entrants	-10.82	
Mass of importers	-5.78	
Mass of exporters	-12.11	
Nominal GDP	-0.25	
Price index	0.90	
Consumption	-1.15	

Notes: The probabilities in row 6-10 are the probabilities conditional on successful entry.

Figure 4.1: Productivity Cutoffs of Final Goods Producers in Country 1



Notes: ϕ_{xj1} refers to the cutoffs for exporting from country 1 to j; ϕ_{m1j} refers to the cutoffs for outsourcing from country j to 1.

Table 4.3: Effects of κ and Fixed Cost on Mass Change

	$\kappa = 6.4, f_{m12} = 1$		$\kappa = 5.4$	
	$t_{ji} = 1.03$	$t_{ji} = 1.09$	$t_{ji} = 1.03$	$t_{ji} = 1.09$
% Change in mass of importers	-5.78		-16.92	
% Change in mass of exporters	-12.11		-20.77	
	$\kappa = 6.4, f_{m12} = 1$		$f_{m12} = 10$	
	t=1.03	t=1.09	t=1.03	t=1.09
% Change in mass of importers	-5.78		-12.23	
% Change in mass of exporters	-12.11		-12.23	

Notes: The upper half of table shows the results of only changing shape parameter of the distribution of firms' productivity. The lower half of table shows the results of only changing the fixed cost of outsourcing.

Table 4.4: Effects of Increasing Export VAT in Country 1 on Consumption

Export VAT from 1.03 to 1.09	%Change
Consumption	-3.1
Consumption ($f_{xj1} = \infty, \quad j \neq 1$)	0
Consumption ($f_{m1j} = \infty, \quad j \neq 1$)	-0.30

Notes: In all three cases, all the fixed costs of outsourcing or exporting in the other two countries are set to 10^{12} (Except their domestic sale and input usage.)

4.4 Conclusions

This chapter theoretically investigates the effects of changes in China's export VAT on its import growth decline. To quantify the effects of the export VAT by characterizing empirical findings of Chinese manufacturing firms, I developed a heterogeneous firm model by highlighting location selection in both imports and exports.

The heterogeneous productivity and fixed cost setup emphasizes firms' self-selection for their location choices of export and outsource. The location choices of export destinations affect firms' average revenue, and the location choices of outsourcing affect firms' marginal cost. An increase in the export VAT will directly reduce the number of countries exporters' will export to as well as the production level. As a result, the demand of imported inputs declines, and the imported inputs will decline on both intensive and extensive margins. In addition, for the model solution, I unveiled that to solve the model, we can solve equilibrium productivity cutoffs for country selection and corresponding location choices due to the duality of an enterprise's optimal location selection and minimum productivity for optimal selection decisions.

The numerical exercises show that increasing the export VAT could generate a decline in firms' input interdependence from other countries and generate a fall in the aggregate import ratio to total income. My model also shows a more significant welfare effect of export VAT on aggregate level consumption relative to models that have only final goods export or intermediate input imports.

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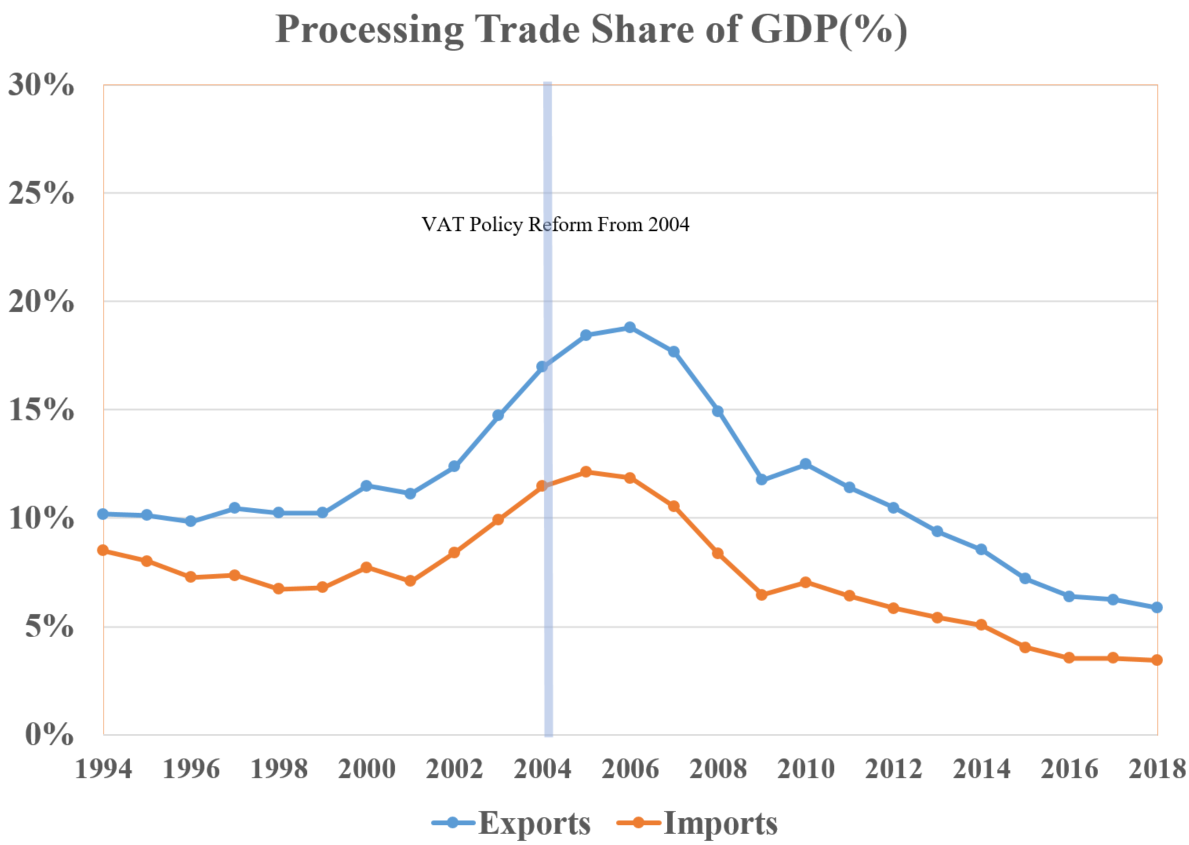
Appendix A

Supplementary Evidences of The Decline in Trade Share

In the introduction chapter, we can see the striking decline in China's trade share started from the mid of 2000s. From figure A.1 and figure A.2, we also find the trend of trade share decline in the two most important trade types ordinary and processing trade.Here, I also show the share variation in "other type" in figure A.3. In the main body of the dissertation, I do not distinguish the difference between other trade and processing trade as the data for identifying this difference is not available after 2005. .

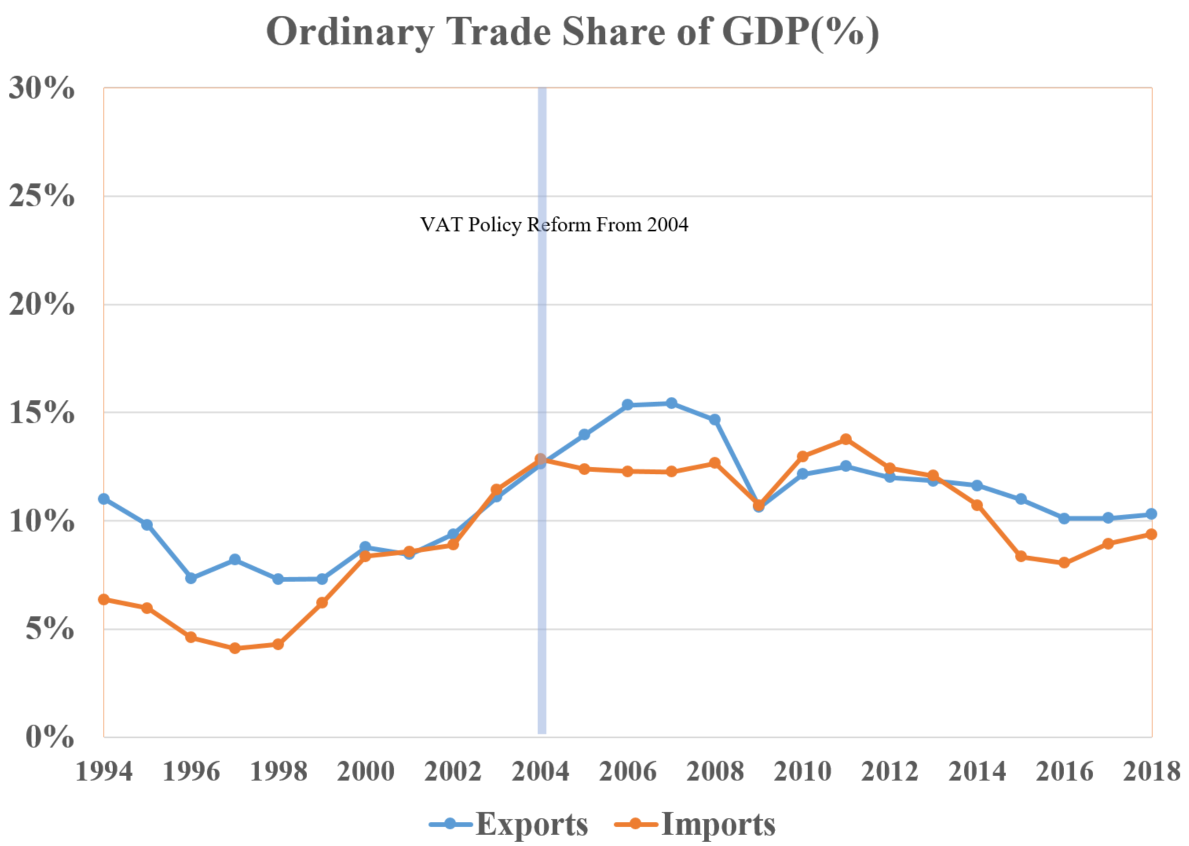
[0]Other trade types are those trade types which are not included in processing trade or ordinary trade, such as "unpriced offset import and export goods", 'other imports and exports provided free of charge", "imported and exported exhibits", etc.

Figure A.1: China's Processing Trade Share of GDP 1990-2018



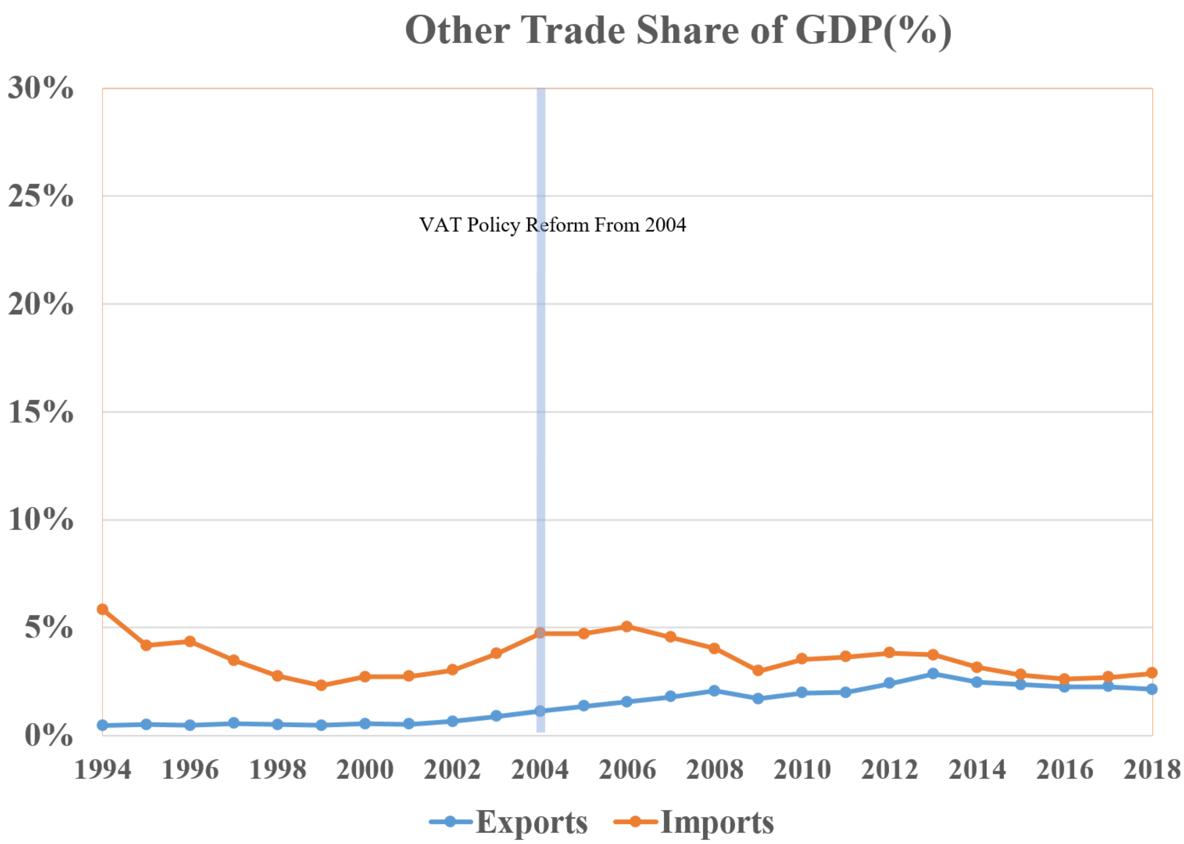
Notes: More details of processing trade can be found in Section 2.4.

Figure A.2: China's Ordinary Trade Share of GDP 1990-2018



Notes: More details of ordinary trade can be found in Section 2.4.

Figure A.3: China's Other Trade Share of GDP 1990-2018



Notes: More details of other trade can be found in NBS' website.

Appendix B

Empirical Appendix

B.1 Summary Statistics

This section mainly shows the summary statistics of China's ASIF data, customs data, and the matched data sets. Furthermore, I also summary the statistics by controlling the firm size in the matched sample. Similar to the definition given in the empirical chapter, firm sizes are measured by employment at the end of each year. Small means less than 300 employees. Medium means employment is between 300 to 1000. Large means firms hire more than 1000 workers.

Table B.1: Summary of Industry Data and Customs Data: Number of Firms and Value of Trade

Year	Industry firms	Exporters	Importers	Exports($)	Imports($)	Imported intermediate goods($)	Share of intermediate imports (%)
2000	150561	62542	62192	2.48E+11	2.15E+11	1.63E+11	75.9
2001	160117	68296	66790	2.66E+11	2.31E+11	1.70E+11	73.4
2002	170769	75609	73671	3.24E+11	2.76E+11	2.01E+11	72.9
2003	191599	90638	82751	4.37E+11	3.85E+11	2.78E+11	72.2
2004	270032	110036	92720	5.87E+11	5.15E+11	3.78E+11	73.3
2005	267676	115886	91825	7.29E+11	5.81E+11	4.42E+11	76.1
2006	297159	171758	129087	9.63E+11	7.18E+11	5.43E+11	75.6
2007	333123	191669	130248	1.21E+12	8.65E+11	6.59E+11	76.2
2008	407781	205335	134749	1.42E+12	1.04E+12	7.89E+11	76.2
2009	362379	215591	135123	1.20E+12	9.17E+11	7.03E+11	76.7

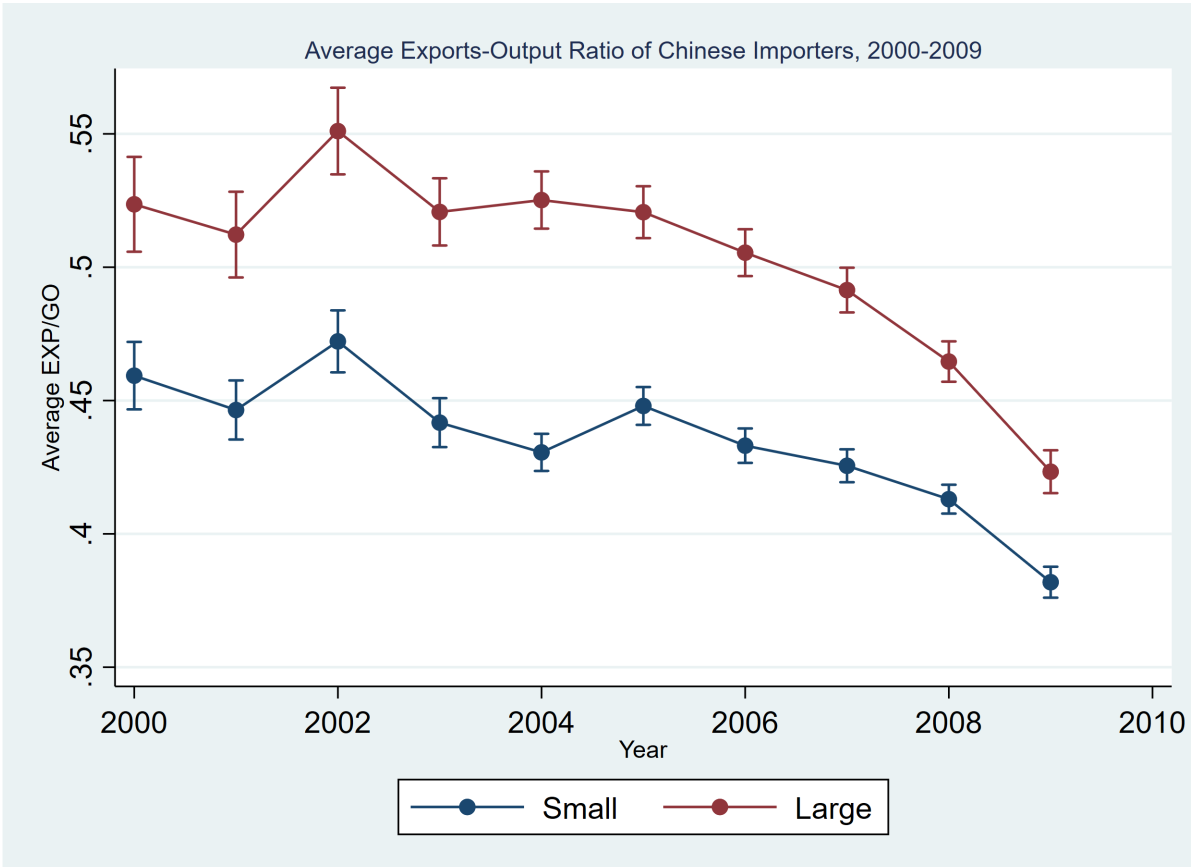
Notes: Exporters or importers are simply defined based on whether or not firms involve in exports or imports. Intermediate goods are defined based on BEC code.

Table B.2: Summary of Matched Sample

Year	2000	2001	2002	2003	2004
Exporters	19545	22668	25739	29962	46574
Fraction of Custom Data(%)	31.3	33.2	34	33.1	42.3
Intermediate goods Importers	16976	18918	20676	23034	34749
Fraction of Custom Data (%)	30.7	32.1	32.1	31.6	42.3
Importers	18058	20189	22329	24824	37476
Fraction of Custom Data	(%) 29	30.2	30.3	30	40.4
Matched exports($)	9.34E+10	1.10E+11	1.42E+11	2.02E+11	3.23E+11
Share of total (%)	37.6	41.4	43.9	46.2	55.1
Matched imported intermediate goods($)	6.35E+10	7.11E+10	8.50E+10	1.18E+11	1.87E+11
Share of total (%)	38.9	41.9	42.4	42.5	49.4
Matched imports(%)	7.93E+10	8.91E+10	1.08E+11	1.52E+11	2.46E+11
Share of total (%)	36.8	38.5	39.2	39.6	47.7
Year	2005	2006	2007	2008	2009
Exporters	47826($)	55382	62756	75952	69158
Fraction of Custom Data(%)	41.3	32.2	32.7	37	32.1
Intermediate goods Importers ($)	34136	37558	39304	45697	40052
Fraction of Custom Data(%)	41.1	34.1	35.7	39.9	34.6
Importers	36556	40486	42835	49783	43316
Fraction of Custom Data(%)	39.8	31.4	32.9	36.9	32.1
Matched exports($)	3.91E+11	5.53E+11	6.29E+11	7.80E+11	6.23E+11
Share of total(%)	53.7	57.4	51.9	54.8	52
Matched imported intermediate goods($)	2.06E+11	2.73E+11	2.90E+11	3.27E+11	2.72E+11
Share of total(%)	46.6	50.3	44	41.5	38.7
Matched imports($)	2.63E+11	3.45E+11	3.64E+11	4.20E+11	3.40E+11
Share of total(%)	45.3	48.1	42.1	40.5	37.1

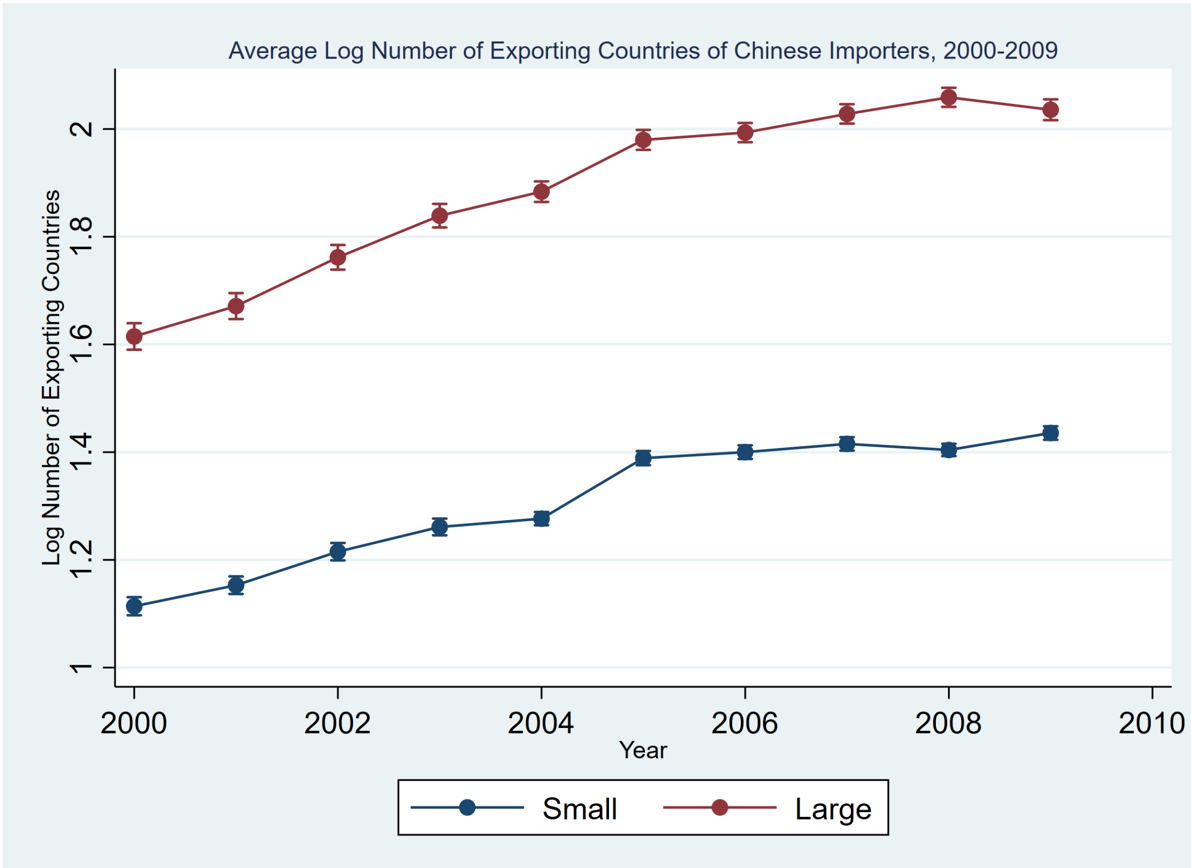
Notes: This table shows how many observations can be matched from customs data or the share of values in the aggregate value of customs data.

Figure B.1: Importers' Average Exports Share of Gross Output 2000-2009



Notes: This figure shows the time trend of the firms' average ratio of exports to gross output in the matched sample during 2000-2009. The bar at each point describes the 95% confidence interval.

Figure B.2: Importers' Average Number of Exporting Countries 2000-2009



Notes: This figure shows the trend of importers' extensive margin in terms of exporting. The bar at each point describes the 95% confidence interval.

Table B.3: Summary Statistics I By Firm Size

	Gross Output (USD MM)			Year Wage Per Worker (USD)		
Year	Small	Medium	Large	Small	Medium	Large
2000	4.8	14.1	70.1	1747.7	1453.7	1391.6
2001	4.9	15.1	77.0	1777.6	1502.9	1505.1
2002	5	15.6	91.7	1852.5	1571.8	1615.3
2003	5.5	17.7	111.1	1900	1652.0	1762.2
2004	5.6	19.6	142.0	2066	1776.8	1965.9
2005	6.4	20.8	155.5	2226.3	2000.7	2210.9
2006	7.6	25.4	187.7	2545.6	2348.7	2606.8
2007	8.5	29.3	220.5	2883.3	2871.3	3335.5
2008	9.1	35.6	261.1			
2009	10.1	38.5	289.7			
	Intermediate Input/GO (%)			Intermediate Input/Total Input (%)		
Year	Small	Medium	Large	Small	Medium	Large
2000	77.8	76.6	76.9	90.2	87.2	87.6
2001	76.9	76.1	75.9	90	87.2	87.5
2002	76	75.0	75.4	89.5	86.9	87.7
2003	76	75.1	75.6	90	87.4	88.0
2004	74.5	74.4	74.2	89.3	86.5	87.3
2005	75.5	74.7	74.2	89.4	86.7	87.1
2006	75.2	74.1	74.1	89.4	86.6	87.0
2007	75.2	73.9	74.2	89.3	86.1	86.5
2008						
2009						
	VAT/Value-Added (%)			Exports/GO (%)		
Year	Small	Medium	Large	Small	Medium	Large
2000	11.7	11.1	14.1	50.1	52.5	33.4
2001	11.8	11.3	13.4	48.9	51.5	35.7
2002	10.1	9.6	11.2	50.8	53.7	40.4
2003	9.5	9.2	10.1	48.5	51.5	44.2
2004	8.8	8.6	9.3	47.6	52.3	46.8
2005	9	8.5	8.8	48.2	50.9	48.0
2006	9.3	9.0	9.6	45.8	49.7	48.6
2007	9.5	8.9	9.0	44.2	48.2	46.9
2008				43.5	45.6	45.1
2009				38.9	41.4	39.8

Notes: This table shows the summary statistic of importers based on firm size. Notice the unit of gross output is million dollar. Also, here the intermediate input value is reported by the database. For VAT data, I only consider those firms' which have positive value-added and VAT. In accounting, VAT can be negative in some periods, but this requires us to consider firms' inter-temporal decision in selling goods which is not my focusing.

Table B.4: Summary Statistics II By Firm Size

	Exported Intermediate Goods/Exports (%)			Imported Intermediate Goods/Imports (%)		
Year	Small	Medium	Large	Small	Medium	Large
2000	49.7	39.1	52.7	77.2	77.2	76.6
2001	50.8	40.5	51.2	76.2	76.5	74.8
2002	50	41.5	48.8	74.9	75.2	73.7
2003	51	42.4	47.3	75.8	75.1	72.6
2004	52	43.3	47.4	75.3	75.4	73.7
2005	51.6	43.6	47.0	77.7	77.4	75.6
2006	52.5	45.2	46.8	77.1	77.0	75.0
2007	52.1	45.8	48.1	77.3	76.8	75.1
2008	52.3	46.4	48.4	77.5	77.9	76.0
2009	52.3	46.2	48.6	79.7	79.4	77.5
	Imports/GO (%)			Imports of Intermediate Input		
Year	Small	Medium	Large	Small	Medium	Large
2000	31.6	33.0	19.9	45.2	49.1	29.4
2001	29.2	30.3	20.0	42.0	47.3	29.2
2002	29.9	30.3	22.2	42.7	45.5	31.5
2003	27.2	27.1	22.6	40.0	41.6	33.4
2004	27.3	27.3	23.8	43.4	43.3	39.6
2005	24.9	23.7	22.7	37.3	36.5	34.8
2006	22.9	21.4	21.4	34.4	33.9	32.7
2007	21.3	19.5	19.1	32.2	30.7	29.3
2008	20.1	17.4	18.0			
2009	17.1	15.1	15.1			
	Number of Exports Destinations			Number of Countries Imports From		
Year	Small	Medium	Large	Small	Medium	Large
2000	4.8	7.2	10.0	3.5	5.1	6.5
2001	5.2	8.0	11.2	3.5	5.0	6.9
2002	5.8	8.8	12.4	3.6	5.1	7.6
2003	6.0	9.6	13.9	3.5	5.1	8.1
2004	6.3	10.2	15.1	3.3	5.2	8.7
2005	7.1	10.8	15.9	3.3	5.0	8.9
2006	7.2	11.0	16.6	3.3	5.0	8.8
2007	7.4	11.6	17.9	3.1	5.0	9.0
2008	7.5	12.0	18.9	3.1	5.1	9.3
2009	7.6	11.8	18.9	3.1	5.1	9.1

Notes: In this table, the traded intermediate goods are determined based on BEC codes.

B.2 Decomposition of Intermediate Goods Classified By BEC Code

In this section, I decompose the import growth change in imported intermediate goods which is classified based on BEC code. The main results are similar to the decomposition in all imports.

Table B.5: Decomposition of China's Intermediate Goods Import Growth

Panel A		Due to Different Margins		
Year	Total Growth(%)	Proportion of Net Entry	Proportion of Extensive Margin	Proportion of Intensive Margin
2000-2004	136.6	52.5	17.2	30.3
2004-2009	86.1	49.7	8.2	42.1
2000-2009	340.2	68.2	11.5	20.3
Panel B		**Trade Types**		
Year	Total Growth(%)	Proportion of Processing Trade	Proportion of Non-processing Trade	
2000-2004	136	47.5	52.5	
2004-2009	86.1	31.1	68.9	
2000-2009	340.2	37.7	62.3	

Notes: The upper half of the table shows the contributions at the extensive margin or intensive margin. The lower half of table shows the contribution from ordinary trade or non-ordinary trade (in this paper, all non-ordinary trade I treat it as processing trade).

Table B.6: Decomposition of Imported Intermediate Goods Share of Intermediate Input

Year	Overall Change(%)	Within	Between	Cov	NetEntry
2000-2004	0.96	-1.19	-5.36	0.15	7.37
2004-2007	-4.34	-3.2	-1.01	-0.03	-0.11
2000-2007	-3.38	-3.67	-5.86	1.85	4.3

B.3 Regression By Controlling Trade Regimes

This section will interact export VAT with trade regime indicator to check the impact of export VAT on non-processing trade and processing trade relative to non-processing trade.

B.3.1 The Impact on Intra-Product Trade

$$\ln IM_{fpt} = \beta_1 \ln v_{pt} + \beta_2 \ln v_{pt} \times Process_f + \beta_3 \ln tr_{pt} + \beta_4 \ln tr_{pt} \times Process_f + \boldsymbol{\beta_X X_{ft}} + \gamma_f + \gamma_t + \epsilon_{fpt} \tag{B.1}$$

In equation (B.1), IM_{fpt} is the value of imported intermediate goods p of firm f in period t. $Process_f$ is a dummy to indicate whether or not an importer is a process firm, which equals to 1 if more than 99% of its imported goods are belong to processing trade. γ_f is firm fixed effect, γ_t is the time fixed effect. v_{pt} is the *product-level* real VAT rate at six-digit HS code level.It is defined as $1+\text{VAT}_{pt}-\text{Rebate}_{pt}$.The industry-level VAT rate and export rebate rate are constructed based on following steps. First, use the simple mean of 10-digit *product-level* VAT rate and export rebate rate to generate the product-level real VAT rate in 6-digit level. Then use a concordance given by WTO to map 6 digit-level to 4-digit industry level.[1] Another important policy which can impact firms' imports of input is tariff, I also include it in my regression. The approach to construct industry-level tariff tr_{nt} is similar to the approach to construct VAT rebate rate.

$\boldsymbol{\beta_X X_{ft}}$ denotes other firm characteristics, such as type of ownership (i.e. State Owner Enterprises or multinational firms). Firm size is important to firms' decision of both intensive and extensive margins. Different firm sizes can respond to trade policy differently based on their productivity(Assume firm size captures firms' productivity.) SOEs are traditionally believed to have relatively low economic efficiency and respond less to trade policy change. For multinational firms which controlled by foreign companies, their imports decision will also be impacted

[1] Ideally, we want to have a firm-level VAT rebate rate, however the data of VAT rebate rate available is product-level which makes constructing a firm-level VAT rebate rate is under high risk of endogeneity.

by other exogenous trade policy specific to them.

$$\mathbb{I}^R_{fpt} = \beta_1 \ln v_{pt} + \beta_2 \ln v_{pt} \times Process_f + \beta_3 \ln tr_{pt} + \beta_4 \ln tr_{pt} \times Process_f + \boldsymbol{\beta_X X_{ft}} + \gamma_f + \gamma_t + \epsilon_{fpt} \quad \text{(B.2)}$$

B.3.2 The Impact on Intra-Industry Trade

I also check the industrial-level impact across different trade treatments.

$$\ln IM_{fpt} = \beta_1 \ln v_{nt} + \beta_2 \ln v_{nt} \times Process_f + \beta_3 \ln tr_{pt} + \beta_4 \ln tr_{pt} \times Process_f + \gamma_f + \gamma_t + \epsilon_{fpt} \quad \text{(B.3)}$$

The results of VAT impact on intra-product and intra-industry imports are in table B.7.

Table B.7: Results of VAT Impact on Intra-Product Intra-Industry Trade of Imports

	(1)	(2)	(3)	(4)	(5)	(6)
	I_{IMft}	$\ln IM_{pt}$	$\ln IM_{pt}$	I_{IMft}	$\ln IM_{pt}$	$\ln IM_{pt}$
$\ln v_{pt}$	0.777***	-5.434***	-4.090***			
	(0.013)	(0.150)	(0.154)			
$\ln v_{pt} \times Process_f$	0.777***	0.643**	1.529***			
	(0.025)	(0.273)	(0.279)			
$\ln v_{nt}$				0.271***	0.352*	0.809***
				(0.024)	(0.205)	(0.200)
$\ln v_{nt} \times Process_f$				-1.619***	-1.469***	-7.337***
				(0.048)	(0.356)	(0.474)
$\ln tr_{pt}$	-1.047***	-4.963***	-6.467***	-0.976***	-5.253***	-5.362***
	(0.014)	(0.115)	(0.134)	(0.015)	(0.120)	(0.147)
$\ln tr_{pt} \times Process_f$	-1.290***	3.283***	-1.643***	-1.505***	3.246***	-1.657***
	(0.029)	(0.189)	(0.247)	(0.033)	(0.192)	(0.339)
$\ln L_{ft}$	0.024***	0.177***	0.221***	0.021***	0.183***	0.199***
	(0.001)	(0.008)	(0.008)	(0.001)	(0.008)	(0.008)
SOE_{ft}	-0.020***	-0.022	-0.058***	-0.015***	-0.023	-0.036
	(0.002)	(0.021)	(0.022)	(0.002)	(0.022)	(0.022)
Foreign_{ft}	-0.016***	-0.042**	-0.075***	-0.012***	-0.047***	-0.058***
	(0.002)	(0.017)	(0.018)	(0.002)	(0.017)	(0.018)
Control Selection Effect		N	Y		N	Y
Firm FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
N	7446928	5622415	5622415	7264020	5491573	5491573
R^2	0.459	0.169	0.170	0.453	0.165	0.166

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Column 1 and column 4 refer to participation estimation in (B.2).Column 2 estimates equation (B.1) without controlling select effect. Column 4 estimates the impact of intra industry VAT impact in equation (B.3) without controlling select effect. SOE_{ft} is a dummy equals to 1 if the firm is state-owned. $Foregin$ is a dummy equals to 1 if the firm is controlled by foreign companies.

B.4 Indirect Impact of VAT

If I use product-level import to run the regression, I also consider constructing an indirect product-level VAT for intermediate input. Here, the relationship between different products is derived from input-output, which gives industry-level relation, then I map industry-level to product-level. The transformation will follow the following model. Consider the intermediate input follows:

$$\boldsymbol{AX} + \boldsymbol{F} = \boldsymbol{X} \tag{B.4}$$

Here,$\boldsymbol{X}$ is the output vector in each industry, $\boldsymbol{F}$ is the final demand vector, $\boldsymbol{A}$ is the direct input coefficients matrix. Construct the indirect VAT based on direct input coefficients matrix:

$$\begin{pmatrix} a_{11} & a_{12} & \dots & a_{1K} \\ a_{21} & a_{22} & \dots & a_{2K} \\ a_{K1} & a_{K2} & \dots & a_{KK} \end{pmatrix}$$

$$v^*_{nt} = \sum_j a_{nj} v_{jt} \tag{B.5}$$

For example: Then the expenditure share of intermediate of industry 1 used in industry 1 is 0.67,

Table B.8: Input Coefficients Matrix

	Industry1	Industry2
Industry1	0.67	0.33
Industry2	0.5	0.5

the export VAT in industry 1 will be weighted 0.67. Similarly, the weight of industry 2 will be 0.33.

Here,direct input coefficients matrix $\boldsymbol{A}$ are calculated by using China's 2002 input-output table.Then use the product-industry concordance provided by Garred(2018) get the product-level VAT for input v^*_{ht}. The indirect VAT measures the weighted average export VAT level based on all the downstream of an industry (Or product). Here, when VAT changes, it means a general change in the export VAT in all downstream industries, it will impact the demand of specific final goods (Which we intend to measure the impact of VAT) used in these downstream industries.

As a result, the demand of the intermediate of producing the final goods will decline. That is the channel how indirect VAT in a specific VAT will impact the imports within this specific subheading of products. The results are in table B.9.

Table B.9 shows the impact of indirect VAT. It shows the impact on a specific product caused by a general domestic input demand shock from all downstream products when a change happens on the VAT rate. The results are similar to product-level VAT change. We notice not like direct product-level VAT change, now pure-processing firms are more sensitive to the VAT change. This because increasing indirect VAT is an overall negative shock to this product rather than only exporters. A general increase of export VAT makes downstream domestic firms better off while exporters worse off; pure processing firms will be impacted less by the domestic firms. So the negative shock of exporters will be mitigated less by domestic firms and they are more sensitive to the indirect VAT shock.

B.5 Check Trade Regime and Firm Size Switching

In my specification, $Process$ indicator represents whether or not a firm only involve in imports through processing trade. I can also classify the sample by whether or not firms only involve in ordinary trade. Summary statistics are shown in table B.10 and table B.11. Table B.12 shows the results that firms never switch its status based on whether or not they are pure-processing trade firms.

Table B.9: The Impact of Indirect VAT on Imports

	(1)	(2)	(3)
	I_{IMft}	$\ln IM_{ft}$	$\ln IM_{ft}$
$\ln v^*_{pt}$	0.611***	-5.047***	-3.942***
	(0.017)	(0.186)	(0.182)
$\ln v^*_{pt} \times Process_f$	0.717***	-1.442***	-0.843***
	(0.031)	(0.292)	(0.301)
$\ln tr_{pt}$	-1.027***	-5.081***	-6.494***
	(0.014)	(0.117)	(0.140)
$\ln tr_{pt} \times Process_f$	-1.276***	3.111***	-1.503***
	(0.029)	(0.192)	(0.258)
$\ln L_{ft}$	0.024***	0.175***	0.216***
	(0.001)	(0.008)	(0.008)
SOE_{ft}	-0.019***	-0.017	-0.051**
	(0.002)	(0.022)	(0.022)
Foreign_{ft}	-0.016***	-0.041**	-0.069***
	(0.002)	(0.017)	(0.018)
Control Selection Effect		N	Y
Firm FE	Y	Y	Y
Year FE	Y	Y	Y
N	7464803	5638433	5638433
R^2	0.457	0.168	0.169

Notes: Standard errors in parentheses. Significant at * $p < .10$, ** $p < .05$, *** $p < .01$. Significance will not change if heteroskedasticity-robust standard errors clustered at the product-level.

Table B.10: Summary of Trade Regime and Firm Size Switch I

		Firm Size Ever Changed		
		N	Y	Total
Trade Regime	N	69891	7654	77545
Ever Changed	Y	14347	4596	18943
	Total	84238	12250	96488

Notes: This is a two-way table to counts the number of firms in the matched sample that changes the trade regime in one year and the number of firms that change firm sizes.

Table B.11: Summary of Trade Regime and Firm Size Switch II

		Firm Size Ever Changed		
		N	Y	Total
Trade Status	N	70985	9235	80220
Ever Changed	Y	13253	3105	16268
	Total	84238	12250	96488

Notes: This is a two-way table to counts the number of firms in the matched sample which change the trade status of ordinary trade (either ordinary or processing) in a specific year and the number of firms that change firm sizes.

Table B.12: Firms Changed Trade Regime or Firm Size Each Year

	Percentage of Firms Deviate From			
Year	Pure Processing	Pure Ordinary	Small	Large
2000	7.1	2.9	3.4	2.7
2001	7.9	3.3	3.8	2.2
2002	7.7	3.6	4.3	2.3
2003	6.0	4.2	4.6	2.6
2004	5.9	3.8	3.9	2.3
2005	6.2	3.9	3.5	2.4
2006	5.8	3.7	3.1	2.3
2007	5.2	3.2	2.7	2.8
2008	5.2	3.2	2.0	3.0
2009				

Notes: This table shows the proportion of firms that change its firm size or trade status in the next year.

Table B.13: Average Firm Size Change

ΔL_t(%)	Share of Firms(%)
≤ -50	6.7
(-50,30]	7.6
(30,10]	11.3
(-10,10]	42.9
(10,30]	8.8
(30,50]	5.5
≥ 50	17.2
Total	100.0

Notes: The table summarizes the change in firm sizes measured by employment in the sample. Firms' employment declined most by 88% and increased by 860% at most(Here, I trim the top and the bottom 0.5% outliers.).

Appendix C

Model Appendix

C.1 Proof of Proposition

C.1.1 Proposition 1

Proposition 1:When $\mu(\sigma-1)\geq\theta$,firms' profits $\pi(I,\phi)$ are supermodular in firms' choice of export and outsourcing countries I.

Proof

Denote firms' trade strategy $I_1\in\{0,1\}^{2J}$,$I_2\in\{0,1\}^{2J}$, and a projection map

$$\mathscr{P}(I)=\left\{k:I_{ki}^{M}=1\right\}\bigcup\left\{j:j=J+k,I_{ki}^{X}=1\right\}$$

. Let V describes the collection of all the subsets of joint export and outsourcing strategy. Now suppose there are two decision set A and B, and $A\subseteq B\subseteq V$. The difference between the corresponding decision vector I_A and I_B gives a set of countries that are different in two vectors. Now suppose there are some new countries either as export to or outsource from will be selected, the difference of choice will be in set $S\in V$ and $S\notin B$. Here, $S=S^X\bigcup S^I$, where S^X is the change in the export decision and S^I is the change in the outsourcing decision.

According to equation (4.12), if we treat $t_{ji},\tau_{ji},B_j,w_i,T_j,f_{ji},f_{ji}^{I},\phi$ as given, firms profit can be written as:

$$\pi(A) = \sum_{k\in A} I^X_{ki}\omega_{k1}\left(\sum_{k\in A} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}} - \sum_{k\in A} I^X_{ki}\omega_{k3} - \sum_{k\in A} I^I_{ki}\omega_{k4}. \tag{C.1}$$

Here,

$$\omega_1 = (1+t_{ki})^{-\sigma}(\tau_{ki})^{1-\sigma}B_k\iota^{1-\sigma}w_i^{(1-\mu)(1-\sigma)},$$

$$\omega_2 = \gamma T_j(\tau_{ij}w_j)^{-\theta},$$

$$\omega_3 = w_i f^X_{ki},$$

$$\omega_4 = w_i f^M_{ik},$$

and notice $\omega_1, \omega_2, \omega_3, \omega_4 > 0$.

Now

$$\begin{aligned}\pi(A\cup S)-\pi(A) = &\sum_{k\in A\cup S} I^X_{ki}\omega_{k1}\left(\sum_{k\in A\cup S} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}} - \sum_{k\in A} I^X_{ki}\omega_{k1}\left(\sum_{k\in A} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}}\\ &- \sum_{k\in S^X} I^X_{ki}\omega_{k3} - \sum_{k\in S^I} I^I_{ki}\omega_{k4},\end{aligned}$$

$$\begin{aligned}\pi(B\cup S)-\pi(B) = &\sum_{k\in B\cup S} I^X_{ki}\omega_{k1}\left(\sum_{k\in B\cup S} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}} - \sum_{k\in B} I^X_{ki}\omega_{k1}\left(\sum_{k\in B} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}}\\ &- \sum_{k\in S^X} I^X_{ki}\omega_{k3} - \sum_{k\in S^I} I^I_{ki}\omega_{k4}.\end{aligned}$$

Here, the last two terms are equal, so to compare $\pi(A\cup S)-\pi(A)$ and $\pi(B\cup S)-\pi(B)$, we only need to compare the first two terms.

$$\begin{aligned}&\sum_{k\in A\cup S} I^X_{ki}\omega_{k1}\left(\sum_{k\in A\cup S} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}} - \sum_{k\in A} I^X_{ki}\omega_{k1}\left(\sum_{k\in A} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}}\\ &= \sum_{k\in S^X} I^X_{ki}\omega_{k1}\left(\sum_{k\in A\cup S} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}} + \sum_{k\in A} I^X_{ki}\omega_{k1}\left(\left(\sum_{k\in A\cup S} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}} - \left(\sum_{k\in A} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}}\right),\end{aligned} \tag{C.2}$$

$$\sum_{k\in B\cup S} I^X_{ki}\omega_{k1}\left(\sum_{k\in B\cup S} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}} - \sum_{k\in B} I^X_{ki}\omega_{k1}\left(\sum_{k\in B} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}}$$
$$= \sum_{k\in S^X} I^X_{ki}\omega_{k1}\left(\sum_{k\in B\cup S} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}} + \sum_{k\in B} I^X_{ki}\omega_{k1}\left(\left(\sum_{k\in B\cup S} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}} - \left(\sum_{k\in B} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}}\right). \tag{C.3}$$

If $A \subseteq B$, obviously we have:

$$\sum_{k\in S^X} I^X_{ki}\omega_{k1}\left(\sum_{k\in B\cup S} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}} \geq \sum_{k\in S^X} I^X_{ki}\omega_{k1}\left(\sum_{k\in A\cup S} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}}. \tag{C.4}$$

We know if $\mu(\sigma-1)\geq\theta$, $\left(\sum_{k\in A\cup S} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}} - \left(\sum_{k\in A} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}}$ is increasing difference in any $A \subseteq V$. Then if $A \subseteq B$, we have:

$$\sum_{k\in B} I^X_{ki}\omega_{k1}\left(\left(\sum_{k\in B\cup S} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}} - \left(\sum_{k\in B} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}}\right) \geq \sum_{k\in A} I^X_{ki}\omega_{k1}\left(\left(\sum_{k\in A\cup S} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}} - \left(\sum_{k\in A} I^I_{ki}\omega_{k2}\right)^{\frac{\mu(\sigma-1)}{\theta}}\right) \tag{C.5}$$

Therefore

$$\pi(B\cup S)-\pi(B) \geq \pi(A\cup S)-\pi(A) \quad if A\subseteq B \tag{C.6}$$

So firms' profits are supermodular in firms' trade decisions. Further more, we notice if AB, all inequality will be strict, so profit function is strictly increasing in firm's trade decision I when $\frac{\mu(\sigma-1)}{\theta}$.

C.1.2 Proposition 2

Proposition 2: When $\mu(\sigma-1)\geq\theta$,firms trade strategy $\mathscr{I}(\phi)=\{I : argmax \quad \pi(I,\phi)\}$ is increasing in ϕ.

Theorem 1:Suppose that X is a lattice,T is a partially ordered set, S_t is a subset of X for each t in T,S_t is increasing in t on T,$f(x,t)$ is supermodular in x on $X\times T$, if t' and t'' are in T, $t' \prec t''$, x' is in $\arg\max_{x'\in S_{t'}} f(x,t)$, and x'' is in $\arg\max_{x'\in S_{t''}} f(x,t)$, then $x' \preceq x''$. (See Topkis (1998).)

Proof:

According to proposition 1, we know profit function is supermodular, obviously profit function is also increasing in ϕ which is partially ordered. So profit function is increasing differences in (I,ϕ). Then proposition can be got directly based on theorem 1.

C.1.3 Proposition 3

Proposition 3:

(a) In equilibrium, the sequence of cutoffs $\{\phi_{i(r)}\}$ satisfies:

$$\phi_{i(r)}^{1-\sigma} = \max_{S_x,S_m} \frac{X_i\left(\mathscr{J}_x(\phi)\bigcup S_x\right)W_i\left(\gamma\Theta_i(\mathscr{J}_m(\phi)\bigcup S_m)\right)^{\frac{\mu(\sigma-1)}{\theta}} - X_i\left(\mathscr{J}(\phi_{i(r-1)})\right)W_i\left(\gamma\Theta_i(\mathscr{J}_m(\phi_{i(r-1)})\right)^{\frac{\mu(\sigma-1)}{\theta}}}{\sum_{S_m} w_i f_{ik}^M + \sum_{S_x} w_i f_{ki}}. \tag{C.7}$$

(b) When $\frac{\mu(\sigma-1)}{\theta} \geq 1$, each cutoff $\phi_{i(r)}$ in the sequence of cutoffs $\{\phi_{i(r)}\}$ given by part (a) has a unique corresponding trade strategy if all zero cutoff conditions hold. *Proof*

For part (a),suppose the above condition does not give an equilibrium, which must exists a firm ϕ between $(\phi_{i(r-1)}, \phi_{i(r)})$ with strategy $I' \neq I_{i(r-1)}$ and also $I' \neq I_{i(r)}$. Then it satisfies:

$$\pi(I'(\phi)) - \pi(I_{i(r-1)}, \phi) > 0 \Longrightarrow$$
$$X_i(J_x(\phi)\bigcup S_x')W_i\left(\gamma\Theta_i(\mathscr{J}_m(\phi)\bigcup S_m')\right)^{\frac{\mu(\sigma-1)}{\theta}}\phi^{\sigma-1} - X_i(J_x(\phi_{i(r-1)}))W_i\left(\gamma\Theta_i(\mathscr{J}_m(\phi_{i(r-1)}))\right)^{\frac{\mu(\sigma-1)}{\theta}}\phi^{\sigma-1}$$
$$> \sum_{S_m'} w_i f_{ik}^M + \sum_{S_x'} w_i f_{ki}$$
$$\Longrightarrow \frac{X_i(J_x(\phi)\bigcup S_x')W_i\left(\gamma\Theta_i(\mathscr{J}_m(\phi)\bigcup S_m')\right)^{\frac{\mu(\sigma-1)}{\theta}} - X_i(J_x(\phi_{i(r-1)}))W_i\left(\gamma\Theta_i(\mathscr{J}_m(\phi_{i(r-1)}))\right)^{\frac{\mu(\sigma-1)}{\theta}}}{\sum_{S_m'} w_i f_{ik}^M + \sum_{S_x'} w_i f_{ki}} > \phi^{1-\sigma} > \phi_{i(r)}^{1-\sigma}.$$

However, according to our condition in proposition, $\phi_{i(r)}^{1-\sigma}$ is the strategy maximize $\phi^{1-\sigma}$,so contradiction. Therefore, the sequence $\{\phi_{i(r)}\}$ satisfies the condition in proposition 3 gives the zero cutoffs which firms have no motivation to deviate.Furthermore, the problem to maximize the productivity sequence is also increasing difference in firms' trade strategy.(Here, only numerator matters, when $\frac{\mu(\sigma-1)}{\theta} \geq 1$ holds, when know it is increasing difference based on proposition 1.)

For part (b), now suppose there are two trade strategies, the sets of choice change are $S_x \neq S_x'$ or $S_m \neq S_m'$ and corresponding vectors are I_s and $I_{s'}$. Now w have:

$$\begin{aligned}
\pi(I + I_{s'}, \phi) &= X_i(\mathscr{J}_x(\phi)\bigcup S_x')W_i\left(\gamma\Theta_i(\mathscr{J}_m(\phi)\bigcup S_m')\right)^{\frac{\mu(\sigma-1)}{\theta}}\phi_{i(r)}^{\sigma-1} - FX_i\left(\mathscr{J}_x(\phi)\bigcup S_x', \mathscr{J}_m(\phi)\bigcup S_m'\right),\\
\pi(I + I_s, \phi) &= X_i(\mathscr{J}_x(\phi)\bigcup S_x)W_i\left(\gamma\Theta_i(\mathscr{J}_m(\phi)\bigcup S_m)\right)^{\frac{\mu(\sigma-1)}{\theta}}\phi_{i(r)}^{\sigma-1} - FX_i\left(\mathscr{J}_x(\phi)\bigcup S_x, \mathscr{J}_m(\phi)\bigcup S_m\right).
\end{aligned} \tag{C.8}$$

Suppose $S_x \neq S_x'$ and we have $\left(\gamma\Theta_i(\mathscr{J}_m(\phi)\bigcup S_m')\right)^{\frac{\mu(\sigma-1)}{\theta}} \geq \left(\gamma\Theta_i(\mathscr{J}_m(\phi)\bigcup S_m)\right)^{\frac{\mu(\sigma-1)}{\theta}}$. If $S_x \subset S_x'$, we know unless $S_x = S_x'$, otherwise $X_i(\mathscr{J}_x(\phi)\bigcup S_x') > X_i(\mathscr{J}_x(\phi)\bigcup S_x)$. Because we Suppose $S_x \neq$

S'_x and $\left(\gamma\Theta_i(\mathscr{I}_m(\phi)\bigcup S'_m)\right)^{\frac{\mu(\sigma-1)}{\theta}} \geq \left(\gamma\Theta_i(\mathscr{I}_m(\phi)\bigcup S_m)\right)^{\frac{\mu(\sigma-1)}{\theta}}$,then we must have $\pi(I+I_{s'},\phi) > \pi(I+I_s,\phi) = \pi(I,\phi)$, contradiction. If $S_x \not\subset S'_x$, we must find at least one country $j \notin S'_x$. We have:

$$(1+t_{ji})^{-\sigma}\tau_{ki}^{1-\sigma}B_k W_i \left(\gamma\Theta_i(\mathscr{I}_m(\phi)\bigcup S'_m)\right)^{\frac{\mu(\sigma-1)}{\theta}} - w_i f_{ji} \geq (1+t_{ji})^{-\sigma}\tau_{ki}^{1-\sigma}B_k W_i \left(\gamma\Theta_i(\mathscr{I}_m(\phi)\bigcup S_m)\right)^{\frac{\mu(\sigma-1)}{\theta}} - w_i f_{ji} \geq 0. \tag{C.9}$$

If so, country j should be included in S'_x based on the zero cutoff condition for sequence $\phi_{i(r)}$, contradiction. When $\frac{\mu(\sigma-1)}{\theta} \geq 1$, we can use similar approach to prove $S_m \neq S'_m$ is impossible. Overall, there does not exist two different trade strategies for one cutoff $\phi_{i(r)}$.

C.2 Derivation of Related Equations

C.2.1 Cost

Given the export decision $\mathscr{I}_{xi}(\phi)$, firms need to use $M_i(\phi)$ unit intermediate bundle to produce q_i units of final goods. Besides intermediate input $M_i(\phi)$, firms will also need to input l_i units of labor, the technology follow Cobb-Douglas function. The final good producer ϕ in country j solves the following problem:

$$\min_{l_i, M_i(\nu)\geq 0} w_i l_i + P_i^M M_i, \tag{C.10}$$

subject to:

$$q_i = \phi l_i^{1-\mu} M_i(\phi)^{\mu}, \tag{C.11}$$

$$M_i(\phi) = \left(\int_0^1 m_i(\nu,\phi)^{\frac{\rho}{\rho-1}} d\nu\right)^{\frac{\rho-1}{\rho}}. \tag{C.12}$$

All suppliers are in perfectly competitive market, so we have an ideal price index $P_i^M(\phi)$ for intermediate bundle $M_i(\phi)$

$$P_i^M(\phi) = \left(\int_0^1 z_i(\nu,\phi)^{1-\rho} d\nu\right)^{\frac{1}{1-\rho}}. \tag{C.13}$$

Because it is from a extreme value distribution, we get:

$$P_i^M(\phi) = \left(\gamma \sum_{j=1}^{J} T_j(\tau_{ij} w_j)^{-\theta}\right)^{-\frac{1}{\theta}}. \tag{C.14}$$

Solve the cost minimization problem, we have marginal cost function for domestic production:

$$c_i(\phi) = \frac{\iota}{\phi} w_i^{1-\mu} P_i^{M\mu}. \tag{C.15}$$

To sell $q_{ji}(\phi)$ units of final good in country j, firms need produce $\tau_{ji} q_{ji}(\phi)$ units. Therefore, we have $c_{ji}(\phi)$:

$$c_{ji}(\phi) = \frac{\tau_{ji}\iota}{\phi} w_i^{1-\mu} P_i^{M\mu}. \tag{C.16}$$

C.2.2 In Pareto Distribution

Based on my discussion in 4.2.4, I can write the profit function as:

$$\begin{aligned}
\pi(I_{i(r)}, \phi) &= X_{i(r)} W_i \left(\gamma \Theta_{i(r)}\right)^{\frac{\mu(\sigma-1)}{\theta}} \phi^{\sigma-1} - w_i \sum_{l=1}^{r} \mathscr{F}_{i(l)} \\
&= \sum_{l=1}^{r} \left(X_{i(l)} W_i \left(\gamma \Theta_{i(l)}\right)^{\frac{\mu(\sigma-1)}{\theta}} - X_{i(l-1)} W_i \left(\gamma \Theta_{i(l-1)}\right)^{\frac{\mu(\sigma-1)}{\theta}} \right) \left(\frac{\phi_{i(l)}}{\phi_{i(l)}}\right)^{\sigma-1} \phi^{\sigma-1} - w_i \sum_{l=1}^{r} \mathscr{F}_{i(l)} \\
&= \sum_{l=1}^{r} \left(\frac{\phi}{\phi_{i(l)}} \right)^{\sigma-1} w_i \mathscr{F}_{i(l)} - \sum_{l=1}^{r} w_i \mathscr{F}_{i(l)}.
\end{aligned} \tag{C.17}$$

Now the free entry condition can be written as:

$$\sum_{r=1}^{R-1} \int_{\phi_r}^{\phi_{r+1}} \sum_{l=1}^{r} \left(\frac{\phi}{\phi_{i(l)}} \right)^{\sigma-1} \mathscr{F}_{i(l)} - \sum_{l=1}^{r} \mathscr{F}_k dG(\phi) + \int_{\phi_R}^{\infty} \sum_{k=1}^{R} \left(\frac{\phi}{\phi_{i(l)}} \right)^{\sigma-1} \mathscr{F}_{i(l)} - \sum_{l=1}^{R} \mathscr{F}_{i(l)} dG(\phi) = f_e. \tag{C.18}$$

Notice the ratio of profit without fixed cost between to cutoffs in the sequence only depend the ratio of firms' productivity, know I can simplify the free entry condition by using the following approach:

$$\begin{aligned}
&\sum_{r=1}^{R-1} \int_{\phi_r}^{\phi_{r+1}} \sum_{l=1}^{r} \left(\frac{\phi}{\phi_{i(l)}} \right)^{\sigma-1} \mathscr{F}_{i(l)} - \sum_{l=1}^{r} \mathscr{F}_{i(l)} dG(\phi) + \int_{\phi_R}^{\infty} \sum_{l=1}^{r} \left(\frac{\phi}{\phi_{i(l)}} \right)^{\sigma-1} \mathscr{F}_{i(l)} - \sum_{l=1}^{R} \mathscr{F}_{i(l)} dG(\phi) \\
&= \sum_{r=1}^{R-1} \int_{\phi_r}^{\infty} \sum_{l=1}^{r} \left(\frac{\phi}{\phi_{i(l)}} \right)^{\sigma-1} \mathscr{F}_{i(l)} dG(\phi) - \sum_{r=1}^{R-1} \int_{\phi_{r+1}}^{\infty} \sum_{l=1}^{r} \left(\frac{\phi}{\phi_{i(l)}} \right)^{\sigma-1} \mathscr{F}_{i(l)} dG(\phi) + \int_{\phi_R}^{\infty} \sum_{l=1}^{R} \left(\frac{\phi}{\phi_{i(l)}} \right)^{\sigma-1} \mathscr{F}_{i(l)} dG(\phi) - \sum_{r=1}^{R} \int_{\phi_r}^{\infty} \mathscr{F}_{i(r)} dG(\phi) \\
&= \sum_{r=1}^{R} \int_{\phi_r}^{\infty} \sum_{l=1}^{r} \left(\frac{\phi}{\phi_{i(l)}} \right)^{\sigma-1} \mathscr{F}_{i(l)} dG(\phi) - \sum_{r=1}^{R-1} \int_{\phi_{r+1}}^{\infty} \sum_{l=1}^{r} \left(\frac{\phi}{\phi_{i(l)}} \right)^{\sigma-1} \mathscr{F}_{i(l)} dG(\phi) - \sum_{r=1}^{R} \int_{\phi_r}^{\infty} \mathscr{F}_{i(r)} dG(\phi) \\
&= \sum_{r=1}^{R} \int_{\phi_r}^{\infty} \sum_{l=1}^{r} \left(\frac{\phi}{\phi_{i(l)}} \right)^{\sigma-1} \mathscr{F}_{i(l)} dG(\phi) - \sum_{r=2}^{R} \int_{\phi_r}^{\infty} \sum_{l=1}^{r-1} \left(\frac{\phi}{\phi_{i(l)}} \right)^{\sigma-1} \mathscr{F}_{i(l)} dG(\phi) - \sum_{r=1}^{R} \int_{\phi_r}^{\infty} \mathscr{F}_{i(r)} dG(\phi) \\
&= \sum_{r=1}^{R} \int_{\phi_r}^{\infty} \left(\frac{\phi}{\phi_r} \right)^{\sigma-1} \mathscr{F}_{i(r)} dG(\phi) - \sum_{r=1}^{R} \int_{\phi_r}^{\infty} \mathscr{F}_{i(r)} dG(\phi).
\end{aligned}$$

Impose the Pareto Distribution:

$$G(\phi) = 1 - (\frac{\phi_{min}}{\phi})^{\kappa},$$

$$\sum_{r=1}^{R} \frac{\sigma - 1}{\kappa + 1 - \sigma} (\frac{\phi_{min}}{\phi_r})^{\kappa} \mathscr{F}_{i(r)} = f_e. \tag{C.19}$$

$$\begin{aligned} P_i^{1-\sigma} &= \sum_{k=1}^{J} N_{ek} \int_{\phi_{xik}}^{\infty} p_{ik}(\phi)^{1-\sigma} dG(\phi) \\ &= \sum_{k=1}^{J} N_{ek} A_{ik} \frac{\kappa \phi_{min}^{\kappa}}{\kappa + 1 - \sigma} \left(\sum_{r=r_{0k}+1}^{R} \left((\gamma \Theta_{k(r)} \right)^{\frac{\mu(\sigma-1)}{\theta}} - \left(\gamma \Theta_{k(r-1)} \right)^{\frac{\mu(\sigma-1)}{\theta}} \right) \phi_{k(r)}^{\sigma-\kappa-1} + (\gamma \Theta_{k(r_{0k})})^{\frac{\mu(\sigma-1)}{\theta}} \phi_{k(r_{0k})}^{\sigma-\kappa-1} \right) \\ &= \sum_{k=1}^{J} N_{ek} A_{ik} \frac{\kappa \phi_{min}^{\kappa}}{\kappa + 1 - \sigma} \left(\sum_{r=r_{0k}}^{R_k} (\gamma \Theta_{k(r)})^{\frac{\mu(\sigma-1)}{\theta}} \left(\phi_{k(r)}^{\sigma-\kappa-1} - \phi_{k(r+1)}^{\sigma-\kappa-1} \right) \right). \end{aligned} \tag{C.20}$$

Here,r_{0k} is the rank of the cutoff to export to country i from country country k in sequence $\{\phi_{k(r)}\}$. And I assume $\phi_{k(R_k+1)}^{\sigma-\kappa-1} = 0$ First consider the gravity of final goods:

$$\begin{aligned} IM_{ij}^F &= N_{ej} \int_{\phi_{xij}}^{\infty} p_{ij}(\phi) q_{ij}(\phi) dG(\phi) \\ &= E_i P_i^{\sigma-1} N_{ej} \int_{\phi_{xij}}^{\infty} p_{ij}(\phi)^{1-\sigma} dG(\phi) \\ &= N_{ej}(1+t_{ij})^{1-\sigma} \tau_{ij}^{1-\sigma} \sigma B_i W_i \int_{\phi_{xij}}^{\infty} \left(\gamma \Theta_i(\phi) \right)^{\frac{\mu(\sigma-1)}{\theta}} \phi^{\sigma-1} dG(\phi) \\ &= N_{ej}(1+t_{ij})^{1-\sigma} \tau_{ij}^{1-\sigma} \sigma B_i W_i \left(\sum_{r=r(0j)}^{(R_j-1)} \int_{\phi_{jr}}^{\phi_{jr+1}} \left(\gamma \Theta_{i(r)} \right)^{\frac{\mu(\sigma-1)}{\theta}} \phi^{\sigma-1} dG(\phi) + \int_{\phi_{(R_j)}}^{\infty} \left(\gamma \Theta_{i(R_j)} \right)^{\frac{\mu(\sigma-1)}{\theta}} \phi^{\sigma-1} dG(\phi) \right). \end{aligned} \tag{C.21}$$

Here,$r(0j)$ gives order in sequence $\{\phi_{j(r)}\}$ for exporting to country i.If we also impose Pareto distribution, we have:

$$IM_{ij}^F = N_{ej}(1+t_{ij})^{1-\sigma} \tau_{ij}^{1-\sigma} \sigma B_i W_i \frac{\kappa \phi_{min}^{\kappa}}{\kappa + 1 - \sigma} \left(\sum_{r=r(0j)}^{R_j} \left(\gamma \Theta_{i(r)} \right)^{\frac{\mu(\sigma-1)}{\theta}} \left(\phi_{j(r)}^{\sigma-\kappa-1} - \phi_{j(r+1)}^{\sigma-\kappa-1} \right) \right). \tag{C.22}$$

Intermediate goods gravity, first for a firm with productivity ϕ, the value of total intermediate it needs:

$$P_{mi}(\phi) M_i(\phi) = \mu(\sigma - 1) \sum_{k \in \mathscr{J}_x(\phi)} \frac{p_{ki}(\phi) q_{ki}(\phi)}{\sigma(1 + t_{ki})} \tag{C.23}$$

The import from specific country j is:

$$P_{mi}(\phi)M_{ij}(\phi)=\chi_{ji}^{M}(\phi)\mu(\sigma-1)\sum_{k\in\mathscr{J}_x(\phi)}\frac{p_{ki}(\phi)q_{ki}(\phi)}{\sigma(1+t_{ki})}. \tag{C.24}$$

Notice the demand of intermediate input between two ordered cutoff will be

$$IM_{ij}(\phi)=\mu(\sigma-1)\chi_{ij}^{M}(\phi)(\frac{\phi}{\phi_{i(r)}})^{\sigma-1}(\sum_{k=1}^{r}w_i\mathscr{F}_{i(r)}). \tag{C.25}$$

We see at the firm-level, firms' intermediate goods import will be affected by export directly through the level of export. VAT has the direct impact on the level of export and the outsourcing strategy $\chi_{ij}^{M}(\phi)$. A general equilibrium effect through the cutoff $\phi_{i(r)}$. Only if $\phi\geq\phi_{i(r_j)}$, the firm will outsource from country j. Here, r_j is the order that a firm will outsource from country j in sequence $\{\phi_{i(r)}\}$

$$\begin{aligned}
IM_{ij}^{M}&=N_{ei}\int_{\phi_i}^{\infty}\chi_{ij}^{M}(\phi)\mu(\sigma-1)\sum_{k\in\mathscr{J}_x(\phi)}\frac{p_{ki}(\phi)q_{ki}(\phi)}{\sigma(1+t_{ki})}dG(\phi)\\
&=\mu(\sigma-1)N_{ei}T_j(\tau_{ij}w_j)^{-\theta}\int_{\phi_{i(r_j)}}^{\infty}\Theta_i(\phi)^{-1}X_i(\mathscr{J}_x(\phi)W_i\left(\gamma\Theta_i(\phi)\right)^{\frac{\mu(\sigma-1)}{\theta}}dG_i(\phi)\\
&=\mu(\sigma-1)\gamma N_{ei}T_j(\tau_{ij}w_j)^{-\theta}\left(\sum_{r=r_j}^{R_i-1}\int_{\phi_{i(r)}}^{\phi_{i(r+1)}}X_{i(r)}W_i\left(\gamma\Theta_{i(r)}\right)^{\frac{\mu(\sigma-1)}{\theta}-1}\phi^{\sigma-1}dG_i(\phi)\right.\\
&\left.+\int_{\phi_{i(R_i)}}^{\infty}X_{i(R_i)}W_i\left(\gamma\Theta_{i(R_i)}\right)^{\frac{\mu(\sigma-1)}{\theta}-1}\phi^{\sigma-1}dG_i(\phi)\right)\\
&=\mu(\sigma-1)\gamma N_{ei}T_j(\tau_{ij}w_j)^{-\theta}\frac{\kappa\phi_{min}^{\kappa}}{\kappa+1-\sigma}\left(\sum_{r=r_j}^{R_i}X_{i(r)}W_i\left(\gamma\Theta_{i(r)}\right)^{\frac{\mu(\sigma-1)}{\theta}-1}\left(\phi_{i(r)}^{\sigma-\kappa-1}-\phi_{i(r+1)}^{\sigma-\kappa-1}\right)\right).
\end{aligned} \tag{C.26}$$

C.3 The Algorithm of Model Solution

In this section I will illustrate the algorithm that I used to solve this model.Solving this model combines solving a discrete choice optimization and standard optimization problem.

In the equilibrium, I solve the aggregate variable $\{B_i,N_i,P_i,E_i\}$ and all cutoff sequence $\{\phi_{i(r)}\}$ and related optimal strategy $\{I_{i(r)}\}$.

Once I solved these variables, other variables can be solved based on the distribution given by the cutoffs and correlated strategies. There are two-loops for solution. The outer-loop solves the aggregate variables and the inner-loop solves the equilibrium cutoff sequences and corresponding strategies.

Step I (Inner-Loop): Guess B_i. According to proposition 3, solving the equilibrium can be transformed to solve the optimal cutoff sequence $\{\phi_{i(r)}\}$. Start from lowerbound a zero vector, get a best vector I_1,solve $\phi_{i(1)}$. Then start from $I_{i(1)}$,iterate until the strategy reach the upper bound which select all countries for both exporting and outsourcing. Proposition 3 allow me to solve a iteration problem:

$$\max_{I_{i(r+1)}} \phi_{i(r+1)}^{1-\sigma} = V(I_{i(r)}). \tag{C.27}$$

Here, V maps the profit optimization problem into productivity minimization.

Step II (Outer-Loop) Get the expected profit based on the solved sequence in Step I, check the difference with the entry fixed cost vector, if small enough then stop; otherwise update the guess of demand value and continue step I.

Step III: Once solved the demand level B_i and the cutoff sequences for all countries. Use the expression of demand level, price index and VAT revenue, solve $N_i, P_i, \mathcal{T}_i$.

Step IV: Solve other variables which are interested in.