THREE ESSAYS ON THE IMPACTS OF TRADE LIBERALIZATION ON FIRMS' BEHAVIOR AND PERFORMANCE

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Yifan Li

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Abstract

This thesis investigates the impacts of changes in the trading environment on the behavior and performance of exporting firms and of firms that import intermediate inputs. The thesis consists of three essays. Each essay contributes both a theoretical development and an empirical analysis, using large scaled micro data from multiple sources. The first essay studies how increased import penetration of inputs affects firms' optimal mark-up and industry concentration. A theoretical model is developed to show how firms, operating under monopolistic competition, may choose to incur a fixed cost of foreign sourcing in order to replace some domestically sourced input with more efficient foreign substitutes. It is shown that changes in variable trade costs not only affect firms' importing decision but also the number and identity of firms in the market and ultimately markups and market structure. We find evidence of a positive relationship between imported input penetration and markup: the average markup rises when import penetration increases following a reduction in trade costs. The second essay develops a two-stage theoretical model to investigate how firms' decision on the number of varieties to export (i.e., their export scope) depends on exchange rate volatility and on other characteristics of the destination countries. In the model, in the first stage, multi-product firms decide on their optimal product scope (the number of varieties to be produced for exporting), incurring fixed investment costs. In the second stage, they decide on the export scope for each destination country, based on country-specific trade costs and expectation of idiosyncratic exchange rate shocks. Firms reduce their export scope to destination countries that suffer negative demand shocks, but they cannot increase their export scope beyond the production scope that they have chosen in the first stage. Using Chinese customs transaction data, we are able to provide empirical evidence that supports the predictions of our theoretical model. The third essay studies the effect of foreign tariff reductions on the adjustment of average quality and export scope of multi-product exporting firms, using China's firm-level micro data and highly disaggregated customs data from 2000 to 2006. We find that in response to tariff cuts in destination countries, exporting firms upgrade product quality and adjust export scope. Our finding provides a novel explanation of what the phenomenon called incomplete tariff pass-through. A fall in the tariff rate seems to be associated with an increase in the tariff-inclusive prices, but this is because the price data has not been adjusted to reflect the increase in product quality.

Key words: Multi-Product Firms; Export Scope; Exchange Rate Volatility; Output Tariff; Trade Liberalization; Product Differentiation; Cost Structure; Market Size; Product Quality; Import Penetration; Globalization

JEL Classification: F12, F14, F31, L10, L13, L19, D22

Résumé

Cette thèse examine les impacts des modifications de l'environnement commercial sur le comportement et les performances des entreprises exportatrices et des entreprises importatrices d'intrants intermédiaires. La thèse comprend trois essais. Chaque essai apporte à la fois un développement théorique et une analyse empirique, en utilisant des microdonnées à grande échelle provenant de sources multiples. Le premier essai étudie comment l'augmentation de la pénétration des importations d'intrants affecte la marge bénéficiaire et la concentration industrielle optimales des entreprises. Un modèle théorique est développé pour montrer comment les entreprises, opérant sous concurrence monopolistique, peuvent choisir de supporter un coût fixe de sous-traitance étrangère afin de remplacer certains intrants d'origine nationale par des substituts étrangers plus efficaces. Il a été démontré que l'évolution des coûts variables des échanges n'affectait pas seulement la décision des entreprises en matière d'importation, mais aussi le nombre et l'identité des entreprises sur le marché, ainsi que leurs marges et leur structure. Nous trouvons des preuves d'une relation positive entre la pénétration des intrants importés et la marge bénéficiaire: la marge moyenne augmente lorsque la pénétration des importations augmente à la suite d'une réduction des coûts du commerce. Le deuxième essai développe un modèle théorique en deux étapes pour examiner comment la décision des entreprises quant au nombre de variétés à exporter (c.-à-d. Leur portée d'exportation) dépend de la volatilité des taux de change et d'autres caractéristiques des pays de destination. Dans le modèle, lors de la première étape, les entreprises multiproduits décident de la portée optimale de leur produit (le nombre de variétés à produire pour l'exportation), ce qui entraîne des coûts d'investissement fixes. Dans un deuxième temps, ils décident du volume des exportations pour chaque pays de destination, en fonction des coûts du commerce spécifiques à chaque pays et des prévisions de chocs de taux de change idiosyncratiques. Les entreprises réduisent leurs exportations vers les pays de destination qui subissent des chocs de demande négatifs, mais elles ne peuvent pas augmenter leurs exportations au-delà de la production qu'elles ont choisie au début. En utilisant les données des transactions douanières chinoises, nous sommes en mesure de fournir des preuves empiriques qui corroborent les prédictions de notre modèle théorique. Le troisième essai étudie l'effet des réductions de tarifs étrangers sur l'ajustement de la qualité moyenne et la portée des exportations des entreprises exportatrices multiproduits, en utilisant les microdonnées au niveau des entreprises chinoises et des données douanières très désagrégées de 2000 à 2006. Nous trouvons que des réductions dans les pays de destination, les entreprises exportatrices améliorent la qualité des produits et ajustent les possibilités d'exportation Notre constatation fournit une nouvelle explication de ce que le phénomène a appelé la transmission incomplète des droits de douane. Une baisse du taux de droit semble être associée à une augmentation des prix tout compris, ce qui s'explique par le fait que les données relatives aux prix n'ont pas été ajustées pour refléter l'amélioration de la qualité du produit.

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Contributions of Authors

The first two essays are co-authored with Zhuang Miao, Ph.D. student at McGill University. Both of us are equally responsible for model formulation, data collection, and empirical tests. I am the single author of the third chapter.

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Introduction

This thesis investigates the impacts of changes in the trading environment on the behavior and performance of exporting firms and of firms that import intermediate inputs. The thesis consists of three essays. Each essay contributes both a theoretical development and an empirical analysis, using large scaled micro data from multiple sources.

The first chapter (co-authored with Zhuang Miao), "Globalization, Import Penetration and Markup", analyzes the effects of the imported intermediate input penetration on average markup. The rise of market power in recent decades has received increased attention, but the determinants of such a rise remain unclear. This paper studies whether and how increasing import penetration of inputs leads to a more concentrated market structure and the associated rise of markups. The use of quadratic preferences in combination with the inclusion of the firm's choice to import create a link between the use of imported inputs and markups. A reduction in importing costs induces non-importers to start importing intermediates. Yet, the effect on profits is shaped by a trade-off between the potential marginal cost advantage and the fixed cost incurred from importing. As a result, only the most productive firms benefit from globalization, while existing importing firms do not fully pass through the reduction in trade costs in the form of lower prices. The selection of importers, cost-savings from imported inputs and firms' entries and exits jointly explain the rise of average markups in the market. Guided by this theoretical framework, we combine firm-level panel data, sector-level trade data and input-output tables to present empirical evidence on the relationship between the increase in imported input penetration and the rise of market power in the US over the last four decades. Using six-digit sectors as the unit of observation, we show that imported input penetration is positively associated with the size of markups. We test the model predictions on both the import decisions of heterogeneous firms and its implications for market structure. A difference-in-difference exercise that exploits China's accession to the WTO and the use of input tariffs as a proxy for imported input penetration provide additional supporting evidence. Overall, we find that average industry markups would have been around 1.4% lower each year in the absence of imported inputs.

The second chapter, "Modelling the Effect of Exchange Rate Volatility on Export Performance" (co-authored with Zhuang Miao), focuses on export scope of Chinese exporters. China becomes a major contributor to the international trade in the 2000s, and a large literature examines the effects of trade liberalization on productivity, but there is little work studying how Chinese exporters adjust their export scope (the number of product varieties) to the different characteristics of destination countries and exchange rate uncertainty. We investigate the relationship between the number of varieties a firm decides to export (its export scope) and the characteristics of the destination country. We develop a two-stage model where firms decide the product scope (the total number of varieties exported) by making fixed investments in the first stage and decide the export scope based on trade costs and the expectation on idiosyncratic exchange rate shocks of each market in the second stage. Firms reduce export scope when destination countries suffer negative demand shocks but are not able to expand export scope in the case of positive shocks, due to insufficient pre-investment in production capacity. As a result, the export scope decreases with the level of exchange rate volatility and trade costs of destination countries. Using Chinese firm-level customs data for 2002 to 2006, we confirm that Chinese firms export fewer varieties to countries that display higher exchange rate volatility, that are farther away from China. The third chapter is titled Foreign Tariff Reduction, Export Quality and Scope of Multi-Product Firms. This chapter studies the effect of foreign tariff reduction on the adjustment in average quality and export scope of multi-product exporting firms using China's firm-level micro data and highly disaggregated customs data from 2000 to 2006. We find that in response to tariff-cut by destination countries, exporting firms upgrade product quality and adjust export scope, providing a novel explanation for incomplete tariff pass-through (i.e. when quality-unadjusted, tariff-inclusive prices increase). The effects are significantly different across firms with different productivity: low productivity firms tend to shrink the number of export varieties in the horizontal differentiation level of the industry, while high productivity firms expand more in the within-firm product export ladder. Our empirical results are consistent with a simple theoretical model under conventional settings of the processing cost function, which incorporates firm heterogeneity, endogenous quality choice and export scope to evaluate the impact of trade liberalization.

Chapter I Globalization, Import Penetration and Markup

1.1 Introduction

Discussions about the rise of market power and its macroeconomic impacts prevail in the most recent economic literature (Kwoka et al., 2015; Barkai, 2016; Gutierrez and Philippon, 2016; Azar et al., 2017; Ganapati, 2017; Traina, 2018). The particularly evident decline in the labor share in the United States since 2000 is primarily attributed to the rise of 'superstar' firms (Autor et al., 2017). Firm-level evidence shows that average markup has increased sharply since 1980, from 18% above marginal cost to 67% in 2014 (De Loecker and Eeckhout, 2017). These studies present the rise of concentration in the market over time and have led to heated policy debates. However, the determinants of such an increase in market power remain unclear.

Importantly, another critical trend in the past several decades is globalization and the accompanied global sourcing. Dramatic removal of trade barriers and a substantial decrease of tariffs as well as advances in communication, information, and transportation technologies have revolutionized how and where firms source their input for production. Indeed, there has been a substantial increase in industry openness and imports in the United States in the last few decades: the ratio of imports to GDP went up from 4.2 percent in 1960 to around 16.5 percent in 2014.[1] How do firms use imported inputs in their production? How does the use of foreign imports affect industry concentration? How are markups impacted by firms' import decisions and the change of market concentration?

Given the transformative impact of globalization, it is natural to consider the effect that import penetration may have had on the market structure and on a firm's decisions to set the markup. The conventional wisdom underlines the intensified foreign competition as the process of globalization continues, which thereby alleviates the distortions associated with monopoly power. But, globalization also transforms the way firms in developed countries procure their inputs, although the ability of firms to select into importing might be limited to only a few firms (Antras et al., 2017). Despite the rapid expansion of global sourcing and widespread policy interest, the existing literature in trade has so far mainly focused on exporting instead of importing and has paid relatively little attention to this facet of the interaction

[1] IMF Databank, USA Imports of goods and services (% of GDP), url: https://data.worldbank.org/indicator/

between imported input penetration and market concentration.

This paper aims to contribute to our understanding of the relationship between trade openness and market structure. On the one hand, import penetration increases competition from foreign producers, which implies pressure for the firms to decrease their markup. On the other hand, trade liberalization also leads to cost reduction due to improved access to imports of foreign intermediate inputs. If trade liberalization benefits only the most productive firms in each industry, the market concentration will rise as industries become increasingly dominated by large firms with high profits and low shares of labor in firm value-added and sales. To study these mechanisms, we provide a theoretical framework which relates the change in markup to the change in the extensive margin of sourcing decisions. We then look at how change in average markups is associated with imported input penetration in the process of globalization over 40 years. We combine firm-level micro panel data, sector-level trade data, and input-output tables and present empirical evidence on the relationship between the increasing trend of imported inputs penetration and the rise of market power over the last four decades. At the six-digit industry level, we find that the increase in imported input penetration is associated with increased market concentration, implying that only the most productive firms benefit from trade liberalization.

Our analysis proceeds in three steps. First, we developed a simple theoretical model that links market structure to global outsourcing. We extend Melitz and Ottaviano (2008) to include the firm's input procurement decision and highlight the firm's choice on importing foreign input in the spirit of Amiti et al. (2014), where the change of markup change with the extensive margin of sourcing decisions. As we work with quadratic preferences with the inclusion of the firm's choice to import intermediate inputs, the model generates linear equations that relate changes in the variable markup with changes in the imported input penetration. A reduction in importing costs induces non-importers to start importing intermediates. Yet, the capability to profit from importing foreign inputs depends on a firm's trade-off between the potential marginal cost advantage and the fixed cost incurred from importing. Since it requires a fixed cost of importing to select cost-efficient intermediate inputs, the capability to benefit from the reduction of trade costs and to employ imported inputs into production depends on the level of productivity. High-productivity firms that can pay the associated fixed cost and import intermediate inputs will be thereby able to magnify their cost advantage relative to less productive firms.

Second, we illustrate some descriptive facts on rising import penetration and markups since 1970 before proceeding onto empirical analysis. We show that the ratio of imports to GDP went up from 4.2% in 1960 to around 16.5% in 2014, while the average markup increased from around 1.2 to over 1.6 in the same period. Import penetration has an ambiguous relationship with markup. Standard trade theory would predict reduced markup due to more imported output competition. But, if the market is imperfectly competitive, a reduction in trade costs due to globalization will have heterogeneous impacts on the markup of firms that import inputs and firms that rely only on domestic input. Therefore we distinguish import penetration in output and input and measure them separately. Indeed, when we look at imported *input* penetration, we find a strong correlation between the rise of imported input penetration ratio at the level of 2-digit sector weighted average markup based on firm-level sales, while the overall import penetration ratio shows an ambiguous relationship with the change of markup. This is because the import penetration ratio mixed the effect of competition from the final goods with the effect of employment of cheaper/better inputs on market structure. Making use of imported inputs contributes to the decrease in the firm's marginal cost and increases the firm's potential of higher markup. But it may require some level of firm ability to take advantage of imported inputs.

Third, we present empirical evidence on the relationship between the rise of market power and the increase in imported inputs penetration over the last four decades. We use firm-level panel data that contain critical balance-sheet variables such as sales, the number of employees and capital for production function estimation from WRDS-Compustat Database. By applying the production-based approach (De Loecker et al., 2016), we estimate markups at firm level from 1972 to 2014. We then measure direct import penetration level from industry-level trade data from the United States import and export Data of the Center for International Data, UN COMTRADE, and USA Trade Online. Combining input-output benchmark table at the 6-digit industry level from the Bureau of Economic Analysis (BEA), we measure indirect intermediates import penetration by weighting the direct import penetration ratio with the degree of interdependence of each industry pair. We find that a 10% increase in the rise of imported input penetration is associated with a 0.2% increase in market concentration, implying that only the most productive firms benefit from trade liberalization. We further test our predictions of heterogeneous firms' decisions on intermediates importing and the implications on the market structure using output and input tariffs as proxies for import: a 10 percent increase of input penetration induces roughly 1.2 percent increase of markup on average. This finding is robust to different model specifications at both the firm and industry levels. It also survives from various concerns of the model including alternative markup measure, alternative benchmark weighting in accounting for input penetration, and the use of derived input tariff as a proxy for input penetration. We also applied a difference-in-difference approach taking China's accession into the WTO as a trade shock to provide additional support to our main predictions.

This paper explores the mechanism that links the globalization process to the trend of rising markups over the last four decades. The contributions of this paper are twofold. First, we construct a theoretical model that links the rise of the input imports and the increase of average markups, and also distinguishes the changes of the market structures during this process, i.e., the entry-exit decisions, outsourcing decisions, and price strategies made by heterogeneous firms. Second, we provide empirical evidence that supports these predictions and the mechanisms identified in theory. A difference-in-difference exercise that exploits China's accession to the WTO and the use of input tariffs as a proxy for imported input penetration provide additional supporting evidence to the theory.

Our paper contributes to several strands of the literature. We add to the vibrant empirical research that looks at the ambiguous effects of trade liberalization on markups (Burstein and Gopinath, 2014). There is empirical evidence of reduction of markups due to more competition following dramatic trade liberalization for some countries. For example, Badinger (2007) finds a decrease of markups in aggregate manufacturing sectors following the EU's Single Market Programme. Some literature discovers that trade liberalization of intermediates inputs may lead to markup increase due to various reasons. Ludema and Yu (2016) explain the incomplete pass-through of foreign tariff reductions with firms' quality-upgrading strategies, which are estimated to be greater for high productivity firms. Amiti et al. (2014) develop an oligopoly framework with variable markups and imported inputs, and find that firms with top import shares have low exchange rate pass-through. Brandt et al. (2017) find that cuts in output tariffs reduce markups while cuts in input tariffs raise both markups and productivity by examining China's WTO accession and the performance of Chinese manufacturing firms.[2]

These case studies focus on the impacts of striking shocks such as trade liberalizations for a relatively short period. They link markup variation exclusively to a market share of the firm, neglecting the effect that exogenous change of variable cost has on industry reallocation in the long run. Instead, our paper looks at the impact on the industry that the broad process of globalization brings over 40 years, which combines short-run effects of trade cost reduction on marginal cost and competition with the impact on industry reallocation in the relative long term.

Our theoretical framework is closely related to and is built upon Melitz and Ottaviano (2008) and Halpern et al. (2015). Melitz and Ottaviano (2008) develop a monopolistic competition model of trade with firm heterogeneity which has been a workhorse model that predicts intra-industry reallocation between firms with different mark-ups following trade liberalization. Halpern et al. (2015) estimate the productivity gain from the improved access to foreign input. They assume a constant elasticity of substitution (CES) utility function and provide a static model of industry

[2]Other case studies include Fan et al. (2018) for China, De Loecker et al. (2016) for India, Altomonte and Barattieri (2015) for Italy, Moreno and RodrÃguez (2011) for Spain, Konings et al. (2005) for Bulgaria and Romania and Harrison (1994) for Cote d'Ivoire.

equilibrium where firms use both domestic and imported intermediates goods for production. However, CES utility directly implies constant markup and make it unsatisfactory to analyze variable markup changes concerning aggregate shocks. We instead employ the linear demand system as in Melitz and Ottaviano (2008) and trace in detail how imported input penetration plays a role in the pricing of firms that have better ability to utilize sourcing opportunities. If firm heterogeneity interacts with fixed sourcing costs, the firm's decision to import from one market will also affect market structure. In our model, a reduction in global sourcing costs induces a firm to increase imports of low-cost input and to increase the markup. But the access to foreign inputs is restricted to the firms that can pay the fixed importing cost and use imported intermediates. Our model predicts that, as the cost of importing decreases, existing importing firms will import more foreign intermediate varieties, leading to even better advantages in both product quality and production cost. These two effects will magnify existing strengths that more productive firms have relative to less productive firms. This, in turn, implies that trade liberalization has asymmetric impacts on the market share of existing market players.

Our paper also relates to the literature that looks at the global trend of market power and its consequences. De Loecker and Eeckhout (2018) document the rising trend of global market power. While it is more salient in the developed world than in the emerging areas, the average global markup increased from 1.1 to 1.6 between 1980 and 2016. For the U.S in particular, the average mark-up has been increasing dramatically since the 1980s, and it is believed to be associated with several other macroeconomic trends such as the decline in labor and capital share, the decrease of low skill labor wage, and the slow down in aggregate output (De Loecker and Eeckhout, 2017). Autor et al. (2017) reassess the secular trend of labor share through micro panel data since 1982 and interpret the fall in the labor share to be the result of the rise of "superstar firms" that dominate the market with high profits and low share of labor in firm value-added and sales. They also notice the potential role that globalization and technological changes might have played but are skeptical as the fall in labor's share also appears in non-traded sectors like retail and wholesale, not just in traded industries like manufacturing. There is other circumstantial evidence in this story of rising market power.[3] A paper that is closely related to ours is that of Elsby et al. (2013), who consider the potential impact consider the possible effects of globalization and rising imports on the decline of labor share. They provide a set of simple cross-industry regressions and graphs and show that the variation in the change in import exposure explains 22 percent of the cross-industry variation in payroll-share changes.

[3] For example, increased profits (Barkai, 2016), decreased investment(Gutierrez and Philippon, 2016), decreased wages in concentrated markets (Azar et al., 2017), weakened antitrust enforcement (Kwoka et al., 2015), and restricted output (Ganapati, 2017).

While these studies try to link the rise of market power of superstar firms as the cause for the decline of labor share, our purpose is to propose a mechanism that drives this rising market concentration and to illustrate how less-frictional international trade enables more efficient firms to be rewarded with higher market shares today than in the past. Our paper looks not only at the direct impact, i.e., the substitution effect, which depresses the labor share of domestic income and reduces the marginal cost of firms that employ cheap foreign inputs, but also the indirect impact, which changes the market structure to be more concentrated as only some firms can pay the fixed cost and utilize global opportunities. We also provide direct empirical evidence of these mechanisms.

Finally, our paper complements a large body of literature that evaluates welfare gains from trade by estimating its impact on markup heterogeneity and allocative efficiency. Epifani and Gancia (2011) document several stylized facts about markup dispersion across industries over time and in a relationship with exposure to trade. They provide an oligopoly framework with CES utility and find that markup heterogeneity entails significant costs and that asymmetric trade liberalization may reduce welfare when there exists restricted entry. Feenstra and Weinstein (2017) consider symmetric translog preferences and structurally estimate the welfare gain of globalization into variety-increase and markup-decline channels. There are two critical differences between the theoretical framework in these papers and the model we present here. First, our paper adopts monopolistic competition with linear demand system which allows markup variability to depend not only on market share but also on imported input substitution and product/industry characteristics. Second, in our framework, a change in the trade costs induces marginal cost change directly and induces price change indirectly through both general equilibrium effects (the number of active firms) that shift or rotate the firm's demand curve.

The rest of the paper is organized as follows. Section 2 presents a general theoretical framework that encompasses monopolistic competition and variable markup to examine the impact of trade cost reductions on firms' markups and associated intra-industry reallocation. Section 3 describes the datasets and measurements used. Section 4 presents our econometric specifications and report the main results, followed by an interpretation of the underlying mechanisms. Section 5 provides a series of robustness checks. The last section concludes.

1.2 Theoretical Framework

In this section, we develop our theoretical framework of global sourcing and markup. Our model is based on an extension of Melitz and Ottaviano (2008). Building upon Halpern et al. (2015), we incorporate Amiti et al. (2014)'s way to model the firm's cost structure and its choice to import intermediate inputs. We extend the model by relating the option of importing to productivity and analyze its comparative statistics. In sections below, we present the model and derive equilibrium prices, sourcing strategies, marginal cost, and markups. Since our model is similar to Amiti et al. (2014), we relegate most of the derivations to the Appendix and examine here in more detail the impact of increasing import penetration on markups.

1.2.1 Consumers

Preferences are defined over a continuum of differentiated varieties indexed by $i \in \Omega$, and a homogeneous good chose as numeraire. As in Melitz and Ottaviano (2008), consumers share the same quasi-linear utility function given by

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

where q_0^c and q_i^c represent the quantities of the numeraire good and the differentiated variety i respectively. The demand parameters α, η, and γ are all positive. The parameters α and η index the substitution pattern between the differentiated varieties and the numeraire good, and the level of competition intensity among differentiated varieties. The parameter γ indexes the decreasing rate of the marginal utility for each variety. Given the price for variety i , consumers decide their quantity demand as followings.

$$q_i \equiv L q_i^c = \frac{\alpha L}{\eta N + \gamma} - \frac{L}{\gamma} p_i + \frac{\eta N}{\eta N + \gamma} \frac{L}{\gamma} \bar{P} \tag{2}$$

where L denotes the population of the economy, N measures the mass of varieties in Ω (which is also the number of active firms) and $\bar{P} = \frac{1}{N} \int_{i \in \Omega^*} p_i di$ is the average price of all varieties existing in the market. The set Ω^* is the collection of the varieties that exist in the market. In other words, the variety which belongs to the set Ω^* must satisfy

$$p_i \leq \frac{1}{\eta N + \gamma} (\gamma \alpha + \eta N \bar{P}) \equiv p_{max} \tag{3}$$

This inequality suggests that all firms' prices will be up-bounded by the price level charged by the lowest productivity firm. This is because low-productivity firms need to charge relatively high level of prices in order to cover their high variable cost. Among the surviving firms, the demand is limited to the price that the lowest productivity firm charges.

1.2.2 Producers

For simplicity, we assume that final-good varieties are prohibitively costly to trade across borders. We do this in order to highlight the trade of intermediate input as the relevant mechanism.[4] Similar to Amiti et al. (2014), we model the cost structure of the firm and its choice to import intermediate inputs. Consider firm i, indexed by its productivity A_i, uses labor Z_i and a composite intermediate input X_i to produce output Y_i according to the production function:

$$Y_i = A_i {X_i}^{\phi} {Z_i}^{1-\phi} \tag{4}$$

The composite intermediate input X_i consists of two types of intermediate goods, one of which could be purchased either locally or imported from the foreign market and the other one of which could only be procured domestically. D_i represents the quantity of the domestic-specific input which can only be purchased domestically, and M_i represents the amount of intermediate inputs which could be sourced from either the domestic or the foreign markets. Let ξ be the elasticity of substitution between D_i and M_i .

$$X_i = \left[D_i^{\frac{\xi}{1+\xi}} + a M_i^{\frac{\xi}{1+\xi}} \right]^{\frac{1+\xi}{\xi}} \tag{5}$$

Intuitively, a measures the productivity advantage of the foreign variety[5]. Although production is still possible without the use of imported inputs, imported inputs are useful due to (i) their potential productivity advantage a, and (ii) the love-of-variety feature of the production function. The prices of imported inputs and domestic inputs are denoted by P_M and P_D respectively, and we assume the firms are price takers in these input markets.

For each imported intermediate good, firm i must incur a fixed cost $f_i(A_i)$, which depends on firm productivity A_i. Examples for the fixed importing costs include the information gathering and search cost, management cost, cost for an import permit, and the production adjustment for various inputs. We believe the high productivity firms pursue cost advantage in both the production and importing processes. For example, the high productivity firms hire the high productivity workers who will lower the management cost. They are more likely to export to more markets and pursue widely international connections, which will lower the search cost. In section 2.5, we relax the assumption on the dependence of the fixed cost while assuming a complementary form of the production function. The main predictions

[4]The model could be extended to accommodate trading of final goods and the extensive margins of both exports and imports wil be jointly determined.

[5]We could also use more standard formulation of equation (5), i.e., to keep the parameter a as a share and a measure of productivity advantage between domestical and foreign input. Here we normalize the level of relative advantage for the simplification of exposition.

of that model are consistent with the one with the fixed cost endogenous to the productivity.

The presence of fixed costs have been founded empirically and have been widely assumed (Amiti et al. 2014; Antras et al. (2017); Gopinath and Neiman (2014); Halpern et al. (2015)). Examples of the fixed costs incurred by importers exist in the required expenses that are paid to find the most cost-efficient input suppliers across different countries. Here we further assume that the fixed sourcing cost a firm has to pay to start importing intermediate inputs is decreasing with productivity. If we think of the fixed cost as the searching and information cost a firm pays to find the most cost-efficient external input supplier, then it is reasonable to believe that high-productivity firms are likely to find the desired trading partner easier.[6] Following this setting, we compute the variable cost index for importers and non-importers as follows

$$V_i = \begin{cases} \left[1+\left(\frac{\tau_m P_{Mf}}{a}\right)^{\frac{1}{1+\xi}}\right]^{1+\xi} & importer \\ \left[1+(P_{Md})^{\frac{1}{1+\xi}}\right]^{1+\xi} & non-importer \end{cases} \tag{6}$$

where P_{Mf} and P_{Md} are the prices for the foreign and domestic intermediates respectively; τ_m captures the trade cost of purchasing the foreign intermediates.

The marginal cost of firm i is equal to:

$$c_i = \varsigma\varphi_i\left(\frac{W}{1-\phi}\right)^{1-\phi}\left(\frac{V_i}{\phi}\right)^{\phi} = \varsigma\varphi_i V_i^{\phi}\bar{D} \tag{7}$$

where W measures the domestic labor cost, thus $\bar{D} \equiv (\frac{W}{1-\phi})^{1-\phi}(\frac{1}{\phi})^{\phi}$ is a common cost factor for both importers and non-importers. φ_i is the inverse productivity of firm i, i.e. $A_i = \frac{1}{\varsigma\varphi_i}$, where ς is a parameter. φ_i is assumed to be randomly drawn from an independent distribution with support $\left[\underline{\varphi}, \overline{\varphi}\right]$. [7]

Notice that the term $\bar{D}$ is identical across all the firms. Moreover, firms only differ in their productivity levels and the term V_i, depending on how much the foreign inputs they use.

In a closed economy, firm i only sources from the domestic market, so the profit maximization problem is:

$$Max_{p_i}\,\pi^D = (p_i - c_i) * q_i$$

[6] Alternatively, this assumption could be replaced by a quantitative constrain on the relative scale of fixed cost and net profit of being an importer. Moreover, we relax this assumption and consider a constant fixed cost case in the following section 2.5.2.

[7] Recall that the productivity level for firm i is denoted as A_i, thus $\varsigma\varphi_i = \frac{1}{A_i}$.

Profit maximization implies the following results:

$$\begin{aligned} p_{\mathrm{iD}} &= \tfrac{1}{2}\left(c_i + c_d\right) \\ \mu_{\mathrm{iD}} &= \tfrac{(c_i + c_d)}{2c_i} \\ q_{\mathrm{iD}} &= \tfrac{L(c_d - c_i)}{2\gamma} \\ r_{\mathrm{iD}} &= \tfrac{L(c_d - c_i)(c_d + c_i)}{4\gamma} \\ \pi_{\mathrm{iD}} &= \tfrac{L(c_d - c_i)^2}{4\gamma} \end{aligned} \tag{8}$$

where $p_i\left(c_d\right) = p_{\max} = \frac{1}{2}\left(c_{\max} + p_{\max}\right)$, therefore, $p_{\max} = c_d$, and c_d is the cut-off cost value for the firms to be able to survive in the market with their exact variable cost, i.e, all the firms whose variable cost is higher than this value will not be able to survive in the market. To simplify our analysis, we assume the firms' entry decision and the reveal of the productivity information take place during the same period.

Assume the firm's variable cost c is drawn from a known distribution $G(c)$ with support $[\underline{c}, \overline{c}]$. [8] The cost (productivity) cut-off is thus determined by the free-entry condition:

$$\int_{\underline{c}}^{c_d} \pi(c_i)dG(c) = f_E \tag{9}$$

where f_E is the fixed cost to enter the market and start to operate. The mass of surviving firms is determined using c_d and the zero demand price condition:

$$c_d = \frac{\gamma\alpha + \eta N\bar{P}}{\eta N + \gamma} \tag{10}$$

which implies

$$N = \frac{\gamma}{\eta}\frac{\alpha - c_d}{c_d - \bar{P}} \tag{11}$$

and the mass of entrants

$$N_E = \frac{N}{G(c_d)} \tag{12}$$

From which it follows

$$\bar{P} = \int_{\omega\in\Omega} p(\omega)d\omega = \int_{\underline{c}}^{c_d} \frac{c_i + c_d}{2} d\mathrm{G}(c_i)/G(c_d) \tag{13}$$

[8] Under the case of closed economy, the variable c follows the same type of distribution as the inverse productivity.

1.2.3 The Equilibrium

Determination of importing productivity cutoff

For simplicity, we keep the number of entrants N_E and the productivity distribution $G(.)$ fixed. The number of survived firms is thus $N = N_E G(\varphi_d)$, where φ_d is the cut-off value of productivity, i.e. $c_d = \varsigma \varphi_d V_i^{\phi} \bar{D}$. Recall that the inverse productivity is assumed to be randomly drawn from a distribution, $\varphi \sim \Gamma(\varphi)$ with support $\left[\underline{\varphi}, \overline{\varphi}\right]$. Following Antras et al. (2017), we assume that importing intermediate from the foreign market requires a fixed cost f_m , whose value is identical to all firms. Firm i decides whether to import the intermediates based on the expected profits it faces. As we assume that the firm only imports one type of input from one foreign country, the index V_i^{ϕ} should be identical across all importing firms, i.e. $V_i^{\phi} = V^{\phi}$. For simplicity, we further define $\Psi = \Psi_i \equiv \varsigma V_i^{\phi} \bar{D}$ for importing firms (where $\bar{D} \equiv (\frac{W}{1-\phi})^{1-\phi}(\frac{1}{\phi})^{\phi}$) and normalize $\varsigma V_i^{\phi} \bar{D} = 1$ for all non-importing firms. The firm will import intermediates if the expected profit difference between paying the fixed cost to become an importer and procuring only domestic inputs, $H(\varphi)$, is larger than the fixed cost it incurs to become an importer, i.e., $H(\varphi_i) \equiv \pi(\varphi_i|importer) - \pi(\varphi_i|non-importer) > f_m$, where $\pi(\varphi_i|importer) = \left(p_i^f - \varphi_i \Psi\right) * q_i^f$ with $\Psi < 1$ and $\pi(\varphi_i|non-importer) = \left(p_i^d - \varphi_i\right) * q_i^d$. This mechanism is presented in the illustrative Figure 1. The unit cost savings that importing brings is constant. When a firm is the most productive (inverse productivity is 0), it can charge highest price, sell most products and get highest profits. Importing foreign inputs brings no change to its unit cost due to the cost structure, so to the price and quantity. Thus the profit difference curve cross the origin. As a firm becomes less productive, it prices relatively lower, sell less and profit decreases. But at the same time importing starts to bring in advantage because it decrease unit cost by a certain amount, counteracting the decrease in productivity, and brings positive profit difference. Until reaching a point where the negative effect that the decreases in productivity brings on profit, exceeds the positive effects that the constant unit cost savings that importing brings on profits. And the profit difference curve starts to become downward sloping.

Proposition 1. *Given the highest inverse productivity of the survived firms in the market and the following assumptions. (i) Importing fixed cost f_m is identical to all firms, and (ii) the fixed cost satisfies the conditions $\underline{\varphi} > \frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}$ and $\overline{\varphi} < \frac{2}{1-\Psi}\sqrt{\frac{\gamma f_m}{L}}$, then there exists an unique solution φ_m which solves $H(\varphi_m) = 0$ in the definition range $\varphi_m \in \left[\underline{\varphi}, \overline{\varphi}\right]$, and it follows that $H(\varphi) \geq 0$ for $\varphi < \varphi_m$ and $H(\varphi) < 0$ for $\varphi > \varphi_m$.*

Proposition 1 implies that only high productivity firms make importing, and the firms whose inverse productivity is higher than a critical value, then they won't make importing. Specifically, this critic value is solved as:

$$\varphi_m = \frac{\varphi_d + \sqrt{\varphi_d^2 - \frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}}}{1+\Psi} \tag{14}$$

When the value of φ_m is less than φ_d, for the firms whose inverse productivity is lower than φ_m will choose to import the inputs, and the firms with higher inverse productivity will choose to use domestic inputs only. If $\varphi_m \geq \varphi_d$, then all the firms in the market will not choose to import the intermediate inputs.

Determination of the number of active firms and productivity cut-off

In the open economy case, equation 11 becomes:

$$\bar{P} = \int_{\underline{\varphi}}^{\varphi_m} \left(\frac{\varphi\Psi + \varphi_d}{2} \right) d\mathrm{G}(\varphi)/G(\varphi_d) + \int_{\varphi_m}^{\overline{\varphi}} \left(\frac{\varphi + \varphi_d}{2} \right) d\mathrm{G}(\varphi)/G(\varphi_d) \tag{15}$$

The example with the uniform distribution function is solved as:

$$\bar{P} = \left(\frac{4}{\varphi_d - \underline{\varphi}} \right) \left[3\varphi_d^2 - (1-\Psi)\,\varphi_m^2 - \left(\Psi\underline{\varphi} + 2\varphi_d \right) \underline{\varphi} \right] \tag{16}$$

Then the firm number is solved as:

$$N = \frac{\gamma}{\eta} \frac{\alpha - \varphi_d}{\varphi_d - \left(\frac{4}{\varphi_d - \underline{\varphi}} \right) \left[3\varphi_d^2 - (1-\Psi)\,\varphi_m^2 - \left(\Psi\underline{\varphi} + 2\varphi_d \right) \underline{\varphi} \right]} \tag{17}$$

Equation 17 shows that the number of survived firms N is negatively correlated with the cut-off value φ_d. Recall from equation 12 that we have another relation between N and φ_d , i.e. $N_E = \frac{N}{G(\varphi_d)}$, which indicates a positive relation between N and φ_d when the entrant mass N_E is fixed in short-run. Equations 12, 14, and 17 uniquely determine the inverse productivity cut-off φ_d and firm number N , which is illustrated in Figure 3. The positive relation between N and φ_d (equation (12)) represented by curve S suggests that the market will be able to support more active firms when the productivity cut-off is low (high φ_d), while the negative relation between N and φ_d (equation (17)) represented by curve D implies that only a limited number of firms could survive in the market due to high choke price induced by low productivity cut-off (high φ_d).

1.2.4 The Impact of Globalization

The process of globalization suggests a continuous reduction of trade costs between countries. According to equation (14), a reduction of variable trade cost will induce a lower price level of intermediate input Ψ, making it more profitable for a firm to engage in intermediate input trading.[9] Equation 14 shows that the inverse productivity cut-off to import foreign input φ_m will be higher. This implies that there are more firms engage in importing cost-efficient intermediate input. This is illustrated in Figure 2, where the expected profit curve moves outward when there is a reduction in trade cost, leading to a higher inverse productivity cut-off value to become an importing firm.

Equations 17 and 12 determine the equilibrium level of N and φ_d as shown in Figure 3. It is clear that when the trade cost V^{ϕ} decreases, the curve D1 shifts downwards while the S curve remains unchanged. This is because the relation between N and φ_d in equation (12) is uncorrelated with trade cost this is is not the case for equation (17). Solving the new equilibrium gives a lower level of N and φ_d as shown in Figure 4. This indicates that the number of active firms in the market shrinks following the reduction of trade costs. Moreover, a smaller φ_d suggests that the productivity cut-off level to survive in the market also increases.

From simple differentiation of equations 14, 17 and 12 it follows that:[10]

Proposition 2. *A decrease in variable trade cost τ induces the number of active firms in the market N and the inverse productivity cut-off to survive φ_d to decrease, i.e.$\frac{\partial N}{\partial \Psi} > 0$ and $\frac{\partial \varphi_d}{\partial \Psi} > 0$; furthermore, if the change of cut-off value is small enough, i.e. $\frac{\partial \varphi_d}{\partial (1+\Psi)} \frac{1+\Psi}{\varphi_d} < 1$, in response to a reduction of the trade cost τ the importing critical value φ_m will increase.* [11]

The average markup across all firms that survive is derived as:[12]

$$\bar{\mu} = \int_{\underline{\varphi}}^{\varphi_m} \left(\frac{\varphi \Psi + \varphi_d}{2 \varphi \Psi} \right) d\mathrm{G}(\varphi)/G(\varphi_d) + \int_{\varphi_m}^{\overline{\varphi}} \left(\frac{\varphi + \varphi_d}{2\varphi} \right) d\mathrm{G}(\varphi)/G(\varphi_d) \tag{18}$$

An example with the uniform distribution is written as:

[9] Trade liberalization can also be interpreted and result in a decrease in the fixed costs of importing. The effect of a reduction in fixed costs would be similar to the change in variable cost in the sense that it will also enable more engagement of importing.

[10] The details of the derivation are presented in Appendix A2.

[11] The condition $\frac{\partial \varphi_d}{\partial (1+\Psi)} \frac{1+\Psi}{\varphi_d} < 1$ is easy to satisfy if the value of Ψ is closed to one.

[12] The details of the derivation are presented in Appendix A3.

$$\bar{\mu} = \underbrace{\frac{\varphi_d}{2\left(\varphi_d - \underline{\varphi}\right)}}_{(1)} \left(\underbrace{\frac{1}{\Psi} ln \frac{\varphi_m}{\underline{\varphi}}}_{(2)} + \underbrace{ln \frac{\varphi_d}{\varphi_m}}_{(3)} \right) - \frac{1}{2}\underline{\varphi} \tag{19}$$

An example with the Pareto distribution $\varphi \sim 1 - \left(\frac{\varphi}{\underline{\varphi}}\right)^{-\alpha}$ is written as:

$$\bar{\mu} = \frac{1}{2}\left[1 - \frac{\alpha}{\alpha+1}\left(\frac{1}{\Psi} - 1\right)\left(\underbrace{\left(\frac{\underline{\varphi}}{\varphi_m}\right)^{-\alpha}}_{(1)} - \underbrace{\left(\frac{\varphi_d}{\varphi_m}\right)^{-\alpha}}_{(2)}\right)^{-1} + \frac{\alpha}{\alpha+1}\underbrace{\frac{\frac{1}{\Psi} - \left(\frac{\varphi_d}{\underline{\varphi}}\right)^{-\alpha}}{1 - \left(\frac{\varphi_d}{\underline{\varphi}}\right)^{-\alpha}}}_{(3)}\right] \tag{20}$$

where k is the parameter for the distribution of inverse productivity; φ_d is the surviving cut-off value of the inverse productivity; φ_m is the critical value of the inverse productivity to import; and Ψ captures the variable cost of importing the inputs.

Combining the latter with equation 14, we observe that if $\frac{\partial \varphi_d}{\partial (1+\Psi)} \frac{1+\Psi}{\varphi_d} < 1$, then $\frac{\partial \varphi_m}{\partial \Psi} < 0$, which means that when importing cost decreases, more firms will use the imported inputs. This condition also implies that the average markup $\bar{\mu}$ decreases in the importing cost Ψ, i.e, $\frac{\partial \bar{\mu}}{\partial \Psi} < 0$. In other words, a lower importing intermediate price index leads to a higher average markup. Specifically, based on the equation (19), we observe that the the link between trade cost and average markup materializes via two different channels. First, there is a higher share of high productivity firms. The first term of equation (19) captures the exit of low productivity firms and then the sales reallocates to the high productivity firms with high markup. The second term of equation (19) captures the fact that in response to a reduction of importing cost, the importing firms will obtain higher markup, where $ln \frac{\varphi_m}{\underline{\varphi}}$ indexes the share of the importing firms out of all survived firms. The third term measures the increase of market competition due to that the importing firms charge a lower price in response to a reduction of input price. When the first and second effects dominate the third effect, then the average markup will increase in response to the reduction of importing cost.

Proposition 3. *In response to a reduction of the trade cost, if the change of the surviving cut-off value is small enough, i.e.* $\frac{\partial \varphi_d}{\partial \Psi} \frac{\Psi}{\varphi_d} < ln\underline{\varphi}$*, the industry's average markup* $\bar{\mu}$ *will increase. This is due to the Cost Reduction Effect and the Reallocation Effect.*

1.2.5 Extensions

This section completes our theoretical framework by altering a few dimensions of our modeling setup and see how the results change. First, we allow the entry mass to be endogenously determined by the free entry condition and discuss the conditions under which that our model main predictions remain. Second, we turn the fixed sourcing costs that are previously increasing in the firm's inverse productivity into a constant independent one, and we show that the relevant expressions would all be very similar. Third, to highlight the importance of importing, we have assumed that final goods cannot be traded across borders. We relax this assumption and study the joint determination of the extensive margins of both exports and imports.

Endogenous Number of Entrants

In the model so far we kept the entry mass N_E constant. It could be endogenously determined by the entry condition and supply of the entry firms, i.e.

$$\begin{cases} \int_{\underline{\varphi}}^{\varphi_m} \frac{L\bar{D}^2(\varphi_d-\Psi\varphi)^2}{4\gamma}dG(\varphi)+\int_{\varphi_m}^{\varphi_d} \frac{L\bar{D}^2(\varphi_d-\varphi)^2}{4\gamma}dG(\varphi)=f_E \\ N=N_E G(\varphi_d) \end{cases} \tag{21}$$

Both equations together determine the supply side of the entry firms. From equation (14), we know that φ_m is an increasing function of φ_d, given the value of Ψ. In this way, the value of φ_d is determined by the entry cost f_E and independent of the firm number N. In this case, the curve which illustrates the supply side of the entry firms is drawn as a horizontal line in the Figure 6 below (the curve S_1). It is easy to prove that when the trade cost Ψ decreases, the demand curve D_1 shifts down to the position of the curve D_2, and the supply curve S_1 shifts down to the position of the curve S_2. In this case, the inverse productivity φ_d decreases but the change in the cut-off value for the firm number N depend on the relative associated change of both the supply and demand curve. Although we are not able to make quantitative statement on the changes of the importing critical value φ_m in this case, it is qualitatively clear that our min prediction on average markup $\bar{M}$ remains as long as the firm entry incurred by the rise of imported input penetration remains in a relatively small scale over the observation period.

Independent Fixed Sourcing Cost

One might be concerned with the seemingly strong assumption that the fixed sourcing cost a firm has to pay to start importing intermediate inputs is decreasing with productivity, though it is well-justified by the fact that the searching and information cost it incurs to find the most cost-efficient trading partner is likely to fall with productivity. To address this issue, we relax this assumption and assume an independent fixed sourcing cost. We make the following assumptions on the production function. It requires two types of inputs in the production, i.e., labor and intermediate input. One unit of composite intermediate input can be transformed into ϕ units of the final output. It requires at least $\frac{1}{A_i}$ unites of labors to complete the transformation of one unit of output, where the parameter A_i captures the labor productivity for the firm i .

$$Y_i = min\{A_i L_i, \phi X_i\} \tag{22}$$

The marginal cost of firm i is computed as:

$$c_i = \varphi_i W + \phi V_i$$

where V_i and W are price for the intermediate input and wage of the labor respectively; ς and ϕ are parameters with given values; and φ_i is inverse productivity of firm i, which is assumed to be randomly drawn from a distribution with support $[0, \overline{\varphi}]$. We can then prove the following lemma:

Lemma 4. *When the importing fixed cost is small enough, i.e.* $f_m < \frac{\left(W\varphi_d - \frac{\phi\Psi+1}{2}\right)}{2\Upsilon}$ *, there exists a* $\varphi_m \in [0, \varphi_d]$ *which solves* $H(\varphi_m) = 0$ *; and* $H(\varphi) \geq 0$ *for* $\varphi < \varphi_m$ *and* $H(\varphi) < 0$ *for* $\varphi > \varphi_m$*.*

In this case, the survived firm who has lowest productivity won't choose to import the intermediates.

Specifically, the critical value φ_m is given by:

$$\varphi_m = \frac{1}{W}\left[W\varphi_d + \frac{1-\Psi}{2} - \frac{2\Upsilon f_m}{L(1-\Psi)}\right] \tag{23}$$

According to Lemma 1 , the firms whose inverse productivity is lower than φ_m will choose to import and the firms with higher inverse productivity will choose to use domestic inputs only.

Similar derivations give the average markup as:[13]

$$\bar{\mu} = \int_0^{\varphi_m} \left[\frac{W\varphi + \Psi + W\varphi_d + 1}{2(W\varphi + \Psi)}\right] d\mathrm{G}(\varphi)/G(\varphi_d) + \int_{\varphi_m}^{\varphi_d} \left[\frac{W\varphi + 2 + W\varphi_d}{2(W\varphi + 1)}\right] d\mathrm{G}(\varphi)/G(\varphi_d) \tag{24}$$

Assuming that the inverse productivity follows uniform distribution, i.e. $k = 1$ and $\bar{\varphi} = 1$, the average markup across

[13] See Appendix A.5

all firms that survive is derived as:

$$\bar{\mu}=\frac{1}{2}\left[1+\left(\underbrace{\frac{W\varphi_d+1}{W\varphi_d}}_{(1)}\right)ln\left(\underbrace{\frac{W\varphi_m+\Psi}{\Psi\left(W\varphi_m+1\right)}}_{(2)}\right)+\underbrace{\left(\frac{W\varphi_d+1}{W\varphi_d}\right)ln\left(W\varphi_d+1\right)}_{(3)}\right] \tag{25}$$

It follows that the average markup $\bar{\mu}$ increases in the importing critical value φ_m. Similar to the results in the case of Cobb-Douglous productivity function, we observe two channels for the rise of the average markup in reacting to the reduction of Ψ, i.e. the reallocation effect and cost reduction effects. Term (1) of equation (25) captures the reallocation effect such that lowering importing cost reduces the surviving cut-off φ_d, which increases the proportion of high productivity firms in the market. Term (2) reveals the fact that lower importing cost reduces the variable cost of the importing firms directly, which enhances the competition capacity of these firms. Term (3) increases in φ_d, which reveals that the firms that never import inputs will face higher intense of market competition after the importing cost reduces, and thus their markups will be lower than before. When the effects of terms (1) and (2) dominates the effect of term (3), the average markup will increase in react to a reduction of the importing cost. As a result, a reduction in variable trade costs increases the average markup due to these two effects. Next, we will show that in response to a reduction of importing cost, the average markup will increase when some conditions satisfy. Recall that from equation (10), the change of φ_d is very small in response to the varying of importing cost when the parameter η is small enough. If we set $\eta=0$, φ_d will be constant in the importing cost Ψ. Given this property, when the importing cost Ψ decreases, the importing critical value φ_m will increase according to equation (23). That means more firms will enter the international input market. Given all these properties, we observe that, terms (1) and (2) of equation (25) are constant in Ψ while term (2) decreases in Ψ. In this case, we will observe an increase of average markup in response to a reduction of importing cost Ψ. Actually, when the parameter η is small enough (not necessary to be zero), the change of term (3) will be very small and the average markup still decreases in Ψ .

1.3 Data and Measurement

Our theoretical framework shows that a decrease in trade cost and the associated rise in input import penetration is associated with a surge in the markup. It is due to both a cost reduction and reallocation effect. The remainder of the paper aims to find empirical evidence that supports this claim. To uncover the relationship between input import penetration and markups, we use Compustat data of US public firms to generate markup, and we combine US trade data and Input-Output tables to test the impacts of import penetration on markups. The empirical exercise is based on three main types of data for the empirical analysis: firm's balance-sheet data, trade data, and input-output tables at detailed commodity level.

1.3.1 Firm Balance-Sheet Data

We use Compustat (North America) Fundamental Annual database to derive firm-level balance sheet information. Compustat has variables that are needed for production function estimation including annual sales, wages, capital stock, as well as the labor of all the US publicly traded firms available from 1950 to 2014 in Wharton Research Data Services (WRDS). We restrict the sample as follows: First, we only consider and identify firms incorporated in the United States based on Stock Exchange Code (EXCH) and Foreign Incorporation Code (FIC); Second, we exclude observations with obviously mis-measured variables of interests, such as negative sales or employment. The final sample counts 504,319 firms-year observations covering the years from 1972 to 2014. The common GDP deflator comes from the Bureau of Economic Analysis's National Income and Product Accounts (NIPA) tables of the United States. Therefore we obtain firm-level markup by applying the so-called cost-based production approach as in De Loecker and Warzynski (2012).

Constrained by the data availability of import penetration measures, we focus on the sample from 1972 to 2014, that we match with industrial level import penetration ratios in the firm-level regression. It reduces our sample to 412,565 firms-year observations with an average of 9,822 firm-level observations per year. Compustat assigns each firm a North American Industry Classification System (NAICS) 2012 6-digit sector code based on the firm's operation reported as required by Financial Accounting Standards Board (FASB). The 2012 NAICS codes have 1,065 disaggregate industries. To match it with the industrial classification in the Input-Output table, we first converted the different versions of NAICS codes to the 2007 version and then assigned each 2007 NAICS code with one of the 389 6-digit IO industries used in the Input-Output table from Bureau of Economic Analysis (BEA). Table 2 shows the IO industrial distribution of the firm-year observations at the most aggregate level between 1972 to 2014. While Compustat only includes publicly traded companies, our sample covers firms across most of the industries and matches closely with the industrial distribution across the economy. A large portion of firms is in the Manufacturing and Finance sector, accounting for 35.5% and 21.8% of the observations respectively in the sample. We are interested in how imported inputs penetration is related to markup at the firm level, but Compustat does not contain information on how much each firm employ foreign inputs. Therefore in the industry-level regression, we compute the sales-weighted markup at the 6-digit BEA I-O industry level to match with industry-level import penetration measures.

Table 1: Summary Statistics

Variables	N	Mean	Min	Max
$Markup_{OLS}$	384,069	1.476711	.0017906	5.767589
$Markup_{OP}$	384,069	1.438996	.0017449	5.620286
$Markup_{ACF}$	348,026	1.757911	.0021316	6.865868
Horizontal Import Penetration Ratio	15,990	.1100257	0	1
Vertical Import Penetration Ratio	15,990	.1910009	1.22e-06	5.586

Notes: The table reports the summary statistics for the main independent and dependent variables used throughout the empirical analysis. The unit of observation for Markups is the production unit in the sector under investigation in each day from 1972 to 2014. Markup_{OLS}, Markup_{OP}, and Markup_{ACF} are estimated firm-level markups by OLS regression, by Olley and Pakes (1996) Method, and by Ackerberg et al. (2015) corrections respectively. Horizontal and Vertical Import Pentration Ratio are calculated by the methods described in Sectoin 4 using weights from 1972 BEA I-O benchmark table.

Table 2: Sample Firm Distribution by Broad Industry

IO Code	IO Description	Firms(%)	Freq(%)
11	Agriculture, forestry, fishing, and hunting	1,513	0.4
7	Arts, entertainment, recreation, accommodation, and food services	10,132	2.5
23	Construction	5,824	1.4
6	Educational services, health care, and social assistance	6,924	1.7
FIRE	Finance, insurance, real estate, rental, and leasing	89,734	21.8
51	Information	35,155	8.5
31G	Manufacturing	146,914	35.6
21	Mining	32,971	8
81	Other services, except government	1,624	0.4
PROF	Professional and business services	21,838	5.3
44RT	Retail trade	17,374	4.2
48TW	Transportation and warehousing	10,572	2.6
22	Utilities	18,015	4.4
42	Wholesale trade	13,941	3.4
	Total	412,565	100

Notes: The table reports the industry distributions for the firms in the firm-level data from Compustats from 1972-2014. The IO Code is based on BEA industry classification at sector level.

1.3.2 Markup Estimation

Defined as the ratio of price over marginal cost, markups can be estimated by a few different methods prevailing in the field of empirical industrial organization. As detailed data on price and marginal cost data is usually unavailable, markup estimation depends on the granularity of the available data and the choice of assumptions. On the one hand, the "demand-based" estimation requires assumptions on the form of demand function and market structure, therefore marginal cost and markups are estimated with the associated demand elasticity and firms' optimal pricing behavior as in Bresnahan (1982) and Berry et al. (1995). On the other hand, the "production-based" method proposed in De Loecker and Warzynski (2012) builds upon the insight of Hall (1988) where markups are inferred by estimating the production function with assumptions on the firms' optimal input choice from total cost minimization. Markup is then derived as the product of the input revenue share and output elasticity of any chosen variable input. Intuitively, it is measured as technology-adjusted cost share. As the input cost shares are often available in the accounting data, it is easy to estimate markup by having an estimate of the input elasticity. The input elasticity is estimated using various production function estimation methods including OLS, Olley-Pakes, and Levin-Petrin methods. And our baseline results are based on Olley-Pakes method.

We adopt the "production-based" method in our markup estimation for several reasons. First, one of our model prediction is that imported input penetration is associated with rising markup through the change of market structure. Therefore it is reasonable to impose as least assumptions as we can on the market structure in markup estimation. Second, Compustat data is firm-level balance sheet accounting data, from which input share is directly calculated. Last, following the same method of markup estimation would make our results comparable to De Loecker et al. (2016). As we are following the same manner, we relegate the necessary derivation of markup in Appendix 6.

1.3.3 Trade Data

The trade data are used to compute direct import penetration measures. The data is divided into three parts: 1972-1988; 1989-2006; and 2007-2014. The first two parts of data come from U.S. trade data assembled by Feenstra (1996). For the period 1972 to 1988, the data are by year at the level of 4-digit 1972-revision SIC industry and the level of 1987 SIC version for the years from 1989 to 2006.[14] The other part of trade data comes from USA Trade Online, which

[14] There are 533 unique 4-digit SIC 1972 version industries appear in the 1972-1988 sample, converted to 507 NAICS 2007 industry codes. For 1989-2006 sample, there are 459 unique SIC 1987 version industries converted to 456 NAICS 2007 industry codes.

contains data on US (down to district-level) export, import, and total trade value at various industrial classification such as 10-digit HTS and 6-digit NAICS for different versions covering from 2007-2014. USA Trade Online always starts using the new NAICS revision the year after the change. So for 2008-2012, the data report the 2007 NAICS codes and for 2013-2017 the 2012 NAICS codes and so on. To match with other sources of data, we harmonized the different industrial classifications and different versions based on the concordance table provided by the Census Bureau and Bureau of Economic Analysis.

1.3.4 Input-Output Table

A crucial component of our empirical analysis is the derivation of a measure of import penetration of intermediate products or vertical import penetration. To build this measure, we take advantage of input-output tables that provide information on the level of interdependence and input use between industries. All the industry and I-O data come from the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce. The I-O tables along with industry economic accounts provide detailed information on the interrelationships between producers and users and the contribution to production across industries. The data are available at three levels: sector (15 industry groups), summary (71 industry groups), and detail (389 industry groups). To get the highest level of disaggregation, we make use of the I-O data at a detail level that is available for each 5-year benchmark years between 1947-2007. We calculate the weights measuring how much each industry's production is relying on the products of another sector by the use values shares of the industry pair appear in detail I-O use table in 1972 in the baseline regression. For example, the weight d_{js} represents the value share of the input used by industry s from industry j of the total inputs utilized by industry s in the benchmark year, i.e., $d_{js} = \frac{use_{js}}{\sum_{j \in s} use_{js}}$. To keep the potential impact of the change of relative input use between different industry due to the shift in trade policy to the minimum, we keep using the year 1997 as the baseline for the calculation of such weights.[15]

1.3.5 Measures of import penetration

This section describes how our main import penetration variables are constructed. We look at the impact of import penetration both directly and indirectly. Horizontal import penetration measures the direct effect of imported prod-

[15] We assume that the input mix remains unchanged over the entire sample period, so ideally we need to use the earliest available benchmark year, 1972. However, there are admittedly significant structural change of industries due to technology and innovation in the 42 years our sample covers. To avoid potential bias caused by the change of industrial classifications, we use year 1997 in the middle of our sample period to be the benchmark year. We also proceed manual industry classfication mapping between years and use the weights calculated from 1972 benchmark I-O table to corroborate our main results in section 6.

uct and within-sector competition. By contrast, vertical import penetration takes the interdependence and input use between sectors into consideration. Horizontal and vertical import penetration is measured for the period 1974–2014 and each of the 389 benchmark I-O industries based on the 1997 benchmark I-O table classification.

The horizontal import penetration (HIMP) for industry s in year t is calculated as:

$$himp_{st} = \frac{imp_{st}}{imp_{st} + prod_{st} - exp_{st}}$$

where imp_{st} and exp_{st} are the value of imports and exports from the world to US in industry s at time t respectively, and $prod_{st}$ is the production value of industry s in year t.

Similar to the way of separating input tariffs from output tariffs in Amiti and Konings (2007), we measure the cumulative impact of foreign input penetration in the industry s that is supplied by sector j by defining a measure of vertical import penetration ratio (VIMP). We define this for industry s as the weighted average of the import penetration of its inputs:

$$vimp_{st} = \sum_{j \in s} d_{js} himp_{jt}$$

where $himp_{jt}$ is the horizontal import penetration of intermediate inputs coming from industry j whose goods are used as inputs in the production processes of industry s. The weights d_{js} are computed as described in section 4.3 from the I-O tables as discussed above.

Horizontal and vertical import penetrations have a different impact on both firms' marginal costs and markup. On the one hand, higher horizontal import penetration leads domestic firms to face tougher final goods competition directly. This implies that an increase in horizontal import penetration leads domestic firms to lower their production and prices, and thus reduce their markup, assuming constant marginal costs. On the other hand, higher vertical import penetration will not affect the competitive environment faced by domestic firms, but it leads to a reduction in firms' marginal costs and thus allowing more room for firms to raise markups.

Table 1 summarizes the features of our key variables, i.e., markup, horizontal and vertical importing penetration rates for the industry level 1972-2014. Figure 8 provides our measure of vertical import penetration with average industry markup between 1974 to 2014.

Table 3: Change of Import Penetration Ratios in Manufacturing Sectors: 1980-2014

Industry Code	Industry Description	ΔHIMP	ΔVIMP
311FT	Wood products	-0.032	0.035
313TT	Nonmetallic mineral products	0.259	0.086
315AL	Primary metals	0.556	0.154
321	Fabricated metal products	-0.182	0.031
322	Machinery	0.189	-0.035
323	Computer and electronic products	0.197	-0.015
324	Electrical equipment, appliances, and components	-0.131	0.05
325	Motor vehicles, bodies and trailers, and parts	-0.835	-0.402
326	Other transportation equipment	0.687	0.014
327	Furniture and related products	0.146	-0.002
331	Miscellaneous manufacturing	0.436	0.279
332	Food and beverage and tobacco products	0.049	0.05
333	Textile mills and textile product mills	0.08	0.095
334	Apparel and leather and allied products	-3.219	0.542
335	Paper products	0.399	0.093
3361MV	Printing and related support activities	-0.314	-0.136
3364OT	Petroleum and coal products	-0.156	0.067
337	Chemical products	0.021	-0.004
339	Plastics and rubber products	0.564	-0.007

Notes: The table reports the change of calculated horizontal and vertical import penetration ratios for manufacturing sectors at BEA industry classification summary level, 1980-2014, taking 1997 Input Output table as benchmark.

1.4 Results

In this section, we test the main predictions of our theoretical model: vertical import penetration is positively associated with average markups across industries and over time. We estimate our baseline specification at the industry level and firm level respectively for a full combined sample from 1972 to 2014.

1.4.1 Import penetration and markups: baseline results

We start by presenting how average markup increase with import penetration across the US economy in the last four decades. Figure 7 reports the time evolution of import exposure along with the sales-weighted markup. Measured as the value of imports of goods and services to GDP, the import exposure ratio has been steadily increasing in the first and half decade (1960s-1970s) despite the slightly drop of markup in the same period. Following the sharp increase in import exposure since 1970, the markup has been increasing since the next decade (1980s) till the present. As noted by De Loecker et al. (2016), there has been a sharp rise from a markup of around 1.2 in 1980 to a markup of 1.6 in 2014, while the import exposure ratio has doubled in the same period: it increase from around 10% in 1980 to 20% in 2014. This figure suggests that import exposure may have changed markup in some ways other than only output competition. In Figure 8, we report the VIMP ratio calculated as described in Section 3.5 with average markup from 1974 to 2014.[16]Recall that this VIMP ratio is the average of direct import penetration ratio in each industry (HIMP), weighted by the ratio of how each industry uses the other industry's output in the production. The VIMP ratio thus indicates the import penetration ratio of input. Remarkably, the pattern of VIMP is very much aligned with the average markup since 1970s: it increased form 0.05 to around 0.2 to 2014. These figures provide suggestive evidence consistent with predictions in the theoretical model. Next, we show the empirical test of these conjectures.

Sector-Level Analysis

With the import penetrations and industry level markup measures in hand, we can implement the following regression specification.

$$ln\mu_{st} = \beta_1 lnHIMP_{st-1} + \beta_2 lnVIMP_{st-1} + \mathbf{X_{st}'}\gamma + \sigma_s + \delta_t + \varepsilon_{st} \tag{26}$$

where $ln\mu_{st}$ is the log of estimated average markup in the 6-digit US Input-Output industry s weighted by sales in year t. $lnHIMP_{st-1}$ and $lnVIMP_{st-1}$ are the horizontal and vertical import penetration ratios in the same sector s. They are lagged for one period to accommodate the time it takes to adjust markups accordingly as described in the model and they also serve to attenuate potential simultaneous bias between import penetration and markup. $\mathbf{X_{st}}$ is a vector of industry-level control including industrial level capital intensity (KL) and average wage ($WAGE$), who serve to capture the factors that could also potentially influence average markups. σ_s and δ_t are industry and time fixed effects, respectively, to control for time-invariant industry-related effect and time effect. ε_{st} is an iid error term. We clustered the standard errors at the industry level in our following regressions to accommodate non-independent residuals across observations within industries. Based on our theoretical framework, we expect β_2 to be significant and positive.

Table 4 reports the baseline regression results. Results from the unweighted from the unweighted sample in column (1) and (2) shows that an increase in one-year lagged vertical import penetration is associated with increase in markup, while horizontal import penetration negatively affects sale-weighted industry markup. In terms of magnitude, a 10% increase in lagged vertical import penetration is associated with a 0.43% increase in markup. Adding industry-level

[16]We would like to extend this to years before 1974 but we are constrained by trade data availability.

controls has little impact on the significance and size of the estimated beta, equal to 0.40% in column (2).

Firm-Level Analysis

In column (3) and (4), we implement a weighted regression specification having as weight the number of observations in each 6-digit BEA Input-Output industry that are used in the estimation of production function in each 2-digit sector. And this magnitude stays stable for these weighted regressions in columns (3) and (4): the coefficient of vertical import penetration increases to 1.23 and remains unchanged when including controls.We test our primary hypothesis further using firm-level observations. In particular, we regress firm-level markups over 6-digit industrial import penetration rations as in Acemoglu et al. (2016) and Olper et al. (2017),[17]

$$ln\mu_{ist} = \beta_1 lnHIMP_{st-1} + \beta_2 lnVIMP_{st-1} + \mathbf{Z'_{ist}}\gamma + \beta_\mathbf{4}\mathbf{I_{st}} + \theta_i + \sigma_s + \delta_t + \varepsilon_{st} \tag{27}$$

where $ln\mu_{ist}$ is the markup of the firm i, who operates in industry s at year t in equation 27. The firm characteristic vector $\mathbf{F_{it}}$ is added to account for time-variant firm-level factors including the number of employment, capital-labor ratio, and productivity that could also influence a firm's capacity of adjusting markups. We also include firm fixed-effects as captured by θ_i.

Table 5 reports the results from the firm level regressions. We find a positive and strongly significant correlation between both types of penetration ratios and the value of markup. According to the results from the unweighted regression specification estimation, implies that a 10% increase of vertical import penetration contributes to .62% and .25% increase of firm-level markup without and with other firm and industry controls. Columns (3) and (4) in Table 5 further reports the firm-level baseline results of weighted regression. Our results show a more significant positive correlation between the vertical import penetration ratio and the markup and they increase in scale comparing to unweighted regressions in column (1) and (2).

[17] In these regressions, we still use the industrial level data for the variables horizontal and vertical penetration ratios due to the lacking of firm level data for these variables.

Table 4: Import Penetration and Markup: Baseline Industry Regression

	Industry-level Markup			
	Panel A: Unweighted Regression		Panel B: Weighted Regression	
	(1)	(2)	(3)	(4)
$\ln Himp_{t-1}$	-0.326**	-0.316**	-0.308	-0.356**
	(0.158)	(0.156)	(0.686)	(0.178)
$\ln Vimp_{t-1}$	0.044*	0.039*	0.123*	0.117*
	(0.024)	(0.022)	(0.065)	(0.061)
Industry FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
Other Firm-level controls	NO	YES	NO	YES
Industries	356	356	356	356
Observations	12,336	12,280	12,264	12,208
R-squared	0.638	0.655	0.804	0.813

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. The robust standard errors are corrected by clustering variables at the 6-digit industry level. Sample is restricted to the 6-digit I-O benchmark industries during 1972-2014. Dependent variable is industry-level markup estimations corrected by Olley-Pakes Method. $\ln Himp_{t-1}$ is 1-year lagged industry horizontal import penetration ratio in log form. $\ln Vimp_{t-1}$ is 1-year lagged industry vertical import penetration ratio in log form. Specifications (1) - (2) report unweighted regressions and specifications (3) - (4) report the regression results that uses the number of firms that arebeing used in the production function estimation of each 2-digit industry as weight in the regressions. Other industry-level controls include industry capital-labor ratio.

Table 5: Import Penetration and Markup: Baseline Firm Regression

	Firm-level Markup			
	Panel A: Unweighted Regression		Panel B: Weighted Regression	
	(1)	(2)	(3)	(4)
$\ln\text{Himp}_{t-1}$	0.066	0.276^{***}	-0.565^{***}	0.715^{***}
	(0.070)	(0.067)	(0.150)	(0.134)
$\ln\text{Vimp}_{t-1}$	0.062^{***}	0.024^{**}	0.191^{***}	0.057^{***}
	(0.011)	(0.011)	(0.017)	(0.016)
Industry FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
Other Industry-level controls	NO	YES	NO	YES
Other Firm-level controls	NO	YES	NO	YES
Firms	27,445	24,146	27,387	24,093
Observations	286,884	236,095	284,885	234,267
R-squared	0.681	0.717	0.706	0.747

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. The robust standard errors are corrected by clustering variables at the firm level. Sample is restricted to the firms that appears during 1972-2014 merged with 6-digit industry code. Dependent variable is firm-level markup estimations corrected by Olley-Pakes Method. $\ln\text{Himp}_{t-1}$ is 1-year lagged industry horizontal import penetration ratio in log form and $\ln\text{Vimp}_{t-1}$ is 1-year lagged industry vertical import penetration ratio in log form. Specifications (1) - (2) report unweighted regressions and specifications (3) - (4) report the regression results that uses the number of firms that are being used in the production function estimation of each 2-digit industry as weight in the regressions. Other firm-level controls include the number of employees, and capital-labor ratio. Other industry-level controls include industry capital-labor ratio.

1.4.2 Mechanisms

Here we further verify the main results presented above by looking into the specific mechanisms that operate in our theoretical model.

Production Frontier

Our model predicts that firms are motivated to employ more foreign inputs when variable sourcing cost decreases, but only firms with relatively high initial productivity can pay the fixed sourcing costs, import foreign intermediate goods and obtain the corresponding market advantage. Therefore, we should be able to observe that the positive effect of vertical import penetration is more substantial for firms that are initially at the fringe of the productivity frontier. We interact vertical import penetration ratio with a measure of the firm's position relative to the production frontier. We define a firm's proximity to the frontier as the ratio of its initial estimated productivity λ_{it}^{ini} to the highest productivity of that year in the industry the firm belongs to as in Amiti and Khandelwal (2013): $PF_{it} = \frac{\lambda_{it}^{ini}}{max_{i\in s}\left(\lambda_{it}^{ini}\right)}$. Table 6 column (1) shows a significant positive effect of the vertical import penetration ratio to markup and the significant positive coefficient of the interaction term between vertical import penetration and production frontier measure indicates the impact is more profound for firms initially at the fringe of productivity frontier. This relationship remains stable with the addition of firm and industry level controls as shown in column (2).

Industry Concentration

To fully understand the impacts of vertical import penetration on domestic market structure, we use HHI index as a measure of market concentration and look at how vertical import penetration may contribute to the reshaping of market structure. Table 6 shows a positive effect of the vertical import penetration ratio but a negative effect of the horizontal import penetration intensity on the market concentration. The reports from Table 6 column (3) and (4) indicate that when the high productivity firms use more ratio of foreign inputs, the low productivity firms will face higher competition pressure from the high productivity firms and the market exiting ratio rises as well.

Industry Exit ratio

The rest of Table 6 relates the percentage of firms' exit in each industry with the import penetration measures. The central prediction on the relationship between vertical import penetration and markup relies on the differential impacts that import penetration has on heterogeneous firms. We thus expect to observe more firms exiting the market as high productivity firms retain cost advantage through importing intermediate inputs. The positive coefficients of vertical import penetration on industry exit ratio reported in Table 6 column (5) and (6) indicate that when the high productivity firms use more foreign inputs, the low productivity firms will face higher competition pressure from the high productivity firms and the market exiting ratio thus rises.

To sum up our results, we test the predicted mechanism of our model: the effect on markup is more profound for firms initially at the fringe of the productivity frontier. This is expected in the model as only firms with relatively high productivity could pay the fixed cost of sourcing intermediate goods from foreign countries and benefit more in the process of globalization. After this, we look at the change of both HHI and firms' exit ratio of each industry concerning the shift of import penetration. They further validate our expectation: the industry's sales are more concentrated to the advantageous firms, and the low productivity firms are forced to exit the market and so the firms' exit ratio of the industry increases.

Table 6: Mechanism: Production Frontier, HHI, Exit Ratio

	Dependent Variables					
	Firm-level Markup		Herfindahl Index		Exit Ratio	
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln\text{Himp}_{t-1}$	-0.928***	-0.795***	-0.033	0.005	0.166	-1.321***
	(0.051)	(0.048)	(0.044)	(0.046)	(0.290)	(0.327)
$\ln\text{Vimp}_{t-1}$	0.255***	0.214***	0.019**	0.025***	0.128**	0.205***
	(0.012)	(0.012)	(0.007)	(0.009)	(0.053)	(0.057)
PF*Vimp_{t-1}	0.005*	0.016***				
	(0.002)	(0.009)				
PF	0.0006***	0.0008***				
	(0.000)	(0.000)				
Industry FE	NO	NO	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
Other controls	NO	YES	NO	YES	NO	YES
Observations	283,197	217,168	12,336	12,280	11,654	11,593
R-squared	0.681	0.689	0.854	0.861	0.536	0.549

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. All variables are in logs. Sample is restricted to the firms that appears during 1972-2014 merged with 6-digit industry code. Dependent variables are: firm-level markup estimations corrected by Olley-Pakes Method in column (1)-(2); 6-digit industry Herfindahl Index in column (3)-(4); and Firm Exit Ratio calculated by the number of firms that appeared in last year but disappear in current year divided by total number of firms in the last year at 6-digit industry level. $\ln\text{Himp}_{t-1}$ is 1-year lagged industry horizontal import penetration ratio in log form and $\ln\text{Vimp}_{t-1}$ is 1-year lagged industry vertical import penetration ratio in log form. PF is the variable that indicates a firm's initial distance to the productivity frontier within its main industry. PF equal to 1 if it is the top productivity firm at its initial year in its main industry. Other firm-level controls include the number of employees and capital-labor ratio. Otherindustry-level controls include industry capital-labor ratio and the Herfindahl index.

1.5 Robustness Checks

1.5.1 Alternative Weighting

As described in Section 4, the measure of VIMP is a weighted average of the HIMP. In the measure of VIMP above, the weights being used are the shares of use values of each industry pair appear in detail input-output table in 1972. One possible concern is that these weights are based on a far distant year to cover the entire sample. It is likely that the structure of the economy has changed structurally and thus the initial industry classification and the associated weights cannot account for these structural changes. Moreover, the use of weights derived from 1972 benchmark input-output table requires re-classifications of secondary products definitions used in I-O tables over different benchmark years. Furthermore, I-O tables from 1972 to 1992 are based on the SIC classification while they are based on NAICS for later years. The concordance between SIC and NAICS as well as the concordance within different versions of each classification are thus unavoidable. To address these issues, we hereby first construct VIMP using use value shares from 1972 I-O table. We then split the sample into two parts, 1972-1988 and 1989-2014, and assign different weights for each sample. We employ the use value shares from 1972 I-O table and that from 1997 I-O table for these two split sample respectively.

The results are reported in Table 7. Our baseline results still hold for the entire sample using weights from 1997 I-O table as in column (1). The VIMP turns out to be insignificant in the first split 1972-1988 sample, but the results hold for the sample of 1989-2014 using weights from 1992 I-O table. This could be well explained by the fact that the observed sharp increase of markup only started in the late 1980s and the impact of VIMP is more significant when large developing economies like China just joined WTO and actively participated in the global value chain in 1990s. Also, the magnitude remains comparable with baseline regressions: a 10% increase in lagged vertical import penetration contributes to the rise in markup by .07%.

Table 7: Robustness: Using Different Benckmark Weighting: Industry Level

	Industry-level Markup			
	A: Pooling Sample		B: Sample I	C: Sample II
	(1)	(2)	(3)	(4)
$\ln\text{Himp}_{t-1}$	-0.009	-0.009	-0.009	-0.010
	(0.014)	(0.006)	(0.022)	(0.011)
$\ln\text{Vimp}_{t-1}$	0.004	0.002	0.013	0.014*
	(0.009)	(0.003)	(0.016)	(0.007)
Other Industry-level controls	NO	YES	NO	NO
Industry FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
Observations	15,406	12,938	3073	12,332
R-squared	0.766	0.673	0.927	0.744

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. The robust standard errors are corrected by clustering variables at the 6-digit industry level. Sample is restricted to the detail level industries during 1972-2014. Dependent variable is industry-level markup estimations corrected by Olley-Pakes Method. $\ln\text{Himp}_{t-1}$ is 1-year lagged industry horizontal import penetration ratio in log form and $\ln\text{Vimp}_{t-1}$ is 1-year lagged industry vertical import penetration ratio in log form. Specifications (1) - (2) report regressions results on the full sample from 1972-2014 where VIMP is calculated using weights based on 1997 benchmark I-O table. Column (3) - (4) report the regression results from splited samples of 1972-1982 and 1983 - 2014, and VIMP is calculated using weights based on 1997 benchmark I-O table. Other industry-level controls include industry capital-labor ratio.

Table 8: Robustness: Using Different Benchmark Weighting - Firm Level

	Firm-level Markup			
	A: Pooling Sample		B: Sample I	C: Sample II
	(1)	(2)	(3)	(4)
lnHimp_{t-1}	-0.253***	-0.123**	0.086	-0.012***
	(0.058)	(0.060)	(0.062)	(0.004)
lnVimp_{t-1}	0.011	0.018**	0.001	0.006***
	(0.007)	(0.007)	(0.010)	(0.001)
Other Industry-level controls	NO	YES	YES	YES
Industry FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
Observations	296,791	245,083	139,902	110,153
R-squared	0.679	0.716	0.733	0.780

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. The robust standard errors are corrected by clustering variables at the 6-digit industry level. Sample is restricted to the detail level industries during 1972-2014. Dependent variable is industry-level markup estimations corrected by Olley-Pakes Method. lnHimp_{t-1} is 1-year lagged industry horizontal import penetration ratio in log form and lnVimp_{t-1} is 1-year lagged industry vertical import penetration ratio in log form. Specifications (1) - (2) report regressions results on the full sample from 1972-2014 where VIMP is calculated using weights based on 1997 benchmark I-O table. Column (3) - (4) report the regression results from splited samples of 1972-1988 and 1989 - 2014. Other industry-level controls include industry capital-labor ratio.

1.5.2 Output and Input Tariff

Presumably, the input and output tariff will determine the profitability of importing one product and thus influence the magnitude of trade flow. In this subsection, we circumvent the measurement issues of VIMP as described in the previous sections by using output tariff as a proxy for HIMP and derive input tariff the same way as deriving VIMP. The data for output tariffs are drawn from WTO trade analysis and information system (TRAINS) combined with tariffs collected by Feenstra et al. (2002). Moreover, the tariff measures are based on SIC which is consistent with 1972 I-O table and makes it more reliable when calculating input tariff using the use value share derived as weights from I-O table. The measure to compute input tariffs are adapted from the approach to measuring VIMP as in section 4:

$$\tau_{st}^{in} = \sum_{j \in s} d_{js} \tau_{jt}^{out}$$

where the input tariff of industry s, τ_{st}^{in}, is calculated as the weighted average of de jure output tariffs τ_{jt}^{out} in any industry k at time t. Similar to the measure of VIMP, d_{js} remains the use value shares of industry j to the production of industry s as in section 4.4. A small difference, however, is that the input tariffs are calculated at 4-digit SIC codes, and the use value shares are concorded using the concordance table between I-O table and SIC provided in the 1972 benchmark I-O table. Next, we replace HIMP and VIMP with output tariff and input tariff in our baseline regression equations (26) and (27).

The results are displayed in columns (1) - (3) in Table 9. We still find a negative relationship between input tariff and markup, suggesting that lowering input tariff leads to rising markup. To get a sense of the magnitude, a 10% increase in lagged vertical import penetration contributes to the rise of markup by .17% and a markup increase by .57% and .41% when we split the sample at 1997. Compared with the baseline results using HIMP and VIMP directly as in section 5.1, the estimation results using output and input tariffs have larger coefficients for their impacts on the markup in scale, yet still confirming the same relationship that our theoretical model predicts: the increase of intermediate inputs penetration contributes positively to the rise of markup in the long run.

Table 9: Robustness: Input Tariff

	Industry-level Markup		
	A: 1972 Weight (1)	B: 1972 Weight (2)	C: 1997 Weight (3)
Output Tariff$_{t-1}$	0.021*	0.006	0.020
	(0.011)	(0.004)	(0.045)
Input Tariff$_{t-1}$	-0.016*	-0.057***	-0.041**
	(0.010)	(0.018)	(0.017)
Other Industry-level controls	YES	YES	YES
Industry FE	YES	YES	YES
Time FE	YES	YES	YES
Observations	4,472	1,572	1,813
R-squared	0.752	0.877	0.843

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. The robust standard errors are corrected by clustering variables at the 6-digit industry level. Sample is restricted to the detail level manufacturing industries during 1972-2014. Dependent variable is industry-level markup estimations corrected by Olley-Pakes Method. Output Tariff$_{t-1}$ is 1-year lagged industry Output Tariff in log form and Input Tariff$_{t-1}$ is 1-year lagged industry input tariff in log form. Specifications (1) report regressions results on the full sample from 1972-2014 where Input Tariff is calculated using weights based on 1972 benchmark I-O table. Column (2) - (3) report the regression results from splited samples of 1972-1988 and 1989 - 2014. And Input Tariff is calculated using weights based on 1972 and 1988 benchmark I-O table respectively. Other industry-level controls include industry capital-labor ratio.

1.5.3 A Difference-in-Difference Exercise: China's WTO Accession

In Section 4.1, we presented evidence showing the association between import penetration and markup. Here, we are able to exploit a specific exogenous policy that changes import penetration to address the potential issue of endogeneity. As China entered WTO in 2001, the trade between the US and China has experienced impressive growth (Autor et al., 2018). We adopt a Difference-in-Difference approach based on the China's accession into WTO in 2001, which eliminated both fixed trade barriers and variable trade costs. A number of researchers have considered this so-called 'China Shock' and have examined its impacts on the US economy in various aspects (Dorn et al. 2016; Acemoglu et al. 2016; Autor et al. 2018, 2016). We consider a sample of industry-level import penetration from China between 1997 to 2006 and begin with a specification in the spirit of Guadalupe and Wulf (2010) as follows,

$$\mu_{st} = \beta_1 AVH_{s98-00} * POST_{2000} + \beta_2 AVV_{s98-00} * POST_{2000} + X'_{st}\Gamma + \sigma_s + \delta_t + \sigma_s \times t + \varepsilon_{st} \tag{28}$$

The measures of import penetrations are similar to above but here we consider only tariff with China. AVH_{s98-00} and AVV_{s98-00}, are the average output and input tariff with China in each industry respectively, taking the averages of the three years prior to the accession. These measures are interacted with post dummy, $POST_{2000}$, a dummy variable equal to 1 in each year after 2001. AndX_{st} is a matrix industry-level control variables to controls for industry size (as the natural logarithm of sales, employment and capital) and the endogeneity of import penetration through interactions of industry fixed effects with a time dummy. Standard errors are clustered at the industry level. Identification in the model thus comes from comparing the average markup of each industry that has different levels of initial tariffs before this China shock in 2001. We are interested in the question that if industries with relatively low levels in initial tariffs changed markup differently after WTO than industries facing high initial levels of tariffs.

Table 12 reports the results of the effect of tariff reduction due to China's WTO accession and the impacts on average markups. In the baseline regression results as shown in the Column (1), we find statistically significant coefficients on the two interaction terms. As expected, the negative coefficient of $AVH_{s98-00} * POST_t$ suggests that industries with higher output tariff prior to 2001 decreased average markup more the period as they faced greater competition due to this China Shock. The positive coefficient of $AVV_{s98-00} * POST_t$ indicates that industries with lower vertical import penetration levels prior to 2001 increase average markup more over the period as they have improved access to input and concentrated market structure due to China's WTO accession in 2001. Column (2) and (3) extend the baseline regression with industry size controls and industry trend interaction respectively. The results remains consistent with the baseline results. As a placebo test, in Column (4) we replace the post dummy variable with the fake year 1999 and recalculating the average tariffs before the fake shock using year 1997 and 1998. The coefficients of the two interaction terms turn out to be insignificant.

Table 10: A Difference-in-Difference Exercise: China's WTO Accession

Dependent variable:	Industry-level Markup			
	(1)	(2)	(3)	(4)
	Baseline	With Control	With Trend	Placebo 1999
$AVH_{s98-00} * POST_{2000}$	-0.029**	-0.037**	-0.013***	
	(0.014)	(0.015)	(0.000)	
$AVV_{s98-00} * POST_{2000}$	0.406**	0.413**	0.485***	
	(0.165)	(0.202)	(0.007)	
$AVH_{s97-98} * POST_{1999}$				-0.062
				(0.039)
$AVV_{s97-98} * POST_{1999}$				0.678
				(0.485)
Industry Trend	NO	NO	YES	NO
Industry Controls	NO	YES	YES	YES
Industry FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
Observations	3373	3118	3118	3118
R-squared	0.848	0.845	1.000	0.845

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. The robust standard errors are corrected by clustering variables at the 6-digit industry level. Dependent variable is industry-level markup estimations in log form corrected by Olley-Pakes Method. AVH_{s98-00} and AVH_{s97-98} are the average horizontal import penetration ratio from China in sector s between 1998 to 2000 and between 1997-1998 respectively. AVV_{s98-00} and AVV_{s97-98} are the average vertical import penetration ratio from China in sector s between 1998 to 2000 and between 1997-1998 respectively. POST_{2000} and POST_{1999} are dummy veriables which takes 1 only if year is 2000 and 1999 respectively. Industry-level controls include industry labor, sales and fixed capital in log form.

1.5.4 Alternative Markup Measure and Sensitivity

The estimation of firm-level markup described in Section 3.2 relies on strict assumptions on the production function such as perfect competition in input markets and constant output elasticity over time. We here adopt an alternative measure of markup. We use economic profits over sales as an indicator for price-cost margin directly and perform the same regression as in section 5.1 to see how the ratio of imports penetration is correlated with the firm's profitability. This approach enables us to circumvent potential measurement error in markup estimation. The results from Table 10 with firm-level panel data show the same results: The coefficients of industry level vertical import penetration ratio remain positive and significant, indicating that higher exposure to intermediate import penetration is associated with higher price-cost margins. In addition, the magnitude of the coefficients is close to results obtained before.

Table 11: Sensitivity to Outliers

Dependent variable:	Industry-level Markup		Firm-level Markup	
	Panel A: Industry Regression		Panel B: Firm Regression	
	(1)	(2)	(3)	(4)
$\ln\text{Himp}_{t-1}$	-0.846***	-0.803***	-0.488***	-0.256***
	(0.321)	(0.307)	(0.104)	(0.097)
$\ln\text{Vimp}_{t-1}$	0.098**	0.092**	0.084***	0.028**
	(0.043)	(0.037)	(0.014)	(0.013)
Other Industry-level controls	NO	YES	NO	YES
Other Firm-level controls	NO	NO	NO	YES
Industry FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
Observations	11513	11467	253735	210074
R-squared	0.743	0.757	0.679	0.721

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. The robust standard errors are corrected by clustering variables at the 6-digit industry level for columns (1) and (2) and clustering at the firm level for columns (3) and (4). Dependent variable is industry-level markup estimations corrected by Olley-Pakes Method. $\ln\text{Himp}_{t-1}$ is 1-year lagged industry horizontal import penetration ratio in log form. $\ln\text{Vimp}_{t-1}$ is 1-year lagged industry vertical import penetration ratio in log form. Only observations that fall between the top and bottom 2.5 percentile of industry markup and firm markup are kept for column (1)-(2) and column (3)-(4) respectively. Specifi-cations (1) - (4) report the weighted regression results that uses the number of firms that are being used in the prod-uction function estimation of each 2-digit industry as weight in the regressions. Other firm-levelcontrols include thenumber of employees and capital-labor ratio. Other industry-level controls include industry capital-labor ratio.

Table 12: Alternative Markup: Profit Margin

	Dependent variable: Firm Level Profit Margin			
	Panel A: Unweighted Regression		Panel B: Weighted Regression	
	(1)	(2)	(3)	(4)
lnHimp_{t-1}	0.084	0.088	0.031	0.118
	(0.053)	(0.053)	(0.104)	(0.105)
lnVimp_{t-1}	0.036***	0.031***	0.060***	0.047***
	(0.008)	(0.008)	(0.014)	(0.014)
Other Industry-level controls	NO	YES	NO	YES
Other Firm-level controls	NO	YES	NO	YES
Industry FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
Observations	253,833	252,580	252,047	250,746
R-squared	0.499	0.517	0.517	0.545

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. The robust standard errors are corrected by clustering variables at the firm level. Sample is restricted to the firms that appears during 1972-2014 merged with 6-digit industry code. Dependent variable is firm-level profit margin measured by profit over sales. lnHimp_{t-1} is 1-year lagged industry horizontal import penetration ratio in log form and lnVimp_{t-1} is 1-year lagged industry vertical import penetration ratio in log form. Specifications (1) - (2) report unweighted regressions and specifications (3) - (4) report the regression results that uses the number of firms that arebeing used in the production function estimation of each 2-digit industry as weight in the regressions. Other firm-levelcontrols include the number of employees, capital-labor ratio, and average wage. Other industry-level controls include industry capital-labor ratio.

1.6 Conclusion

The value of imports to annual GDP in the US went up from 4.2 percent to around 16.5 percent from 1960 to 2014. The rapid increase in US exposure to trade over this period indicates that both foreign competition and input penetration may have grown considerably relative to earlier decades. Much previous research has studied the effects of imports on firm strategies after dramatic removal of trade barriers in specific periods of time. But the question of how and to what degree is increasing import penetration contributes to the more concentrated market structure and the associated rise of markups remain unclear. By analyzing heterogeneous firms that respond differently to the reduction of trade costs according to the initial productivity within each industry, our paper extends the analysis of the consequences of trade liberalization beyond change in export participation and average productivity . Specifically, we relate changes in market structure with firms' sourcing decisions and we relate average markups across US industries to the changes in imported input exposure.

In our analysis, we propose and test this relationship. First, we construct a theoretical framework to explicitly flesh out how vertical import penetration impacts the market concentration and the firms' markups. We obtain the following main predictions: increased input import penetration is associated with (i) higher average markups; (ii) higher market concentration; and (iii) higher exiting ratio at the industrial level. Second, we test these predictions and find empirical evidence that supports them. Our research contributes to and improves on the existing literature along two dimensions: First, we look at the structural impact on industry that the broad process of globalization brings over 40 years, which will not only nest the short-run effects of trade cost reduction on marginal cost and competition but also on industry reallocation in the relatively long-term. Second, we trace in detail how imported input penetration plays a role in the pricing of firms who have a better ability to utilize sourcing opportunities.

This paper does not incorporate the decisions in the boundaries firms such as outsourcing to contracting firms and offshoring to foreign countries. Quantifying the combinatorial effects on markups of these factors both theoretically and empirically is an essential avenue for further research. The consequences of import penetration for market power may contribute to public ambivalence toward globalization and specific anxiety about resources redistribution between workers, consumers and owners of firms.

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Figures

Figure 1: Inverse Productivity Cut-off of Importing Firms

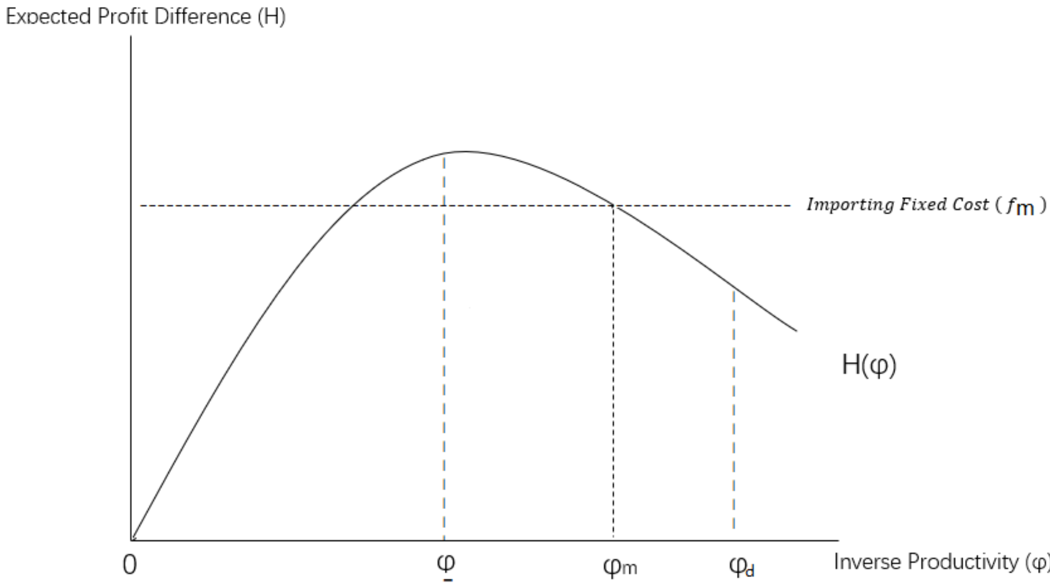


Figure 2: Inverse Productivity Cut-off of Importing Firms: A Reduction of Trade Cost

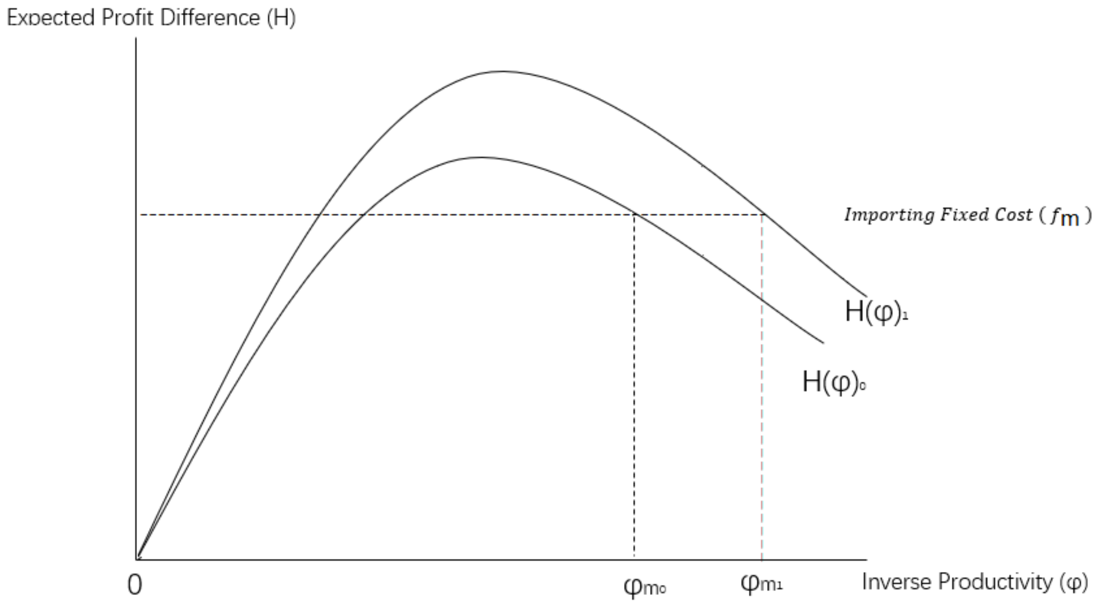


Figure 3: Inverse Productivity and the Firm Number

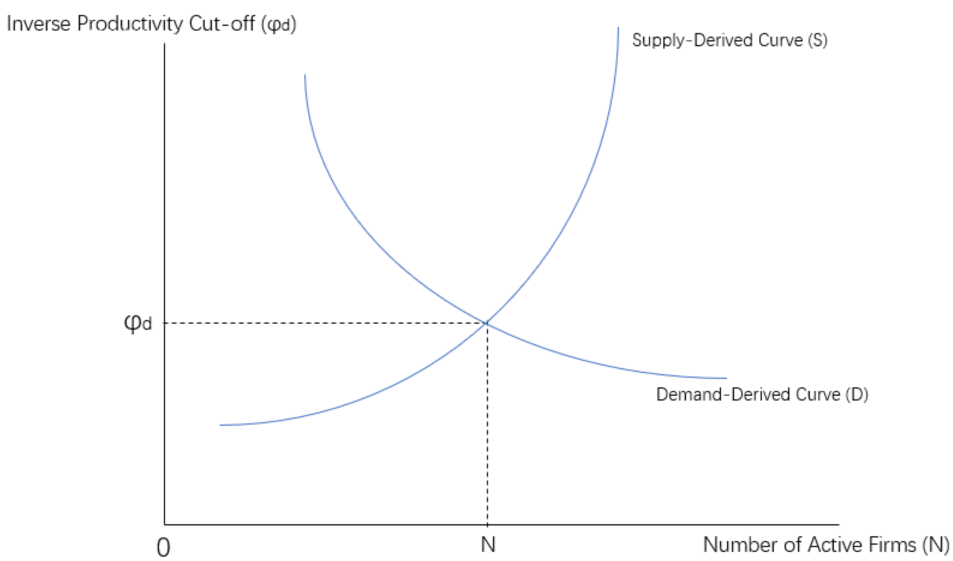


Figure 4: Inverse Productivity and the Firm Number: A Reduction of Trade Cost

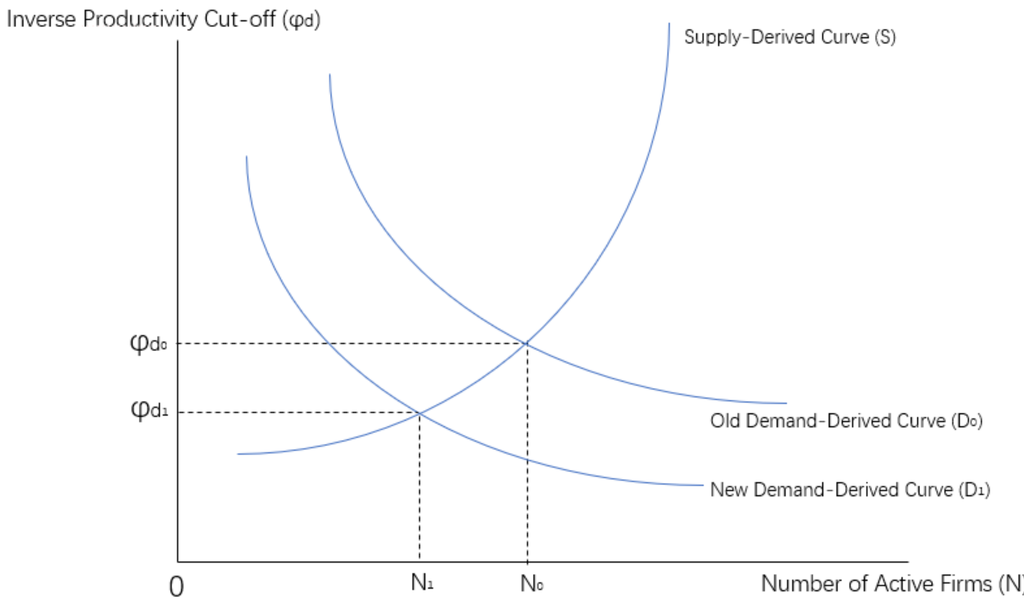


Figure 5: Import Productivity Cut-off: Constant Fixed Cost

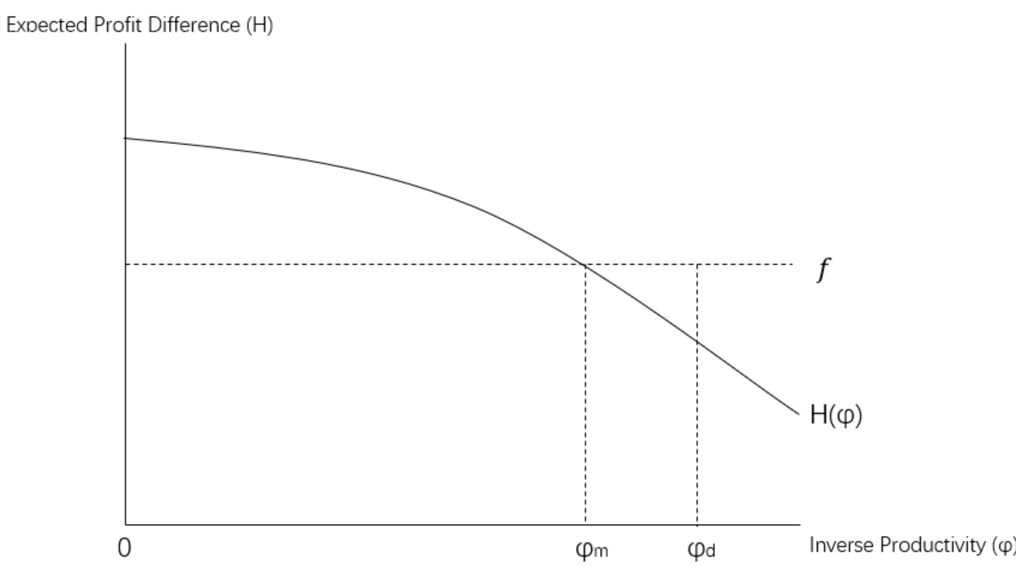


Figure 6: Inverse Productivity and Firm Number, Endogenous Entrants

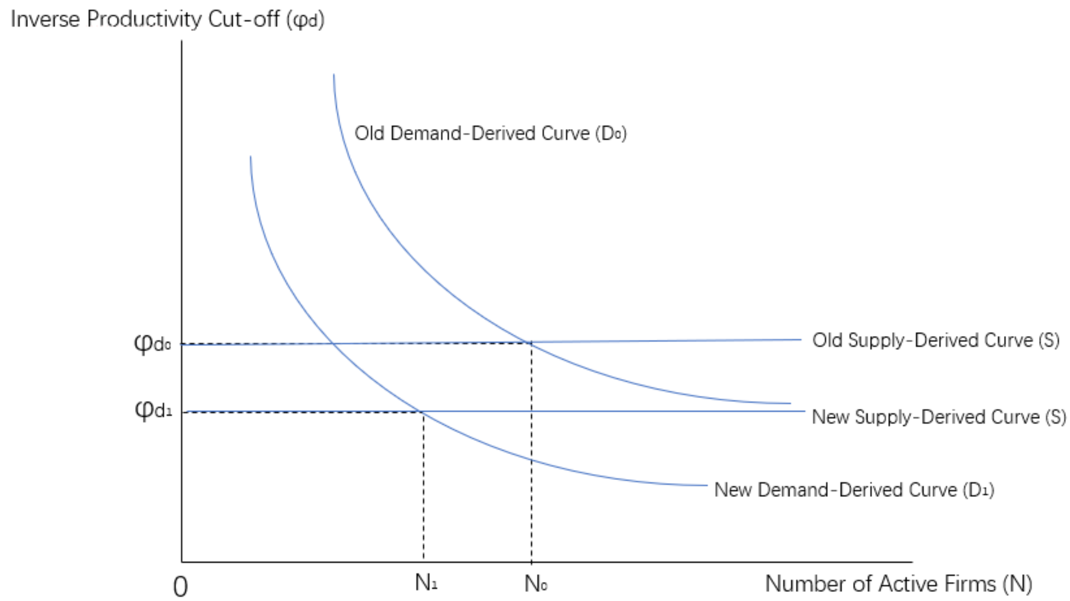


Figure 7: The Evolution of Average Markups and Import to GDP Ratio in the US (1960 - 2014)

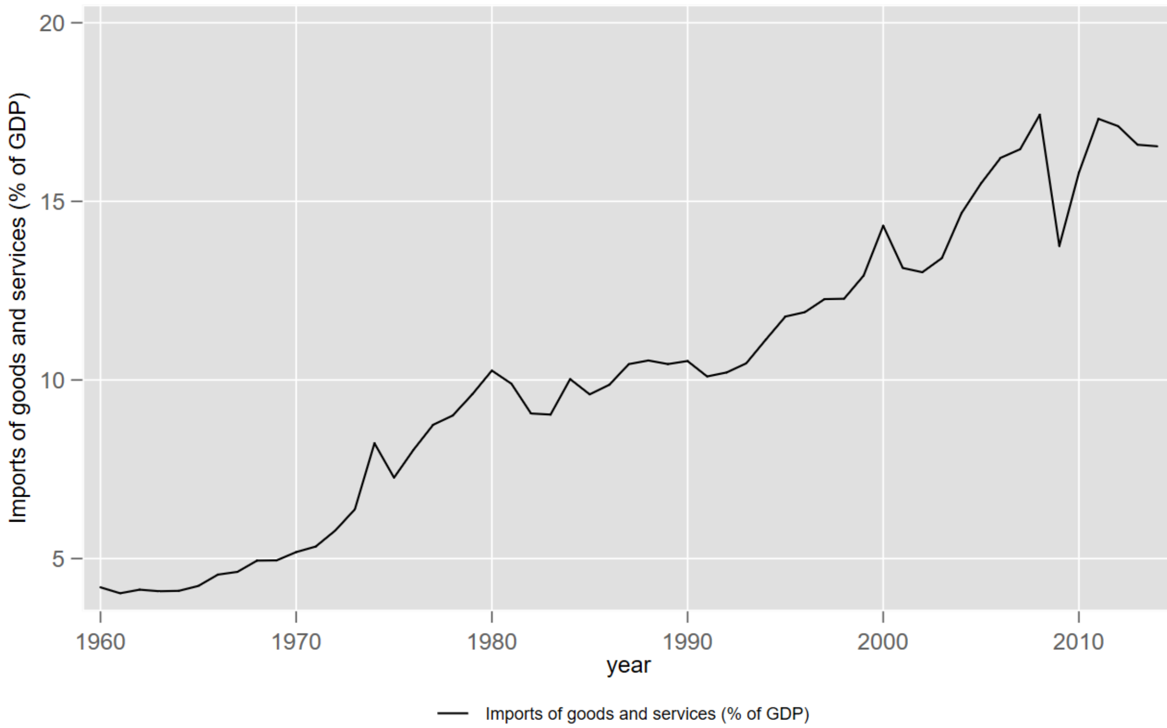


Figure 8: The Evolution of Average Markups and Imported Input Penetration in the US (1974 - 2014)

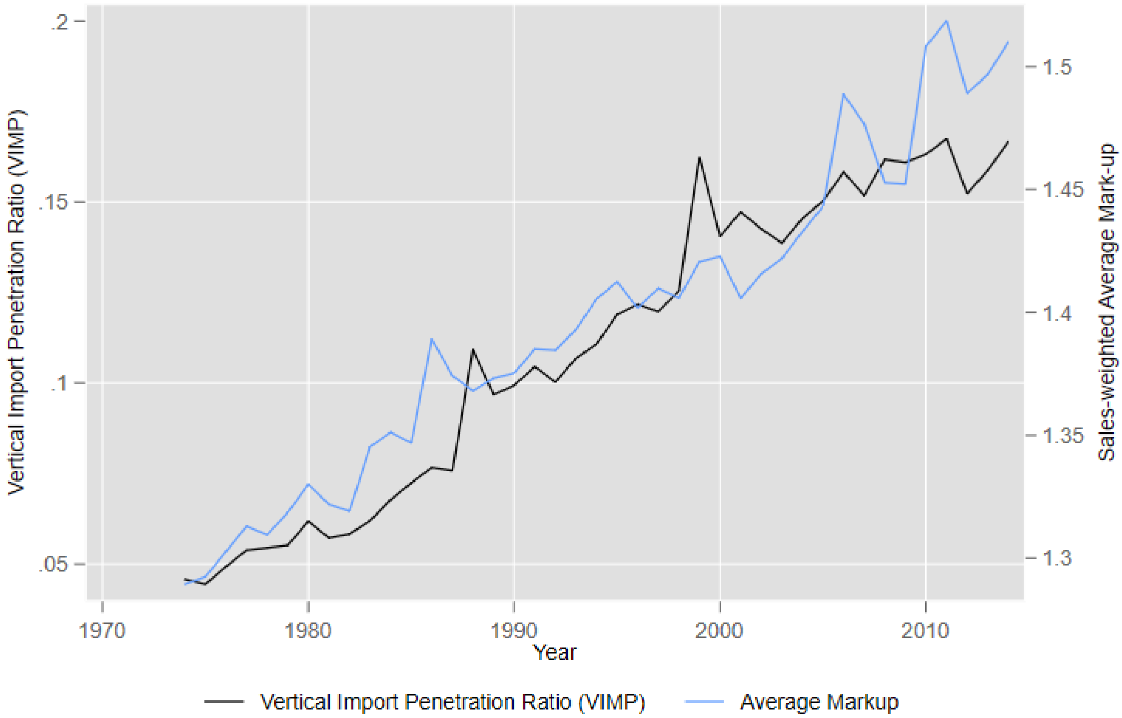
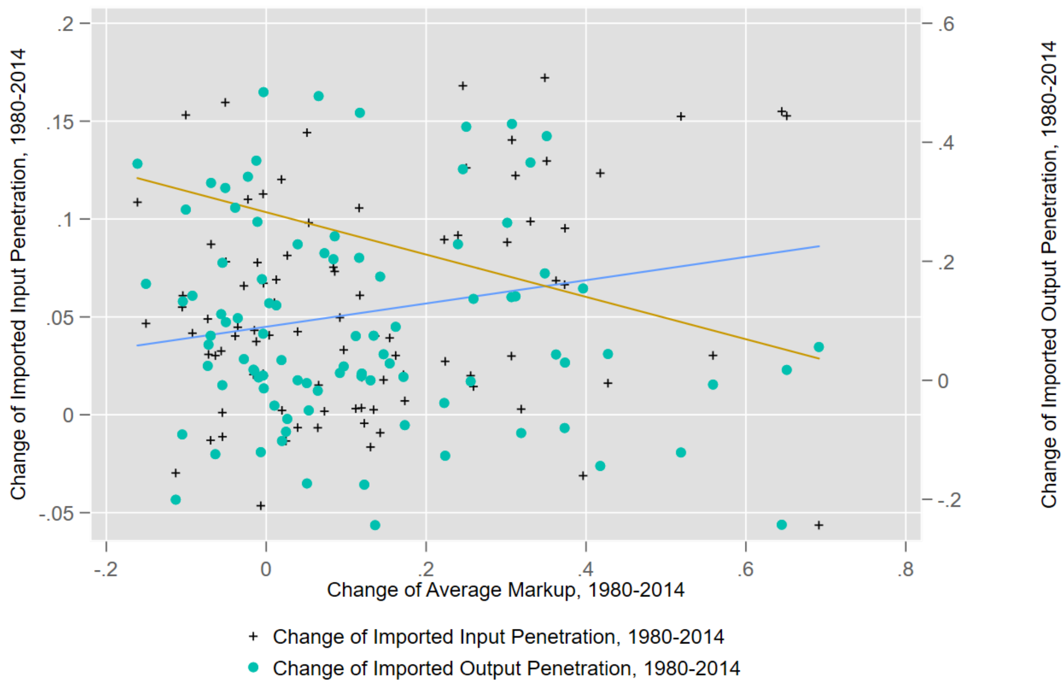


Figure 9: The Change of Average Markups and the Change in Import Penetration in the US (1980 - 2014)



Appendix A

A.1 Proof of Proposition 1

Claim 1 is equivalent to the following conditions: φ_m is the unique solution to the equation $H(\varphi_m) \equiv \frac{\left[2\varphi_d - \left(V^{\phi}+1\right)\varphi_m\right]\left(1-V^{\phi}\right)\varphi_m \bar{D}^{2}}{4\gamma} - f_m = 0$ in the definition range $\left[\underline{\varphi}, \overline{\varphi}\right]$; $H(\varphi_i) > 0$ for $\varphi_i < \varphi_m$; and $H(\varphi_i) < 0$ for $\varphi_i > \varphi_m$.

The solutions to the equation $H(\varphi_m) = 0$ in the definition range $\varphi_m \in R$ are: $\varphi_{m1} = \frac{\varphi_d - \sqrt{\varphi_d^2 - \frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}}}{1+\Psi}$ or $\varphi_{m2} = \frac{\varphi_d + \sqrt{\varphi_d^2 - \frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}}}{1+\Psi}$. Moreover, when $\varphi < \varphi_{m1}$ or $\varphi > \varphi_{m2}$, then $H(\varphi) < 0$; when $\varphi_{m2} \geq \varphi \geq \varphi_{m1}$, then $H(\varphi) \geq 0$. As follows and the assumptions in proposition 1, we get the following properties: (i) $\underline{\varphi} > \frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}$ and $\overline{\varphi} < \frac{2}{1-\Psi}\sqrt{\frac{\gamma f_m}{L}}$; (ii) $\varphi_d \in \left[\underline{\varphi}, \overline{\varphi}\right]$; (iii) $\frac{2}{1-\Psi}\sqrt{\frac{\gamma f_m}{L}} > \sqrt{\frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}}$; (iv) $\frac{\varphi_d - \sqrt{\varphi_d^2 - \frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}}}{1+\Psi}$ decreases in φ_d ; and (v) $\frac{\varphi_d - \sqrt{\varphi_d^2 - \frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}}}{1+\Psi}$ increases in φ_d. So we have $\underline{\varphi} > \frac{\sqrt{\frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}} - \sqrt{\frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)} - \frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}}}{1+\Psi} > \frac{\varphi_d - \sqrt{\varphi_d^2 - \frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}}}{1+\Psi}$ and $\frac{\varphi_d + \sqrt{\varphi_d^2 - \frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}}}{1+\Psi} \leq \frac{\overline{\varphi} + \sqrt{\overline{\varphi}^2 - \frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}}}{1+\Psi} < \overline{\varphi}$. Thus, we get a unique solution $\varphi_m = \frac{\varphi_d + \sqrt{\varphi_d^2 - \frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}}}{1+\Psi}$ such that $H(\varphi_m) \equiv \frac{\left[2\varphi_d - \left(V^{\phi}+1\right)\varphi_m\right]\left(1-V^{\phi}\right)\varphi_m \bar{D}^{2}}{4\gamma} - f_m = 0$ in the definition range $\left[\underline{\varphi}, \overline{\varphi}\right]$; $H(\varphi_i) > 0$ for $\varphi_i < \varphi_m$; and $H(\varphi_i) < 0$ for $\varphi_i > \varphi_m$.

Q.E.D.

A.2 Proof of Proposition 2: change of φ_m, φ_d and N

Proof of $\frac{\partial N}{\partial \Psi} > 0$ and $\frac{\partial \varphi_d}{\partial \Psi} > 0$:

Given the value of Ψ, equation equation (17) describes a negative relation while equation equation (12) shows a positive relation between N and φ_d . (See 3) In 3, the intercept of the curves for equation equation (17) and equation equation (12) determines the values for both N and φ_d . A decrease of Ψ will shift the curve for equation equation (17) to move downwards, which leads to lower values for both

N and φ_d .

Proof of $\frac{\partial \varphi_m}{\partial \Psi} < 0$:

Recall that the equation for φ_m is $\varphi_m = \frac{\varphi_d + \sqrt{\varphi_d^2 - \frac{4\gamma f_m(1+\Psi)}{L(1-\Psi)}}}{1+\Psi} = \frac{\varphi_d}{1+\Psi} + \sqrt{\frac{\varphi_d^2}{(1+\Psi)^2} - \frac{4\gamma f_m}{L\left(1-\Psi^2\right)}}$. If $\frac{\partial \varphi_d}{\partial(1+\Psi)}\frac{1+\Psi}{\varphi_d} < 1$, then the terms $\frac{\varphi_d}{1+\Psi}$ and $\frac{\varphi_d^2}{(1+\Psi)^2}$ decreases in Ψ. Also, we observe that the term $-\frac{4\gamma f_m}{L\left(1-\Psi^2\right)}$ decreases in Ψ, thus $\frac{\partial \varphi_m}{\partial \Psi} < 0$.

Q.E.D.

A.3 Derivative of equation equation (19)

$$\bar{\mu} = \int_{\underline{\varphi}}^{\varphi_m} k\left(\frac{\varphi\Psi+\varphi_d}{2\varphi\Psi}\right)\left(\frac{\varphi-\underline{\varphi}}{\varphi_d-\underline{\varphi}}\right)^{k-1}\left(\frac{1}{\varphi_d-\underline{\varphi}}\right)d\varphi + \int_{\varphi_m}^{\varphi_d} k\left(\frac{\varphi+\varphi_d}{2\varphi}\right)\left(\frac{\varphi-\underline{\varphi}}{\varphi_d-\underline{\varphi}}\right)^{k-1}\left(\frac{1}{\varphi_d-\underline{\varphi}}\right)d\varphi$$

$$\bar{\mu} = \int_{\underline{\varphi}}^{\varphi_m}\left(\frac{\varphi\Psi+\varphi_d}{2\varphi\Psi}\right)\left(\frac{1}{\varphi_d-\underline{\varphi}}\right)d\varphi + \int_{\varphi_m}^{\varphi_d}\left(\frac{\varphi+\varphi_d}{2\varphi}\right)\left(\frac{1}{\varphi_d-\underline{\varphi}}\right)d\varphi$$

$$\bar{\mu} = \frac{1}{2\left(\varphi_d-\underline{\varphi}\right)}\left[\left(\varphi+\frac{\varphi_d}{\Psi}ln\varphi\right)|_{\underline{\varphi}}^{\varphi_m} + \left(\varphi+\varphi_d ln\varphi\right)|_{\varphi_m}^{\varphi_d}\right]$$

$$\bar{\mu} = \underbrace{\frac{\varphi_d}{2\left(\varphi_d-\underline{\varphi}\right)}}_{(1)}\left(\underbrace{\frac{1}{\Psi}ln\frac{\varphi_m}{\underline{\varphi}}}_{(2)} + \underbrace{ln\frac{\varphi_d}{\varphi_m}}_{(3)}\right) - \frac{1}{2}\underline{\varphi}$$

Q.E.D.

A.4 Proof of Proposition 3

As $\bar{\mu} = \frac{\varphi_d}{2\left(\varphi_d-\underline{\varphi}\right)}\left(\frac{1}{\Psi}ln\frac{\varphi_m}{\underline{\varphi}} + ln\frac{\varphi_d}{\varphi_m}\right) - \frac{1}{2}\underline{\varphi}$, we get the following properties for partial derivatives: $\frac{\partial\bar{\mu}}{\partial\varphi_d} < 0$, $\frac{\partial\bar{\mu}}{\partial\Psi} < 0$, and $\frac{\partial\bar{\mu}}{\partial\varphi_m} > 0$. If $\frac{\partial\varphi_d}{\partial\Psi}\frac{\Psi}{\varphi_d} < ln\underline{\varphi}$, we have $\frac{d\bar{\mu}}{d\Psi} = \frac{\partial\bar{\mu}}{\partial\varphi_d}\cdot\frac{\partial\varphi_d}{\partial\Psi} + \frac{\partial\bar{\mu}}{\partial\varphi_m}\cdot\frac{\partial\varphi_m}{\partial\Psi} + \frac{\partial\bar{\mu}}{\partial\Psi} < 0$, indicating that the trade reduction process leads to an increasing trend of the average markup.

Q.E.D.

A.5 Market Equilibrium in the Independent Fixed Sourcing Cost case

In the open economy case, the equation (13) becomes :

$$\bar{P} = \int_0^{\varphi_m}\left(\frac{W\varphi+\Psi+W\varphi_d+1}{2}\right)d\mathrm{G}(\varphi)/G(\varphi_d) + \int_{\varphi_m}^{\varphi_d}\left(\frac{W\varphi+2+W\varphi_d}{2}\right)d\mathrm{G}(\varphi)/G(\varphi_d) \tag{29}$$

As $\varphi \sim \left(\frac{\varphi}{\bar{\varphi}}\right)^k$, we can simplify the equation above as:

$$\bar{P} = \frac{\Psi-1}{2}\left(\frac{\varphi_m}{\varphi_d}\right)^k + \frac{(2k+1)W}{2(k+1)}\varphi_d \tag{30}$$

Substituting into equation (11) we get

$$N = \frac{\gamma}{\eta}\frac{\alpha-\varphi_d}{\varphi_d - \left[\frac{\Psi-1}{2}\left(\frac{\varphi_m}{\varphi_d}\right)^k + \frac{(2k+1)W}{2(k+1)}\varphi_d\right]} \tag{31}$$

Combining equations 23 and 31 , we get:

$$N = \frac{\gamma}{\eta}\frac{\alpha-\varphi_d}{\frac{[2k(1-W)+2-W]\varphi_d}{2(k+1)} + \frac{1-\Psi}{2}\left(\frac{1}{W}\right)^k\left(1-\frac{\left(1-\Psi^2\right)L+4\gamma f_m}{2\varphi_d(1-\Psi)L}\right)^k} \tag{32}$$

Equation 32 shows that if k is small enough, e.g. k=1, the number of survived firms N decreases in the surviving critical value φ_d, and increases in Ψ. Similar to section 2.3.2, now equations 32 and $N_E = \frac{N}{G(\varphi_d)}$ uniquely determine the inverse productivity cut-off φ_d and firm number N. When variable trade cost V decreases, new equilibrium get to a lower level of N and φ_d , i.e. $\frac{\partial \varphi_d}{\partial \Psi} > 0$ and $\frac{\partial N}{\partial \Psi} > 0$. In addition, if the marginal effect of cost reduction on the surviving cut-off value is small enough such that $\frac{\partial \varphi_d}{\partial \Psi} < \frac{L(1-\Psi)^2+4\gamma f_m}{2WL(1-\Psi)^2}$, the critical value for importing will decrease in Ψ, i.e. $\frac{\partial \varphi_m}{\partial \Psi} > 0$.

A.6 Estimation of Markup

The estimation of markup follows exactly the same method as in De Loecker et al. (2016). Here we sketch out the basic ideas. Using the methodology in De Loecker and Warzynski (2012), no inference from demand or mkt structure. Starting with a production technology

$$Q_{it}(\mathbf{V}_{it};K_{it};\Omega_{it}) = F_{it}(\mathbf{V}_{it};K_{it};)\Omega_{it}$$

The associated Lagrangian function (with one composite input) is

$$L(V_{it};K_{it};\Omega_{it}) = P^V_{it}V_{it} + r_{it}K_{it} - \lambda_{it}(Q_{it}(.) - Q_{it})$$

First-Order Condition with respect to the variable input V gives

$$\frac{\partial Q_{it}(.)}{\partial V_{it}}\frac{V_{it}}{Q_{it}} \equiv \theta^V_{it} = \frac{1}{\lambda_{it}}\frac{P^V_{it}V_{it}}{Q_{it}}$$

where θ^V_{it} is the output elasticity of the variable input V and the Laglangian multiplier λ_{it} is a measure of marginal cost. Rearranging the terms we have markup μ_{it} defined as price over marginal cost

$$\mu_{it} \equiv \frac{P}{\lambda} = \theta^V_{it}\frac{P_{it}Q_{it}}{P^V_{it}V_{it}}$$

where the output elasticity θ^V_{it} is estimated from production function estimation and $\frac{P_{it}Q_{it}}{P^V_{it}V_{it}}$ is the inverse of input revenue share of the variable input V, which could be directly calculated from firm-level accounting data.

Chapter II Modelling the Effect of Exchange Rate Volatility on Export Performance

2.1 Introduction

How exchange rate risk plays a role in export firms' decisions has been widely discussed in recent years, e.g., market-entry decisions and price and quantity strategies. However, very few studies examine how the exchange rate risk affects firms' behavior in deciding the exported product varieties. [1] The importance of a firm's decision of how many product varieties to produce and export rests on two points: (i) different varieties of products are imperfectly substitutable, and thus, consumers will prefer a greater diversity of consumption (Dixit and Stiglitz, 1977; Krugman, 1979; Melitz, 2003); and (ii) diversifying exported varieties also reduces the overall market risks that each firm faces by dispersing the individual demand risks over multiple products. Among the relevant existing studies, some papers study how firms adjust the number of products and exports varieties in response to trade liberalization, e.g., Qiu and Yu (2014) and Lopresti (2016); others study how export varieties are adjusted with different levels of exchange rate volatility, e.g., Héricourt and Poncet (2013) and Berthou and Fontagné (2013). However, the answers to certain questions remain unknown or incomplete: (i) how does a firm adjust the number of export varieties to different levels of exchange rate volatility? (ii) What is the mechanism by which exchange rate volatility affects firms' decisions on export varieties? [2] Several papers find some relevant empirical evidence, but the theoretical framework remains missing. Modeling the effect of exchange rate movements on export performance is important, providing a tractable framework to check the performances or consequences of a country's exchange rate policy. In addition, it can help us to explain firms' behaviors in an open world and understand some macro-level characteristics of an open economy.

To model the effect of exchange rate volatility on firm performance, the easiest method is to assume firms' risk-averse preference, e.g., Arize (1997) and Broll and Mukherjee (2017). [3] However, this simple assumption has been

[1] To the best of our knowledge, only Héricourt and Poncet (2013) and Berthou and Fontagné (2013) analyze this issue.

[2] We suppose that the entry-exit of product variety in each market is a concept between the intensive and extensive margins of export. In most previous studies, the analysis focuses on a firm's export volume or entry-exit decision to each market.

[3] Both papers model the intensive margin of export, while our study models the extensive margin of export product within each firm. Our model

challenged by many recent empirical studies. Some of these studies find a positive or insignificant correlation between exchange rate volatility and the export volume, i.e., Wang and Barrett (2002), Daly (1998), Zhang et al. (2006), Sercu and Vanhulle (1992), Qiu et al. (2019), Bahmani-Oskooee and Hegerty(2007), and Cushman (1983); others find a non-linear effect of exchange rate fluctuation, i.e., Baum et al. (2004) and Chen and Juvenal (2016); while others find that credit constraints deepen the effectiveness of the demand volatility, i.e., Aghion et al. (2009) and Héricourt and Poncet (2013). As stressed by Franke (1991), as increasing evidence violates the risk-averse assumption, the existing theoretical framework must be substantially adjusted.

Our theoretical framework follows a great deal of literature, i.e., Melitz and Ottaviano (2008), Dhingra (2013), Qiu and Yu (2014),Franke (1991),Sercu and Vanhulle (1992), and Aghion et al. (2009). Abandoning the assumption that firms are risk-averse, our model allows firms to be risk neutral, just as the setting of other theoretical studies, e.g., Franke (1991) and Aghion et al. (2009). In our theoretical framework, the key factor that affects firms' attitude towards demand volatility becomes the constraint on firms' production capacity. There are two main features of making this adjustment. First, although our analysis is based on the risk-neutral assumption, the main predictions do not change if a risk-averse assumption is made. Second, our theoretical model is consistent with a rich number of empirical findings, e.g., Aghion et al. (2009), Héricourt and Poncet (2013), Wang and Barrett (2002), Daly (1998), Zhang et al. (2006) and Cushman (1983). These studies find inconsistent effects of exchange rate volatility, i.e., positive, negative, or insignificant. These results are difficult to explain by a purely risk-averse-agent model. We can hardly believe that a risk-averse firm increases the export volume in response to a rise in market risk. However, in our theoretical framework, all these results can be explained by varying firm or market conditions. [4] Our main empirical results show a negative effect of the exchange rate volatility on export scope, our theoretical model mainly aims to explain why the firms sometimes dislike the demand volatility.

The intuition of our model is as follows. The firm needs to make some fixed cost to start a new variety, which we refer to as the pre-investment in firms' production capacity. When firms make this investment, they do not know or incompletely know the realization of the market demand due to the uncertainty of the exchange rate in the future. In this case, the firm cannot invest in as many varieties as possible; otherwise, when there is a negative demand

does not contradict these studies. We simply add more factors that may lead firms to reject market volatility, e.g., we assume that firms need to pre-invest their production capacity. The purpose of adding these factors is to make our model consistent with the empirical findings of certain studies.

[4] This property has been shown in Franke (1991)).

shock, the firms will suffer losses. This investment decision causes the firms to not export as much as possible when the destination country's demand goes up due to the constraint in the production capacity. However, when the demand decreases due to a depreciation in the destination's currency, the firms will undoubtedly adjust their exports downwards. This asymmetric effect of exchange rate fluctuation has been empirically proven by Cheung and Sengupta (2013) using Indian export data. Our study confirms the finding of Cheung and Sengupta (2013) using Chinese export data. As a consequence of this asymmetric effect, on average, the countries with flexible exchange schemes will import fewer product varieties than the markets with a relatively stable exchange rate. Héricourt and Poncet (2013) provide a similarly intuitive explanation. They argue that the rise of market uncertainty equivalently increases the firm's variable and fixed costs. The former impedes the intensive margin of firms' exports and the latter impedes the extensive margin. One of our research motivations is to complete the argument of Héricourt and Poncet (2013) by constructing a theoretical framework.

Next, we will review the key literature related to our study in detail. For convenience, we categorize this literature into two groups. The first group studies how firms adjust their product and export scope in response to varying market conditions or trade liberalization. The second group focuses on the effect of market uncertainty on firms' performance.

Among the first group of studies, we find four key studies, Qiu and Yu (2014), Berthou and Fontagné (2013), Héricourt and Poncet (2013) and Sauer and Bohara (2001). Qiu and Yu (2014) looked at how Chinese export firms adjust their product scope in response to China's entry into the WTO. They find that only the firms with low management costs positively adjust their product scope during trade liberalization. Berthou and Fontagné (2013) use the introduction of the euro as the market shock to French firms in deciding their export scope. However, despite its implications for firm production and export performance, there are fundamental differences between product scope and export scope. By definition, product scope refers to a firm's total varieties produced, while export scope is the number of varieties that the firm decides to export to a specific market. The choice of product scope reflects the firm's individual production condition and the market demand faced by this firm. Differently, the choice of export scope is related to each single market's characteristics. Studying the firm's export scope decision allows us to understand how a country's macro policies affect trading.

Both Héricourt and Poncet (2013) and Sauer and Bohara (2001) study how the exchange rate volatility affects firms' export performance, including the product's price and quality and the firm's investment strategies. Between these studies, the study of Héricourt and Poncet (2013) is most closely related to ours. Héricourt and Poncet (2013) studies how the Chinese firms adjust their export volumes, scopes, and destinations in response to varying levels of exchange rate volatility among the destination countries. There are two main findings in Héricourt and Poncet (2013): (i) Exchange rate risks have negative effects on the firm's market entry decision, the export volume, and export scope; and (ii) these negative effects are more significant among firms that suffer tighter financial constraints. However, they did not provide a theoretical model for their empirical findings. In addition, they fail to involve two other important control variables in their regressions, i.e., transportation distance and the tariff rate. Our research aims to fill both gaps: First, we provide theoretical foundations on the relationship between exchange rate volatility and export scope; and second, we provide firm-level empirical evidence on the effect of transportation cost and tariffs. As addressed by Héricourt and Poncet (2013), Greenaway and Kneller (2007) and Ethier (1973), the effect of exchange rate volatility is equivalent to an increase in the variable and fixed costs of trading. Our theoretical model is built based on this intuition.

The papers that study the firms' behaviors and market uncertainty include Chen and Juvenal (2016), Berman et al. (2012), Nguyen (2012), López and Nguyen (2015) and Békés et al. (2017). Chen and Juvenal (2016) find that when the exchange rate fluctuates, the price of the high-quality products changes dramatically, but the volume changes insignificantly. Berman et al. (2012) find a similar result as Chen and Juvenal (2016) using French firm-level data. Nguyen (2012) attempts to provide a theoretical explanation for the stylized fact that firms enter into some foreign markets quickly but then leave the market later on. He finds that the uncertainties existing in the new markets force the firm to make its entry decision before making the output supply decision for that market. Using Chilean firm-level data from 1995 to 2007. López and Nguyen (2015) study how the fluctuation of the real exchange rate affects the input import by Chilean plants. This paper finds that the exchange rate movement reduces the import volume but does not affect firms' decision on whether to make the import.

Among the rest of the literature that studies the individual market conditions and firms' export performance, the works by Bastos and Silva (2010), Manova and Zhang (2012), and Lugovskyy and Skiba (2016) are most closely related to ours. Using Portuguese firm-level data, Bastos and Silva (2010) find that plants tend to charge higher f.o.b. prices to more distant countries. In contrast, using Chinese data, Manova and Zhang (2012) find that the f.o.b. export price decreases in the distance with a sample of the poor destinations, but the relation is positive with rich destinations.

Using distance as proxy for transportation cost is widely accepted in the literature, a more comprehensive review of the distance-cost measure is presented in Fisher et al. (2015). In another paper, Lugovskyy and Skiba (2016) find contrary results to the findings by Manova and Zhang (2012) with firm-level data from nine Latin American countries, i.e., the distance elasticities of the export price are positive for poor destinations but negative for the destinations. The other related papers concerning the impacts of the characteristics of the destinations on the export strategies include Brambilla and Porto (2016), Comite et al. (2014), and Gorg et al. (2016). With multi-national data, Brambilla and Porto (2016) find that high-income countries prefer to import products from the plants with high average wages, indicating that the rich countries prefer high-quality products. Gorg et al. (2016) reach the same conclusion from the empirical evidence with the Hungarian firm-level data. Comite et al. (2014) prove that consumers in different countries have different preferences for the same variety, and thus, we will observe that the price of the same product varies across countries.

The rest of the paper is arranged as follows. Section 1.2 illustrates our dataset and the main empirical results; Section 1.3 develops the model and provides theoretical fundamentals for our empirical findings; Section 1.4 checks the robustness of our theoretical model by testing several predictions of the model; and Section 1.5 concludes our empirical and theoretical findings.

2.2 Data and Descriptive Analysis

In this section, we will provide firm-level evidence on the effects of the trade cost and exchange rate volatility on firms' export scope decisions using Chinese firm-product-level data. First, we introduce our dataset and discuss some stylized facts we find. Second, we construct estimation models to explore our research question. Lastly, we summarize and briefly explain our empirical findings. In Section 3, we explain our empirical findings using a conventionally theoretical framework.

2.2.1 Data & empirical approach

Table 1. Summary of the Key Variables

Variables	Mean	Minimum	Maximum	Standard Dev.	No. of Obs
$ln(Export\_scope)$	0.401	0	12.670	0.639	3,773,906
$Exchange\_volatility\_RMB$	0.092	0	1.851	0.145	915
$Exchange\_volatility\_USD$	0.091	0	1.841	0.146	915
$Exchange\_rate\_RMB$	1	0.00138	4.286	0.154	910
$Exchange\_rate\_USD$	1	.00142	4.268	0.154	910
$Tariff\_rate$	0.117	0	5.333	0.125	68,063
$ln(Distance)$	8.808	-0.0048	9.901	0.838	50,176
$ln(GDP)$	25.825	17.177	32.017	3.257	1,179
$ln(GDP\_per\_capita)$	8.988	6.302	11.683	1.204	1,179

Notes: The exchange_rate_RMB is computed as the yearly average nominal exchange rate of a country's currency against the Chinese yuan. The exchange_rate_USD is computed as the yearly average nominal exchange rate of a country's currency against U.S. dollars. We also use the real effective exchange rate to perform the robustness check, and we find that the results are consistent with our main regressions.

Table 1 summarizes the statistical features of our main variables, including the export scope, exchange rate volatility, exchange rate, tariff rate, distance, GDP, and GDP per capita. The data cover the years 2002 to 2006. All firm-level data are collected from the National Bureau of Statistics. The data for GDP and GDP per capita are collected from the World Bank website. The data for the distance between two countries is from the CEPII website. Lastly, the tariff data are from the World integrated Trade Solutions (WITS) Tariff Schedule.

Following Héricourt and Poncet (2013), we specify our estimation model for the effect of the trade cost on the export scope as follows. [5]

$$Export\_scope_{\iota jt} = \beta_1 * exchange\_rate\_volatility_{jt} + \beta_2 * distance_j$$

$$+\beta_3 tariff\_rate_{jvt} + X_{jt}\gamma_1 + \lambda_{\iota t} + \varepsilon_{\iota jt}$$

[5] This construction is also theoretically specified by lemma 1 and proposition 1 in section 3. Our model differs from Héricourt and Poncet (2013) by including the distance and import tariff rate.

where ι, j, v and t denote each individual firm, destination country, industry (HS2 code) and time, respectively. All variables are in logs except for the exchange rate volatility. $Export\_scope_{\iota jt}$ measures the single firm's export scope associated with each destination in each year, which is computed as the (log) number of the varieties by the firm-country-year level, i.e., $Export\_scope_{\iota jt} \equiv ln(number\_of\_varieties)_{\iota jt}$. The product variety is distinguished by the HS8 code. The key explanatory variables include the exchange rate volatility ($exchange\_rate\_volatility_{jt}$), the distance between China and the destination country j ($distance_j$), and the import-tariff rate imposed by the destination country $ln(tariff\_rate_{jvt})$. Exchange rate volatility is computed as the yearly standard deviation of the exchange rate for country j in year t using the monthly data; the distance to the home country is computed as the log of the distance between the largest city in country j and the largest city in China; and the tariff rate is measured at the industrial level (HS2 code). [6] X_{jt} controls for the scale of sales for firm ι in market j and other macro characteristics of market j, i.e., GDP and GDP per capita.[7] $\lambda_{\iota t}$ controls for the firm-year level fixed effects.

Among previous relevant studies, some rely on the real effective exchange rate (REER), e.g., Aizenman and Marion (1999) and Héricourt and Poncet (2013), while others study the effect of the nominal exchange rate, e.g., Schnabl (2008). In our analysis, we use the nominal exchange rate in our main regression models, which is computed against U.S. dollars or Chinese yuan. To check the robustness of our main regressions, we also run the model with the REER, which is computed as the weighted average of the exchange rate of a country's currency in terms of a basket of currencies while adjusting for the country's inflation. All of these regression results are consistent with each other.

2.2.3 Results

Table 2 below shows the estimation results that explore the effects of exchange rate volatility, transportation cost, and tariffs on firms' export scopes. The results show significant negative coefficients for the exchange rate volatility, distance, and the tariff rate variables, indicating a negative impact of these factors on the export scope. Specifically, we reach the following findings: (i) the export scope decreases by approximately 70 percent from the nearest destinations to the farthest destinations; (ii) as the exchange rate volatility level increases by a value of 0.1, the export scope

[6] We also use the monthly standard deviation of the exchange rate from each year to compute the exchange rate volatility. The empirical findings are invariant to this change.

[7] GDP and GDP per capita control the firm-country level trade scale and taste heterogeneity among countries, e.g., the parameters in the preference function may differ across countries.

decreases in the range of approximately 2 to 4 percent; and (iii) when the tariff rate increases by 1 percent, the export scope decreases in the range of approximately 0.17 to 0.45 percent. Our estimation results are similar to those of Héricourt and Poncet (2013), except that we include the distance and import tariff rate in our estimations. It is easy to understand the impact of the distance and tariff, but the mechanism for the effect of exchange rate volatility is still unclear in the existing literature. In the next section, we attempt to construct a theoretical model with some conventional assumptions to explain our empirical findings, emphasizing our answer regarding how exchange rate volatility affects firms' export behaviors.

Table 2. Exchange Rate Volatility and the Export Scope

Dependent Variable: Log of Number of Varieties at Firm-country-year Level				
	Panel A: Exchange Rate Volatility (RMB)		Panel B: Exchange Rate Volatility (USD)	
$exchange\_volatility$	-0.387***	-0.210***	-0.437***	-0.278***
	(0.00986)	(0.01009)	(0.00945)	(0.00967)
$ln(exchange\_rate)$	-0.0807***	-0.0613***	-0.0994***	-0.0811***
	(0.00451)	(0.00446)	(0.00457)	(0.00452)
$ln(distance_j)$	-0.0693***	-0.0710***	-0.0688***	-0.0699***
	(0.000987)	(0.00983)	(0.000985)	(0.000979)
$ln(tariff\_rate_{jvt})$	-0.448***	-0.170***	-0.445***	-0.167***
	(0.00734)	(0.00788)	(0.00735)	(0.00790)
Observations	2,167,123	2,166,103	2,166,871	2,165,829
Adj R-squared	0.2420	0.2593	0.2424	0.2595
Country-Level Controls	NO	YES	NO	YES
Firm-year FE	YES	YES	YES	YES

Standard errors are clustered at firm level

*** p<0.01, ** p<0.05, * p<0.1

Notes: All variables are in logs except the exchange rate volatility. The exchange rate volatility is computed as the standard deviation of the annual exchange rate of the destination country's currency against the Chinese yuan or U.S. dollar. Panel A shows the results using the exchange rate against the Chinese yuan and Panel B shows the results using the exchange rate against the U.S. dollar. The distance is computed as the geographic distance between the largest city of the two countries. The tariff rate is the industry-level import tariff imposed by the destination market. [8]

[8] Industry is classified by HS2 code.

The country-level controls include the GDP and GDP per capita. The estimation results show that the export scope is decreasing in the distance, tariff rate and exchange rate volatility.

2.3 A Baseline Theory

How do multi-product firms arrange their product and export scopes across different markets? In this section, we model multi-product firms' choice of production and exports when facing exchange rate risks and other market characteristics. Three decisions that firms make in order to maximize profits in each destination are highlighted: the optimal range of products to produce, the optimal range of markets to enter, and the optimal product varieties to export to each market. The firms make production decisions first and then decide the varieties to export to each market. We identify the key economic mechanisms that govern these decisions and derive empirically testable predictions that allow us to validate them in the data. We highlight that the existence of exchange rate risks and a two-stage decision making process play critical roles in observable firm outcomes. We examine multi-product exporters in a stylized conceptual framework with standard assumptions about underlying demand, production and market structure. Our theoretical framework aims at explaining the following stylized facts, i.e., the export scope decreases in the level of the exchange rate volatility, distance, and tariff rate of a destination country. Before our theoretical analysis, one question regarding our empirical result arises: the firm is risk neutral, but how could the risk-neutral agent behave like a risk-averse agent when facing exchange rate risks across many destination countries? To answer this question, our model follows some settings of Aghion et al. (2009) on firms' cost structure and the way they make dynamic investment decisions. In addition, we distinguish firms' decisions on their production and export scopes. A similar intuitive explanation is also mentioned by Héricourt and Poncet (2013).

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

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

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

2.3.1 Households

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

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

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

The quasi-linear preference assumes a constant marginal utility of the numeraire good (captured by the first term), a decreasing marginal utility for the differentiate good (captured by the second and fourth terms with a quadratic formula), and a measure of the competition among the differentiate products (captured by the third term). The quasi-linear preference captures the consumption feature that consumers compare when deciding the purchase amount among different varieties and deciding whether or not to buy a variety. For example, if the price of one variety is relatively high compared with other varieties, and then the sales of this variety will be relatively low. If the price of the variety increases further, then the consumers may decide not to buy this product and save money on the consumption of the numeraire good. The advantage of choosing this preference is that it induces a market demand function, which can allow firms to frequently withdraw their varieties from the market.

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

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

where M is the income of a typical consumer, which is identical across countries. Without loss of generality, we assume the price of the numeraire good is identical across countries and normalized as one. The prices of the differentiated products are different across country-variety pairs.

From the above, it follows that the demand function for variety i in country j is

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

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

Here, we conduct a conventional method to identify whether the two products belong to different varieties or not. The products are categorized as follows: they are different varieties if they are produced by different firms or their HS8 codes are different.

2.3.2 Firms

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

$$C_f = \int_{j \in J_f} \left[\int_{i \in \Omega_f} \left(\frac{c}{\varphi_i} q_{ji}^{L} di + F_i \right) di \right] dj$$

Here, to avoid a cumbersome notation, we have omitted the subscript f in the symbol for the firm-specific productivity level. F_i is the sunk cost for the firm f to be able to produce variety i . Ω_f collects all varieties produced by the firm f, and J_f collects all the markets in which the firm f sells its products. As a conventional assumption following Qiu and Yu (2014), we assume a non-decreasing marginal cost function in variety i. In this case, we have $r \geq 1$. Then, we can write the expected profit function for firm ι as follows:

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

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

The firms make decisions on both the price of each variety in the specific country and the horizontal scope of the products they produce. We assume that the scope decision is made before the realization of the exchange rate, and the price strategy is decided after observing the exchange rate. Recall from Section 2.1 that it takes a long time and incurs fixed cost to invest in a new variety but the decision regarding the export scope can be made each period. In this case, the firms can adjust their exported products with a specific exchange rate level but the scope sunk cost is made with an expectation of the situations in the market.

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

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

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

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

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

[5] the negative realization of the exchange rate does not cause the firm to exit the market, $B\varepsilon_{min} > t_{max}$.

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

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

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

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

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

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

Lemma 1. *Given the product scope chosen in the first stage, the firm chooses the export scope towards the stable market as*

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

and towards the risk market as

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

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

See the proof in the Appendix.

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

Given the solutions for $\bar{i}$ and i_j^*, we can obtain Lemma 1.2 below.

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

See the proof in the Appendix.

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

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

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

where N is the total number of destination countries; $g(t;S_c)$ is the density function of the distance for countries belonging to set S_c and $g(t;S_v)$ is the density function of the distance for countries belonging to set S_v ; and $\rho(t) \in (0,1)$ is the fraction of the destination countries that are located at distance t and that have a fixed exchange regime.[9]

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

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

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

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

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

Lemma 3. $R^{f}(I)$ is a decreasing function of I .

See the proof in the Appendix.

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

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

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

$$R^{v}(I) \equiv \int_{0}^{t_{max}} R^{v}(t,I)\, h(t;S_{v})\, dt$$

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

Lemma 4. $R^{v}(I)$ is a decreasing function of I .

See the proof in the Appendix.

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

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

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

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

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

Thus, the equation that determines I^* is

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

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

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

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

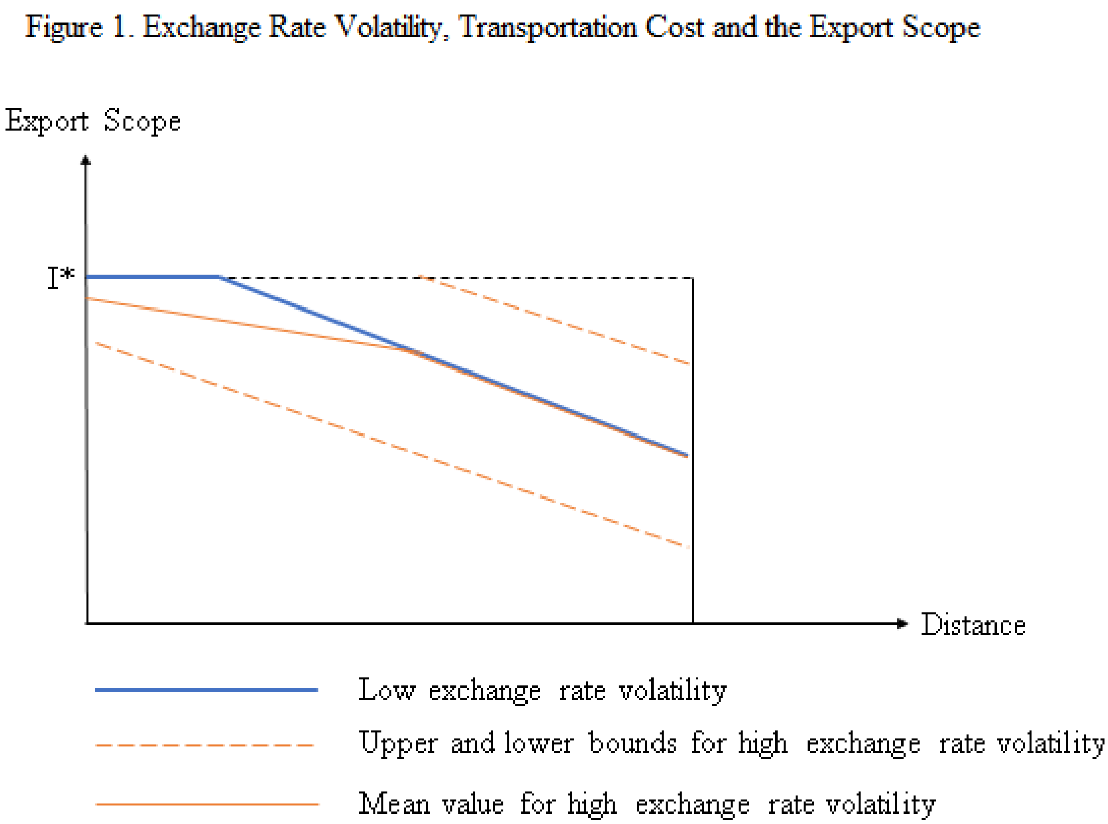
See the proof in the Appendix.

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

2.4 Discussion on the theoretical results

2.4.1 Intuitive explanation

Figure 1: Exchange Rate Volatility, Transportation Cost and the Export Scope



The intuition for the results of the transportation cost and the trade scopes is very straightforward: the increase in the marginal cost lowers the marginal profits for each variety and thus forces the firms to withdraw some varieties that they do not produce well. The mechanism behind the correlation between the exchange rate risks and the trade scopes is a little complex. As shown in the theoretical model, each firm faces identical consumers across nations. Because firms must incur sunk costs for each product variety, they will decide the total number of the invested scopes based on the average demand across the world. However, among the countries, the specific number of varieties for each country may be different due to the variety of the exchange rate risks and the transportation cost. In markets with highly volatile exchange rates, the firms will decrease their export scopes if the destination's currency depreciates a great deal; however, when the currency appreciates, firms may not be able to increase their export scopes due to the constraints of the pre-invested product scopes. This intuitive explanation is similar to the one by Héricourt and Poncet (2013), who argued that the export volume will decrease if the destination's currency depreciates, and this process is equivalent to wasting part of the pre-invested sunk cost in trade. In this case, the firms will be averse to enter into the markets with high exchange rate risks. Graph 1 above illustrates how the export scope towards the countries with flexible exchange rate schemes are, on average, less than that towards the countries with relatively stable exchange rate schemes. The red dashed lines label the upper and lower bounds for the export scopes towards the risk markets – i.e., when the currency appreciates, the export scope increases, and when the currency depreciates, the movement will be opposite – and the red solid line refers to the average export scopes towards these countries. The blue line denotes the export scopes towards the risk-free markets. All export scopes are constrained by the upper bound of the product scope. The horizontal line describes the heterogeneous transportation cost among countries (to simplify our analysis, without loss of generality, we assume that all countries conduct the same import tariff in this section). From the graph, we observe that the export scopes towards the risk countries are on average less than or equal to those towards the risk-free countries, and for some group of countries (near China), a strict inequality holds.

2.4.2 Relationship with the previous literature: The role of financial constraints

In the literature on the effect of exchange rate volatility on firms' overall investment, some authors mentioned the role of financial constraints (see, for example, Aghion et al., 2009; Héricourt and Poncet, 2013). However, they do not provide a model that sorts out how the exchange rate volatility negatively affects the firm's export performance and how financial constraints reinforce this effect. In this sub-section, we show that our model (which does not necessarily include financial constraints) can be re-interpreted as a model in which firms face financial constraints, and thus, our model can be seen as complementary to the literature on financial constraints in that our model nests the intuition of previous models into a two-stage framework where in the first-stage firms decide on their product scope. Recall that the firm determines its optimal product scope based on the following formula

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

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

Let us re-interpret μ as U divided by ω, i.e., $\mu\equiv\frac{U}{\omega}$, where U is the lumpy setup cost for each variety and omega is the prescribed number of years over which U has to be paid back in equal yearly installments. Financial constraints may impact the decision in three aspects: first, the length of the pay-back period; second, the costs of loans; and third, the ceiling on loans. Consider the first factor. If firms do not face financial constraints, they can make long-term investments. They can extend their investments to less profitable product varieties, for which it takes a longer time to recover the sunk cost. Thus, on average, ω would be bigger, i.e., μ would be smaller. The decrease in μ will lead to an increase in the product scope. Conversely, an increase in these costs leads to a smaller product scope. Such changes in the product scope in response to varying financial restrictions have already been proven empirically by Manova and Zhang (2012). As discussed above, with a greater product scope, the effect of volatility on export performance will decrease. The second factor is the cost of loans. Firms that face more severe financial constraints will face a higher cost of financing. For example, when a Chinese firm cannot borrow from state-owned banks with relatively low interest rates, it must find help from private banks or shadow banks, in which case, it must bear higher financial costs. Thus, the marginal cost of expanding the scope is higher. The third mechanism is that credit rationing in its strongest form can effectively eliminate the firm's plan to invest in new varieties. In this case, the realized product scope will be below the optimal scope. All these mechanisms reduce the firm's product scope and weakens its ability to cope with exchange rate risks.

2.4.3 The case with the firm-variety-market specific cost

In this subsection, we will discuss the prediction of our model when the fixed cost arises at the firm-variety-market level, i.e., μ_j for market j. Notice that the assumption about the firm-variety level fixed cost still holds. In this case, the pre-invested export scope in market j is solved as

$$I_j = argmin\left\{E\left\{\frac{L}{4\gamma(1-\tau)\varepsilon}\left[(1-\tau)B\varepsilon - \frac{c}{\kappa}I_j^r - t\right]^2\right\} = \mu_j, I_j \geq I\right\}$$

where I is the product scope. The realized export scope in each market should be bounded by the pre-invested export scope. [10] With this restriction, proposition 1 still holds, which means that firms will export less varieties to the risky market than the stable market on average, which is consistent with our previous prediction. The new prediction from this adjusted setting is that as the market size L increases, the pre-invested export scope will increase. Given this property, we expect that firms export more varieties to a larger country. The intuitive explanation for this result is as follows. A large market means large demand. Each firm will export a greater quantity of each variety to a larger market. A large export volume will lower the market-specific fixed cost per unit of product, which induces firms to export more varieties to this market.

2.5 Robustness checks on theoretical predictions

Before checking the robustness of our theoretical frameworks, we need to summarize some testable predictions from our theoretical model. Based on the empirical checks of these theoretical predictions, we could test the robustness of our theoretical model indirectly. As illustrated in Figure 1 and the discussion following the figure, we first know that the effectiveness of the exchange rate volatility decreases in the transportation distance. Second, according to Lemma 1, the effect of the exchange rate is more pronounced when it experiences depreciation than when it experiences appreciation. These predictions are summarized as follows.

Predictions

[1] The influence of the exchange rate volatility is stronger in the markets with a lower trade cost;

[2] The appreciation of destination country's currency is less pronounced than depreciation in affecting the export scope.

To confirm the robustness of our theoretical model, we need to test whether the firm's exports can be bounded by its production capacity, that is, whether the change in the export scope is constrained by product scope of each firm. This

[10] Recall that the export scope is bounded by the product scope in the original setting.

test cannot be performed directly. Alternatively, we will test the two key predictions of our model listed above. In addition, we will also check out the statistical features of our data. We find that, on average, each firm exports all its product varieties to 15.4% of countries. This feature indicates that firms' exports in some markets can be easily bounded by the firms' production capacity.

Tables 3 & 4 illustrate our main results on the test of both predictions. The average trade cost may vary with the transportation distance and the market size of the destination countries. The first argument is easy to understand. The second argument comes from the idea that firms may export more quantity to a larger country, which makes the fixed cost per unit of good decline and further lower the average cost. Although our main theoretical framework excludes the existing market-specific fixed cost to match reality, we still discuss the potential for such costs to arise and reach the conclusion that exporting to a larger market is equivalent to facing a lower average trade cost.

From Table 3, we find that the coefficients on the interaction of distance and exchange rate volatility are positive, while the coefficients on the interaction of market size and exchange rate volatility are negative. These results indicate that following the increase in the trade cost (increase in distance and decrease in GDP), the effect of the exchange rate volatility weakens. Table 4 demonstrates the empirical results when we add the interaction of the appreciation dummy of the destination country's currency into our empirical model. The results show a positive coefficient on the interaction term but a negative coefficient on the exchange rate volatility, which indicates that the negative effect of the exchange rate volatility on trading becomes less effective when the currency is in the appreciation cycle. The appreciation cycle is defined as the cycle in which currency's value is higher than its average value during the observation years. The dummy App_dum is assigned a value of 1 if the currency is at the appreciation cycle and a value of 0 for the depreciation cycle. The average value of the currency is computed with two methods. The first method uses the simple average of the annual exchange rates over the observation years (2002 to 2006). In the second method, we smooth the data using the HP filter method and define the appreciation cycle as one standard deviation from the trend path. The results from both empirical tests are consistent with our theoretical predictions, i.e., the appreciation of destination country's currency is less effective than depreciation.

2.6 Conclusion

In this paper, we explore two questions that remain unanswered in the existing literature: how firms decide their export scopes in response to different characteristics of destination countries, i.e., exchange rate scheme, distance, and tariff rate; and what is the mechanism behind these findings.

Using Chinese firm-level data covering the years 2002 to 2006, we obtained the following empirical findings: firms export fewer varieties (indexed by HS8 code) to destinations farther from the home country or that have higher exchange rate volatility; the effectiveness of the exchange rate volatility decreases with the trade cost; and this effectiveness weakens when the destination country's currency is at the appreciation stage. As indicated by Héricourt and Poncet (2013), Greenaway and Kneller (2007), and Franke (1991), the intuition behind the first finding is that the distance and the exchange rate risks increase the trading cost of the exporters and therefore worsen the exporter's performance in the destination market. With a theoretical framework that assumes that firms are risk neutral, we explain our empirical findings with the following mechanism: firms will reduce the export scope if the destination countries suffer negative demand shocks; however, when a positive demand shock occurs, firms find it difficult to expand the export scope due to insufficient pre-investment in production capacity.

Compared with the previous literature, our research is the first to provide firm-level evidence regarding the relation between trade costs and export scope; we are also the first to provide a theoretical explanation for the relation between export diversification and exchange rate volatility.

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Appendix A

A.1 Proof of Lemma 1.

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

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

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

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

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

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

Thus, the export scope decreases as t_j increases.

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

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

i.e.,

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

Then,

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

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

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

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

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

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

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

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

i.e.,

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

Then

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

Q.E.D.

A.2 Proof of Lemma 2.

If the risk-free countries that are near enough to the home country, the export scope will touch the upper bound of the product scope, i.e.,

$$\left\{\left[(1-\tau)B\overline{\varepsilon} - t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} \ge I^*$$

Then we have $\bar{i}_t = I^*$. Given the distance unchanged, the export scope towards the risk countries will be adjusted as the following rule $i_t^* = I^*$ whenever $\varepsilon_j \ge \overline{\varepsilon}$, but $i_t^* = \left\{\left[(1-\tau)B\varepsilon_j - t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} \le I^*$ whenever $\varepsilon_j \le \overline{\varepsilon}$. In this case,

$$Ei_t^* = \int_{\varepsilon_{min}}^{\overline{\varepsilon}} i_t^* d\varepsilon + \int_{\overline{\varepsilon}}^{\varepsilon_{max}} I^* d\varepsilon \le \bar{i}_t = I^*$$

If $\left\{\left[(1-\tau)B\varepsilon_{min} - t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} < I^*$, then we have the strict inequality, i.e.,

$$Ei_t^* = \int_{\varepsilon_{min}}^{\overline{\varepsilon}} i_t^* d\varepsilon + \int_{\overline{\varepsilon}}^{\varepsilon_{max}} I^* d\varepsilon < \bar{i}_t = I^*$$

If the risk-free countries are far from the home country, the export scope will be interior solution, i.e.,

$$\bar{i}_t = \left\{\left[(1-\tau)B\overline{\varepsilon} - t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} < I^*$$

Next, we need to discuss whether the export scope towards the risk markets will touch the upper bound of the product scope, i.e.,

$$\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} > or \leq I^*$$

When $\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} > I^*$, we define $\hat{\varepsilon}\left(t_j, I\right) \in [\overline{\varepsilon}\, \varepsilon_{max}]$, such that

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

Recall that $r \geq 1$, then we have

$$Ei_t^* = \int_{\varepsilon_{min}}^{\hat{\varepsilon}(t_j;I)} \left\{\left[(1-\tau)B\varepsilon-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} + \int_{\hat{\varepsilon}(t_j;I)}^{\varepsilon_{max}} I^* d\varepsilon$$

$$< \int_{\varepsilon_{min}}^{\varepsilon_{max}} \left\{\left[(1-\tau)B\varepsilon-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} d\varepsilon$$

$$\leq \left\{\left[(1-\tau)B\overline{\varepsilon}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} = \bar{i}_t$$

When $\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} \leq I^*$, we have

$$Ei_t^* = \int_{\varepsilon_{min}}^{\varepsilon_{max}} \left\{\left[(1-\tau)B\varepsilon-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} d\varepsilon$$

$$\leq \left\{\left[(1-\tau)B\overline{\varepsilon}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} = \bar{i}_t$$

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

Q.E.D.

A.3 Proof of Lemma 3.

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

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

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

Q.E.D.

A.4 Proof of Lemma 4.

Differentiating

$$\frac{dR^v(I)}{dI}=\int_0^{t_{max}}h\left(t;S_v\right)\left(1-\rho(t)\right)$$

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

Thus

$$\frac{dR^v(I)}{dI}<0$$

.

Q.E.D.

A.5 Proof of Proposition 1.

Based on the proof of the lemma 1, the sufficient condition for the holding of the strict inequality is that

$$\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}>I^*$$

for some $t\in[0,\widetilde{t})$,where $\widetilde{t}\in(0,t_{max})$.

In the second stage, the I^* variety shows up in the market j only if the net value of the price and the marginal cost is non-negative, i.e.,

$$(1-\tau)B\varepsilon_j - \frac{c}{\varphi_i} - t_j \geq 0$$

In this case, whenever $(1-\tau)B\varepsilon_j - \frac{c}{\varphi_i} - t_j \geq 0$, the profit from selling the variety I^* in the market j ,

$$\nu(\varepsilon_j, t_j) \equiv \frac{L}{4\gamma(1-\tau)\varepsilon_j}\left[(1-\tau)B\varepsilon_j - \frac{c}{\varphi_i} - t_j\right]^2$$

is increasing in ε_j and decreasing in t_j; and when $(1-\tau)B\varepsilon_j - \frac{c}{\varphi_i} - t_j < 0$, $\nu(\varepsilon_j, t_j) = 0$. Thus

$$\nu(\varepsilon_j, t_j) \equiv \frac{L}{4\gamma(1-\tau)\varepsilon_j}\left[(1-\tau)B\varepsilon_j - \frac{c}{\varphi_i} - t_j\right]^2$$

is non-decreasing in ε_j and non-increasing in t_j.

If for $\forall t_j \in [0, t_{max}]$,

$$\left\{[(1-\tau)B\varepsilon_{max} - t_j]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} < I^*$$

we get $\left\{[(1-\tau)B\varepsilon - t_j]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} < I^*$ for any ε and t_j.

In this case, $R(I^*) = 0 < \mu$, then the variety I^* won't be invested , which conflicts the assumption that the product scope is I^*. Thus we have for some $t_j \in [0, t_{max}]$,

$$\left\{[(1-\tau)B\varepsilon_{max} - t_j]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} \geq I^*$$

Next, we need to show that the strict inequality holds for some $\varepsilon \in [\varepsilon_{min}, \varepsilon_{max}]$ and $t_j \in [0, t_{max}]$. To achieve this target, we just need to show

$$\left\{[(1-\tau)B\varepsilon_{max} - t_j]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} > I^*$$

In fact, this condition holds naturally: if

$$\left\{[(1-\tau)B\varepsilon_{max} - t_j]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} = I^*$$

then $\nu(\varepsilon_j, t_j) = 0$ for any $\varepsilon \in [\varepsilon_{min}, \varepsilon_{max}]$ and $t_j \in [0, t_{max}]$ ($\nu(\varepsilon_j, t_j)$ is non-decreasing in ε_j and non-increasing in t_j).

Because

$$\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}} > I^*$$

and

$$\left\{\left[(1-\tau)B\varepsilon_{max}-t_j\right]\left(\frac{\kappa}{c}\right)\right\}^{\frac{1}{r}}$$

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

Q.E.D.

A.6 Proof of Lemma 5.

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

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

Q.E.D.

Appendix B

Table 3. Exchange Rate Volatility and the Export Scope: The Role of Trade Cost

Dependent Variable: Log of Number of Varieties at Firm-country-year Level						
	Panel A: Exchange Rate Volatility (RMB)			Panel B: Exchange Rate Volatility (USD)		
$Exchange\_volatility$	-10.3167***	3.820***	-6.919***	-9.480***	3.677***	-5.974***
	(0.189)	(0.143)	(0.263)	(0.157)	(0.128)	(0.219)
$ln(Dist) \times Exchange\_volatility$	1.107***		1.063***	1.013***		0.984***
	(0.0204)		(0.0207)	(0.0170)		(0.0172)
$ln(GDP) \times Exchange\_volatility$		-0.153***	-0.113***		-0.148***	-0.122***
		(0.00544)	(0.00558)		(0.00484)	(0.00495)
Observations	2,166,103	2,166,103	2,166,103	2,165,829	2,165,829	2,165,829
Adj R-squared	0.2620	0.2598	0.2623	0.2630	0.2602	0.2634
Country Level Controls	YES	YES	YES	YES	YES	YES
Firm-year FE	YES	YES	YES	YES	YES	YES

Standard errors are clustered at firm level

*** p<0.01, ** p<0.05, * p<0.1

Table 4. The Positive and Negative Effect of Exchange Rate

Dependent Variable: Log of Number of Varieties at Firm-country-year Level				
	Panel A: Simple Mean of Exchange Rate		Panel B: HP Filter of Exchange Rate	
$ln(Exchange\_rate)$	-0.0826***	-0.0629***	-0.0544***	-0.0475***
	(0.0138)	(0.0138)	(0.0074)	(0.0073)
$App\_dum \times ln(Exchange\_rate)$	0.0713***	0.0487**	0.0643***	0.0659***
	(0.0195)	(0.0196)	(0.0156)	(0.0156)
Observations	1,548,797	1,548,356	1,548,797	1,548,356
Adj R-squared	0.6683	0.6683	0.6683	0.6683
Country Level Controls	NO	YES	NO	YES
Firm-Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Standard errors are clustered at firm level

*** p<0.01, ** p<0.05, * p<0.1

Table 4. Exchange Rate Volatility and the Export Scope: Measure the Exchange Rate Volatility with Monthly Data

Dependent Variable: Log of Number of Varieties at Firm-country-year Level					
$Exchange\_volatility$	-1.134***	-1.126***	-29.112***	8.006***	-22.100***
	(0.0422)	(0.0418)	(0.780)	(0.711)	(1.124)
$ln(Dist) \times Exchange\_volatility$			3.030***		2.979***
			(0.0835)		(0.0840)
$ln(GDP) \times Exchange\_volatility$				-0.336***	-0.241***
				(0.0263)	(0.0265)
Observations	1,903,668	1,814,249	1,814,249	1,814,249	1,814,249
Adj R-squared	0.2432	0.2652	0.2666	0.2653	0.2666
Country Level Controls	NO	YES	YES	YES	YES
Firm-year FE	YES	YES	YES	YES	YES

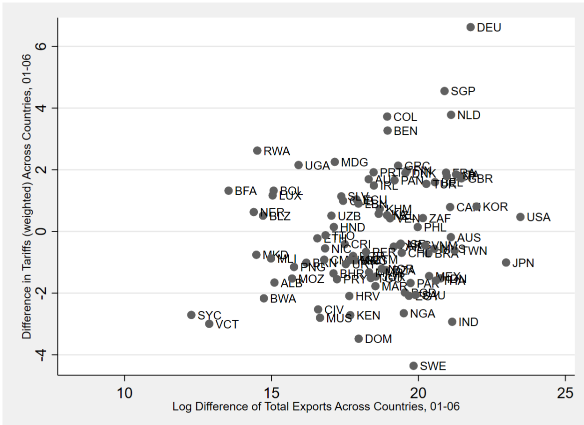
Standard errors are clustered at firm level

*** p<0.01, ** p<0.05, * p<0.1

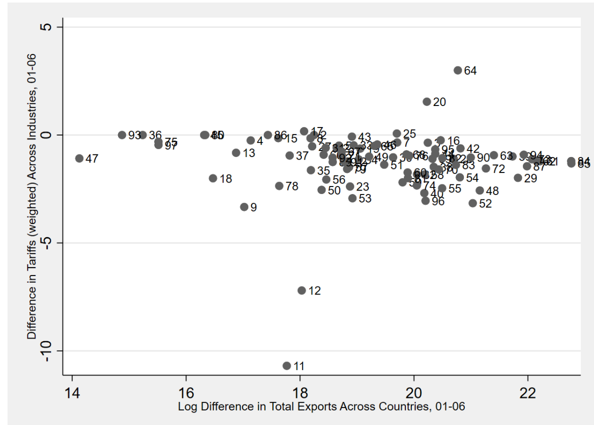
Chapter III Foreign Tariff Reduction, Export Quality and Scope of Multi-Product Firms

3.1 Introduction

Following the accession into the World Trade Organization (WTO) in 2001, China has become the largest producer and exporter of manufacture goods. While China agreed to take considerable measures to liberalize domestic markets, it also enjoys significant foreign tariff reductions from multiple export destination countries who share membership within the WTO. As shown in Figure 1(a), most of China's trade partners reduce their import tariffs imposed on Chinese exporters during the period between 2001 to 2006. At the same time, China's export value increased from 249.2 billion in 2001 to 1.22 trillion in 2006. And the reduction in foreign tariff is unanimous across almost all industries as presented in Figure 1(b). The question regarding how multi-product exporters react to foreign tariff reduction is of great importance both in the sense of trade theory and policy. Recently, a considerable literature has grown up around the theme of the reaction of exporters in the context of trade liberalizatoin. The extent to which a firm choose to pass the tariff-savings to consumers in the form of lower prices is still not clear: in terms of tariff-exclusive price, a considerable amount of literature shows that exporters pocket a significant part of the tariff decrease by raising the price instead (e.g., Broda et al. 2008; Qiu and Zhou 2013; Ludema and Yu 2016). Existing research recognises the critical role played by the product quailty. But exporters could also let the tariff reduction pass through price to consumers and increase export scope by allowing previous negative margin profit products into the country, thus enjoying a growth of the total value of exports. This makes it difficult to identify the sources of the price response: whether it is driven by changes in factor prices, qualities, markups, or compositional effects, such as heterogeneous price responses at the firm level or reallocations of market shares between firms with different prices. Any of these nuances could alter the welfare effect of a tariff, but to uncover them empirically requires a firm-level investigation.



((a)) Foreign Tariff Reduction Across Destination Countries, 01-06



((b)) Foreign Tariff Reduction Across Industries, 01-06

Notes: This figure shows reduction of foreign tariffs both across countries and across HS two-digit industries. of welfare gains from an optimal non-discriminatory multilateral trade friction reduction. In particular, we report the welfare gain each country would achieve if all countries in the world were to alter their trade frictions in order to maximize world welfare (where the country Pareto weights are those imposed by the competitive equilibrium. Countries are sorted by deciles; red indicates a greater increase in welfare while blue indicates a smaller increase in welfare.

This paper aims at exploring how multi-product firms' exports respond to foreign tariff reduction and how the effects differ in the productivity of various exporters. China's entry into the WTO in 2001 provides an excellent opportunity to identify the causal effect of foreign tariff reduction on multi-product firms' changes in export behavior: pricing strategy, quality choice and export scope. We use highly disaggregated firm-product level data and the shock of China's entry into the WTO to trace in detail the mechanisms through which trade liberalization contributes to changes in prices, qualities, markups, or compositional effects by Chinese firms. We find that in response to tariff-cut by destination countries, exporting firms incompletely pass through tariff savings by increasing prices and adjusting both product quality and export scope. The effects are significantly different across firms with different productivity: low productivity firms tend to increase prices more in the horizontal differentiation level of the industry, while high productivity firms expand more in within-firm product export scopes. The purpose of this study is to answer how heterogeneous firms differ in their responses of quality upgrading and trade scope adjustment to trade liberalization. The intuition is that scope expansion will make firms start to export relatively high marginal costs goods which used to have negative profits before trade liberalization. Meanwhile, relatively larger scope expansion from high productivity firms will lead to export products structured with a higher portion of high quality goods.

Our paper relates directly to a thread of growing literature that study tariff pass-throughs. Many studies are conducted at the industry level to study how the average price of all firms in an industry responds to a tariff change. Among the theoretical literature, almost all the papers, except Qiu and Zhou (2013) , reach the conclusion that the multi-product firms reduce the number of the export varieties in response to trade liberalization, e.g. Bernard et al. (2011), Dhingra (2013), Eckel and Neary (2010), and Mayer et al. 2016. However, Qiu and Zhou (2013) prove that the high productivity firms may increase the product scopes in response to the trade liberalization. Qiu and Yu (2014) and Lopresti (2016) study the impacts of the trade liberalization on firms' export performance at the firm level. The most related paper in this sense is Ludema and Yu (2016), who identifies the sources of the price response empirically at firm-level investigation. They find that exporting firms respond to foreign tariff reductions by upgrading product quality and increasing prices, resulting in incomplete tariff pass-through. Our paper incorporate exporting firms adjustment of exporting scopes along with quality and price changes with a conceptually similar theoretical framework.

Our paper also contribute to a large literature use microdata to study firm in export strategies with heterogeneity. Fan et al. (2015), for example, assumes that the product's price will change immediately but the adjustment of the quality is lagged one period in response to the change of the tariff rate. Manova and Zhang (2012) document varous stylized linkages between exporters strategies, performance and heterogeneous features. Different from previous studies, who find that upgrading response is greater for high productivity firms and the effect is greater for the level of quality differentiation of a product's scope, our empirical results found two main stylized factors: firstly, in response to the trade-liberalization, firms with higher productivity upgrade the quality level of their products in larger scale; secondly, when the output-tariff is cut down, the exported product's price and quality decrease in level but the growth rates of the two variables increase.

We provide a simple, partial equilibrium model to materialize the mechnisms at work. Our model is based on an extension of Melitz and Ottaviano (2008), with variable mark up as in the work of Antoniades (2015). We follow Ludema and Yu (2016)'s inclusion of an ad valorem tariff and introduce firm's choice of export scope. In the model, firms differ in their productivity and maximize profits by choosing the quality of their output quantity of their output and the scope of their export into each destination. The model features heterogeneous firm's quality choice when facing positive foreign demand shocks from trade liberalization induced by removal of trade barriers such as reduced output tariff or increased export subsidy. With these features, we estimate our model using panel data for Chinese firms over the period 2000-2006. Covering the periods where China joins WTO giving rise to the abrupt trade liberalization imposed unilaterally on China, we are able to examine exporters responses and behaviors including productivity change and quality choices with consideration of different firm characteristics. We find that exporting firms in China mfrequently adopt strategies to maintain their market share against tariffs by adjusting their exporting scope and product quality.

The rest of the article proceeds as follows. Section 3.2 briefly summarize literature that are closely related trade liberalization, quality choice and productivity. Section 3.3 offers a theoretical framework where a partial equilibrium analysis is provided to guide our main estimation. Section 3.4 describes estimation specifications including a description of our data and definition and measurement of main variables of interests. Section 3.5 contains our empirical analysis. Section 3.6 discuss the potential alternatives to our theory and the ways to check the robustness of estimation results. Lastly, Section 3.7 concludes.

3.2 Literature Review

Our work complements a related literature trying to understand how foreign tariffs are passed through to export prices. **?** investigate the incidence of U.S. sugar duties using high-frequency historical data and find a similar results: 60 percent of tariff reduction is absorbed by foreign exporters. Marquez and Schindler (2007) conduct a similar analysis for the post-trade-liberalization period in India (1990–2001) and confirm that tariff rate passthrough is incomplete in most of industries. Most of these studies focuse on the most-favoured-nation (MFN) rates, several studies have examined the effect of preferential tariff rates such as regional trade agreement (RTA) rates. In this sense, our paper is closely related to Qiu and Zhou (2013) , who study how multiproduct firms adjust scope in the process of globalization. The main differences between our study and Qiu and Zhou (2013) is two-folds: first, Qiu and Zhou (2013) do not distinguish the production scope by the firm level and the export scope in each firm-country-year transaction, and the product scope in their study is supposed to be the same as the production scope in our analysis; second, Qiu and Zhou (2013) only make a theoretical analysis and do not provide the empirical evidence, while our analysis is fully supported by the empirical evidences. Our theoretical model contributes to the existing literature in two points: firstly, our model distinguishes the production scope and the export scope; secondly, we consider the product quality by the heterogeneous firms and the firm's ability to adapt to the increased competition after the trade liberalization. The rest of the relevant literatures which study the firms' production scope include the Goldberg et al. (2009), Turco and Maggioni (2014). Using the Indian firm level data, Goldberg et al. (2009) find that a reduction of import tariff induces the firms to invest in the product innovation and expand their production scopes. Turco and Maggioni (2014) investigate the relation between the firm's exporting status and the production scopes through the evidence from Turkey, and find that the exporting has a prominent role for firm product innovation (expansion of the production scopes).

Furthermore, while all the above studies have analyzed the issue at a product level, some studies have examined firm-level tariff pass-through. The papers most closely related to ours in this direction are Ludema and Yu (2016). Ludema and Yu (2016) found significant firm-level tariff pass-through in U.S. exports and examine a setting where a tariff reduction can also lead to higher prices as firms upgrade the quality of exported product. Using firm level data, Ludema and Yu (2016) find evidence consistent with this possibility, particularly for low productivity firms. Besides, Gorg et al. (2012) examined the tariff pass-through for Hungarian exports at the firm level but did not find significant tariff pass-through. Our current paper differs in that it incorporate exporters strategies of adjusting export scope along with existing change of quality. Our model fleshes out the mechnism by two channels: in general firms expand their export scope after trade liberalization, and scope expansion will make firms start to export relatively high marginal costs goods which used to be negative profit before trade liberalization. Moreover, firms with relatively low processing cost (high productivity) will expand more in export scope than firms with low productivity, therefore relatively larger scope expansion from high productivity firms will lead to export products strucutured to higher portion of high quality goods. These two effects will all causing prices to increase after foreign tariff reduction.

In addition to the literature on the tariff pass-through, this paper also contributes to the literature on trade liberalization and firm performance with heterogeneous characteristics. Most of the literature focuses on gains from trade and investigates the effect of a reduction of tariff on firms' total factor productivity (TFP). For example, Bresnahan et al. (2016) confirms the association between export intensity and higher productivity but find instances of negative average TFP growth among exporters using firm-level evidence from Africa. They attribute this result to the effects of lower external tariffs as productivity of non-exporting firms move down with the reduction of external tariff rate. Moreover, there are a few paper who extended the Melitz (2003) firm heterogeneity model to multiproduct firms to examine the role of trade liberalization on multi-product firms' product scope and its relationship with firm productivity. Eckel and Neary (2010) model multiproduct firms' adjustment of production scope in response to globalization. They predict that productivity increases as firms become "leaner and meaner", concentrating on their core competence thus reducing their product variety. Similar conclusions are drawn with productivity difference across firms and across products in Mayer et al. (2016) and Bernard et al. (2011) as the least productive products within each multiproduct firm would be dropped out. Qiu and Zhou (2013) propose a model of heterogeneous firms with variety-specific fixed costs and demonstrates that more-productive firms may expand their product scope, which in turn may push up their average costs under the condition that the fixed cost of introducing more varieties increases rapidly with the product scope. Consistent with empirical evidence found in of adjustment of export scope, we propose the change of export scope to complement existing story of quality upgrading after trade liberalization.

3.3 The Model

In this section, we provide a simple, partial equilibrium model to materialize the mechnisms at work. Our model is based on an extension of Melitz and Ottaviano (2008), due to Antoniades (2015). We follow Ludema and Yu (2016)'s inclusion of an ad valorem tariff and extend the model with firm's choice of export scope. In the model, firms differ in their productivity and maximize profits by choosing the quality of their output quantity of their output and the scope of their export into each destination. In sections below, we present the model and derive equilibrium prices, quantities and qualities.

3.3.1 Consumers and Demand

To study how firms behave both within and across industries, preferences are defined over a homogeneous numeraire good, and a continuum of differentiated varieties indexed by $i \in Y$. A representative consumer in destination country k has quasi-linear utility function:

$$v = q_0 + \delta \int_0^{I_k} q_i d_i + \beta \int_0^{I_k} z_i q_i d_i - \frac{1}{2}\gamma \int_0^{I_k} (q_i)^2 di - \frac{1}{2}\eta (\int_0^{I_k} q_i d_i)^2 \tag{1}$$

where z_i represents the index for the country-specific tastes for the variety i(or interpreted as quality level), and q_i represent the product's quantity. The increase of the value for z_i may mean that the firm upgrades the quality of the products or adjust the horizontal characteristics of the products to cater the customers in the destination country. The demand parameters $\delta > 0$, $\beta > 0$ and $\eta > 0$ determine the substitution pattern between the numeraire and the differentiated varieties, while $\gamma > 0$ indexes the degree of horizontal differentiation between the varieties.

Each consumer chooses the optimal quality and quantity of variety i by maximizing the utility function above in a market with aggregate expenditure Y, implying the following linear market demand for variety i in country k:

$$q_i = \frac{1}{\gamma}(\delta + \beta z_i - p_i - \eta Q_k) \tag{2}$$

where $i = 0, 1, 2......I_k$, and I_k is the total number of the available variety for consumption in destination country k, and

$Q_k = \int_0^{I_k} q_i d_i$ is the index of consumption varieties in country k.

Then we can get the inverse-demand function for variety i as $p_i = \delta + \beta z_i - \gamma q_i - \eta Q_k$, We assume that Q_k cannot be altered by any single firm's production choice. For simplicity, we rewrite the variety inverse-demand function as

$$p_i = A + \beta z_i - \gamma q_i \tag{3}$$

, where $A = \delta - \eta Q_k$, a variable that is exogenous from the point of view of individual firms. The inverse-demand function implies that demand for variety i is negatively related to its own price and positively related to its own quality, while it is positively related to the average price and negatively related to average quality.

3.3.2 Firms, Production and Exports

Each firm produces a collection of varieties and faces a fixed entry cost , which is common across firms. The subsequent production cost of firm j to produce variety i given by:

$$TC_i^j = c_i^j q_i + \delta q_i z_i + \theta {z_i}^2 \tag{4}$$

where $c_i^j = hI_j^{r_j}$. This cost function follows from Ludema and Yu (2016) and is composed of three parts: the first term is varies only with the quantity produced, independent of quality, and high productivity firms have low unit processing cost carried out by small efficiency parameter r_j. The second term $\delta z_i q_i$ depends on both the quantity and the quality of the output, where z_i represents the country-specific tastes for quality. For example, the firm can upgrade the quality of the product, adjust the horizontal characteristics or make more advertisements in the destination country to increase the value of z_i. The third term θz_i^2 depends only on the quality level, independent of quantity. Note that the cost function Eq. (4) is specific to a firm and destination market. Thus, each firm varies both its quantity and quality – including components and design – by destination.

Consider a exporting firm with parameter c. Given our assumptions, the firm j independently maximizes the profits earned from export sales in a single country:

$$\underset{I_i,q_i,z_i}{Max} \int_0^I [(1-t_i)(A + \beta z_i - \gamma q_i) q_i - q_i c_i^j - q_i \delta z_i - \theta (z_i)^2] di \tag{5}$$

where t_i is the ad valorem tariff rate for variety i imposed by a foreign country. Profit maximization implies the following (derivation in Appendix A):

$$\begin{cases} q_i^* = & \frac{2\theta(A(1-t_i)-c_i^j)}{4(1-t_i)\theta\gamma-(\beta(1-t_i)-\delta)^2} \\ z_i^* = & \frac{(\beta(1-t_i)-\delta)(A(1-t_i)-c_i^j)}{4(1-t_i)\theta\gamma-(\beta(1-t_i)-\delta)^2} \\ I_j^* = & [\frac{(1-t_i)A}{h}]^{\frac{1}{r_j}} \end{cases} \tag{6}$$

The first two equations in (6) implies that the optimal export volumn and quality level of variety i depends on the firm-specific processing cost (r_j), the degree of substitutability among varieties ($\frac{1}{\gamma}$) but decreasing in the toughness of upgrading (θ) and the variety-specific ad valorem tariff t_i. The higher the productivity of the firm, the lower the firm-specific processing cost, inducing a higher volumn of export for i. The dependence of the optimal quality on the interaction between quality scope and firm productivity is important, as it implies that changes in quality scope (due to, say, a tariff change) will have an amplified effect on the quality level for a higher productivity firms.

The last equation of (6) implies that an exporter's export scope is a decreasing in both firm-specific processing cost (r_j) and destination country's variety-specific ad valorem tariff rate (t_i). The lower these two factors the larger the firm's export scope to destination k. The reason is that lower r_j indicates higher firm productivity, which is reflected in lower processing cost. This increases the marginal operating profit of exporting the marginal variety which is the variety that gives the lowest marginal profit.

3.3.3 Implications

We begin our analysis of the effect of tariffs on exporter's choice by partially defferentiating the logrithm forms of equation (6) with respect to t_i. First, we look at quality choice, from (6) we have $lnz_i^* = ln(\beta(1-t_i)-\delta)+ln(A(1-t_i)-c_i^j)-ln\{4(1-t_i)\theta\gamma-[\beta(1-t_i)-\delta]^2\}$, then we obtain:

$$\frac{\partial lnz_i^*}{\partial t_i} = \frac{-\beta}{\beta(1-t_i)-\delta} + \frac{-A}{A(1-t_i)-c_i^j} + \frac{4\theta\gamma-2\beta[\beta(1-t_i)-\delta]}{4(1-t_i)\theta\gamma-[\beta(1-t_i)-\delta]^2} \tag{7}$$

The necessary condition for firms to operate is $A(1-t_i)-c_i^j > 0$ (otherwise the price will be lower than the marginal cost), therefore the signs of the first and second terms are all negative. The sign for the third term is ambiguous. However, the value of the partial derivative $\frac{\partial lnz_i^*}{\partial t_i}$ is decreasing in c_i^j . In this case, if the quality level lnz_i^* is decreasing in the tariff rate, then the scale of the partial derivative will be increasing in c_i^j . That means the low productivity firms will adjust more in quality level in response to the tariff-reduction.

Next, we consider firms' choice of export scope. The logrithm forms of the last equation of (6) gives: $lnI_j^* = \frac{1}{r_j}(lnA + ln(1-t_i) - lnh_j)$. By partially defferentiating with respect to t_i we have:

$$\frac{\partial lnI_j^*}{\partial t_i} = -\frac{1}{r_j(1-t_i)} \tag{8}$$

we can get the partial derivative of the scope index with respect to the tariff rate, which means that the scale of the partial derivative is increasing in productivity.

The intuition for the change-patterns of quality is as following. The marginal cost of the low productivity firms is relatively high. In this case, the marginal profits of the low productivity firms will be low, and then the quality-investment of the low productivity firms will be smaller than the high productivity firms. When the tariff rate drops down, the marginal revenue increases in the same speed (same growth rate) for both the high and low productivity firms meanwhile the marginal cost doesn't change for each firm. In this case, the gap in the marginal profits among firms will be shortened. As a consequence, the quality gaps among firms will be shortened as well. In this case, we would observe the stylized facts that the upgrading rate of the quality is relatively high for the low productivity firms.

The intuition for the expansion of export scope is direct: before the foreign tariff reduction, firm's profit from all export products is positive, which is a precondition for firms exporting a certain product. From the perspective of the export product ranking of multi-product firms, the export product that ranked at bottom (i.e., the marginal product) is the fringe product which can bring positive profit to firms (the next-to-fringe product yields negative profits, then will reduce total profits). Following foreign tariff reduction, the profits will increase for all products due to the reduction of cost and increase of export price, and the next-to-fringe products may now start to reap positive rather than negative profits, as a result, the firms will start exporting these profitable products.the high productivity firms pursue advantages in horizontal-scope investment and expansion based on the exponential type of the cost function assumed. Since firms with relatively lower productivity have higher processing costs, they will expand less varieties than that of high-productivity firms.

3.4 Data and Descriptive Statistics

3.4.1 Foreign Tariff Reduction and China's Entry into WTO

The period under study, 2000–2006, corresponds both to a drastic increase in Chinese foreign trade (e.g., the yearly export growth increased by 50% over the period) and to a significant episode of trade liberalization. Following China's accession to the WTO in December 2001, the authorities undertook a series of important commitments to open and liberalize the economy and to offer a more predictable environment for trade and foreign investment. In turn, foreign trade partners also gradually provide reduced tariffs, non-tariff measures, licenses and quotas. We make use of this policy variation in tariff reductions to capture the impact of trade liberalization on export prices and scopes. Potential endogeneity might come from the fact that liberalization is dependent of expected exports and lobbying activities. Indeed, Gilbert and Oladi (2012), for instance, empircially show that lobbying was signicant in passing of Permanent Normal Trade Relations (PNTR) with China bill in the US Congress in 2000. Notably, one can argue that this bill was a precursor and a necessary condition for the admission of China to the WTO in 2001. In order to address issues of endogeneity, we must verify that tariffs were set independently of industries' expected exports and lobbying activities. First, Branstetter and Lardy (2006) confirm that China's accession into WTO is mainly motivated by the domestic reform agenda and willingness to become a market economy. Thus it is hard to believe that exporters would have expected or have influence on the change of foreign countries' tariff. Moreover, Brandt et al. (2017): the convergence in tariffs is more likely to reflect a requirement from WTO to reach low tariffs in all sectors rather than a selective allocation of tariff reduction in response to sector performances or lobbying activities. Lastly, there is a growing literature take advantage of China's accession into WTO. Bas and Strauss-Kahn (2015) for example, analyze exporters performance using this policy variation.

3.4.2 Data and Descriptive Statistics

Our analysis of the effects of foreign tariff reduction on the adjustment of export quality and scope relies on transaction-level Chinese customs data, firm-level survey data, country-product level tariff data and other external macro data.

Export Transaction Data

The main part of our data is the product-level transaction data (CCTS-GAC) over the period 2001 to 2006. The Chinese custom data is transaction based monthly data at firm-country-product level. This custom trade data also contains variables of trade mode and destination country. We observe both the nominal value and quantity exported for each firm-product-country transaction. And the product are coded at eight-digit Harmonized System (HS) category for each trading firm and destination. We aggregate trade variables (quantity and value) to yearly basis and also collapse the data to six-digit HS codes in order to match with tariff data. We deflate the export value using output deflator provided in Brandt et al. Combing with information on quantity, we construct unit prices for each variety exported in real terms. In the sample of 2006, 2258 products are exported across 160 destinations.

The sample selection procedure are done according to Brandt et al. (2017). We delete all processing and intermediaries trading firms from exporting firms as they are not relatvent in the adjustment modeld theoretically in the section above. We drop all observations with no destination information or destination country reported as PRC China. We further drop all observations with zero or missing quantity or value. We deflate the export value using output deflators from Brandt et al. (2017). Note that the deflators in Brandt et al. (2017) are by 4-digit CIC industry in China, while there is no information about CIC industry code in the Customs Data. Therefore, we use the concordance between the HS codes and the CIC industries by Brandt et al. (2017) to merge each HS code with a CIC industry. Eventually, we are able to compute the deflated value at HS6 level. The change in deflated unit price is shown in Table 1

Firm Data

The second part of our data comes from the annual survey of above-scale enterprises in China. This data from National Bureau of Statistics of China (NBS) covers all enterprises with annual sales above the scale of RMB 5 million ($\approx$ \$770,000 USD). And it contains major balance-sheet nominal variables including value added, output, capital stocks, employment and materials inputs. We utilize the firm level variables to have controls at firm level and also to construct measures of firm-level productivity.

We clean the data following the steps described in Brandt et al. (2017). Basically, we keep the firms that have a valid year label and have non-missing unique identification number over time. We further keep the observations that meet the basic requirement of accounting rules. We drop the firms that have liquid assets, fixed assets (net) or total fixed assets greater than the total assets. We then estimate firm productivity as the standard revenue-based total factor productivity (TFPR) based on Olley-Pakes method. As decribed in Table 2, we end up with a sample of 237,368 unique firms in total.

Tariff Data

Lastly, we collect country-product level MFN (most-favored nation) applied foreign tariff data from World integrated Trade Solutions (WITS) Tariff Schedule. The tariff data are available at the HS 6-digit level from 2000 to 2006. The tariff data is then combined and attached to the firm level data. Table 3 shows the average foregin tariff reduction at both product and firm level.

As China joined the WTO in December of 2001, we use the data from 2001 to represent the pre-reduction period and data from 2006 to represent the post-reduction period. All firms we examine are incumbent exporting firms that are present in both pre- and post-redution periods. Since a product is defined at either HS6 or HS6-destination level, it is convenient to compare the changes in export prices at different levels of aggregation that can uncover how changes in the composition of destination markets affect average export prices and scopes.

Table 1: Change in Quality, Export Scope and Destinations, 2001-2006

	Average Changes	Maximum Changes
Change in Quality - Product Level		
Price Measure	3.18%	34.16%
Baseline Measure	2.08%	31.63%
Change in Export Scope		
By HS6 per destination	2.14	65.00
By HS2 per destination	0	0
No. Destination	6.71	133.00

Notes: This figure shows distribution of welfare gains from an optimal non-discriminatory multilateral trade friction reduction. In particular, we report the welfare gain each country would achieve if all countries in the world were to alter their trade frictions in order to maximize world welfare (where the country Pareto weights are those imposed by the competitive equilibrium. Countries are sorted by deciles; red indicates a greater increase in welfare while blue indicates a smaller increase in welfare.

Table 2: Characteristics of Exporting Firms

	Obs.	Mean	Median	Std. Dev.	Min	Max	Change in 01/06
Value Added	237368	89035.32	18576.01	631216.38	0.93	27300000.00	32074.45
No. Labor	237368	737.98	304.00	1694.96	1.00	44233.00	-182.63
Capital Labor Ratio	237368	118.20	54.74	291.05	0.01	18834.00	8.54
Wage	237368	20.23	15.80	38.81	0.00	6952.00	6.47
Log(TFP)	237368	4.42	4.43	1.04	-5.97	9.11	0.36

Notes: This figure shows distribution of welfare gains from an optimal non-discriminatory multilateral trade friction reduction. In particular, we report the welfare gain each country would achieve if all countries in the world were to alter their trade frictions in order to maximize world welfare (where the country Pareto weights are those imposed by the competitive equilibrium. Countries are sorted by deciles; red indicates a greater increase in welfare while blue indicates a smaller increase in welfare.

Table 3: Change in Destination Country Tariff Cuts, 2001–2006

	Average Changes	Maximum Changes
Change in Tariff - Product Level		
By HS6 product	-1.21%	-604.27%
By HS2 product	-1.24%	-10.69%
Change in Tariff - Firm Level		
By HS6 product	-2.68%	-604.27%
By HS2 product	-2.72%	-20.75%

Notes: This figure shows distribution of welfare gains from an optimal non-discriminatory multilateral trade friction reduction. In particular, we report the welfare gain each country would achieve if all countries in the world were to alter their trade frictions in order to maximize world welfare (where the country Pareto weights are those imposed by the competitive equilibrium. Countries are sorted by deciles; red indicates a greater increase in welfare while blue indicates a smaller increase in welfare.

3.5 Empirics

3.5.1 Baseline Specification

This section presents our main results. Our results restrict to a sample of only ordinary Chinese manufacturing exporters as processing exporters are exempted from tariffs on imported inputs into final goods for resale in the foreign markets. We first consider a pooled sample of all industries to find the average effect of falling output tariffs on firm's choices on export price, quantity and quality. We then look at heterogenous firms with levels of productivity and show that the response of export price, quality and quantity to falling output tariff differ substantially across these levels of productivity, as predicted in proposition specified in section 3.3. Finally we present evidence at extensive margins to supplement our discussion. Our baseline regression model takes the following form:

$$\Delta lnY_{fpc} = \beta_1 \Delta ln\tau_{pc} + \beta_2 \Delta ln\tau_{pc} * lnTFP_f + \beta_3 \Delta lnTFP_f + \beta_X \Delta X_f + \beta_Z \Delta Z_c + \sigma_s + \varepsilon_{fpct} \tag{9}$$

where Δ represents the long difference of any variable during the five-year period between 2001 and 2006. The dependent variable, ΔlnY_{fpct}, is the log difference of the quality measures at firm-product-country level between 2001 and 2006. Our baseline measures for quality follow the same way as in recent literature (Amiti and Khandelwal, 2013; Khandelwal et al., 2013; Fan et al., 2015). We first use unit price as proxy for quality and then we proceed with the quality measure inferred from observed prices and market shares as in Khandelwal et al. (2013). The variable $\Delta ln\tau_{pct}$ denotes the log difference of the country-product specific tariff between 2001 and 2006. $\Delta ln\tau_{pct} * lnTFP_f$ is the interaction term of the change in destination-product tariff and the firm's initial productivity (measured in the first year of the firm when it started to export). X_f is a vector of firm level controls, and β_X is a vector of coefficients for X_f. ΔX_f serves to control characteristics of firm f during the 5-year period, which includes the the following: (i) the change of capital to labor ratio; (ii) the change of total employment, and (iii) the change of total wage bill. We also add a vector of export destination characteristics, Z_c to control for the market-specific demand shocks that potentially could also affect quality. ΔZ_c includes the change in the destination contry's GDP and CPI, which all come from the Penn World Tables. σ_s controls for HS2 level sector fixed effects.

According to our model prediction, we expect the quality level decreases in the tariff rate. It indicates that the coefficient for the tariff change, β_1, which measures the direct impact of the change in destination tariff on export quality for a low productivity firm should be negative. Our model further indicates that low productivity firms will adjust more in quality level in response to the tariff-reduction, which indicates that the coefficient for the interaction term between tariff change and the high TFP dummy, β_2,should be positive.

We next look at how export scope changes with respect to tariff cuts and how the initial productivity affects this effect by a similar specification as the above:

$$\Delta lnS_{fc} = \beta_1 \Delta ln\tau_{fc} + \beta_2 \Delta ln\tau_{fc} * TFP_f + \beta_3 TFP_f + \beta_X \Delta X_f + \beta_Z \Delta Z_c + \varepsilon_{fc} \tag{10}$$

Here our main variable of interest is the change in firm-destination level export scope, ΔlnS_{fc}. We calculate firm-country specific tariff measures,τ_{fct}, a export-value weighted measure of country-product tariff as $\tau_{fct} = \sum_p w_{fpct} *$

τ_{pct}, where $w_{fpct} = Export_{fpct} / \sum_{pc} Export_{fpct}$ is the share of firm's exported product p to country c in the total value of the firm's export at time t. As implied by our model, the upgrading rate of the quality is relatively high for the low productivity firms. A positive β_1 and negative β_2 will imply that low productivity firms have a higher response in scope with respect to tariff cuts than high productivity firms due to increasing market competition.

3.5.2 Foreign Tariffs Reduction, Export Quality and Scope

In this section, we present our main results using our constructed sample merging from multiple sources described above. We begin by considering a pooled sample of all industries to find the average effect of falling foreign tariffs on firms' export prices and on their export scope choices. We then consider two subsamples defined by the scope for quality differentiation and show that the response of export prices to falling tariffs differs across these types of industries, as predicted by our model. In all specifications, we present results at same levels of aggregation within the firm so as to shed light on effects associated with tariff reductions. Finally, we present evidence at new export varieties that are only exported in the sample of 2006 to supplement our discussion.

Table 4 reports the results of our baseline regression equation above, with various dependent variables, including firm-product-country price change in columns 1 to 3, and its interaction with firms' estimated initial TFP. We first discuss the results associated with long differences at the firm-product-destination level shown in columns 1 to 3 of Table 4. In column 1, we report the coefficient estimate of regression of log changes in export prices on log changes in the intensive measure of foreign tariff reductions. The statistically significant positive coefficient indicates that tariff reductions on exported varieties are associated with lower unit prices. The estimate for the coefficient of $\Delta Tariff$ is -0.013 in column (1), indicating that a 10% reduction in foregin gross tariff will induce 1.3% increase in log price. Yet this effects differ with firms having different level of productivity as shown in columns 2-3 and 5-6. For firms with a relatively lower TFP level (in log form) , the negative sign of the tariff change would be significantly more pronounced. This result is consistent with our model implication where the all exporters has a increased price with reduced foreign tariff, but the low-productivity firms increases more as they have a larger room for quality upgrading in the exported goods. Similar results pertain when we use estimated product quality in Table 5 As shown in column (6), this effects is even greater for low productivity firms regardless of industry fixed differences.

Table 4: Change of the Destination Tariff Rate and Export Prices in the Destination Country

Dependent Variable: change of price and quality at firm-product-country-year level						
	Panel A: $\Delta lnPrice$			Panel B: $\Delta lnQuality$		
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta Tariff$	-0.013***	-0.016**	-0.025***	-0.106***	-0.056***	-0.023**
	(0.005)	(0.007)	(0.005)	(0.007)	(0.011)	(0.010)
$\Delta Tariff \times ln(TFP)$		0.015***	0.019***		0.038***	0.042***
		(0.004)	(0.004)		(0.008)	(0.008)
Fixed Effects	ict	it+ct	it	ict	it+ct	it
Other Country Level Controls	NO	NO	YES	NO	NO	YES
Observations	1692084	1112591	1112602	1692084	1112591	1112602
R-squared	.00297	.00343	.00262	.0167	.0199	.0152

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses and are corrected by clustering variables at the firm level. This table report regression results for the change in export unit price using long difference sample between 2001-2006. Dependent variable is firm-destination-product (HS6) level export scopes in natural log form. $Tariff$ is computed as destination-product (HS6) specific and is calculated as the simple average of the de jure tariff. Initial firm productivity takes the estimated revenue based productivity in 2001 using Olley-Pakes methods. Both firm and destination country level control variables are the 5-year long difference between 2001 and 2006. Firm Destination-level controls include annual real GDP, CPI and physical distance between China and export destinations in natural log forms.

Table 5 and Table 6 shows that with tariff reduction, firms may introduce more varieties to markets with higher marginal cost, thus raising up average price. The estimate for the coefficient of $\Delta Tariff$ is around -0.019 and that for the interaction with initial productivity is around -0.01 in column (2) to (3) in table 5, when we control firm and destination level characteristics, indicating that the tariff increase of 10% will cause firms to expand more around 1.9% exported varieties in a certain destination. This effect is greater for high-productivity firms as indicated by column (2) and (3). The key message from those facts is the gap between less and more productive firms in terms of their export scopes under considerable foreign tariff reduction. One possible explanation is as follows: before the foreign tariff reduction, firm's profit from all export products is positive, which is a precondition for firms exporting a certain product. From the perspective of the export product ranking of multi-product firms, the export product that ranked at bottom (i.e., the marginal product) is the fringe product which can bring positive profit to firms (the next-to-fringe product yields negative profits, then will reduce total profits). Following foreign tariff reduction, the profits will increase for all products due to the reduction of cost and increase of export price, and the next-to-fringe products may now start to reap positive rather than negative profits, as a result, the firms will start exporting these profitable products.

Table 5: Change of the Tariff Rate and Export Scopes in the Destination Country

Dependent Variable: change of export scope at firm-country-year level						
	Panel A: $\Delta lnExportScope(HS8)$			Panel B: $\Delta lnExportScope(HS6)$		
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta Tariff$	-0.019***	-0.026***	-0.028***	-0.019***	-0.024***	-0.018***
	(0.005)	(0.007)	(0.006)	(0.004)	(0.006)	(0.006)
$\Delta Tariff \times ln(TFP)$		-0.010**	-0.010***		-0.010***	-0.006
		(0.004)	(0.004)		(0.004)	(0.004)
Fixed Effects	ict	it+ct	it	ict	it+ct	it
Other Country Level Controls	NO	NO	YES	NO	NO	YES
Observations	940119	655555	655566	940119	655555	655566
R-squared	.0429	.0455	.042	.031	.0319	.0297

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses and are corrected by clustering variables at the firm level. This table report regression results for the change in export scope using long difference sample between 2001-2006. Dependent variable is firm-destination-product (HS6) level export scopes in natural log form. $Tariff$ is computed as destination-product (HS6) specific and is calculated as the simple average of the de jure tariff. Initial firm productivity takes the estimated revenue based productivity in 2001 using Olley-Pakes methods. Both firm and destination country level control variables are the 5-year long difference between 2001 and 2006. Firm Destination-level controls include annual real GDP, CPI and physical distance between China and export destinations in natural log forms.

We further label the newly exported varieties which appear only in the sample of 2006 rather than 2001 to test whether it is the expansion of export scope drives up price in Table 6. The significant coefficients of the dummy variable for new export varieties confirms our prediction as showed in column (1), (2) and (3).

Table 6: Price of the new variety in 2006

Dependent Variable: $\Delta lnPrice$			
	(1)	(2)	(3)
Regressors			
Dum_New	0.0678***	0.346***	0.209***
	(0.0125)	(0.0125)	(0.0138)
$ln(TFP))$		0.118***	0.107***
		(0.00317)	(0.00673)
$ln(Labor)$		-0.0521***	-0.0141**
		(0.00262)	(0.00553)
$ln(Capital/Labor)$		0.0865***	0.104***
		(0.00276)	(0.00633)
HHI		1.221***	-0.850***
		(0.0711)	(0.111)
Industry FE	NO	YES	YES
Firm FE	YES	NO	NO
New Firms	NO	YES	NO
Observations	71,732	402,964	71,732
R-squared	0.238	0.237	0.209

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses and are corrected by clustering variables at the firm level. This table report regression results for the change in export unit price for new varieties using long difference sample between 2001-2006. Dependent variable is firm-destination-product (HS6) level export scopes in natural log form. $Tariff$ is computed as destination-product (HS6) specific and is calculated as the simple average of the de jure tariff. Initial firm productivity takes the estimated revenue based productivity in 2001 using Olley-Pakes methods. Both firm and destination country level control variables are the 5-year long difference between 2001 and 2006. Herfindahl index (HHI) is computed at the 4-digit CIC industry in China. Firm Destination-level controls include annual real GDP, CPI and physical distance between China and export destinations in natural log forms.

3.6 Robustness Checks

3.6.1 Pooled Sample

The observed increase of quality-unadjusted, tariff-inclusive price at the industrial level after foreign tariff reduction has multiple potential explanations. It could first be result of factor prices changes due to the process of trade liberalization along the way of foreign tariff rate reduction. Factors such as change in import tariff or increasing access to intermediate goods supply will lower the marginal cost of production, which give more room for the exporting firms to absorb tariff reduction. Therefore we look at similar specifications but using a pooled sample of all exporters from 2000 to 2005.

$$lnY_{fpct} = \beta_1 ln\tau_{pct} + \beta_2 lnTFP_{ft-1} + \beta_3 ln\tau_{pct} * lnTFP_{ft-1} + \beta_X X_{ft} + \beta_Z Z_{ct} + \delta_f + \eta_c + \sigma_s + \varepsilon_{fpct} \tag{11}$$

$$lnS_{fc} = \beta_1 ln\tau_{fc} + \beta_2 TFP_f + \beta_3 ln\tau_{fc} * TFP_f + \beta_X X_f + \beta_Z Z_c + \delta_f + \varepsilon_{fpct} \tag{12}$$

Again, we obtain similar results in Table 7 and Table 8. The coefficient of $Tariff$ is still significantly negative to product quality, and the coefficient for the interaction term is still positive. While when looking at export scope, the coefficient of $Tariff$ is still significantly positive and that for the interaction term is still negative.

Table 7: Change of the Destination Tariff Rate and Export Prices in the Destination Country, 2000-2005

Dependent Variable: $lnQuality$					
Regressors	(1)	(2)	(3)	(4)	(5)
$Tariff$	-0.257***	-0.278***	-0.211***	-0.145***	-0.090***
	(0.012)	(0.043)	(0.026)	(0.015)	(0.017)
$lnTFP \times Tariff$		0.073*	0.038***	-0.016	0.018*
		(0.041)	(0.014)	(0.011)	(0.011)
$lnTFP$		1.149***	0.198***	0.106***	0.112***
		(0.226)	(0.037)	(0.025)	(0.025)
Fixed Effects	ict	it+ct	it+ct	it	it+s
Other Country Level Controls	NO	NO	NO	YES	YES
Other Firm Level Controls	NO	NO	YES	YES	YES
Observations	2143527	282669	487532	481978	481978
R-squared	.371	.476	.0132	.354	.355

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses and are corrected by clustering variables at the firm level. This table report regression results for the change in export quality using pooled sample from 2000-2005. Dependent variable is firm-destination level export scopes in natural log form. $Tariff$ is contructed as firm-destination specific by export-value weighted country-product de jure tariff and are lagged by one period to take account of the gradual adjustment by exporting firms. Herfindahl index (HHI) is computed at the 4-digit CIC industry in China. Destination-level controls include annual real GDP, CPI and physical distance between China and export destinations in natural log forms.

Table 8: Change of the Destination Tariff Rate and Export Prices in the Destination Country, 2000-2005

Dependent Variable: $lnExportScope$					
Regressors	(1)	(2)	(3)	(4)	(6)
$lnTariff$	-0.042	-0.000	0.211***	0.201***	0.189***
	(0.048)	(0.017)	(0.018)	(0.018)	(0.016)
$lnTFP \times lnTariff$		-0.005	-0.036***	-0.036***	-0.034***
		(0.009)	(0.009)	(0.009)	(0.009)
$lnTFP$		-7.279***	0.055**	0.090***	0.079***
		(1.050)	(0.024)	(0.025)	(0.025)
Fixed Effects	ict	it+ct	it+ct	it	it+s
Other Country Level Controls	NO	NO	NO	YES	YES
Other Firm Level Controls	NO	NO	YES	YES	YES
Observatoins	444384	168159	192824	192461	192478
R-squared	.438	.554	.0484	.057	.0366

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses and are corrected by clustering variables at the firm level. This table report regression results for the change in export scope using pooled sample from 2000-2005.Dependent variable is firm-destination level export scopes in natural log form. $Tariff$ is contructed as firm-destination specific by export-value weighted country-product de jure tariff and are lagged by one period to take account of the gradual adjustment by exporting firms. $lnTFP$ is the variable that indicates a firm's initial productivity at its initial year in operation in the sample. Herfindahl index (HHI) is computed at the 4-digit CIC industry in China. Destination-level controls include annual real GDP, CPI and physical distance between China and export destinations in natural log forms.

3.6.2 Discussions

Another alternative explanation to explore is the intra-industry reallocation. Observed incomplete tariff pass-through at the industry level could be due to the intra-industry reallocation between firms with different prices. For intra-industry reallocation to explain incomplete tariff pass-through, it must be that the low-productivity firms that quit exporting in response to a tariff increase charge higher prices than the surviving exporters, so that the average industry price after the tariff increase is lower than before. Lastly, changes in the demand side also need to be cleared out. It is possible that the increased exported varieties are new inventions brought out to overseas consumers rather than existing products that start to be exported. Further checks are needed.

3.7 Conclusion

Reduction in foreign tariff induces upgrading of product quality, raising up export price. In general, we find that in response to tariff-cut by destination countries, exporting firms increase prices, upgrade product quality and expand export scope. We thus provides a novel explanation to incomplete tariff pass-through (quality-unadjusted, tariff-inclusive prices increase). The effects are significantly different across firms with different productivity: low productivity firms tend to increase prices more in regardless of horizontal differentiation level of the industry, while high productivity firms expand more in within-firm product export ladder. firms expand their export scope after trade liberalization. It is due to two effects, firstly, scope expansion will make firms start to export relatively high marginal costs goods which used to be negative profit before trade liberalization. As varieties of high marginal costs goods are exported in the market, the average price will be driven up in general. Secondly, we show that relatively larger scope expansion are from high productivity firms. As it is commonly showed in relevant literature that it is the high productivity firms export products with high quality, the relatively larger export scope expansion from high productivity firms will give rise to a great portion of high quality goods in the increasing portion of export varieties, leading to an increase of exporting prices in general.

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