Market Interdependence Through Shared Suppliers:

Theory and Evidence from Chinese Textile and Clothing Exporters

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Abstract

If trade liberalization negatively affects trade flows to non-participating countries through shared suppliers, its gains can be lower than expected. In this paper, we explore the impact of an exogenous trade policy event, the quota elimination of textiles and clothing when the Multi Fibre Arrangement expired, on China's exports to countries that never imposed import quotas. We document strong evidence in favor of market interdependence: The quota removal leads to a significant decrease in the exports of the previously-capped products to the policy-free destinations. The suppliers with dampened sales are found to be new entrants to the previously capped markets. We interpret these findings in a multi-country firm heterogeneity trade model with increasing-marginal-cost production in the short run possibly arising from fixed production inputs. The model also features endogenous sales strategies that match the empirical findings at the extensive margin. The studied circumstance highlights that gains of trade liberalization in some countries may be at the expense of the others and that the welfare changes given by canonical "sufficient statistic" may be biased.

KEYWORD: Increasing-marginal-cost, Trade policy, Welfare gains from trade.

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1 Introduction

Countries often source from the same suppliers. In canonical trade models featuring constant marginal cost, export decisions across markets are independent at the supplier level. Market independence entails that the impact analyses of trade liberalization need involve only the participating countries as long as aggregate environment maintains (Bustos (2011) on MERCOSUR; Khandelwal, Schott, and Wei (KSW henceforth) (2013) on MFA termination; Lileeva and Trefler (2010) on CUSFTA).[1] If, however, exporters produce with fixed inputs in the short run facing increasing marginal cost of production, market interdependence arises.[2] Exports to non-participants of liberalization policies can be affected. In this paper, we empirically document a negative direct effect of the elimination of an import quota system in the United States, the European Union, and Canada on trade flows of the rest of the world who share the same suppliers with them. The evidence suggests relaxing the assumption of constant marginal cost. In a stylized model with increasing marginal cost, we highlight that gains of trade liberalization in some countries may be at the expense of the others and that the canonical "sufficient statistic" in evaluating welfare changes may be biased.

In the empirical exercises, we show that a liberalization policy could affect exports to non-participating members in ways which general equilibrium effects alone may fail to justify. We take advantage of a policy event of the quota removal of textiles and clothing when the Multi Fibre Arrangement (MFA henceforth) expired. Previously under the MFA, the USA, the EU, and Canada[3] imposed import quotas on designated Chinese textile and clothing products. Meanwhile, China's exports of these MFA-capped products to the rest of the world (for example, Japan, Korea, and Mexico), referred to as the **MFA policy-free** countries in this paper, were not subject to additional policy interventions. On January 1st, 2005, all quotas were lifted by the imposing countries, representing the last but most significant stage of the phasing-out of the quotas. This within-industry set-

[1]There could be indirect effects of trade liberalization on incomes and price indices of the non-participating countries through general equilibrium effects (Caliendo and Parro, 2015). However, we focus on exporters' direct responses to trade liberalization in the non-participating countries.

[2]A currently small but growing literature has also shown evidence for market interdependence (Krishna and Kee, 2008; Almunia et al., 2018; Blum, Claro, and Hortsmann, 2013; Medina 2018).

[3]Turkey is one of the imposing countries. Due to the lack of data availability and its small share in China's total textile and clothing export, we exclude Turkey in our analysis.

ting of an earlier import quota restriction and a later elimination on some products but not others is ideal to investigate how China's exports of the previously-capped products to the rest of the world are affected by the quota system termination in the USA, the EU, and Canada. Particularly, we examine whether Chinese exporters respond to a reduced trade barrier in some markets by reallocating exports from elsewhere in the short run.

The empirical analyses unfold in three stages. In a product-country-year sample, we first estimate event-study models that show differences in exports to the MFA policy-free countries of the previously-capped and uncapped products before and after the MFA termination in 2005. These graphs allow us to carefully examine export trends in these destinations by products' quota status up to the event. Second, we perform two decomposition exercises: we decompose total exports to a product-country pair into the number of firms and average export per firm serving there. The exercise demonstrates which margin plays a more important role in reallocation. We further decompose the changes in average export per firm by incumbent exporters, entrants, and exiters using Melitz and Polanec (2015)'s methods to distinguish the response of each type to the quota removal. Third, we trace out the changes in exports to the previously-capped markets after 2005 in the sample of incumbent exporters that also sell to the rest of the world before the quota termination. Last but not least, we supplement results in the product-country-year sample with direct firm-level evidence. We study which firm ownership type reacts most strongly.

At the product-country-year level, event-study graphs show that pre-event trends of the export outcomes are parallel. The difference-in-differences estimates indicate that the quota removal leads to 19.6 log points, or equivalently 17.7% $(1 - \exp(-0.196))$, lower total exports of the previously-capped products to the policy-free countries, relative to those of the uncapped products. We include product-country and country-year fixed effects in the regressions to control for heterogeneity on these levels potentially biasing the results. Three quarters of the estimated -17.7% are driven by a relative decrease in average export per firm of the previously-capped products rather than a relative decrease in the number of firm serving the markets. The Melitz-Polanec decomposition results further imply that the average firm exports of the new entrants and exiters do not vary by the MFA event in 2005. Incumbent exporters account for most of the relative decrease in the average export per firm of the capped products. We emphasize that estimates of the MFA effects on the export outcomes of the capped products are relative to those of the uncapped ones. Though the uncapped products are presumably also affected by the event through general equilibrium effects, difference-in-differences estimates still capture the reallocation effects as long as the general equilibrium effects on the capped and uncapped textile and clothing products are symmetric. [4]

Furthermore, we find that total exports to the previously-capped product-destination pairs in 2005 are significantly larger in the sample of incumbent exporters in the policy-free countries prior to the event, relative to the exports of the uncapped ones. The MFA termination is associated with 40.3% more exporters entering the previously-capped product-destination pairs after 2005 relative to the uncapped pairs. This extensive margin contributes to the majority of the high export increase to the new markets.[5]

The firm-product-country-year level analyses exhibit very similar results. The firm-level estimates show that the MFA termination leads to relatively 6.8% lower firm-level exports of the previously-capped products to the policy-free countries after controlling for firm-product-country and year fixed effects. Besides, breaking down results by firm ownership types, we find that private domestic manufacturers respond most strongly to the quota elimination. On average, they relatively decrease exports of the previously-capped products by 10.1% (4.0% for foreign-invested enterprises and 6.4% for state-owned enterprises) compared to the firm-level exports of the uncapped products.

The above product-country- and firm-level results on the differential effects of the MFA quota removal by products' quota capped status are hard to reconcile by the general equilibrium effects alone in a canonical trade model with constant marginal cost. We illustrate by considering two scenarios: (i) Any quota termination-induced general equilibrium effects on market aggregates of the rest of the world, such as expenditures or price indices, should affect trade flows of the previously-capped and uncapped products uniformly;[6] (ii) Within-industry wages and prices of intermediate inputs reequilibrate after the MFA event takes place. Given the MFA-capped and uncapped products belong to

[4]One general equilibrium effect associated with the MFA quota removal would be wage increase in China for both previously-capped and uncapped products, as the demand for output products increases.

[5]Our findings comply with the results in KSW (2013) in which they show that more productive new entrants export to the previously-capped product-destination pairs after the MFA quota removal in 2005.

[6]In 2005, the USA, the EU, and Canada diverted product sourcing from the MFA policy-free destinations to China, due to the decreased trade barriers with China. The fierce competition introduced by the entry of the Chinese products in the previously-capped markets indirectly affects the MFA-free countries through aggregate income or price indices there

a close-knit product family under any Harmonized System (HS henceforth) 4-digit codes, changes in input prices should not affect the marginal costs of the products differently. In summary, the exports of the previously-capped and uncapped products should not exhibit differential export growth trends after the quota removal in the rest of the countries in a canonical trade model with constant marginal cost, even when one allows general equilibrium effects to operate.

Therefore, to rationalize the above empirical patterns, we develop a multi-country firm heterogeneity model with *increasing marginal cost* of production. This framework deviates from the current workhorse firm heterogeneity models (Melitz, 2003; Eaton, Kortum, and Kramarz, 2011; Arkolakis, Costinot, and Rodríguez-Clare, 2012) that usually assume constant marginal cost. The increasing-marginal-cost assumption is motivated by facts that the production of textiles and clothing relies heavily on costly machinery and specific inputs and that the scope of timely adjustment in the short run is limited. The proposed model endogenizes firms' decisions on their *sales strategies*, the set of countries they serve, and their sales to each destination conditional on their strategies. Based on the characterized optimal decisions, we study theoretical implications on the impact of the MFA quota removal on firms' export behavior.

Our main theoretical result implies that the MFA termination, modelled as a reduction in bilateral trade costs to the previously-capped markets, induces exporters to decrease their exports to the policy-free destinations if selling, the intensive margin, or to exit those destinations, the extensive margin. The key mechanism is as follows: The removal of the quotas induces entry into new export destinations and increases firms' global market access. As a result, output expands, and marginal cost of production rises. In equilibrium, prices rise in the policy-free countries, dampening sales.[7] More colloquially, we describe a situation in which firms allocate limited production inputs to serve multiple destinations. To fulfill the expanding demands in particular destinations, in our context the USA, the EU, and Canada in 2005, firms have to decrease export sales elsewhere relative to the unaffected products.

Our framework combined with empirical evidence indicate welfare implications dif-

[7]In our production framework, the average cost of production is proportional to the marginal cost. Due to the assumptions of CES demand and the monopolistic competition market structure, price is proportional to marginal cost. Therefore, there is a monotonic relation between the average cost of production and the optimal price.

ferent from the ones generated by models with constant marginal cost. In a framework with increasing marginal cost, expansion in some destinations caused by a liberalization policy is achieved at the expense of the non-participating countries. If the interdependence is not accounted for, the welfare analysis of the policy would be incomplete. Moreover, we build on Arkolakis, Costinot, and Rodríguez-Clare (2012) and derive a welfare statistic with an adjustment term capturing the global trade connections through shared suppliers. The absence of such an adjustment term may lead to biased estimates of welfare changes.

This paper makes three contributions to the literature. First, we document clear evidence on firm export reallocation across destinations in response to a policy event that affects some products and countries but not others. We propose a framework with increasing-marginal-cost production to rationalize the observations. While Krishna and Kee (2008) and the contemporaneous Almunia et al. (2018) directly examine relationships of sales across destinations, or of domestic versus export sales at the firm level, we exploit the MFA quota removal in 2005 by the USA, the EU, and Canada, which is presumably exogenous to decisions of Chinese exporters.

Second, under proposed assumptions, we characterize the changes in firms' sales strategies and exports to different destinations when a policy event takes place. This paper is in a similar vein with what KSW (2013) concludes on the outstanding role played by the extensive margin of entry to the previously-capped market, but it differs from Almunia et al. (2018) that abstracts away export participation decisions in a model featuring increasing-marginal-cost production as well.

Third, our analyses suggest spillover effects in welfare through shared suppliers with inflexible adjustment in inputs in the short run. The production assumption directly leads to interdependence among markets that is otherwise absent in the canonical models. The welfare gains of some countries brought by a trade policy may be at the expense of the others. Moreover, we derive a welfare statistic built on Arkolakis, Costinot, and Rodríguez-Clare (2012) that incorporates the increasing-marginal-cost assumption. In a nutshell, the observed changes in domestic trade shares in the trade data, together with trade elasticity, is no longer sufficient to evaluate the welfare changes. Accounting for the changes in the marginal cost due to changes in firms' global market access is essential in the new sufficient statistic of welfare changes.

This paper also relates to a broad literature on trade diversion (Viner, 1950; Panagariya, 2000). Trade diversion usually refers to a situation in which a country diverts its imports to trade bloc partners from trade partners outside the bloc when a trade agreement is established. Brambilla, Khandelwal, and Schott (BKS henceforth) (2010) studies the trade diversion of the MFA termination from the standpoint of the USA and identifies the winner (diverted to) and loser (diverted from) countries. We take a different perspective: We study the optimal export decisions at the Chinese supplier level in response to the quota system termination. This paper documents how a country diverts or reallocates its exports across destinations in response to a policy change.

The rest of the paper is organized as follows. Section 2 introduces the background of the Multi Fibre Arrangement , discusses the data, and presents our empirical identification strategy. Section 3 reports the difference-in-differences estimates and discusses implications of our results. Section 4 details our model setup and characterizes firms' optimal decisions. Section 5 explores the welfare implications. Section 6 concludes.

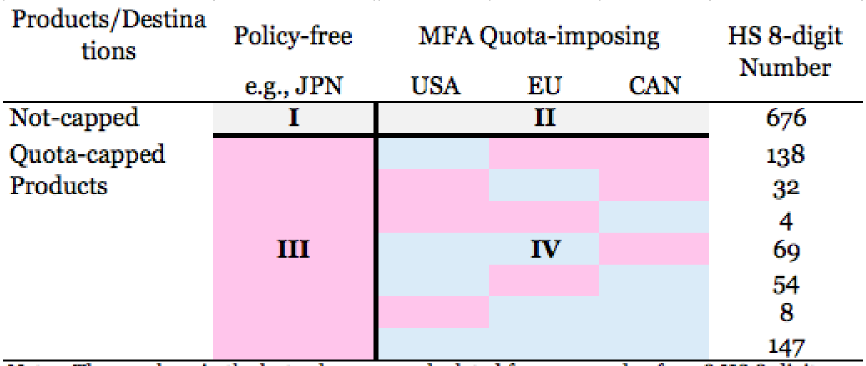
2 Export Reallocation

2.1 Background: Multi Fibre Arrangement Termination in 2005

In this section, we briefly discuss the institution of the Multi Fibre Arrangement, its relevance to the Chinese textile and clothing industries, and its termination in 2005.

From 1974 till 2005, trade of textile and clothing from developing countries to the developed world is mainly regulated by the Multi Fibre Arrangement through a quota system. As depicted in Figure 1, the USA, the EU, and Canada imposed import quotas on a set of refined HS 8-digit product codes (Area IV). These restricted products accounted for approximately 40% of all Chinese export products during 2002-2004. KSW (2013) uses the variations in the product-country pairs in area IV to identify the effects of the quota system termination on China's exports to these previously-capped markets. We take a different perspective from theirs and focus on the rest of the world. The MFA policy-free countries imposed no quotas on the textile and apparel products, and had been sourcing products from China that were either subject to quota caps in the USA, the EU, Canada, or not at all (Area I and III in Figure 1) in the past. Our analyses on the effects of the MFA termination on China's exports of the previously-capped products depend precisely on the variations in products' quota-capped status in Area I and III. As long as the general equilibrium effects of the event that affect the policy-free countries are symmetric to the previously-capped and uncapped products, contrasting exports of the capped ones against those of the uncapped provides a design to identify reallocation effects induced by the quota lifting.

Figure 1: MFA Quota Policy: Variations in Products and Countries



Notes: The numbers in the last column are calculated from a sample of 1128 HS 8-digit product codes in Chinese export transaction database from 2002-2004. The number in each row represents the number of HS 8-digit product codes that satisfy the quota-imposing combination of countries.

In 1995 and 1998, the MFA underwent two stages of phasing out import quotas. China was ineligible for quota reductions until 2002 when it entered the WTO, during which quotas in the previous stages were lifted at the same time. On January 1st, 2005, the Multi Fibre Arrangement officially expired, and all the rest of the quotas were removed. The termination had significant impacts in both the number and the range of products affected: 40% of all HS 8−digit products experienced quota elimination; within an average 4−digit product code, approximately 36.5% of the 8−digit product subcategories were affected. This also means that the previously MFA-capped and uncapped products belong to a close-knit product family within an HS 4-digit code. China reacted more strongly to the MFA quota removal than any of the other developing countries (for example, Bangladesh, Indonesia, and Vietnam): its export quantities to the United States alone in the previously quota-capped products jumped 270 percent in the year 2005 alone (BKS 2010). We refer the audience to BKS (2010) and KSW (2013) for a more thorough discussion on the Multi Fibre Arrangement.

2.2 Data and Main Variables

Our analysis samples are drawn from the universal firm-product-country-year level transactions from the Chinese Customs Database. Any export or import products are recorded at the HS $8-$digit level. The sample includes all textile and clothing exporters in China over the years 2002 to 2007. We delete all transactions reported under processing purposes or through a trade intermediary, as their optimization problem may not be standard. This restricts the sample to have $2,641,857$ firm-product-country-year observations. We conduct and report results on both a firm-product-country-year level and a more aggregate product-country-year level. The latter sample leaves us with $246,795$ observations.

To identify whether an HS $8-$digit product code was once on any quota lists in the MFA-imposing countries, we rely on the definition and data compiled and used in KSW (2013). In their paper, the quota-bound status[8] is defined on a product-country pair, the level of the policy treatment, among the MFA-imposing countries (Figure 1 Area IV). We define our key variable of interest, *quota-capped*, as 1 if an HS 8-digit product whose imports were capped in any of the USA, the EU, or Canada between 2002 and 2004. Since the quota status differs only across products, this definition relates to our analyses better. The main outcomes of interest include total exports to a product-country market, number of firms, and average export per firm serving the market. In the firm-level analyses, we examine firm-level exports and the number of destinations penetrated as our outcomes.

2.3 Identification: A Different-in-Differences Model

The core of our empirical strategy is difference-in-differences. We use variations in the quota status, whether previously-capped by the MFA-imposing countries, and years before and after 2005 to identify the effects of the MFA quota removal on export outcomes to the policy-free destinations. The validity of the difference-in-differences identification strategy hinges on the parallel pre-trends assumption. That is, the outcomes of the quota-capped and uncapped products do not differ significantly prior to the MFA termination event, suggesting that exporters do not react significantly to the event before it takes place. We test this assumption by directly showing event-study estimates of coefficients on the three periods before the event interacted with products' quota status.

[8]"Quota-bound" status is precisely the name of the variable that KSW used in their paper.

Additionally, we contrast exports to the previously-capped markets and uncapped markets in the USA, the EU, and Canada periods before and after 2005 in a matched sample of incumbent exporters who serve the rest of the world prior to the termination. Since the lifting is operated at the product-country level by the MFA-imposing countries, we adopt the identification strategy in KSW (2013) [9] to show differential export performances by quota-capped and uncapped product-destination combinations. Due to precisely the nature of the MFA, the export pre-trends of the quota-capped and uncapped product-country pairs should not be parallel. This exercise aims to descriptively support the hypothesis that incumbent exporters who serve multiple countries reallocate sales to compensate for demand expansions in the newly opened markets in 2005.

We estimate and report results using both product-country-year variations and firm-product-country-year variations. The latter firm-level observations allow us to control for firm-product-country and year fixed effects, taking out heterogeneity across firms that may bias the results.

Product-Country-Year Variations in Policy-free Destinations

Let y_{hct} denote outcomes of interest at the product(h)-country(c)-year(t) level, which we call markets. Our baseline analyses estimate coefficients of the time period indicators $\left\{\mathbb{1}\{t = 2005 + \tau\}\right\}_\tau$ interacted with the quota-capped status associated with three regression outcomes: total export sales to a market, total number of firms serving that market, and average export per firm to that market. The outcomes pertain to the **policy-free** countries only, and we take logs of the outcomes. The event-study specification takes the form:

$$\begin{aligned} y_{hct}^{\text{policy-free}} &= \overbrace{\sum_{\tau=-3}^{\tau=2} \boldsymbol{\beta_\tau} \mathbb{1}\{t = 2005 + \tau\} \times b_h}^{\text{interaction term}} + \\ &+ \sum_{\tau=-3}^{\tau=2} \alpha_\tau \mathbb{1}\{t = 2005 + \tau\} \\ &+ \alpha_b b_h + \delta_{hc} + \epsilon_{hct} \end{aligned} \tag{1}$$

We start the analyses in a more aggregate sample. Product-level quota status $b_h = 0$

[9] KSW (2013) uses the full sample of all exporters while we condition on the exporters who sell to the policy-free destinations. Moreover, KSW (2013) excludes the cases in which all countries, USA, the EU, and Canada, imposed the quotas. We instead preserve these variations in our sample.

and $b_h = 1$ respectively indicates whether imports of the HS 8-digit product were restricted by quotas in any imposing countries prior to 2005 and later than 2002. In compliance with KSW (2013), we focus on estimating the effects of the last, but most significant, stage of the quota phasing-out, and therefore, we restrict the analyses to the products whose quotas were eliminated only in the last stage. b_h does not vary over time in the policy-free countries. We estimate and plot β_τs for each $\tau \in \{-3, -2, -1, 0, 1, 2\}$, and we normalize β_{-1} to be 0. In all regressions, we control for product-country fixed effects δ_{hc}.

In addition to the event-study style model, our main difference-in-differences specification takes the form:

$$\begin{aligned} y_{hct} &= \beta \mathbb{1}\{b_h = 1\} \times \mathbb{1}\{t \geq 2005\} \\ &\quad + \gamma_0 \mathbb{1}\{b_h = 1\} + \gamma_1 \mathbb{1}\{t \geq 2005\} \\ &\quad + \delta_{hc} + \delta_{ct} + \epsilon_{hct} \end{aligned} \tag{2}$$

The parameter of interest in equation (2) is β that estimates the effects of the MFA quota removal on total exports of a market, number of firms, and average export per firm serving there in the policy-free countries only. We control for product-country and country-year fixed effects, δ_{hc} and δ_{ct}, in these regressions.

To be more precise on responses of the extensive and/or intensive margin to the MFA termination, we decompose the changes in average firm exports into three subgroups of firm types: incumbents ($\mathbb{S}$), entrants ($\mathbb{E}$), and firms that exit ($\mathbb{X}$). Using methods in Melitz and Polanec (2015), we show that the changes in average firm exports ($\bar{y}_2 - \bar{y}_1$) between any two consecutive years ($t = 1, 2$) and contrast the differences by products' quota-capped and uncapped status ($b_h \in \{0, 1\}$). Take the uncapped products, $b_h = 0$, as an example, the decomposition follows:

$$\begin{aligned} \Delta y_2 &= \bar{y}_2 - \bar{y}_1 \\ &= \Big(\sum_{j \in \mathbb{E}} y_{j2} + \sum_{j \in \mathbb{S}} y_{j2}\Big)\frac{1}{N_2} - \Big(\sum_{j \in \mathbb{S}} y_{j1} + \sum_{j \in \mathbb{X}} y_{j1}\Big)\frac{1}{N_1} \\ &= \underbrace{\frac{N_{\mathbb{E}2}}{N_2}(\bar{y}_{\mathbb{E}2} - \bar{y}_{\mathbb{S}2})}_{\text{Entrants}} + \underbrace{\frac{N_{\mathbb{X}1}}{N_1}(\bar{y}_{\mathbb{S}1} - \bar{y}_{\mathbb{X}1})}_{\text{Exiters}} + \underbrace{(\bar{y}_{\mathbb{S}2} - \bar{y}_{\mathbb{S}1})}_{\text{Incumbent}} \end{aligned} \tag{3}$$

N_1, N_2 denote the total number of firms in beginning period $t = 1$ and end period $t = 2$, and the subscripts $\{\mathbb{S}, \mathbb{E}, \mathbb{X}\}$ reflecting the subcategory to which each firm belongs. We then use the decomposed changes for incumbents, entrants, and firms that exit in equation (3) as outcomes of interests, $y_{hct}^{\text{policy-free}}$, and estimate event-study models contrasting their respective changes by quota-capped status before and after 2005.

Firm-Product-Country-Year Variations in Policy-free Destinations

To supplement the product-country-year results, we show event-study estimates of the effects of the quota elimination in the firm-product-country-year sample. This disaggregated data set allows us to control for firm-level heterogeneity and to show directly firm-level evidence of intensive margin reactions after firm-product-country fixed effects are controlled for. The firm-level specification bears a close resemblance to equation (1):

$$\begin{aligned} y_{fhct}^{\text{policy-free}} &= \overbrace{\sum_{\tau=-3}^{\tau=2} \boldsymbol{\beta}_{\boldsymbol{\tau}} \mathbb{1}\{t = 2005 + \tau\} \times b_h}^{\text{interaction term}} \\ &+ \sum_{\tau=-3}^{\tau=2} \alpha_\tau \mathbb{1}\{t = 2005 + \tau\} \\ &+ \alpha_b b_h + \delta_{fhc} + \epsilon_{fhct} \end{aligned} \tag{4}$$

Subscript f indicates a firm f. $y_{fhct}^{\text{policy-free}}$ is the firm-product-country-year logged export sales in value in the policy-free countries. δ_{fhc} indicates firm-product-country fixed effects, which control for demand or productivity shocks on that level that may potentially bias the results. The estimates in equation (4) should render a more similar result to the estimated effects on average export per firm in the product-country-year sample.

Product-Country-Year Variations in MFA-imposing Countries

Lastly, we study the export changes to the previously-capped markets in the sample of incumbent exporters serving the rest of the world before the quota removal as well. The specification we run is:

$$\begin{aligned} y_{hct}^{\text{Imposer}} &= \sum_{\tau=-3}^{\tau=2} \tilde{\boldsymbol{\beta}}_{\boldsymbol{\tau}} \mathbb{1}\{t = 2005 + \tau\} \times \tilde{b}_{hc} + \\ &+ \sum_{\tau=-3}^{\tau=2} \tilde{\alpha}_\tau \mathbb{1}\{t = 2005 + \tau\} \\ &+ \tilde{\alpha}_{\tilde{b}} \tilde{b}_{hc} + \delta_{hc} + \epsilon_{hct} \end{aligned} \tag{5}$$

Since at the MFA-imposing countries, the policy operates at the product-country (hc) level. We indicate a previously-capped market, $\tilde{b}_{hc}$, as 1 if country c among the USA, the EU, and Canada imposed import quotas on product h; 0 otherwise. The parameters of interests are $\tilde{\beta}_\tau$s that track the relative differences in the exports to the previously-capped markets associated with the MFA termination. If the incumbent Chinese exporters reallocate sales from the rest of the world to the newly liberalized markets in 2005, we would expect their exports of the previously-capped product-country pairs increased more dramatically relative to those of the uncapped pairs.

3 Empirical Results

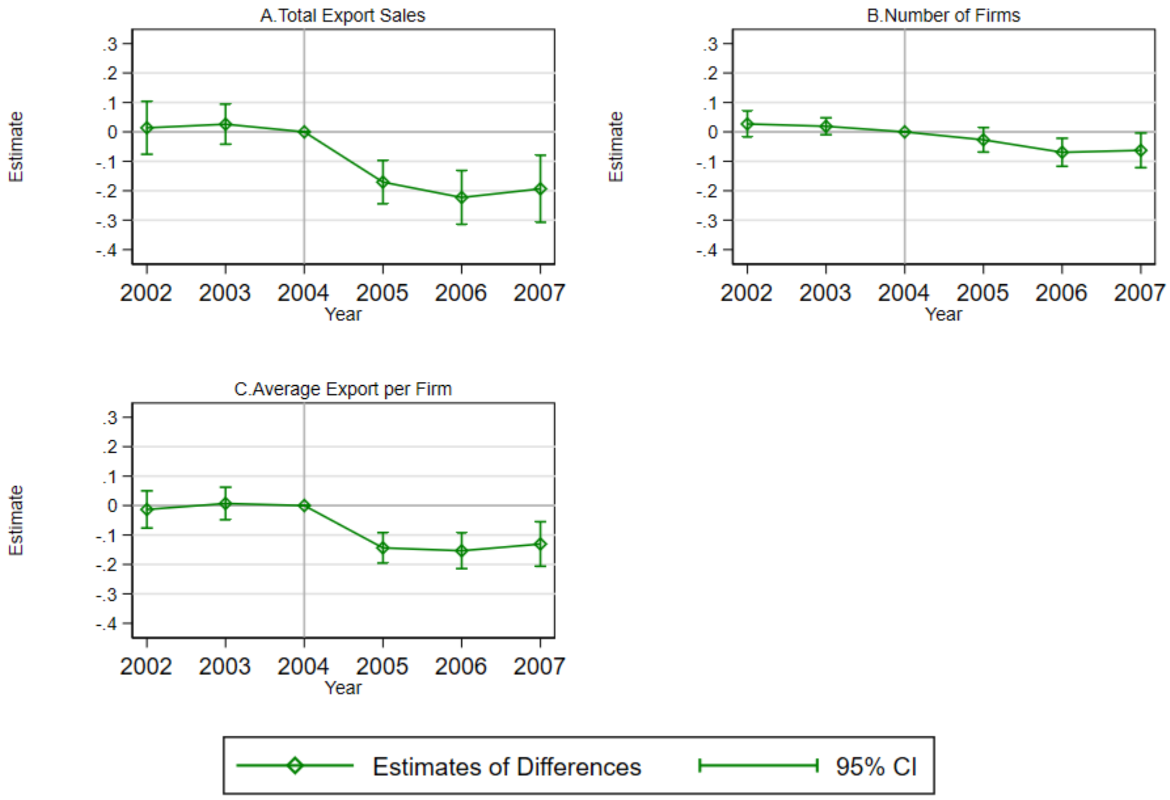
3.1 Product-country-year Level Evidence

This section discusses the results of event-study style models and difference-in-differences estimates in the product-country-year sample. Figure 2 reports estimates of the coefficients of period indicators β_τs interacted with the quota-capped status variable. The outcomes of interest are (A) total exports at the product-country level, (B) total number of firms serving the market, and (C) average export per firm.

Several findings stand out. First, in policy-free destinations, pre-event trends (i.e., 2002-2004) of all three export outcomes are relatively parallel after product-country fixed effects are controlled for. That is, we do not find statistically significant differences in the growth of the outcomes by quota-capped and uncapped products before the quota elimination in 2005. Second, relative to the exports of the uncapped products, the exports to the policy-free countries of the quota-capped products respond strongly to the MFA termination in 2005. We see that the MFA termination is associated with -17.7 log points, or equivalent 15.6%, lower total exports of the previously-capped products to the policy-free countries in 2005 alone, relative to the exports of the uncapped products. The estimates of the effects are -19.9% and -17.6% respectively in 2006 and 2007. Third, we decompose the Chinese exporters' total export value to any product-country pairs into two terms: the number of firms serving the markets; and the average export per firm (Figure 2 Panel B and Panel C). Mechanically, the coefficients of the interaction terms in Panel A are the respective sum of the coefficients in Panel B and C. Therefore, we find that the relatively lower total exports of the previously-capped products caused by the

MFA termination are driven more by the relatively lower average firm exports than the net number of firms entering and exiting the markets. On average, the average export per firm contributes to over 70% of the relatively lower total exports during the three years after the MFA termination.

Figure 2: Event Study Estimates of the MFA Quota Removal



Product-country-year sample. MFA Policy-free countries only. Outcomes are logged.

To supplement the results of the event-study models in Figure 2, Table 1 reports the estimates of the effects of the MFA quota removal βs in equation (2) in the product-country sample. For each outcome, we run specifications that control for product-country fixed effects only and specifications that also control for country-year fixed effects. When compared across Columns (1) to (6), the two sets of fixed effects essentially show very similar results, which suggests that the country-year level aggregate shocks do not account for observed effects of the quota removal after we take out product-country fixed effects. Using our favored specifications in Columns (2), (4), and (6), we see that the quota removal in 2005 leads to 19.6 log points, equivalently 17.8%, decrease in total exports of the quota-capped products to the policy-free destinations, relative to those of the uncapped products. This result is statistically and economically significant. Moreover, three quarters of the estimated effects are attributed to 13.8 log points, equivalent to 12.9%, decrease in the average firm export size of those selling quota-capped products (Column (6)). The rest one quarter of the effects, shown in Column (4), is contributed by the decreased number of firms serving there: 5.8 log points (5.6%).

Table 1: Difference-in-differences Estimates of Effects of Quota Removal in the MFA Policy-free Destinations

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	log(export sales)		log(number of firms)		log(ave. sales per firm)	
Quota-capped* Post 2005	-0.197***	-0.196***	-0.059**	-0.058**	-0.138***	-0.138***
	(0.047)	(0.048)	(0.028)	(0.029)	(0.028)	(0.028)
Product-country FEs	Yes	Yes	Yes	Yes	Yes	Yes
Country-year FEs		Yes		Yes		Yes
Number of Obs.	180,133					

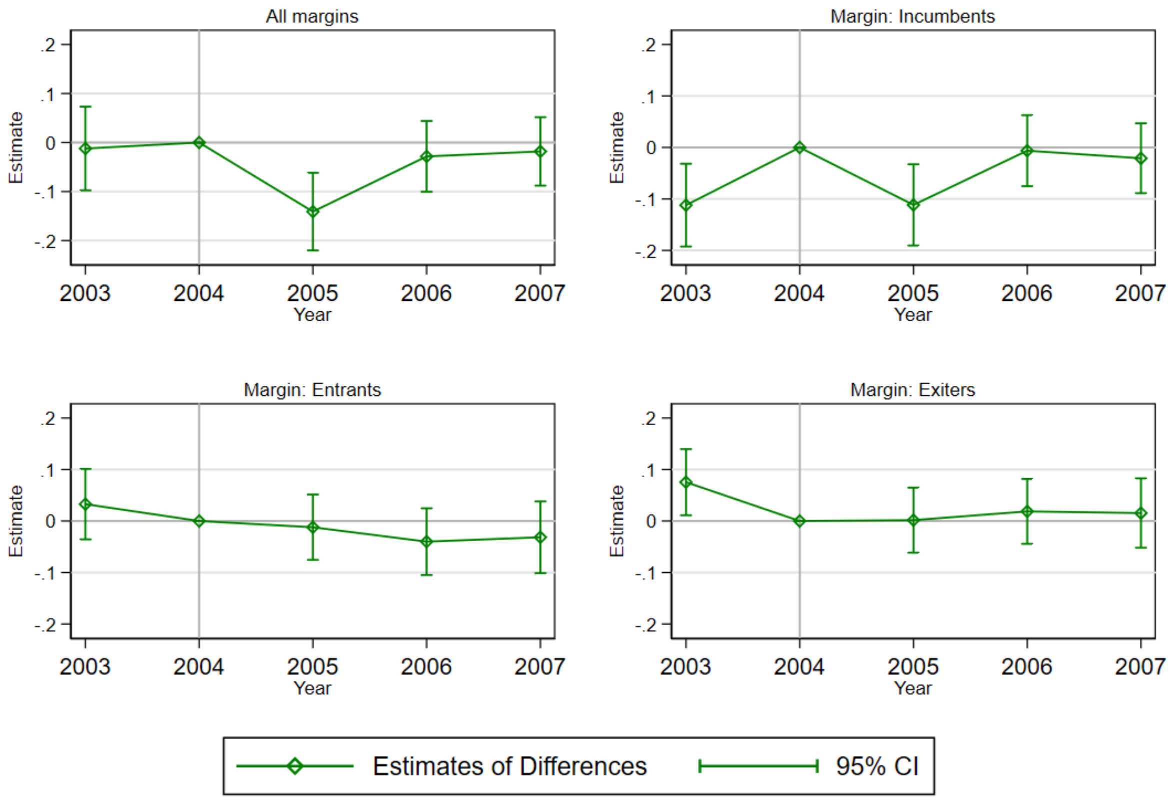
Notes: This table documents estimates of regressions in a product-country-year sample from Chinese Customs database. The sample covers from the year 2002 to 2007 and is further restricted to policy-free destinations only. The estimates are from regressions of outcomes on products' quota-capped status, post-2005 dummy, and the interaction term of the two. Quota-capped status is equal to 1 if a product is on any quota lists in the MFA policy-imposing countries (the USA, the EU, and Canada). Fixed effects are respectively controlled for as specified. This table reports estimates of coefficients on the interaction terms. Estimates are clustered at the product level.

3.2 Decomposition of Changes in Average Export per Firm in Policy-free Countries

To be more precise on the intensive/extensive margin of the effects of the MFA termination in 2005 on the changes in average export per firm (Figure 2 Panel C), we decompose the changes into three subgroups: incumbent exporters serving a product-country market, new entrants to the market, and firms that exit the market. Details of the decomposition method are discussed in section 2.3. Figure 3 shows the results by firm subgroups.

When we include all firms, Figure 3 panel "All margins" reports the same results as that in Panel C Figure 2. When the results are decomposed by firm subgroups, we find that the relative decrease in average export per firm of the previously-capped products is driven by a significant change among the incumbent exporters: The MFA quota removal is associated with 9.5% lower average export per firm in 2005 among the incumbents selling to the policy-free countries. Notwithstanding the dips in 2005 in the panel "Incumbents", the bottom row of Figure 3 suggest that firms that either newly enter or recently exit the markets in 2005 (Panels: "Entrants" and "Exiters') are not significantly different from their earlier cohorts before the event. These results suggest that the MFA quota elimination does not elicit different responses from the firms at the extensive margin.

Figure 3: Decomposition of Changes in Average Export per Firm



Product-country-year sample. MFA Policy-free countries only.

The combined results in Figure 2 and 3 pull against a mere competition-by-entrants story one may craft to explain the empirical patterns observed. If market sales of the incumbent exporters are competed away by productive new entrants to the policy-free markets that particularly entered in response to the MFA event, we would expect to find significant changes in either the number of firms serving the policy-free markets or the average export size of these new entrants in 2005. We also do not find significant changes in the average size of the firms that exit these policy-free product-countries. We feel that a competition-by-entrants theory perhaps is not sufficient to account for the relatively lower total exports and average export per incumbent of the capped products to the countries that never impose quota barriers on Chinese products.

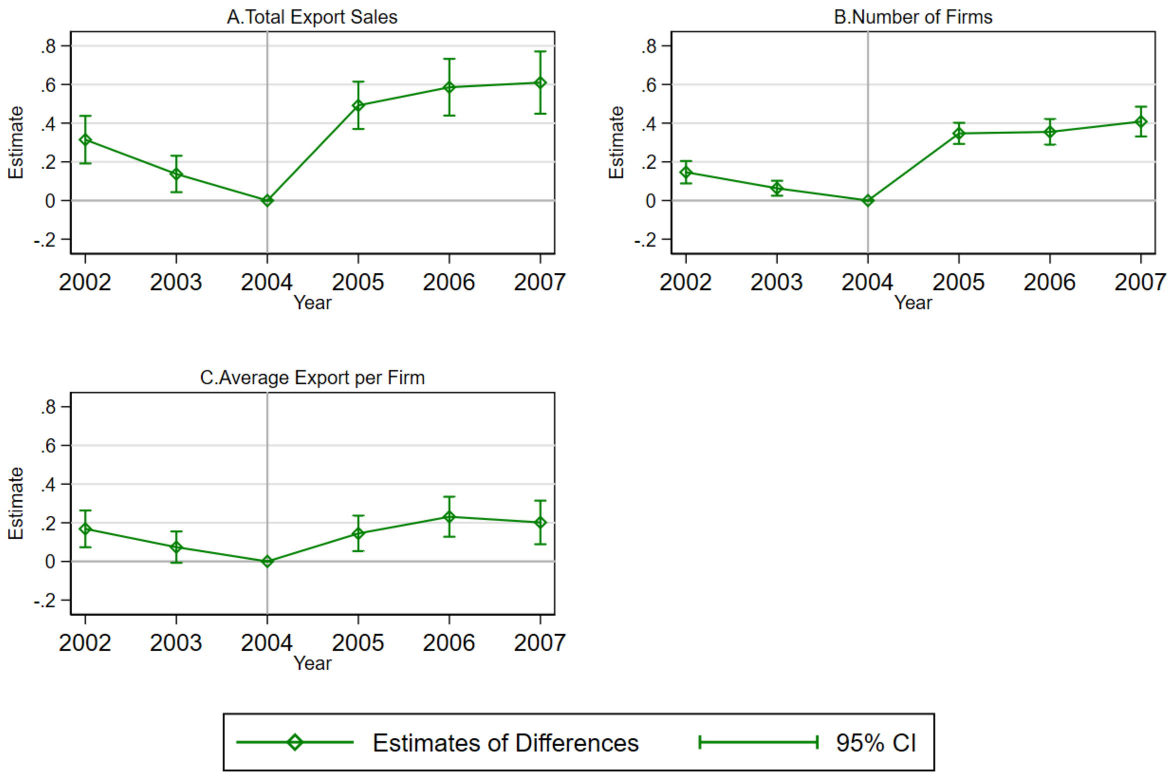
3.3 Exports to the USA, the EU, and Canada in the Sample of Matched Incumbent Exporters

We report changes in export outcomes to the MFA quota-imposing destinations, the USA, the EU, and Canada, before and after the MFA termination by previously-capped and uncapped product-country pairs. We restrict to the *matched* sample of incumbent exporters serving the policy-free countries prior to 2005 so that we exclude the export increase contributed by new entrants to any export markets.

Several observations in Figure 4 stand out. First, total exports of the previously-capped product-country markets increase significantly at the year of the quota removal, relative to those of the uncapped. In 2005 alone, The MFA termination leads to 50% higher exports to the previously-capped markets. Second, the extensive margin, measured by the total number of firms, contributes to the majority of the higher exports to the previously-capped markets. Third, the pre-trends of the export outcomes before the quota removal takes place are statistically different for the previously-capped and uncapped markets. The differential pre-trends should not be so surprising given the nature of the policy: Before 2004, the uncapped products had a higher export growth rate than the previously-capped ones. After 2005, the trends reversed after all markets became accessible to all Chinese exporters.

Table 2 documents and quantifies the reallocation results. The matched sample of incumbent exporters who serve the policy-free countries increase the total exports to the previously-capped product-destinations by 43.7 log points, or equivalently 54.8% relative to those of the uncapped. The estimated 54.8% is driven mostly by the increased number of Chinese manufacturers serving these markets: 40.3% more exporters serving the previously-capped markets than those serving the uncapped.

Figure 4: Event Study Estimates by Products' Quota-applied Status at the Policy Markets



Product-country-year sample. Matched sample of firm-product before 2005 in policy-free destinations. Outcomes are logged.

3.4 Firm-level Evidence

Response by Ownership. Firm-level Evidence

This section aims to supplement the product-country level analyses with direct firm-level results on export reallocation. In a balanced sample of firm-product-country-year observations, after controlling for firm, product-country, and year fixed effects, we show whether exports of the previously-capped products to the rest of the world would relatively decrease, compared to the exports of the uncapped products. In addition, we define three ownership types: (i) state-owned enterprises (SOE), (ii) privately-owned domestic firms, and (iii) foreign-invested enterprises (FIE). The state-owned enterprises are the firms that are invested with state capital. Privately-owned firms are further categorized as domestically-funded or invested by foreign corporations. We disentangle which ownership types respond to the MFA termination through reallocation most strongly.

Table 2: Difference-in-differences Estimates of Effects of the Quota Removal at Product-Country Level in Quota-imposing Destinations

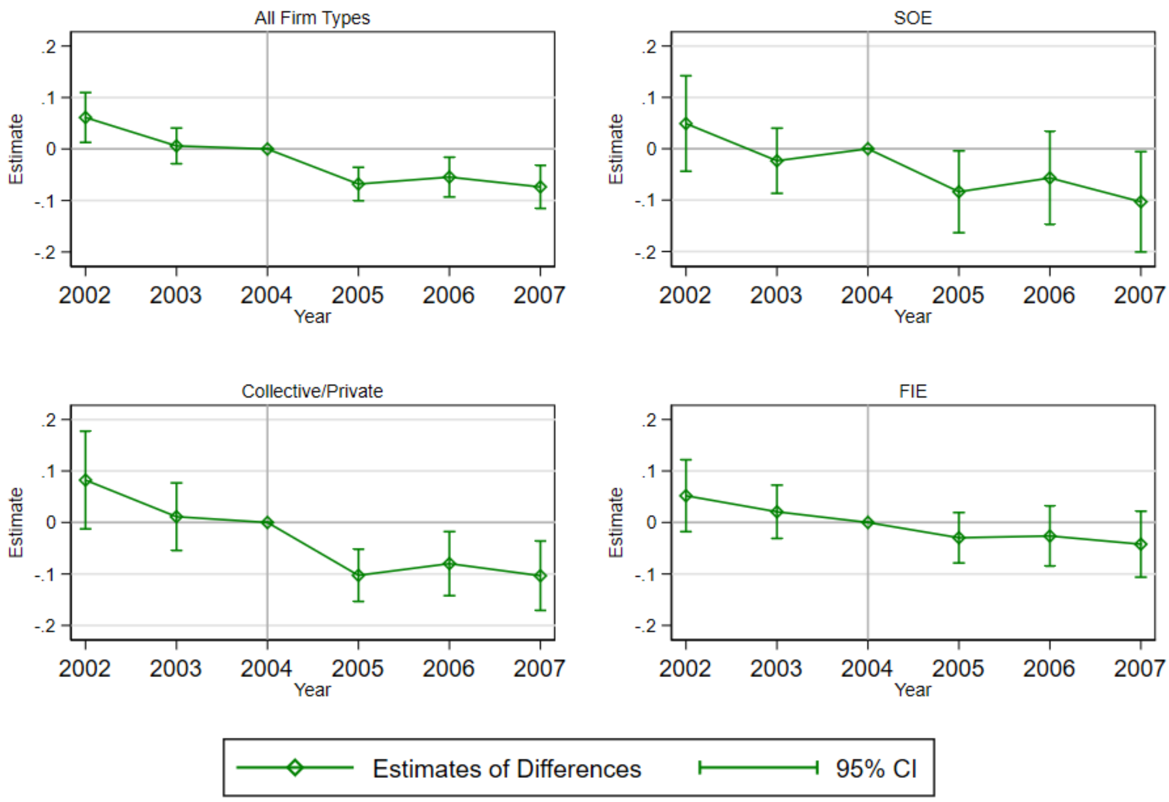
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	log(export sales)		log(number of firms)		log(ave. sales per firm)	
Quota-capped* Post 2005	0.406***	0.437***	0.317***	0.339***	0.089**	0.098**
	(0.070)	(0.075)	(0.040)	(0.044)	(0.040)	(0.041)
Product-country FEs	Yes	Yes	Yes	Yes	Yes	Yes
Country-year FEs		Yes		Yes		Yes
Number of Obs.				56,720		

Notes: This table documents estimates of regressions in a product-country-year sample from Chinese Customs database from 2002 to 2007. The sample is restricted to incumbent exporters who sell to policy-free destinations in that year. The outcomes of interest are export sales, number of exporters, and average export sales per firm in the MFA-imposing destinations (the USA, the EU, and Canada). The estimates are from regressions of outcomes on products' quota-capped status, post-2005 dummy, and the interaction terms of the two. Quota-capped status at the product-country level is equal to 1 if a country imposes an import quota restriction on a product. Fixed effects are respectively controlled for as specified. This table reports estimates of coefficients on the interaction terms. Estimates are clustered at the product level.

Figure 5 shows the event-study difference-in-differences estimates in a balanced firm-product-country sample. Including all firms, we find that the MFA termination in 2005 alone leads to about 6.5% relative decrease in the firm-level exports of the previously-capped products to the policy-free countries. This result is smaller but similar to the estimated -10% found in the product-country-year sample regression of average export per firm as the outcome in 2005 alone. Table 3 Column (2) reports the average effects in a difference-in-differences framework: the MFA termination is associated with 7.1 log points, or equivalent 6.8% lower firm-level exports of the previously-capped products to the rest of the world.

Moreover, both Figure 5 and Table 3 show that different ownership types react to the MFA termination differently. We find that on average the privately-owned domestic firms decrease the most in their relative exports of the previously quota-capped products: approximately 9.6% in the year of the quota removal and an average 10.1% across three years after the termination (Table 3 Column (6)). Among SOEs, the firm-level exports of the previously-capped products are about 6.5% lower relative to the exports of the uncapped after 2005 (Table 3 Column (4)). This estimate is 4% among the foreign-invested enterprises (Table 3 Column (8)). This last effect is economically small and statistically

Figure 5: Event Study Estimates of the MFA Quota Removal at Firm Level



Firm-Product-country-year sample. MFA Policy-free countries Only. Outcomes are logged.

insignificant. The different reactions by firm ownership seem to indicate that the level of credit constraints perhaps plays a crucial role in explaining the export reallocation we document in this paper. Compared to the SOEs and FIEs who are either funded through the Chinese government or foreign investors, privately-owned domestic firms are likely more constrained financially in supporting the same degree of production adjustments that SOEs and FIEs could entertain.

4 A Model with Increasing Marginal Cost

The empirical difference-in-differences results show that ***relative to*** the exports of the quota not-capped products, exporters react to the quota removal in the US, the EU, and Canada by decreasing their exports of the previously quota-capped elsewhere to satisfy the demands in the new markets.

Table 3: Difference-in-differences Estimates of Effects of Quota Removal at Firm Level in the MFA Policy-free Destinations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	All firms		SOE		Collective/Private		FIE	
Quota-capped* Post 2005	-0.072***	-0.071***	-0.076**	-0.067*	-0.107***	-0.107***	-0.042	-0.041
	(0.027)	(0.026)	(0.038)	(0.038)	(0.035)	(0.035)	(0.031)	(0.030)
Firm-product-country FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-year FEs		Yes		Yes		Yes		Yes
Number of Obs.	1,804,798		328,972		787,989		570,191	

Note: This table documents estimates of regressions in a firm-product-country-year sample from Chinese Customs database. The sample covers from the year 2002 to 2007 and is further restricted to policy-free destinations only. Estimates by three different ownership types are also reported. The estimates are from regressions of outcomes on products' quota-capped status, post-2005 dummy, and the interaction term of the two. Quota-capped status is equal to 1 if a product is on any quota lists in the MFA policy-imposing countries (the USA, the EU, and Canada). Fixed effects are respectively controlled for as specified. This table reports estimates of coefficients on the interaction terms. Estimates are clustered at the product level.

The canonical trade models (Melitz, 2003; Eaton, Kortum, and Kramarz 2011; Arkolakis, Costinot, and Rodríguez-Clare 2012) featuring constant marginal cost in production imply that markets are independent at the firm level. Therefore, policy-induced demand shocks in some destinations should not directly affect firms' exports to other destinations. Furthermore, given the MFA quota-capped and uncapped products belong to a close-knit product family under any HS 4-digit product codes, the general equilibrium effects through domestic wage increase should not't expect to affect the products differently. Therefore, general equilibrium effects alone in a constant marginal cost framework seems insufficient to justify the difference-in-differences estimates on exports across refined HS 8-digit products.

We develop a multi-country heterogeneous firm trade model featuring increasing marginal costs to capture the empirical regularities. This production assumption is motivated from several facts: Textile and clothing industries are capital-intensive; in the short- and medium-run, some production inputs, such as machinery and specific intermediates, are inflexible to adjust due to either non-convex adjustment costs (for example, pecuniary costs or delayed time in adjustment) or search frictions. Furthermore, industry case studies show that sourcing specific intermediate inputs takes average 60 days, and with multiple production processes, the snowball effects delay the production adjustment further (Brown et al. (2005)).

This increasing-marginal-cost assumption introduces interdependence of export markets directly. The intuition is straightforward: when a firm experiences a positive demand shock in some destinations and decides to expand its total output, its marginal cost increases. Price increases globally as a result. The firm's total sales would not go up as much as it would otherwise be in the case of constant marginal cost. A firm needs to shift sales elsewhere to compensate for the increased demand in the markets experiencing firsthand demand changes.

We outline the model as follows. A firm's maximization problem proceeds in two stages. At the first stage, a firm with productivity ϕ chooses a set of destinations it enters. We refer to this destination set *sales strategy* denoted as $\Omega(\phi)$, which can also include the domestic market as a destination. At the second stage, conditional on the sales strategy, the firm chooses optimal quantities and price at each destination in its set. In this section, we first describe and characterize the solutions to the firm's optimization problem, followed by changes in the optimal decisions induced by the event of the quota system termination. Our model is otherwise similar to the standard trade models in the demand function and market structure: The demand is constant-elasticity-of-substitution (CES). Firms engage in monopolistic competition; firms pay fixed costs to enter an export destination.

4.1 Environment

The model features $N+1$ countries in the world. A country o is faced with N foreign destinations and a domestic market. To enter a market, a firm pays a fixed cost. We suppress the notation o in this section as this discussion takes the viewpoint of a given country.

Demand

Each destination d (including the home country) houses a representative consumer with a CES demand for a firm with productivity ϕ's output:

$$q_d(\phi, \Omega(\phi)) = p(\phi, \Omega(\phi))^{-\sigma} D_d$$

where $D_d \equiv \tau_d^{-\sigma} P_d^{\sigma-1} E_d$ is a aggregate demand shifter regarding destination d that consists of a variable trade cost term τ, price index P, and aggregate expenditure E. $\sigma > 1$ is the elasticity of substitution across goods. $p(\phi, \Omega(\phi))$ is the free-on-board price (or price at the dock) and is invariant across destinations (including the domestic market) due to the iceberg trade cost assumption.

We denote D_d as "aggregate demand" in destination d, where d denotes a country such as the US, the EU, or Canada. At any time, a firm can rank all foreign destinations by their aggregate demands $\{D_d\}_{\forall d}$. As we will illustrate later, ranking destinations according to D_d is essential to solving for firms' optimal strategy. To avoid abuse of notation, we thus define the following rank function $s(\cdot)$:

$$s(d) = \sum_{j \in \text{All Countries}} \mathbb{1}\left\{D_d \leq D_j\right\}$$

where the indicator function $\mathbb{1}\{D_d \leq D_j\}$ takes the value of 1 if $D_d \leq D_j$ and 0 otherwise. Effectively, the $s(\cdot)$ function returns the rank of foreign destination d regarding its aggregate demand. $s(d)$ is equal to 1 if D_d is the largest among all foreign destinations, and is equal to N if D_d is the N^{th}-largest, or smallest country in aggregate demands.

Production

Firm ϕ produces its total output q with the following technology with increasing marginal cost:

$$q(\phi, \Omega(\phi)) = \phi[l(\phi, \Omega(\phi))]^{\beta}, \quad 0 < \beta < 1 \tag{6}$$

where $l(\phi, \Omega(\phi))$ is the flexible input purchased by firm ϕ. The input demand for total $q(\phi, \Omega(\phi))$ units of output is:

$$l(\phi, \Omega(\phi)) = [\frac{q(\phi, \Omega(\phi))}{\phi}]^{\frac{1}{\beta}}$$

$0 < \beta < 1$ captures the property of increasing marginal cost. The average cost and marginal cost of production increases as $q(\phi, \Omega(\phi))$ increases.[10] When $\beta = 1$, the produc-

[10]The total cost function, suppressing notion of $\Omega(\phi)$, is:

$$\text{TC}(\phi) = \frac{w}{\phi^{\frac{1}{\beta}}} q(\phi)^{\frac{1}{\beta}}; \quad 0 < \beta < 1$$

$$\text{AVC}(\phi) = \frac{w}{\phi^{\frac{1}{\beta}}} q(\phi)^{\frac{1-\beta}{\beta}}$$

$$\text{MC}(\phi) = \frac{1}{\beta} \frac{w}{\phi^{\frac{1}{\beta}}} q(\phi)^{\frac{1-\beta}{\beta}}$$

tion function is linear in labor assumed in Melitz, (2003); Eaton, Korutm, and Kramarz (2011); and Arkolakis, Costinot, and Rodríguez-Clare (2012).

4.2 Firm-level Export Decisions

Firm ϕ's decision includes the set of destinations it chooses to enter (*sales strategy*), $\Omega(\phi)$, and the quantities at each destination, $q_d(\phi, \Omega(\phi))$ to maximize total profits:

$$\max_{\Omega(\phi)} \Big\{ \max_{q_d(\phi,\Omega(\phi))} \{ \sum_{d\in\Omega(\phi)} p(\phi, \Omega(\phi)) q_d(\phi, \Omega(\phi)) - w[\frac{\sum_{d\in\Omega(\phi)} q_d(\phi, \Omega(\phi))}{\phi}]^{\frac{1}{\beta}} \} - \sum_{d\in\Omega(\phi)} f_d \Big\} \tag{7}$$

w is the price per input unit, and f_d is the fixed cost paid to sell at destination d. Market interdependence becomes a salient feature in equation (7) through total costs of production: optimal quantities in one destination affect those in other destinations.

We solve for the firm's optimization problem in (7) backward. At the second stage, assuming firm ϕ has chosen $\Omega(\phi)$, we determine the optimal price and quantities. This step expresses firm ϕ's *conditional global profits* given a sales strategy as a function of fundamentals.[11] We then determine the optimal sales strategy, $\Omega^*(\phi)$, that achieves the highest conditional global profits.

4.2.1 Export Sales Allocation, Optimal Price, Optimal Quantities

Conditional on a sales strategy $\Omega(\phi)$, firm ϕ chooses optimal $\{q_d^*(\phi, \Omega(\phi))\}_d$ that maximize global profits of this export set $\Omega(\phi)$:

$$\max_{q_d(\phi,\Omega(\phi))} \big[p(\phi, \Omega(\phi)) \sum_{d\in\Omega(\phi)} q_d(\phi, \Omega(\phi)) - w[\frac{\sum_{d\in\Omega(\phi)} q_d(\phi, \Omega(\phi))}{\phi}]^{\frac{1}{\beta}} \big]$$

The CES demand structure renders the optimal allocation rule:

$$\frac{q_d(\phi, \Omega(\phi))}{q_s(\phi, \Omega(\phi))} = \frac{D_d}{D_s} \tag{8}$$

That is, once $q_s(\phi, \Omega(\phi))$ is determined, $q_d(\phi, \Omega(\phi))$ is pinned down by $q_d(\phi, \Omega(\phi)) = \frac{D_d}{D_s} q_s(\phi, \Omega(\phi))$. The property (8) proves to be useful in solving the firm's maximization

Two things are worth noting: (1) When $\beta = 1$, we have constant marignal cost technology. The marginal cost and average cost functions are $\frac{w}{\phi}$. (2) Equation (6) shows that $\text{AVC}(\phi) = \beta \text{MC}(\phi)$.

[11] "Conditional" refers to conditioning on a sales strategy.

problem, given a sales strategy $\Omega(\phi)$. We rewrite the optimization problem as:

$$\max_{p(\phi,\Omega(\phi))} \{p(\phi,\Omega(\phi))^{1-\sigma} \sum_{d\in\Omega(\phi)} D_d - p(\phi,\Omega(\phi))^{-\frac{\sigma}{\beta}} w[\frac{\sum_{d\in\Omega(\phi)} D_d}{\phi}]^{\frac{1}{\beta}}\} \tag{9}$$

Firm ϕ sets its free-on-board price to maximize global profits given a sales strategy. Simple calculation gives firm ϕ's optimal price equation if it sells to the destination set $\Omega(\phi)$:

$$p^*(\phi,\Omega(\phi)) = (\frac{\sigma}{(\sigma-1)\beta})^{\frac{\beta}{\sigma(1-\beta)+\beta}} (\frac{w^\beta}{\phi})^{\frac{1}{\sigma(1-\beta)+\beta}} (\sum_{d\in\Omega(\phi)} D_d)^{\frac{1-\beta}{\sigma(1-\beta)+\beta}} \tag{10}$$

We note first that more productive firms always set lower prices given the same destination set. Second, given $\Omega(\phi)$, a firm's price is increasing in its *market access*, $\text{MA}(\phi,\Omega(\phi))$, which measures firm ϕ's effective total market size. We define $\text{MA}(\phi,\Omega(\phi))$:

$$\text{MA}(\phi,\Omega(\phi)) = \sum_{d\in\Omega(\phi)} D_d \tag{11}$$

The pricing equation (10) describes the key mechanism that our model illustrates: When a firm increases its total output globally, it moves up along its marginal cost curve, subsequently charging a higher price. When $\beta = 1$, equation (10) collapses to the constant marginal case in which price is independent of the market access. Market interdependence is shut down in this special case.

$$p^*(\phi,\Omega(\phi)) = \frac{\sigma}{\sigma-1}\frac{w}{\phi}$$

We then express firm ϕ's optimal global sales, $X(\phi,\Omega(\phi))$, and its exports to destination d, $X_d(\phi,\Omega(\phi))$, as:

$$\begin{aligned} X(\phi,\Omega(\phi)) &= p(\phi,\Omega(\phi))^{1-\sigma}\text{MA}(\phi,\Omega(\phi)) \\ &= (\frac{\sigma}{(\sigma-1)\beta})^{\frac{(1-\sigma)\beta}{\sigma(1-\beta)+\beta}} (\frac{w^\beta}{\phi})^{\frac{1-\sigma}{\sigma(1-\beta)+\beta}} \text{MA}(\phi,\Omega(\phi))^{\frac{1}{\sigma(1-\beta)+\beta}} \end{aligned} \tag{12}$$

$$\begin{aligned} X_d(\phi,\Omega(\phi)) &= \frac{D_d}{\sum_{d\in\Omega(\phi)} D_d} X(\phi,\Omega(\phi)) \\ &= (\frac{\sigma}{(\sigma-1)\beta})^{\frac{(1-\sigma)\beta}{\sigma(1-\beta)+\beta}} (\frac{w^\beta}{\phi})^{\frac{1-\sigma}{\sigma(1-\beta)+\beta}} D_d \big(\text{MA}(\phi,\Omega(\phi))^{\frac{(1-\sigma)(1-\beta)}{\sigma(1-\beta)+\beta}}\big) \end{aligned} \tag{13}$$

Higher market access, $\left(\sum_{d\in\Omega(\phi)} D_d\right)$, unambiguously increases a firm's total sales. More importantly, conditional on selling to a destination d, higher market access increases marginal cost of production and subsequently price. The increased price leads to lower sales at destination d in equilibrium, all else equal. The model implies that a positive demand shock in destinations other than d, in our context the MFA quota removal, decreases the firm's exports to destination d. When $\beta = 1$, market interdependence across destinations disappears at the intensive margin.

The combination of a CES demand and monopolistic competition market structure concludes that variable profits are a constant fraction of sales. Therefore, the *conditional global profits* of firm ϕ given the destination set to which it sells, $\Omega(\phi)$, is thus:

$$\begin{aligned} \pi(\phi, \Omega(\phi)) &= X(\phi, \Omega(\phi)) - w\big[\frac{q(\phi, \Omega(\phi))}{\phi}\big]^{\frac{1}{\beta}} \\ &= \frac{\sigma - (\sigma-1)\beta}{\sigma} X(\phi, \Omega(\phi)) \end{aligned} \tag{14}$$

Equation (14) is what we set to achieve in this subsection, based on which we solve for firm ϕ's optimal sales strategy in the next step.

4.2.2 Optimal Sales Strategy

Once we determine firm ϕ's conditional global profits $\pi(\phi, \Omega(\phi))$ conditional on ϕ and $\Omega(\phi)$, we proceed to solve for the optimal sales strategy $\Omega^*(\phi)$ that generates the highest global profits. The maximization problem is:

$$\begin{aligned} &\max_{\Omega(\phi)} \pi(\phi, \Omega(\phi)) - \sum_{d \in \Omega(\phi)} f_d \\ \Longleftrightarrow &\max_{\Omega(\phi)} \Gamma \cdot (\frac{\phi}{w^\beta})^\eta (\sum_{d \in \Omega(\phi)} D_d)^\gamma - \sum_{d \in \Omega(\phi)} f_d \end{aligned} \tag{15}$$

where $\Gamma = \frac{\sigma-(\sigma-1)\beta}{\sigma}(\frac{\sigma}{(\sigma-1)\beta})^{\frac{(1-\sigma)\beta}{\sigma(1-\beta)+\beta}}$, $\eta = \frac{\sigma-1}{\sigma(1-\beta)+\beta}$, and $\gamma = \frac{1}{\sigma(1-\beta)+\beta}$; $0 < \gamma < 1$.

Searching for the set maximizer $\Omega^*(\phi)$ requires solving a combinatorial discrete choice problem. In our setting with $0 < \gamma < 1$, this set function is submodular. Our problem is therefore different from the choice of input sourcing strategy in Antras, Fort and Tintelnot (2017), where they assume $\gamma > 1$ and thus the set function is supermodular.[12] A submodular maximization problem is generally NP-hard to solve. Arkolakis and Eckert (2017) propose an iteration algorithm to solve supermodular/submodular maximization problems given all parameters and fundamentals. However, it is still difficult

[12] Although Antras, Fort and Tintelnot (2017) studies a firm's global sourcing decision, which is a different research question from ours, their paper solves for a similar discrete choice problem as equation (14). The difference from ours is that our model implies that the parameter is $0 < \gamma < 1$, while their paper assumes $\gamma > 1$.

to analytically characterize the general solution to a submodular maximization problem. Since this paper's major contribution does not lie in solving the submodular maximization problem, we make the following simplifying assumption that makes the problem and solution more tractable:

$$\begin{aligned} &f_d = 0, \quad \text{if } d \text{ is the domestic market, namely } d = o \\ &f_d = f, \quad d \neq o \end{aligned} \tag{16}$$

This assumption entails: (1) selling in the domestic market does not require paying any fixed costs; (2) fixed costs of exporting to any destinations are the same. This implies selection into exporting: while all firms sell at their domestic market, only a subset exports to any export destinations. Domestic market o always enters a firm's sales strategy. A firm determines $\Omega(\phi)$, the set of foreign destinations it exports to.

To determine the optimal sales strategy, we first solve a simpler problem of finding the optimal sales strategy assuming selling to S foreign countries. We denote the sales strategy that contains S foreign destinations as $\Omega^S(\phi), \quad 0 \leq S \leq N$.[13] The simplified optimization problem is:

$$\max_{\Omega^S(\phi)} \Gamma \cdot (\frac{\phi}{w^\beta})^\eta (\sum_{d \in \Omega^S(\phi)} D_d)^\gamma - S \cdot f \tag{17}$$

Problem (17) is significantly simpler to solve. In fact, the solution to (17) requires to merely choose the S foreign destinations with the highest aggregate demands $\{D_d\}_d$ in addition to the domestic market: That is,

$$\Omega^{S*}(\phi) = \{d : s(d) \leq S\} \cup \{o\} = \Omega^{S*} \tag{18}$$

This solution is intuitive: suppose firm ϕ chooses a set of S foreign destinations that are not the largest S countries in their aggregate demands. This leaves room for higher total profits if the firm replaces the lowest-demand country in the current set with a higher-demand one while maintaining the fixed costs at $S \cdot f$. The firm trades countries with higher aggregate demands until it exports to the S largest ones.

Equation (18) also shows that optimal $\Omega^{S*}(\phi)$ is identical across firms as long as they export to S countries. Due to the one-to-one mapping between Ω^S and the number of export countries S, the maximization problem in equation (17) boils down to choosing

[13] Note that such a sales strategy contains $S+1$ destinations in total because the domestic market is always in the strategy.

the optimal number of destinations S^*. We further formalize the optimal sales strategy in two propositions: (1) there exists a unique optimal sales strategy $\Omega^*(\phi)$ for firm ϕ; (2) the optimal strategy $\Omega^*(\phi)$ depends on productivity ϕ.

Proposition 1. *For a firm with productivity ϕ, there exists a unique number of export destinations $S^*(\phi)$ and a unique sales strategy $\Omega^*(\phi) = \Omega^{S^*}(\phi)$ such that global profits $\pi(\phi, \Omega(\phi))$ is maximized.*

Proof. See Appendix. □

Proposition 1 establishes the existence and uniqueness of the optimal sales strategy given our assumptions. A firm's crucial trade-off lies in balancing the marginal benefit and marginal cost of exporting to an additional destination. The marginal benefit of raising the number of export countries from $S-1$ to S is

$$\frac{\Gamma}{w^{\beta\eta}}\phi^{\eta}\Big[(D_o + \sum_{s(d)=1}^{S} D_d)^{\gamma} - (D_o + \sum_{s(d)=1}^{S-1} D_d)^{\gamma}\Big]$$

If the evaluated marginal benefit at S exceeds the marginal cost, f, the firm will keep expanding. Since the marginal benefit is decreasing in S as the firm expands its export set, while the marginal cost remains constant, a firm selling to S^* countries optimally must have:

$$\frac{\Gamma}{w^{\beta\eta}}\phi^{\eta}\Big[(D_o + \sum_{s(d)=1}^{S} D_d)^{\gamma} - (D_o + \sum_{s(d)=1}^{S-1} D_d)^{\gamma}\Big] \geq f$$
$$\frac{\Gamma}{w^{\beta\eta}}\phi^{\eta}\Big[(D_o + \sum_{s(d)=1}^{S+1} D_d)^{\gamma} - (D_o + \sum_{s(d)=1}^{S} D_d)^{\gamma}\Big] < f$$

This naturally allows us to characterize the searching for the optimal sales set size by defining a set of indifference productivity cutoffs $\{\phi_d\}_d$ at which a firm is indifferent of exporting to $s(d)$ foreign destinations and $s(d)-1$ foreign destinations:

$$\begin{aligned} &\frac{\Gamma}{w^{\beta\eta}}(\phi_d)^{\eta}\Big[(D_o + \sum_{s(j)=1}^{s(d)} D_j)^{\gamma} - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j)^{\gamma}\Big] = f \\ \Rightarrow \forall d, \quad &\phi_d \equiv \Big(\frac{w^{\beta\eta}\cdot f}{\Gamma\big[(D_o + \sum_{s(j)=1}^{s(d)} D_j)^{\gamma} - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j)^{\gamma}\big]}\Big)^{1/\eta} \end{aligned} \tag{19}$$

For firms with ϕ_d, the inclusion of destination d does not affect their global profits.

Proposition 2. *With the indifference productivity cutoffs defined in equations (18), firm ϕ's optimal number of export destinations and optimal sales strategy are:*

$$\begin{aligned}
&\textit{If } \ \phi \in (0, \phi_d) \ \ \textit{where} \ \ s(d) = 1 \\
&\qquad S^*(\phi) = 0; \ \Omega^*(\phi) = \{o\} = \Omega^0 \\
&\textit{If } \ \phi \in [\phi_{d_1}, \phi_{d_2}) \ \ \textit{where} \ \ s(d_1) = S \ \& \ s(d_2) = S+1 \\
&\qquad S^*(\phi) = S; \ \Omega^*(\phi) = \{d : s(d) \leq S\} \cup \{o\} = \Omega^S \\
&\textit{If } \ \phi \in [\phi_d, \infty) \ \ \textit{where} \ \ s(d) = N \\
&\qquad S^*(\phi) = N; \ \Omega^*(\phi) = \{d : s(d) \leq N\} \cup \{o\} = \Omega^N
\end{aligned}$$

where integer $S \in [1, N-1]$. Both $S^*(\phi)$ and $\Omega^*(\phi)$ are non-decreasing in ϕ.

Proof. See Appendix. □

Proposition 2 describes how firms endogenously sort into different sales strategies given productivity. Since the indifference productivity cutoffs are such that

$$\phi_{d_1} \leq \phi_{d_2} \ \text{ if } \ s(d_1) \leq s(d_2) \tag{20}$$

, these cutoffs divide the whole productivity support into $N+1$ intervals. Firms falling into the same productivity interval choose the same sales strategy. Exporters serving more countries are more productive. Put it differently, more productive firms are more likely to penetrate countries with smaller aggregate demands. Proposition 2 also predicts a hierarchy structure of export market penetration: if a firm ϕ exports to d, a firm ϕ' with $\phi' > \phi_1$ must export to d as well. Meanwhile, ϕ_d is also the productivity cutoff of exporting to the country with D_d.

4.3 The Effects of Quota Removal

This section analyzes the impacts of the MFA quota elimination on firm-level production and export adjustments. Suppose that foreign country k previously imposed import quotas on a product. The aggregate demand is D_k before it lifts quota bans and becomes D_k' after it lifts. We characterize this policy event of the quota elimination as k changing its relative ranking in the world's aggregate demand list:

$$s(k) = G > 1; \ \ s'(k) = 1$$

To interpret, country k is ranked $s(k) = G^{\text{th}}$-largest in aggregate demand D_k before the quota removal. After the event, it jumps to becoming the $s'(k) = 1^{st}$-largest country in aggregate demand. The particular formulation is micro-founded: the quota restriction is quite binding before, while the underlying aggregate demand in the previously-capped markets is substantial. In other words, we study a *large shock*. Such a formulation is consistent with the MFA quota elimination discussed in section 2.1. For the quota-capped HS 8-digit product codes, the USA becomes the 2nd largest importer, relative to its 4th rank before the removal. The EU and Canada jumped 2 and 5 ranks ahead respectively in its total imports after 2005 (previously in 2004, the EU ranked 3rd; and Canada the 14th).

Suppose wage w is determined by an outside sector producing with constant marginal cost and is freely traded across the world. We study the changes in individual firms' sales strategies and export value when D_k increases to D'_k due to the quota removal. We introduce standard notations: define x as a variable before the termination event; x' as the same variable after the event. $\hat{x} = x'/x$ represents the relative change.

Proposition 3. *The quota removal of country k, formulated as $D_k \to D'_k$, induces the following changes in the indifference productivity cutoffs, $\{\phi_d\}_{\forall d}$. Let $s(d)$ denote the initial ranking of the destination d:*

If $s(d) < G$,

$$\hat{\phi}_d = \Big(\frac{(D_o + \sum_{s(j)=1}^{s(d)} D_j)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j)^\gamma}{(D_o + \sum_{s(j)=1}^{s(d)} D_d + D'_k)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j + D'_k)^\gamma}\Big)^{1/\eta} > 1,$$

If $s(d) = G$, *so* $d = k$

$$\hat{\phi}_d = \Big(\frac{(D_o + \sum_{s(j)=1}^{G} D_j)^\gamma - (D_o + \sum_{s(j)=1}^{G-1} D_j)^\gamma}{(D_o + D'_k)^\gamma - (D_o)^\gamma}\Big)^{1/\eta} < 1,$$

If $s(d) > G$,

$$\hat{\phi}_d = \Big(\frac{(D_o + \sum_{s(j)=1}^{s(d)} D_j)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j)^\gamma}{(D_o + \sum_{s(j)=1}^{s(d)} D_j + D'_k - D_k)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j + D'_k - D_k)^\gamma}\Big)^{1/\eta} > 1.$$

The cutoff ϕ_k of exporting to destination k decreases after $D_k \to D'_k$. The cutoffs of exporting to other destinations $\{\phi_d\}_{\forall d \neq k}$ increase. The new ranks of the cutoffs are:

$$s'(d) = 1 \;\; if \;\; s(d) = G$$
$$s'(d) = s(d) + 1 \;\; if \;\; s(d) < G$$
$$s'(d) = s(d) \;\; if \;\; s(d) > G$$

The new sales strategies after the trade shock are:

$$\text{If } \phi \in [0, \phi'_k)$$
$$S^*(\phi) = 0;\ \Omega^*(\phi)' = \{o\},$$
$$\text{If } \phi \in [\phi'_k, \phi'_d) \text{ where } s(d) = 1$$
$$S^*(\phi) = 1;\ \Omega^*(\phi)' = \{o, k\},$$
$$\text{If } \phi \in [\phi'_{d_1}, \phi'_{d_2}) \text{ where } s(d_1) = S \ \&\ s(d_2) = S + 1 \ \&\ 1 \le S < G - 1$$
$$S^*(\phi) = S + 1;\ \Omega^*(\phi)' = \Omega^S \cup \{k\}$$
$$\text{If } \phi \in [\phi'_{d_1}, \phi'_{d_2}) \text{ where } s(d_1) = G - 1 \ \&\ s(d_2) = G + 1$$
$$S^*(\phi) = G;\ \Omega^*(\phi)' = \Omega^G,$$
$$\text{If } \phi \in [\phi'_{d_1}, \phi'_{d_2}) \text{ where } s(d_1) = S \ \&\ s(d_2) = S + 1 \ \&\ G < S < N$$
$$S^*(\phi) = S;\ \Omega^*(\phi)' = \Omega^S,$$
$$\text{If } \phi \in [\phi'_d, \infty) \text{ where } s(d) = N$$
$$S^*(\phi) = N;\ \Omega^*(\phi)' = \Omega^N,$$

Proof. See appendix. □

Proposition 3shows that productivity cutoffs of exporting to destinations other than the quota-imposing country k increase. The productivity cutoff of selling to destination k becomes the lowest among all export countries. This induces massive entry into country k.

Proposition 3 features the extensive margin of firm reallocating in the export market participation: Increasing entry and export sales to country k raises firm-level average and marginal costs. For any particular destinations other than destination k, only the more productive firms can sell there after the quotas in k are removed. Furthermore, depending on firms' productivity and its position relative to the new indifference productivity cutoffs, some firms may export to fewer destinations other than k; and other firms maintain their previous sales strategies other than k. However, as discussed later, the change of the total number of export destinations cannot be precisely determined.

The theoretical implications underpin our empirical findings. The decrease in the productivity cutoff ϕ_k corresponds to the massive entry into the US, the EU, and Canada documented in KSW (2013). In this paper, we show that part of the new entrants come from those previously exporting to the MFA policy-free destinations (Section 3.3). Meanwhile, the number of firms selling quota-capped products to those policy-free destinations decreases by 5.6% as reflected in the Column (4) in Table 1. Though we do not overemphasize the extensive margin especially when it is under comparison with the reduction in the average export per firm, the empirical estimates still suggest that extensive margin plays a role. Linking back to the theory, we see that the exit margin is captured by the increase in ϕ_d in destinations other than k.

However, for a given firm with productivity ϕ, the effects of the quota removal on its number of foreign destinations cannot be precisely determined:

Corollary 1. *The number of foreign destinations penetrated by firm with ϕ, $S(\phi)$, can either increase, remain unchanged, or decrease when the quota removal happens.*

Proof. See appendix. □

The intuition of the indeterminacy is as follows: When aggregate demand of a country rises, to determine its optimal sales set, a firm balances between higher global sales (and thus higher operating profits) and higher fixed costs of exporting. On the one hand, exporting to more destinations increases its total sales; on the other hand, exporting to more destinations incurs higher fixed costs. When the quotas are lifted with destination k's aggregate demand increasing, a firm may find it optimal to reduce its global market access and export only to a smaller set of relatively larger countries. In other words, the firm's strategy is to increase profits by saving export fixed costs. To put it differently, when the marginal benefit of increased global sales is larger, the number of export set increases; if the marginal cost of expanding is larger, the number of export set decreases.

Empirically, we find that on average the MFA quota removal is associated with a small but statistically significant increase in the firm-level number of export destinations globally in the previously-capped products, relative to that of the uncapped ones (Appendix Figure 6). The finding has important implications for theoretical analysis: it suggests that increasing global sales plays a more important role in maximizing global profits than saving fixed costs does. A firm's growing global sales and market access increase a firm's marginal cost, resulting in a decrease in sales in the destinations that do not have quota policies. We formalize this claim in the following proposition.

Proposition 4. *If the quota removal event $D_k \to D'_k$ does not lead firm ϕ to decrease its number of export destinations $S^*(\phi)$, the event of the quota removal causes an increase in market access, $MA(\phi, \Omega^*(\phi))$, and decreases in sales in destinations other than k.*

Proof. See appendix. □

Proposition 4 captures the main finding in our empirical analyses discussed in sections 3.1-3.4: The quota removal leads to reallocation from destinations not imposing a direct policy change. It is worth noting that an increase in market access and global sales is paramount in generating this pattern. As marginal cost increases in total output, export price rises in the rest of the world where policy interventions are absent. In equilibrium, sales decrease there.

5 Aggregation and Welfare Implications

In this section, we explore the welfare consequence of market interdependence highlighted in the previous sections.

5.1 Aggregate Trade Flow and Import Price Index

We first derive aggregate trade flow between the origin o and a destination d. Assume that firm productivity ϕ of the origin o is drawn from a distribution $G_o(\phi)$. The total exports from origin o to destination $d(o)$ is thus:

$$X_{do} = \Gamma^X \cdot M_o \cdot D_{do} \int_{\phi_{do}}^{\infty} (\frac{\phi}{w_o^{\beta}})^{\eta} \mathrm{MA}_o(\phi)^{\gamma-1} \, dG_o(\phi) \tag{21}$$

where M_o is the mass of firms in the exporting country and Γ^X is a constant. ϕ_{do} is the indifference productivity cutoff of including or excluding d into sales strategy for the *origin* o. Recall ϕ_{do} takes the formula below, and it is also the minimum productivity requirement of selling from o to d:

$$\phi_{do} \equiv (\frac{w_o^{\beta\eta} \cdot f_o}{\Gamma\left[(D_{oo} + \sum_{s_o(j)=1}^{s_o(d)} D_{jo})^{\gamma} - (D_{oo} + \sum_{s_o(j)=1}^{s_o(d)-1} D_{jo})^{\gamma}\right]})^{1/\eta}$$

$s_o(j)$ returns the rank of destination j regarding its aggregate demand D_{jo} among all foreign destinations that country origin o can export to. D_{oo} denotes the aggregate demand a firm in o faces when selling to the domestic market. $\mathrm{MA}_o(\phi)$ is the market access for firms ϕ in origin o. Finally, D_{do} is now the aggregate demand of destination d for origin o:

$$D_{do} = \tau_{do}^{-\sigma} \cdot P_d^{\sigma-1} \cdot E_d$$

where τ_{do} is the variable iceberg trade cost of selling from o to d. We define *aggregate marginal cost* of firms selling from o to d as Φ_{do}:

$$\Phi_{do} = \Big[\int_{\phi_{do}}^{\infty} \phi^{\eta} \mathrm{MA}_o(\phi)^{\gamma-1}\, dG_o(\phi) \Big]^{-1}$$

This term takes into account both the contributions of an exogenously drawn productivity and an endogenous choice of market access on the marginal cost of production. The simplified aggregate trade flow from o to d is thus:

$$X_{do} = \Gamma^X \cdot \frac{M_o \cdot D_{do}}{w_o^{\beta\eta}} \cdot \Phi_{do}^{-1}$$

We note that when trade barriers decrease due to a liberalization policy in k (i.e., τ_{ko} is reduced by k), in our empirical context the MFA quota removal, origin o's exports to a third-country d is directly affected through the *aggregate marginal cost* Φ_{do}. First, changes in D_{ko} directly affect the market access term of that firms selling from o to d through an increase in $\mathrm{MA}_o(\phi)$. Second, changes in D_{ko} also affect the set of country o's firms that could sell from o to d through altering the firms' sales strategies when ϕ_{do} increases. According to Proposition 3 and 4, both effects lower X_{do} by raising the aggregate marginal cost Φ_{do}. Holding fixed M_o and D_{do}, X_{do} is thus negatively affected by the decrease in τ_{ko}, $k \neq o$ and $k \neq d$:

$$\frac{\partial \ln X_{do}}{\partial \ln \tau_{ko}} = -\frac{\partial \ln \Phi_{do}}{\partial \ln \tau_{ko}} > 0$$

which captures the effect of export reallocation to k from other destinations.

It is worth noting that $\gamma = 1$ corresponds to the canonical case of constant marginal cost production, in which the market access no longer affects marginal cost or price. Equation (21) of bilateral trade flow collapses to

$$X_{do} = \Gamma^X \cdot \frac{M_o \cdot D_{do}}{w_o^{\beta\eta}} \int_{\phi_{do}}^{\infty} \phi^{\eta}\, dG_o(\phi)$$

where $\phi_{do}^{\sigma-1} \propto \frac{w_o^{\sigma-1} \cdot f_o}{\cdot D_{do}}$. Therefore, changes in the aggregate demand of a third country D_{ko} do not directly affect trade flow X_{do}. In fact, when market aggregates in countries d and o, i.e., D_{do}, w_o, M_o, are assumed fixed in partial equilibrium, trade flows from o to d, X_{do}, stay the same when τ_{ko} or equivalently D_{ko} changes. In addition, when we allow general equilibrium effects of the quota removal to change domestic wage, w_o, or aggregate demand in d, D_{do}, the general equilibrium effects would affect the previously-capped and uncapped products symmetrically.

The changes in the trade flow X_{do} lead to changes in the price index of goods imported in d from the origin. Notice that due to the CES demand structure and $D_{do} = \tau_{do}^{-\sigma} P_d^{\sigma-1} E_d$, the import price index of goods from o to d is:

$$
\begin{aligned}
P_{do}^{1-\sigma} &= M_o \int_{\phi_{do}}^{\infty} \tau_{do}^{1-\sigma} p_o(\phi)^{1-\sigma} \, dG_o(\phi) \\
&= \frac{\tau_{do}^{1-\sigma} X_{do}}{P_d^{\sigma-1} E_d} \propto \frac{\tau_{do}^{1-\sigma} M_o}{w_o^{\beta\eta}} \Phi_{do}^{-1}
\end{aligned}
$$

Reductions in trade cost τ_{ko} directly increase the price index of exports from o to d by (1) raising the marginal cost of firms that sell from o to d; and (2) reducing the firms/varieties from o available for customers in d. Namely,

$$
\frac{\partial \ln P_{do}}{\partial \ln \tau_{ko}} = \frac{1}{\sigma - 1} \frac{\partial \ln \Phi_{do}}{\partial \ln \tau_{ko}} < 0
$$

Since a unilateral decrease in τ_{ko} affects the price index P_{do} in the third country d through their shared suppliers from the same origin o, this leads to an important welfare implication: With increasing marginal cost production, a liberalization policy can lead to a welfare loss in countries that are outside the trade partnership.

We link the theoretical welfare implication to the studied event. The MFA termination leads to a decrease in China's exports of the previously-capped products to the rest of the world, or to exit there entirely, in order to serve the liberalized US, EU, and Canada markets. As a result, take Japan (d in this section) as an example. Japan's import price index from China increases, hurting the welfare of Japanese consumers and firms. Such a spillover effect in welfare is absent when $\gamma = 1$ when price index is not directly affected by the market conditions in destinations other than Japan.

5.2 Calculating Welfare Changes

Lastly, we relate our results to the sufficient statistic approach of evaluating welfare changes in the trade models. In the presence of increasing marginal cost of production, we show that incorporating the changes in the aggregate marginal cost term mentioned in the previous section is essential to obtain the accurate measures of welfare changes.

To derive the welfare statistic consistent with our theoretical framework, we first set $d = o$ for X_{do} and express the inverse of the origin o's price index as follows:

$$
P_o^{-1} = \big(\frac{w_o^{\beta\eta}}{\Gamma^X \cdot M_o} \cdot \lambda_{oo} \cdot \Phi_{oo} \big)^{1/(1-\sigma)}
$$

where $\lambda_{oo} = X_{oo}/E_o$ is the domestic trade share.

Proposition 5. *Assume that M_o and w_o are fixed. When a shock takes place, the change in (the inverse of) price index at origin o is:*

$$\hat{P_o}^{-1} = \left(\hat{\lambda}_{oo} \cdot \hat{\Phi}_{oo}\right)^{1/(1-\sigma)} = \hat{W}_o \tag{22}$$

where $\hat{W}_o$ denotes the welfare (or real wage) change of country o.

According to Proposition 5, the changes in the origin o's welfare depends on both the changes in the domestic trade share and the aggregate marginal cost of firms selling from o to o. The change in the aggregate marginal cost, $\hat{\Phi}_{oo}$, is

$$\hat{\Phi}_{oo} = \left[\frac{\int_{\phi'_{oo}}^{\infty} \phi^{\eta} \mathrm{MA}_o(\phi)'^{\gamma-1}\, dG_o(\phi)}{\int_{\phi_{oo}}^{\infty} \phi^{\eta} \mathrm{MA}_o(\phi)^{\gamma-1}\, dG_o(\phi)}\right]^{-1} = \left[\frac{\int_{0}^{\infty} \phi^{\eta} \mathrm{MA}_o(\phi)'^{\gamma-1}\, dG_o(\phi)}{\int_{0}^{\infty} \phi^{\eta} \mathrm{MA}_o(\phi)^{\gamma-1}\, dG_o(\phi)}\right]^{-1}$$

The second equality holds due to the assumption that the fixed costs of selling in the domestic market are zero, i.e., $f_d = 0$, and therefore all firms sell domestically. This simplification allows us to illustrate how our welfare statistic differs from the one usually used in canonical trade models. When $\gamma = 1$, $\hat{\Phi}_{oo} = 1$, and we arrive at the canonical "sufficient statistic" for welfare evaluation proposed by Arkolakis, Costinot and Rodríguez-Clare (2012) (ACR henceforth):

$$\hat{W}_o^{\mathrm{ACR}} = \left(\hat{\lambda}_{oo}\right)^{1/(1-\sigma)}$$

Comparing equation (22) and the welfare sufficient statistic in ACR(2012), we find that when increasing marginal cost of production is present, the domestic trade share itself is no longer sufficient to capture all the changes in the domestic price index when a shock takes place. A firm's marginal cost of production and its price are also affected by its global market access reflected in the aggregate term $\hat{\Phi}_{oo}$. We further illustrate by comparing the gains from trade relative to the hypothetical autarky equilibria in both our framework and ACR (2012)'s framework. Since $\lambda_{oo} = 1$ in the autarky equilibrium, the gains from trade (GFT) are:

$$\mathrm{GFT} = \left(\lambda_{oo} \cdot \hat{\Phi}_{oo}\right)^{1/(1-\sigma)}$$
$$\mathrm{GFT}^{\mathrm{ACR}} = \left(\lambda_{oo}\right)^{1/(1-\sigma)}$$

where λ_{oo} is the domestic trade share in the trade equilibrium observed in the data. As firms have larger global market access in the trade equilibrium than in autarky, $\hat{\Phi}_{oo} > 1$

due to increasing marginal cost. As a result, the ACR sufficient statistic formula tends to overestimate the gains from trade when in theory the underlying model features increasing marginal cost.

Moreover, expansions in the export markets, such as an increase in E_d or a reduction in τ_{ko} , $k \neq o$, generally lead to increases in Φ_{oo} and decreases in X_{oo}. The alternative scenario when E_o is reduced holds as well. In a contemporaneous paper, Almunia et al. (2018) coin the term "venting out effect" to capture their empirical finding that a decrease in E_o leads to an export boom of Spanish manufacturing firms during the Great Recession in Spain. When $\gamma = 1$, $\hat{\Phi}_{oo} = 1$, the "venting out" effect disappears. The assumption of constant marginal cost implies that independence of export decisions across markets. Therefore, only observing the changes in domestic trade share $\hat{\lambda}_{oo}$ in the data, together with demand elasticity σ, is insufficient to calculate the welfare changes in o.

In the case of the MFA termination, when the quota removal decreases trade costs from China of exporting to the previously-capped markets, i.e., a decrease in $\tau_{US,CHN}$, $\tau_{EU,CHN}$ and $\tau_{CAN,CHN}$, the global market access and total output of Chinese firms in the textile and clothing sectors start to increase, leading to higher marginal cost and higher price in the domestic market as well. As a result, $\hat{\Phi}_{oo} > 1$. Conditional on the observed change in $\hat{\lambda}_{oo}$ in the data, the ACR sufficient statistic overestimates the gains of the MFA quota removal for China. This is intuitive given the assumption of increasing marginal cost of production: Decreased trade costs in the export market induces Chinese firms to reallocate their domestic sales to the export market, therefore hurting the welfare of Chinese domestic consumers.

6 Conclusion

If two countries source from the same suppliers, changes in market conditions in some countries can affect the others through the altered decisions of the shared suppliers. In this paper, we document strong evidence in favor of market interdependence. We use the Multi Fibre Arrangement quota elimination in 2005 as a trade policy event to identify the impact of the quota removal on China's exports to destinations that never imposed quotas. The removal of quotas in the US, the EU, and Canada leads to substantial export reallocation: China's exports of the previously-capped products to policy-free destinations decrease significantly, accompanied by a surge of entry and exports of these previously-capped products to the previously restricted markets.

Our empirical findings are hard to reconcile with the constant-marginal-cost assumption in the current canonical models in the trade literature. Alternatively, we propose a multi-country firm heterogeneity trade model featuring increasing marginal cost of production to rationalize these findings. The removal of quotas in particular destinations leads to firm-level expansion of its global market access and total output, raising the marginal cost of production and consequently price. The firm's exports to other destinations that do not experience the quota removal decrease as a result of higher price. Our framework suggests that bilateral trade cost reductions between any two countries may hurt the welfare of the countries that do not experience trade shocks firsthand. Meanwhile, our model also suggests that welfare changes computed using canonical "sufficient statistic" as in ACR (2012) could be biased due to the omission of adjusting changes in marginal cost due to changes in global market access.

The micro-foundation of the increasing-marginal-cost assumption is not groundless. The production of textiles and clothing relies heavily on costly and specialized textile machinery and that the scope of adjusting physical capital in the short-run seems limited. We aim to provide further empirical evidence backing these observations.

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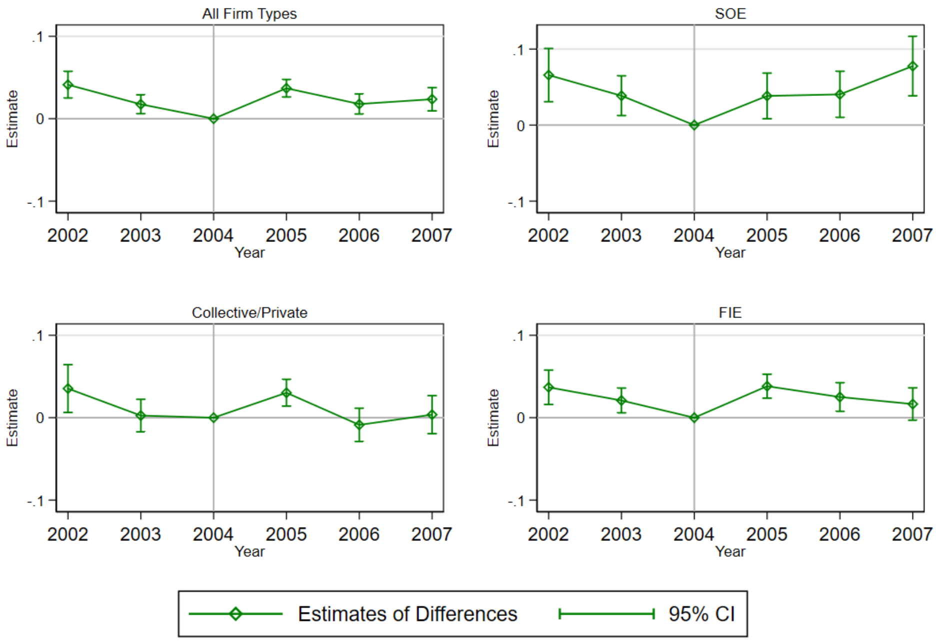
7 Appendix

7.1 Empirical Evidence

Number of Destinations Penetrated

We show the firm-level event-study estimates of the outcome: the number of export destinations in response to the MFA termination in the below Figure 6.

Figure 6: Number of Destinations



Firm-Product-year sample. Outcomes are logged.

7.2 Proof of Propositions

Proof of Proposition 1

For a firm with productivity ϕ, there exists a unique number of export destinations $S^*(\phi)$ and a unique sales strategy $\Omega^*(\phi) = \Omega^{S^*}(\phi)$ such that global profits $\pi(\phi, \Omega(\phi))$ is maximized.

Proof. For a firm ϕ, the marginal benefit of entering destination d with $s(d) = S + 1$, conditional on its current sales strategy Ω^S, is

$$\Gamma(\frac{\phi}{w^\beta})^\eta\big[(D_o+\sum_{s(d)=1}^{S+1}D_d)^\gamma-(D_o+\sum_{s(d)=1}^{S}D_d)^\gamma\big]$$

where D_o is the domestic aggregate demand. For any given S, because $\gamma<1$ and $D_d|_{s(d)=S+1}\le D_d|_{s(d)=S}$, $\big[(D_o+\sum_{s(d)=1}^{S+1}D_d)^\gamma-(D_o+\sum_{s(d)=1}^{S}D_d)^\gamma\big]$ is decreasing in S. Therefore, for any firm, the marginal benefit of entering the subsequent destination decreases as the firm expands its sales strategy.

At the same time, the marginal cost of entering the subsequent destination is simply $(S+1)\cdot f-S\cdot f=f$.

Since marginal benefit is decreasing in S and marginal cost is invariant to S, there are three possible scenarios in determining the optimal sales strategy $\Omega^*(\phi)$, dependent on firm's productivity ϕ.

(1) $\Gamma(\frac{\phi}{w^\beta})^\eta\big[(D_o+\sum_{s(d)=1}^{1}D_d)^\gamma-(D_o)^\gamma\big]-f<0$: In this case, even exporting to only one destination is not worthwhile, and firm ϕ only sells at the domestic market. Conditional on all the aggregate demands $\{D_d\}$, this strategy applies to firms with very low productivities;

(2) $\Gamma(\frac{\phi}{w^\beta})^\eta\big[(D_o+\sum_{s(d)=1}^{N}D_d)^\gamma-(D_o+\sum_{s(d)=1}^{N-1}D_d)^\gamma\big]-f>0$: In this case, firm ϕ finds it optimal to enter all possible destinations. Conditional on all the aggregate demands $\{D_d\}$, this strategy applies to firms with very high productivities;

(3) Condition (1) and (2) do not hold: In this case, because $\big[(D_o+\sum_{s(d)=1}^{S+1}D_d)^\gamma-(D_o+\sum_{s(d)=1}^{S}D_d)^\gamma\big]$ is decreasing in S, there exists a unique S^* such that

$$\Gamma(\frac{\phi}{w^\beta})^\eta\big[(D_o+\sum_{s(d)=1}^{S^*}D_d)^\gamma-(D_o+\sum_{s(d)=1}^{S^*-1}D_d)^\gamma\big]-f\ge 0$$
$$\Gamma(\frac{\phi}{w^\beta})^\eta\big[(D_o+\sum_{s(d)=1}^{S^*+1}D_d)^\gamma-(D_o+\sum_{s(d)=1}^{S^*}D_d)^\gamma\big]-f\le 0$$

Such an S^* therefore maximizes the global profits.

As a result, under all these three scenarios, there is a unique $S^*(\phi)$ that maximizes the global profits. The corresponding sales strategy is

$$\Omega(\phi)=\Omega^{S^*(\phi)}$$

□

Proof of Proposition 2

With the indifference productivity cutoffs defined in equations (18), firm ϕ's optimal number of export destinations and optimal sales strategy are:

$$
\begin{aligned}
&S^*(\phi) = 0;\ \Omega^*(\phi) = \{o\} = \Omega^0 \\
&\qquad\qquad\text{if } \phi \in (0, \phi_d) \text{ with } s(d) = 1 \\
&S^*(\phi) = S;\ \Omega^*(\phi) = \{d : s(d) \leq S\} \cup \{o\} = \Omega^S \\
&\qquad\qquad\text{if } \phi \in [\phi_{d_1}, \phi_{d_2}) \text{ with } s(d_1) = S \ \&\ s(d_2) = S+1 \\
&S^*(\phi) = N;\ \Omega^*(\phi) = \{d : s(d) \leq N\} \cup \{o\} = \Omega^N \\
&\qquad\qquad\text{if } \phi \in [\phi_d, \infty) \text{ with } s(d) = N
\end{aligned}
$$

where integer $S \in [1, N-1]$. Both $S^*(\phi)$ and $\Omega^*(\phi)$ are non-decreasing in ϕ.

Proof. Assume that the support of ϕ is $(0, \infty)$. To characterize the optimal sales strategy more precisely, we again discuss the following three scenarios:

(1) $\Gamma(\frac{\phi}{w^\beta})^\eta\left[(D_o + \sum_{s(d)=1}^{1} D_d)^\gamma - (D_o)^\gamma\right] - f < 0$: This condition suggests that $\phi \in (0, \phi_d)$ with $s(d) = 1$, and implies $S^*(\phi) = 0$ and $\Omega^*(\phi) = \{o\}$.

(2) $\Gamma(\frac{\phi}{w^\beta})^\eta\left[(D_o + \sum_{s(d)=1}^{N} D_d)^\gamma - (D_o + \sum_{s(d)=1}^{N-1} D_d)^\gamma\right] - f > 0$: This condition suggests that $\phi \in (\phi_d, \infty)$ with $s(d) = N$, and implies $S^*(\phi) = N$ and $\Omega^*(\phi) = \{d : s(d) \leq N\} \cup \{o\}$.

(3) Condition (1) and (2) do not hold: This condition suggests that $\phi \in [\phi_{d_1}, \phi_{d_2})$ with $s(d_1) = S$ and $s(d_2) = S + 1$ for integer $S \in [1, N-1]$, and implies that S is the unique number of penetrated foreign destinations that maximizes the global profits. This also implies that $\Omega^*(\phi) = \{d : s(d) \leq S\} \cup \{o\}$.

Applying these rules, for any ϕ_1 and ϕ_2 with $\phi_1 \geq \phi_2$, it is immediate that

$$
\begin{aligned}
S^*(\phi_1) &\geq S^*(\phi_2) \\
\Omega^*(\phi_1) &\supseteq \Omega^*(\phi_2)
\end{aligned}
$$

So $S^*(\phi)$ and $\Omega^*(\phi)$ are nondecreasing in ϕ. □

Proof of Proposition 3

The shock of the quota removal ($D_k \rightarrow D'_k$) induces the following changes in the indifference productivity cutoffs, $\{\phi_d\}_{\forall d}$. Let $s(d)$ denote the initial ranking of the destination.

If $s(d) < G$,

$$\hat{\phi}_d = \Big(\frac{(D_o + \sum_{s(j)=1}^{s(d)} D_j)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j)^\gamma}{(D_o + \sum_{s(j)=1}^{s(d)} D_d + D'_k)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j + D'_k)^\gamma}\Big)^{1/\eta} > 1,$$

If $s(d) = G$, so $d = k$

$$\hat{\phi}_d = \Big(\frac{(D_o + \sum_{s(j)=1}^{G} D_j)^\gamma - (D_o + \sum_{s(j)=1}^{G-1} D_j)^\gamma}{(D_o + D'_k)^\gamma - (D_o)^\gamma}\Big)^{1/\eta} < 1,$$

If $s(d) > G$,

$$\hat{\phi}_d = \Big(\frac{(D_o + \sum_{s(j)=1}^{s(d)} D_j)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j)^\gamma}{(D_o + \sum_{s(j)=1}^{s(d)} D_j + D'_k - D_k)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j + D'_k - D_k)^\gamma}\Big)^{1/\eta} > 1.$$

The cutoff ϕ_k of exporting to destination k decreases after $D_k \rightarrow D'_k$. The cutoffs of exporting to other destinations $\{\phi_d\}_{\forall d \neq k}$ increase. The new ranks of the cutoffs are:

$$s'(d) = 1 \text{ if } s(d) = G$$
$$s'(d) = s(d) + 1 \text{ if } s(d) < G$$
$$s'(d) = s(d) \text{ if } s(d) > G$$

The new sales strategies after the trade shock are:

$$\begin{aligned}
&\text{If } \phi \in [0, \phi'_k) \\
&\qquad S^*(\phi) = 0;\ \Omega^*(\phi)' = \{o\}, \\
&\text{If } \phi \in [\phi'_k, \phi'_d) \ \text{ where } \ s(d) = 1 \\
&\qquad S^*(\phi) = 1;\ \Omega^*(\phi)' = \{o, k\}, \\
&\text{If } \phi \in [\phi'_{d_1}, \phi'_{d_2}) \ \text{ where } \ s(d_1) = S \ \&\ s(d_2) = S+1 \ \&\ 1 \leq S < G-1 \\
&\qquad S^*(\phi) = S+1;\ \Omega^*(\phi)' = \Omega^S \cup \{k\} \\
&\text{If } \phi \in [\phi'_{d_1}, \phi'_{d_2}) \ \text{ where } \ s(d_1) = G-1 \ \&\ s(d_2) = G+1 \\
&\qquad S^*(\phi) = G;\ \Omega^*(\phi)' = \Omega^G, \\
&\text{If } \phi \in [\phi'_{d_1}, \phi'_{d_2}) \ \text{ where } \ s(d_1) = S \ \&\ s(d_2) = S+1 \ \&\ \ G < S < N \\
&\qquad S^*(\phi) = S;\ \Omega^*(\phi)' = \Omega^S, \\
&\text{If } \phi \in [\phi'_d, \infty) \ \text{ where } \ s(d) = N \\
&\qquad S^*(\phi) = N;\ \Omega^*(\phi)' = \Omega^N,
\end{aligned}$$

Proof. Recall that $s(k) = G$. For destinations d with $s(d) < G$, because $\forall d,\ D'_k \geq D_d$, the cutoffs become:

$$(\phi'_d)^\eta = \frac{w^{\beta\eta} \cdot f}{\Gamma\left[(D_o + \sum_{s(j)=1}^{s(d)} D_j + D'_k)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j + D'_k)^\gamma\right]}$$

For destination $d = k$, the cutoff is now:

$$(\phi'_d)^\eta = \frac{w^{\beta\eta} \cdot f}{\Gamma\left[(D_o + D'_k)^\gamma - (D_o)^\gamma\right]}$$

For destinations d with $s(d) > G$, the cutoffs are now:

$$(\phi'_d)^\eta = \frac{w^{\beta\eta} \cdot f}{\Gamma\left[(D_o + \sum_{s(j)=1}^{s(d)} D_j + D'_k - D_k)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j + D'_k - D_k)^\gamma\right]}$$

Therefore the changes in productivity cutoffs $\hat{\phi}_d = \phi'_d / \phi_d$ of selling to different destinations are:

If $s(d) < G$,

$$\hat{\phi}_d = \Big(\frac{(D_o + \sum_{s(j)=1}^{s(d)} D_j)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j)^\gamma}{(D_o + \sum_{s(j)=1}^{s(d)} D_d + D'_k)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j + D'_k)^\gamma}\Big)^{1/\eta} > 1,$$

If $s(d) = G$, so $d = k$

$$\hat{\phi}_d = \Big(\frac{(D_o + \sum_{s(j)=1}^{G} D_j)^\gamma - (D_o + \sum_{s(j)=1}^{G-1} D_j)^\gamma}{(D_o + D'_k)^\gamma - (D_o)^\gamma}\Big)^{1/\eta} < 1,$$

If $s(d) > G$,

$$\hat{\phi}_d = \Big(\frac{(D_o + \sum_{s(j)=1}^{s(d)} D_j)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j)^\gamma}{(D_o + \sum_{s(j)=1}^{s(d)} D_j + D'_k - D_k)^\gamma - (D_o + \sum_{s(j)=1}^{s(d)-1} D_j + D'_k - D_k)^\gamma}\Big)^{1/\eta} > 1.$$

The new indifference productivity cutoffs follow the new ranking:

$$s'(d) = 1 \text{ if } s(d) = G$$
$$s'(d) = s(d) + 1 \text{ if } s(d) < G$$
$$s'(d) = s(d) \text{ if } s(d) > G$$

The new sales strategies are therefore straightforward according to the new productivity cutoffs. □

Proof of Corollary 1

The number of foreign destinations penetrated by firm with ϕ, $S(\phi)$, can either increase, remain unchanged, or decrease when the quota removal happens.

Proof. We discuss three simple examples to show that the change in the number of foreign destinations in indeterminate.

Case 1: Suppose there are two export destinations a, b and a domestic market o. The quota removal shock happens in destination b. Therefore,

$$D_a > D_b;\ D'_b > D_a$$

Suppose before the shock, a firm with ϕ's sales strategy is $\{a, b\}$. After the shock its sales strategy becomes $\{b\}$. The following relationships must hold:

$$\begin{aligned}
&\Gamma(\frac{\phi}{w^\beta})^\eta(D_o+D_b')^\gamma - f > \Gamma(\frac{\phi}{w^\beta})^\eta(D_o+D_b'+D_a)^\gamma - 2f\\
&\Gamma(\frac{\phi}{w^\beta})^\eta(D_o+D_b')^\gamma - f > \Gamma(\frac{\phi}{w^\beta})^\eta(D_o)^\gamma\\
&\Gamma(\frac{\phi}{w^\beta})^\eta(D_o+D_a+D_b)^\gamma - 2f > \Gamma(\frac{\phi}{w^\beta})^\eta(D_o+D_a)^\gamma - f\\
&\Gamma(\frac{\phi}{w^\beta})^\eta(D_o+D_a+D_b)^\gamma - 2f > \Gamma(\frac{\phi}{w^\beta})^\eta(D_o)^\gamma
\end{aligned}$$

For the relationships above to hold, it must be that:

$$\begin{aligned}
&\Gamma(\frac{\phi}{w^\beta})^\eta[(D_o+D_b'+D_a)^\gamma - (D_o+D_b')^\gamma] < f\\
&\Gamma(\frac{\phi}{w^\beta})^\eta[(D_o+D_b')^\gamma - (D_o)^\gamma] > f\\
&\Gamma(\frac{\phi}{w^\beta})^\eta[(D_o+D_a+D_b)^\gamma - (D_o+D_a)^\gamma] > f\\
&\Gamma(\frac{\phi}{w^\beta})^\eta[(D_o+D_a+D_b)^\gamma - (D_o)^\gamma] > 2f
\end{aligned}$$

Without any restrictions on the magnitudes of D_ds other than $D_a > D_b$ and $D_b' > D_a$, it is possible that the conditions above hold. Therefore number of export destinations may decrease.

Case 2: Suppose there are two export destinations a, b and a domestic market o. The quota removal shock happens in destination b. Therefore,

$$D_a > D_b;\ D_b' > D_a$$

Suppose before the shock, a firm with ϕ's sales strategy is $\{a,b\}$. After the shock its sales strategy remains $\{a,b\}$. The following relationships must hold:

$$\begin{aligned}
&\Gamma(\frac{\phi}{w^\beta})^\eta(D_o+D_b'+D_a)^\gamma - 2f > \Gamma(\frac{\phi}{w^\beta})^\eta(D_o+D_b')^\gamma - f\\
&\Gamma(\frac{\phi}{w^\beta})^\eta(D_o+D_b'+D_a)^\gamma - 2f > \Gamma(\frac{\phi}{w^\beta})^\eta(D_o)^\gamma\\
&\Gamma(\frac{\phi}{w^\beta})^\eta(D_o+D_a+D_b)^\gamma - 2f > \Gamma(\frac{\phi}{w^\beta})^\eta(D_o+D_a)^\gamma - f\\
&\Gamma(\frac{\phi}{w^\beta})^\eta(D_o+D_a+D_b)^\gamma - 2f > \Gamma(\frac{\phi}{w^\beta})^\eta(D_o)^\gamma
\end{aligned}$$

For the relationships above to hold, it must be that:

$$\Gamma(\frac{\phi}{w^{\beta}})^{\eta}[(D_o + D_b' + D_a)^{\gamma} - (D_o + D_b')^{\gamma}] > f$$
$$\Gamma(\frac{\phi}{w^{\beta}})^{\eta}[(D_o + D_b' + D_a)^{\gamma} - (D_o)^{\gamma}] > 2f$$
$$\Gamma(\frac{\phi}{w^{\beta}})^{\eta}[(D_o + D_a + D_b)^{\gamma} - (D_o + D_a)^{\gamma}] > f$$
$$\Gamma(\frac{\phi}{w^{\beta}})^{\eta}[(D_o + D_a + D_b)^{\gamma} - (D_o)^{\gamma}] > 2f$$

Without any restrictions on the magnitudes of D_ds other than $D_a > D_b$ and $D_b' > D_a$, it is possible that the conditions above hold. Therefore number of export destinations may remain unchanged.

Case 3: Suppose there are two export destinations a, b and a domestic market o. The quota removal shock happens in destination b. Therefore,

$$D_a > D_b;\ D_b' > D_a$$

Suppose before the shock, a firm with ϕ's sales strategy is $\{a\}$. After the shock its sales becomes $\{a, b\}$. The following relationships must hold:

$$\Gamma(\frac{\phi}{w^{\beta}})^{\eta}(D_o + D_b' + D_a)^{\gamma} - 2f > \Gamma(\frac{\phi}{w^{\beta}})^{\eta}(D_o + D_b')^{\gamma} - f$$
$$\Gamma(\frac{\phi}{w^{\beta}})^{\eta}(D_o + D_b' + D_a)^{\gamma} - 2f > \Gamma(\frac{\phi}{w^{\beta}})^{\eta}(D_o)^{\gamma}$$
$$\Gamma(\frac{\phi}{w^{\beta}})^{\eta}(D_o + D_a)^{\gamma} - f > \Gamma(\frac{\phi}{w^{\beta}})^{\eta}(D_o + D_a + D_b)^{\gamma} - 2f$$
$$\Gamma(\frac{\phi}{w^{\beta}})^{\eta}(D_o + D_a)^{\gamma} - f > \Gamma(\frac{\phi}{w^{\beta}})^{\eta}(D_o)^{\gamma}$$

For the relationships above to hold, it must be that:

$$\Gamma(\frac{\phi}{w^{\beta}})^{\eta}[(D_o + D_b' + D_a)^{\gamma} - (D_o + D_b')^{\gamma}] > f$$
$$\Gamma(\frac{\phi}{w^{\beta}})^{\eta}[(D_o + D_b' + D_a)^{\gamma} - (D_o)^{\gamma}] > 2f$$
$$\Gamma(\frac{\phi}{w^{\beta}})^{\eta}[(D_o + D_a + D_b)^{\gamma} - (D_o + D_a)^{\gamma}] < f$$
$$\Gamma(\frac{\phi}{w^{\beta}})^{\eta}[(D_o + D_a)^{\gamma} - (D_o)^{\gamma}] > f$$

Without any restrictions on the magnitudes of D_ds other than $D_a > D_b$ and $D_b' > D_a$, it is possible that the conditions above hold. Therefore number of export destinations may increase.

To sum up, we propose three cases showing that the number of foreign destinations may increase, decrease, or remain unchanged due to the quota removal shock. □

Proof of Proposition 4

If the quota removal shock $D_k \to D_k'$ does not lead firm ϕ to decrease its number of export destinations $S^*(\phi)$, the quota removal shock always causes an increase in market access, $\text{MA}(\phi, \Omega^*(\phi))$, and decreases in sales in destinations other than k.

Proof. If the quota removal shock $D_k \to D_k'$ does not lead firm ϕ to decrease its number of foreign destinations $S(\phi)$, then either $S(\phi)' = S(\phi)$ or $S(\phi)' > S(\phi)$.

For firms with $\phi \in (0, \phi_k)$, either $S(\phi)' = S(\phi)$ or $S(\phi)' > S(\phi)$ can occur. According to Proposition 3, the market access before and after the quota removal event are

$$\text{MA}(\phi) = (D_o + \sum_{s(d)=1}^{S(\phi)} D_d),\ \text{MA}(\phi)' = (D_o + \sum_{s(d)=1}^{S(\phi)-1} D_d + D_k')),\ \text{ if } S(\phi)' = S(\phi)$$

$$\text{MA}(\phi) = (D_o + \sum_{s(d)=1}^{S(\phi)} D_d),\ \text{MA}(\phi)' = (D_o + \sum_{s(d)=1}^{S(\phi)} D_d + D_k'),\ \text{ if } S(\phi)' > S(\phi)$$

For firms with $\phi \in [\phi_k, \infty)$, only $S(\phi)' = S(\phi)$ is likely to occur given the empirical finding that $S(\phi)' \geq S(\phi)$. According to Proposition 3, the market access before and after the quota removal event is

$$\text{MA}(\phi) = (D_o + \sum_{s(d)=1}^{S(\phi)} D_d),\ \text{MA}(\phi)' = (D_o + \sum_{s(d)=1}^{S(\phi)} D_d + (D_k' - D_k))$$

Because $\forall d \neq k$, $D_k' > D_d$ and $D_k' > D_k$, it is immediate that

$$\text{MA}(\phi)' > \text{MA}(\phi)$$

Firm ϕ's export sales to a destination $d \neq k$ before and after the shock, conditional on that d is always in ϕ's sales strategy, is

$$\hat{X}_d(\phi) = \frac{X_d(\phi)'}{X_d(\phi)} = \Big(\frac{\text{MA}(\phi)'}{\text{MA}(\phi)}\Big)^{\gamma-1} < 1,\ if\ d \neq k$$

Therefore, the quota removal shock in k induces firm ϕ to decrease its export sales to destinations other than k. It is trivial to show that once the firm exit market d due to the quota removal shock, its export sales to that destination also decreases. □