Import Liberalization and Export Product Mix

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Abstract

This paper develops a heterogeneous-firm monopolistic competition model with product flexibility to explain the effects of unilateral trade liberalization on the product mix of multi-product exporting firms. The model shows that the import policy of the domestic country has significant impacts on the export product mix of the domestic exporters. Reduction of tariffs on imported inputs leads to increases in the export values of all exported products. By contrast, reduction of tariffs on imported outputs leads to decreases in the export values of all exported products. The strengths of both effects rise with the rank of the product: the magnitudes of both effects on export values are higher the further the product is from the firm's core competency. Consequently, the domestic exporter expands its export product scope following cuts of imported-input tariffs but shrinks its export product scope following cuts of imported-output tariffs. These predictions are supported by a number of empirical tests using Chinese data for the period 2000-2006 that covers the bulk of the tariff changes associated with China's accession to the World Trade Organization. The paper also calibrates the parameters of the model based on U.S.-China trade data, and quantifies the impacts of reduction in imported-output and imported-input tariffs.

Keywords: Trade liberalization; Product churning; Global sourcing
JEL: F1, F4, O4

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1 Introduction

World trade has been dominated by large exporters. Theoretically, only large firms are able to afford the fixed costs that are associated with selling goods to foreign countries (Melitz 2003). Empirically, it has been documented that exporters employ more workers and have higher revenues than non-exporters (Bernard and Jensen 1995). Most of the export values come from multi-product firms. Indeed, exporters with more than 10 products sold abroad account for more than 80 percent of French exports (Mayer and Ottaviano, 2007). There are similar statistics for other countries, such as Brazil (Arkolakis and Muendler, 2008).

The dominance of multi-product firms in international trade has prompted economists to study the changes in export product mix, a phenomenon known as "product churning." Bernard, Redding and Schott (2010) report that half of U.S. firms alter their product mix every five years. For every two firms that alter their product mix, there is one that adds or drops at least one product. Moreover, exporters are more likely to change their product mix than non-exporters. The changes in product mix are attributed to idiosyncratic shocks to consumer tastes for individual products. New products are introduced if they receive sufficiently large positive taste shocks. In contrast, products might be dropped upon negative taste shocks.

Mayer, Melitz and Ottaviano (2014) suggest that the degree of market competitiveness induces firms to adjust their product scope. In particular, firms expand the export scope if the foreign market condition is favorable and reduce the scope otherwise. Inspired by their paper, we build a model to provide the micro-foundation for the determination of competitiveness of the foreign market to study export product mix. In a globalized world where countries are connected in a production supply chain, the import policy of the domestic country can affect the competitiveness of foreign markets, especially when they are important trading partners. In particular, a reduction in tariffs on imported intermediate goods, which we call imported-input tariff reduction hereafter, allows domestic firms to employ more and better inputs, thus lowering their costs and raising the probability of exporting. However, a reduction in the tariffs of imported-final goods, which we call imported-output tariff reduction hereafter, raises foreign firms' expected profits and induce more foreign firm entry in the foreign market. As a result, the foreign market becomes more competitive, and so it is difficult for domestic firms to gain a footing in the foreign market.

Our model predicts that a reduction in the imported-input tariffs leads to an increase in the export value for each final product produced by a multi-product firm, and more so for the final products that are further away from the core competency of the firm. This is consistent with the findings of Mayer, Melitz and Ottaviano (2014), because reduction in the imported-input tariffs makes domestic exporters relatively more competitive, rendering foreign markets easier for them to break into. In contrast, reduction in imported-output tariffs leads to a decrease in the export value of each final product produced by a multi-product firm, and more so for final products that are further away from the core competency of the firm. This is because foreign markets become more competitive for domestic firms after the cuts in imported-output tariffs, which induce the firm to reallocate its resources toward its core competency.

After developing the theory, we test it using Chinese data which are disaggregated at the firm-product-destination level. This data set is especially suitable for testing the theory for two reasons. First, as a condition of China's accession to the World Trade Organization (WTO) in December 2001, tariffs imposed by China on imported goods significantly decreased. In particular, the average input tariff fell by approximately 40 percent from 2000 to 2006. Meanwhile, Chinese export tariffs did not change much when China joined the WTO, as China long enjoyed Most Favored Nation (MFN) treatment from major trading partners prior to WTO accession. Thus it is reasonable to assume that China's WTO accession has resulted in unilateral trade liberalization (Fan, Li and Yeaple forthcoming). This unilateral feature of Chinese trade liberalization serves as a quasi-natural experiment that allows us to estimate the effect of import tariff reductions on firms' activities. Second, our data set distinguishes between the two trading regimes in China: ordinary trade (wherein firms pay import tariffs on import intermediate goods) and processing trade (wherein firms do not pay import tariffs on intermediate goods). From 2000 to 2006, more than 50 percent of transactions carried out in China trade involved the processing trade mechanisms.[1] As the processing-trade firms are not subject to tariffs reduction, our data allows us to carry the placebo test as a robustness check.

In the central part of our empirical work, we shall examine the effects of tariff reduction on imported inputs for ordinary trade firms. As predicted by our theory, imported-input tariff cuts results in switches of production toward the peripheral products, reducing the gap in export value between products in the top group (i.e. the core products) and the bottom group (i.e. the peripheral products). In contrast, a firm typically skews its production toward its core product in response to a reduction in inported-output tariffs. That is, the products further away from the core product would be more affected by a imported-input tariff reduction and experience larger increases in export values relative to the core product. Similarly, the same products would be more affected by imported-output tariff reduction and experience larger decreases in export values, relative to the core product. To be more precise, a one standard deviation increase in the log rank (of distance from the core product) is associated with a 2 to 3 percent increase in the

[1] Processing trade is a prevalent feature among Chinese trading firms; see Yu (forthcoming) and Manova and Yu (2014) for more details

export value following a 1 percent reduction in imported-input tariffs. Similarly, a one standard deviation increase in the log rank is associated with a 0.5 to 0.7 percent fall in the export value following a 1 percent reduction in imported-output tariffs. Moreover, as the impact of tariff reduction rises with the trade flow between two trading countries, we find that the effects of imported-input and imported-output tariff reduction become much stronger, statistically and economically, when we limit our sample countries to China's important importing and/or exporting trade partners.

Our results are robust to using various measures of product ranks and difference estimators, the use of the whole universe of Chinese exporting firms (as opposed to a merged sample that only includes large exporters), and the inclusion of some other mechanisms that can be at work, such as exchange rate reforms or the removal of uncertainty in tariffs. We do not find any evidence of the effects of imported-input and imported-output tariff cuts on the processing trade sample, which is used for our placebo test. Finally, we deal with the potential endogeneity issue of the tariff cuts by using the instrumental variable approach.

In addition to the effect of trade liberalization on export value, we also analyze the effect of trade liberalization on the firm's number of products exported. Trade liberalization in the final goods market leads a firm to concentrate most of its exports in a smaller number of products, thereby increasing the skewness of export values. On the other hand, trade liberalization in imported-intermediate goods induces a firm to spread its exports to a larger number of products, thereby reducing the skewness of export values among the products exported by the firm.

We calibrate the parameters of our model to match the moments of the U.S.-China trade data at the industry level. Among the parameters calibrated are the shape parameter of the productivity distribution, the customization costs, and the state of the technology. The estimates of these parameters enable us to investigate quantitatively how the unilateral trade liberalization policy in China eases Chinese firms' access to the U.S. market. In particular, our results show that a reduction in the imported-intermediate input tariff lowers the export productivity cutoff by 3 percent on average, while a reduction in the imported-final good tariff raises the export productivity cutoff by 3 percent. We also look into how export values respond to these tariff reductions. We came to the conclusion that imported-input tariff cuts raise the export value of a product by 2 to 3 percent (depending on the rank of the product) and imported-output tariff cuts lower the export value of a product by 1.5 to 2.5 percent.

The paper is organized as follows. Section 2 reviews the related literature. Section 3 lays out the model, carries out general equilibrium analyses and derives the main results. Section 4 discusses the data and the specifications of the empirical tests. Section 5 reports the main empirical test results. In Section 6 we carry out a battery of robustness checks and calibrate the parameters. In Section 7 we quantify the effects of imported-input and imported-output tariff cuts, respectively, on export productivity cutoffs and export values using U.S.-China trade data. Section 8 concludes.

2 Related Literature

This paper is related to several strands of literature. The first reflects a growing interest in understanding the impact of improved import access on domestic firms' performance. For instance, better import access has been documented to improve total factor productivity (Amiti and Konings, 2007; Halpern, Koren and Szeidl, 2011; ¿Gopinath and Neiman, 2014). Access to imports also purportedly enables firms to upgrade their product quality (Amiti and Khandelwal, 2013; Fan, Li and Yeaple, forthcoming; Bas and Strauss-Kahn, 2015). In addition, imported-goods trade reforms can lead to product scope expansion (Goldberg et al., 2010). A common feature in these papers is that they adopt a partial equilibrium approach. In our paper, we build a general equilibrium model and distinguish between the effects of imported-intermediate goods tariff reductions and those of imported-final goods tariff reductions on an exporter's product mix. Antras, Fort and Tintelnot (2014) develop a general equilibrium model by incorporating the choice of imported intermediate goods from different sources into the Melitz (2003) model and study the extensive and intensive margins of firms' global sourcing decisions.

We complement the study of Antras, Fort and Tintelnot (2014) by tackling a different question. In particular, we aim to link the importing of intermediate goods to one important dimension of export performance, viz. the product mix. To achieve this objective, we combine the framework in Antras, Fort and Tintelnot (2014) with that in Mayer, Melitz and Ottaviano (2014) to investigate the impact of import policy on exporters' product mix. First, imported-final goods tariff reduction results in purchase adjustments by domestic consumers. These adjustments clearly have an impact on the foreign firms' profits, which feedbacks to the foreign markets. Second, in response to imported-intermediate good tariff reduction, domestic producers adjust the purchase of imported intermediate inputs, which influences their competitiveness in foreign markets. Both effects imply that the degree of competition in the trading partners' markets must change in response to the reduction of import tariffs in the domestic country. This induces domestic exporters to reallocate their resources devoted to different final goods. Consequently, relative export values of the goods are affected.

Our paper is also related to another important literature that discusses multi-product firms. In Feenstra and Ma (2008), multi-product firms are large, and therefore can influence the aggregate price index. As a result, adjustments along the extensive margin within firms create a cannibalization effect. Dhingra (2013) introduces brand differentiation by grouping different varieties supplied by the same firm (brand) together. The cannibalization effect occurs even though firms are assumed to be relatively small, as consumers' willingness to pay for a variety falls if they consume more varieties from the same brand (firm). Bernard, Redding and Schott (2010) extend the firm-heterogeneity framework in Melitz (2003) by adding another dimension of heterogeneity: the same product attractiveness to consumers varies across producers. Hence, the interaction between the firm's productivity shock and the shock on consumers' taste for a firm's product explains the frequent dropping and adding of products by firms.

Nocke and Yeaple (2014) decompose heterogeneity of firms into two dimensions: organizational capital and organizational efficiency. The fixed amount of the former dictates the trade-off within the firm between extending the product scope and lowering the marginal cost of each product. In some work in the literature, the idea that a firm has a core competency has been extensively explored. For instance, Eckel and Neary (2010) consider a model of flexible manufacturing where each firm faces rising marginal cost with the distance of the product from its core competency. On the other hand, Mayer, Melitz and Ottaviano (2014) assume that firms face a product ladder, where there is diminishing productivity associated with each additional variety produced.

We use the framework in Mayer, Melitz and Ottaviano (2014) to analyze resource reallocation within firms following trade liberalization. This question has now become an important topic in international economics. Baldwin and Gu (2009) show that trade liberalization induces exporters to reduce their product diversification. Bernard, Redding and Schott (2011) show that firms tend to drop the least attractive products as a result. The common feature in these models is that they analyze bilateral trade liberalization in the final goods markets. We complement their studies by analyzing unilateral trade liberalization in imported goods. Consequently, the implications of our study are different, as we show that trade liberalization leads to more or less diversification depending on whether the import tariff reduction applies to final or intermediate goods. In particular, although liberalizing the imported intermediate goods markets would imply more product diversification, liberalizing the imported final goods markets would have the opposite effect.

Finally, our paper is related to the literature that emphasizes the difference between trade reforms in the final goods markets and the intermediate goods markets. Compared with trade liberalization in final-good markets, trade liberalization in intermediate-good markets has been reported to have a far more important impact on firms' productivity (Amiti and Konings, 2007). De Loecker et al. (forthcoming) analyze the different effects of imported-output tariff reductions and imported-input tariff reductions on firm-product markups. Luong (2011) shows that output tariff reductions and input tariff reductions can have different impacts on firms' productivity, and the direction of the impacts depends on the level of differentiation of the products. Following this line of thinking, we show in this paper that while imported-input tariff cuts raise the probability of exporting and induce firms to expand their export product scope, cuts in imported-output tariffs have the opposite effect.

3 Model

We build a variable markup model with heterogeneous firms based on Mayer, Melitz and Ottaviano (2014) and Antras, Fort and Tintelnot (2014) to explain the effect of unilateral trade liberalization on the product mix of exporters. Our model consists of two countries, Home (H) and Foreign (F), with L_H and L_F consumers in each country. Each consumer is endowed with one unit of labor.

3.1 Demand

The representative consumer's utility function in country l ($l = H, F$) is:

$$U_l = q_{l,0}^c + \alpha \int_{i\in\Omega_l} q_{l,i}^c di - \frac{1}{2}\gamma \int_{i\in\Omega_l} \left(q_{l,i}^c\right)^2 di - \frac{1}{2}\eta \left(\int_{i\in\Omega_l} q_{l,i}^c di\right)^2 \tag{1}$$

where $q_{l,0}^c$ and $q_{l,i}^c$ denote the individual consumption levels of the homogeneous good and the differentiated good i respectively in country l. The homogeneous good is chosen as the numeraire.

Ω_l denotes the set of differentiated goods sold in country l. The demand parameters α, γ, and η are all positive. In particular, γ indexes the degree of product differentiation between any pair of varieties. When $\gamma = 0$, the varieties are perfect substitutes. In this case, consumers only have to maximize their consumption level over all varieties, $Q_l^c = \int_{i\in\Omega_l} q_{l,i}^c di$. We assume that incomes of the consumers in both countries are high enough so that the demand for the numeraire good is positive ($q_{l,0}^c > 0$). The profit-maximizing price for any given variety i in country l is given by

$$p_{l,i} = \alpha - \gamma q_{l,i}^c - \eta Q_l^c \tag{2}$$

whenever $q_{l,i}^c > 0$. Then we have:

$$M_l \overline{p}_l = \alpha M_l - (\eta M_l + \gamma)\, Q_l^c$$

where M_l is the measure of the consumed varieties in Ω_l and $\overline{p}_l = (1/M_l) \int_{i\in\Omega_l} p_{l,i} di$ is their average price (both local and exporting firms) in country l. Substituting for Q_l^c in

Equation (2) from the previous expression, we have:

$$q_{l,i} \equiv L_l q^c_{l,i} = \frac{\alpha L_l}{\eta M_l + \gamma} - \frac{L_l}{\gamma} p_{l,i} + \frac{\eta M_l}{\eta M_l + \gamma} \frac{L_l}{\gamma} \overline{p}_l, \quad \forall i \in \Omega_l \tag{3}$$

Then, $p_{l,i}$ satisfies:

$$p_{l,i} \leq \frac{\alpha\gamma + \eta M_l \overline{p}_l}{\eta M_l + \gamma} \equiv p^{\max}_l, \tag{4}$$

where the right-hand side price bound $p^{\max}_l \leq \alpha$ represents the price at which the demand for the variety is driven to zero.

3.2 Supply

Technology — The production of each unit of homogeneous good requires one unit of labor. We assume this outside good is produced by both countries and is freely traded so that the wages in both countries can be normalized to one. The production of the differentiated final goods, however, requires a bundle of intermediate inputs. Entry in the differentiated final product sector is costly, as each firm incurs product development and production startup costs. Subsequent production of each final good variety exhibits constant returns to scale.

While a firm may decide to produce more than one variety of differentiated goods, each firm has one key variety corresponding to its "core competency". This key variety is associated with a core productivity φ. Firms learn about their core productivity only after making the irreversible investment f_e required for entry. We model this as a draw from a common (and known) distribution $G(\varphi)$ with support $[\varphi_{\min}, \infty)$. A firm can introduce any number of new varieties, but each additional variety entails an additional customization cost as it pulls a firm away from its core competency. In other words, the productivity in producing each additional variety decreases as it gets further away from the core product. The variable m denotes the rank of a variety's distance, in the product space, from the firm's core variety, where $m = 0$ corresponds to the firm's core variety. The productivity of variety m produced by a firm with core productivity φ is given by $\phi(m, \varphi) = \omega^m \varphi$ with $0 < \omega < 1$.

We index the final-good variety by the productivity $\phi(m, \varphi)$. The production of each variety requires the assembly of a bundle of intermediates. Following Antras, Fort and Tintelnot (2014), we assume that the production of intermediates has to be offshored. The intermediate inputs are assumed to be imperfectly substitutable with each other with a constant elasticity of substitution ρ. All intermediates are produced with labor using variety-specific technologies.

Input sourcing and marginal costs — We denote by $a_j(v, \phi)$ the variety-specific labor requirements to produce the intermediate good $v \in [0,1]$ that can be used in the production of the final-good variety ϕ in country $j \in [H, F]$. There is no fixed cost of offshoring. As a result, the final good producer can source each of its inputs either from its home country or from the foreign country. We call $\{h(v)\}_{v=0}^{1}$ the vector of production locations corresponding to the bundle of intermediate inputs. As in Antras, Fort and Tintelnot (2014) the marginal cost of producing the final-good variety ϕ in country l is given by:

$$c_l\left(\{h(v)\}_{v=0}^{1}, \phi\right) = \frac{1}{\phi}\left(\int_0^1 \left[\tau_{h(v)l}^{i} a_{h(v)}(v,\phi)\right]^{1-\rho} dv\right)^{\frac{1}{1-\rho}}$$

where τ_{hl}^{i} denotes the trade costs for importing the intermediate goods by the base country l from the production location $h(v)$, where $\tau_{ll}^{i} = 1$ and $\tau_{h(v)l}^{i} > 1$ if $h(v) \neq l$. From now on, the first subscript of a variable refers to the origin country and the second subscript refers to the destination market.

Following Eaton and Kortum (2002), we assume that the country's efficiency distribution for producing the intermediate goods follows the Frechet distribution.

$$\Pr\left(a_h(v,\phi) \leq a\right) = e^{-T_h a^{-\theta}}$$

with $T_h > 0$. The variety-specific efficiency $a_h(v,\phi)$ is drawn independently across locations, inputs, and the productivity of producing this variety ϕ. The parameter T_h governs the state of technology in country $h \in \{H, F\}$, while θ determines the variability of productivity draws across inputs. As a result, the marginal cost of producing the final-good variety ϕ in country l satisfies:

$$c_l(\phi) = \frac{1}{\phi}\left[\zeta \Theta_l\right]^{-1/\theta} \tag{5}$$

where $\Theta_l = T_l + T_h\left(\tau_{hl}^{i}\right)^{-\theta}$ is the sourcing capability, $\zeta = \left[\Gamma\left(\frac{\theta+1-\rho}{\theta}\right)\right]^{\theta/(1-\rho)}$ and Γ is the Gamma function. Note that all the firms share the same sourcing capability Θ_l.

Firm behavior — Because the entry cost is sunk, firms need only to cover the marginal cost of their core variety in order to produce. Taking the average price level $\overline{p}_l$ and total number of varieties M_l as given, these firms maximize their profits based on the residual demand function (3). Denote by $p_{lh}(\phi)$ and $q_{lh}(\phi)$ the price and quantity, respectively, of a variety ϕ that is produced in country l and sold in country h. Combining Equations (3) and (4), we have:

$$q_{lh}(\phi) = \frac{L_h}{\gamma}\left[p_h^{\max} - p_{lh}(\phi)\right] \tag{6}$$

In the domestic market, for any variety ϕ to be produced, the profit-maximizing price $p_{ll}(\phi)$ must be below $p_l^{\max}$. Let ϕ_{ll} denote the productivity cutoff of the variety that yields zero profit. Firms with the core productivity $\varphi < \phi_{ll}$ cannot profitably produce any variety, including their core variety. Therefore, they have to exit the sector. Hence, $\varphi_{ll} = \phi_{ll}$ is also the productivity cutoff for firm survival and measures the "toughness" of competition in the market. By definition, the demand for the marginal variety $q_{ll}(\phi_{ll})$ is zero and hence the marginal cost cutoff is given by $c_{ll} = p_{ll}(\phi_{ll}) = p_l^{\max}$ which satisfies Equation (5). Solving the firm profit maximization problem $\underset{p_{ll}(\phi)}{max}\ \pi_{ll}(\phi) = [p_{ll}(\phi) - c_l(\phi)]\, q_{ll}(\phi)$ by using Equations (5) and (6), we have:

$$p_{ll}(\phi) = \frac{1}{2}\left[c_{ll} + c_l(\phi)\right] = \frac{[\zeta\Theta_l]^{-1/\theta}}{2}\left[\frac{1}{\phi_{ll}} + \frac{1}{\phi}\right]$$

Correspondingly, the other performance measures, (absolute) markup $\mu_{ll}(\phi)$, quantity $q_{ll}(\phi)$, revenue $r_{ll}(\phi)$ and profit $\pi_{ll}(\phi)$, are given by:

$$\begin{aligned}
\mu_{ll}(\phi) &= \frac{1}{2}\left[c_{ll} - c_l(\phi)\right] = \frac{[\zeta\Theta_l]^{-1/\theta}}{2}\left[\frac{1}{\phi_{ll}} - \frac{1}{\phi}\right] \\
q_{ll}(\phi) &= \frac{L_l}{2\gamma}\left[c_{ll} - c_l(\phi)\right] = \frac{L_l\,[\zeta\Theta_l]^{-1/\theta}}{2\gamma}\left[\frac{1}{\phi_{ll}} - \frac{1}{\phi}\right] \\
r_{ll}(\phi) &= \frac{L_l}{4\gamma}\left[c_{ll}^2 - c_l^2(\phi)\right] = \frac{L_l\,[\zeta\Theta_l]^{-2/\theta}}{4\gamma}\left[\frac{1}{\phi_{ll}^2} - \frac{1}{\phi^2}\right] \\
\pi_{ll}(\phi) &= \frac{L_l}{4\gamma}\left[c_{ll} - c_l(\phi)\right]^2 = \frac{L_l\,[\zeta\Theta_l]^{-2/\theta}}{4\gamma}\left[\frac{1}{\phi_{ll}} - \frac{1}{\phi}\right]^2
\end{aligned}$$

In addition to selling to the domestic market, firms in country l can export the final-good variety to country h as long as it yields a non-negative profit. Each traded final good is subject to a per-unit trade cost $\tau_{lh}^o > 1$, which we call output tariff.[2] The marginal cost of exporting variety ϕ from country l inclusive of the trade cost is therefore $\tau_{lh}^o c_l(\phi)$. Similar to the situation in the domestic market l, in the foreign market h, there is the marginal cost cutoff c_{hh}, which corresponds to the variety-specific productivity cutoff ϕ_{hh} and firm productivity cutoff φ_{hh}. Maximization of firms' export profit

[2]We assume here that there is no transportation cost.

$\pi_{lh}(\phi) = (p_{lh}(\phi) - \tau^o_{lh} c_l(\phi))\, q_{lh}(\phi)$ yields:

$$p_{lh}(\phi) = \frac{1}{2}\left(c_{hh} + \tau^o_{lh} c_l(\phi)\right) = \frac{\tau^o_{lh}\left[\zeta\Theta_l\right]^{-1/\theta}}{2}\left[\frac{1}{\phi_{lh}} + \frac{1}{\phi}\right] \tag{7}$$

$$\mu_{lh}(\phi) = \frac{1}{2}\left[c_{hh} - \tau^o_{lh} c_l(\phi)\right] = \frac{\tau^o_{lh}\left[\zeta\Theta_l\right]^{-1/\theta}}{2}\left[\frac{1}{\phi_{lh}} - \frac{1}{\phi}\right] \tag{8}$$

$$q_{lh}(\phi) = \frac{L_h}{2\gamma}\left[c_{hh} - \tau^o_{lh} c_l(\phi)\right] = \frac{L_h \tau^o_{lh}\left[\zeta\Theta_l\right]^{-1/\theta}}{2\gamma}\left[\frac{1}{\phi_{lh}} - \frac{1}{\phi}\right] \tag{9}$$

$$r_{lh}(\phi) = \frac{L_h}{4\gamma}\left[c^2_{hh} - \left(\tau^o_{lh} c_l(\phi)\right)^2\right] = \frac{L_h\left(\tau^o_{lh}\left[\zeta\Theta_l\right]^{-1/\theta}\right)^2}{4\gamma}\left[\frac{1}{\phi^2_{lh}} - \frac{1}{\phi^2}\right] \tag{10}$$

$$\pi_{lh}(\phi) = \frac{L_h}{4\gamma}\left[c_{hh} - \tau^o_{lh} c_l(\phi)\right]^2 = \frac{L_h\left(\tau^o_{lh}\left[\zeta\Theta_l\right]^{-1/\theta}\right)^2}{4\gamma}\left[\frac{1}{\phi_{lh}} - \frac{1}{\phi}\right]^2 \tag{11}$$

where ϕ_{lh} is the productivity cutoff of a variety exported from country l to country h, which corresponds to the marginal cost inclusive of the trade cost $\tau^o_{lh} c_{lh} = \frac{\tau^o_{lh}[\zeta\Theta_l]^{-1/\theta}}{\phi_{lh}}$. By construction this marginal cost inclusive of the trade cost should equal the maximum price in the foreign market, i.e., $\tau^o_{lh} c_{lh} = p^{\max}_h = c_{hh} = \frac{[\zeta\Theta_h]^{-1/\theta}}{\phi_{hh}}$. Hence, the variety-specific productivity cutoff satisfies:

$$\phi_{lh} = \frac{\tau^o_{lh}\left[\zeta\Theta_l\right]^{-1/\theta}}{\left[\zeta\Theta_h\right]^{-1/\theta}}\phi_{hh} \tag{12}$$

Firms with core productivity $\varphi < \phi_{lh}$ cannot profitably sell any variety in the foreign market, including their core variety. Hence, the threshold $\varphi_{lh} = \phi_{lh}$ is also the domestic firms' export productivity cutoff. Hence, we also have:

$$\varphi_{lh} = \frac{\tau^o_{lh}\left[\zeta\Theta_l\right]^{-1/\theta}}{\left[\zeta\Theta_h\right]^{-1/\theta}}\varphi_{hh} \tag{13}$$

3.3 Equilibrium

All the results derived so far hold for any distribution of core productivity draw $G(\varphi)$. To simplify the analysis, we assume that core productivity φ is drawn from a Pareto distribution with the scale parameter $\varphi_{\min}$ and shape parameter $k \geq 1$, which is given by:

$$G(\varphi) = \left(\frac{\varphi}{\varphi_{\min}}\right)^{-k}, \quad \varphi \in [\varphi_{\min}, \infty)$$

The shape parameter k indicates the dispersion of productivity draws. Any truncation of the productivity distribution from below will increase $\varphi_{\min}$ but retain the same distribution function and shape parameter k. The productivity distribution of surviving firms will therefore also be Pareto with shape k, and the truncated productivity distribution for the domestic producing firm and the truncated productivity distribution for the domestic exporting firm are respectively:

$$G_{ll}(\varphi) = \left(\frac{\varphi}{\varphi_{ll}}\right)^{-k}; \quad G_{lh}(\varphi) = \left(\frac{\varphi}{\varphi_{lh}}\right)^{-k}$$

We can then define a firm's total profits from the domestic and export markets by aggregating over these varieties:

$$\Pi_{ll}(\varphi) = \sum_{m=0}^{M_{ll}(\varphi)-1} \pi_{ll}(\phi(m,\varphi)); \quad \Pi_{lh}(\varphi) = \sum_{m=0}^{M_{lh}(\varphi)-1} \pi_{lh}(\phi(m,\varphi))$$

where the total number of varieties produced and sold in the domestic market by a firm with productivity φ, $M_{ll}(\varphi)$, and the total number of varieties produced and exported to the foreign market, $M_{lh}(\varphi)$, are respectively given by:

$$\begin{aligned}
M_{ll}(\varphi) &= \begin{cases} 0 & \text{if } \varphi < \varphi_{ll} \\ \max\{m|\varphi \geq \omega^{-m}\varphi_{ll}\} + 1 & \text{if } \varphi \geq \varphi_{ll} \end{cases} \\
M_{lh}(\varphi) &= \begin{cases} 0 & \text{if } \varphi < \varphi_{lh} \\ \max\{m|\varphi \geq \omega^{-m}\varphi_{lh}\} + 1 & \text{if } \varphi \geq \varphi_{lh} \end{cases}
\end{aligned}$$

Now, the free entry condition implies that the sunk cost equals each potential entrant's expected profits:

$$\begin{aligned}
f_e &= \int_{\varphi_{ll}}^{\infty} \Pi_{ll}(\varphi)\, dG(\varphi) + \int_{\varphi_{lh}}^{\infty} \Pi_{lh}(\varphi)\, dG(\varphi) \\
&= \int_{\varphi_{ll}}^{\infty} \sum_{m=0}^{M_{ll}(\varphi)} \pi_{ll}(\phi(m,\varphi))\, dG(\varphi) + \int_{\varphi_{lh}}^{\infty} \sum_{m=0}^{M_{lh}(\varphi)} \pi_{lh}(\phi(m,\varphi))\, dG(\varphi) \\
&= \sum_{m=0}^{\infty} \int_{\omega^{-m}\varphi_{ll}}^{\infty} \pi_{ll}(\phi(m,\varphi))\, dG(\varphi) + \sum_{m=0}^{\infty} \int_{\omega^{-m}\varphi_{lh}}^{\infty} \pi_{lh}(\phi(m,\varphi))\, dG(\varphi) \\
&= \frac{\Omega\varphi_{\min}^{k}}{2\gamma(k+1)(k+2)} \left[L_l[\zeta\Theta_l]^{-2/\theta} \varphi_{ll}^{-k-2} + L_h(\tau_{lh}^{o})^2 [\zeta\Theta_l]^{-2/\theta} \varphi_{lh}^{-k-2}\right] \\
&= \frac{\Omega\varphi_{\min}^{k}}{2\gamma(k+1)(k+2)} \left[L_l[\zeta\Theta_l]^{-2/\theta} \varphi_{ll}^{-k-2} + L_h[\zeta\Theta_h]^{-2/\theta} \left(\frac{\tau_{lh}^{o}[\zeta\Theta_l]^{-1/\theta}}{[\zeta\Theta_h]^{-1/\theta}}\right)^{-k} \varphi_{hh}^{-k-2}\right]
\end{aligned}$$

In the expressions above, $\Omega = \sum_{m=0}^{\infty} \omega^{mk} = \left(1-\omega^{k}\right)^{-1} < 1$. This variable indicates multi-product flexibility that increases with ω.

The two free-entry conditions above (one for each country) forms a 2x2 system which can then be solved for the domestic productivity cutoffs in both countries:[3]

$$\varphi_{ll}^{-k-2} = \frac{2\gamma(k+1)(k+2)\varphi_{\min}^{-k} f_e}{\Omega L_l [\zeta\Theta_l]^{-2/\theta}} \frac{1 - \left[\frac{\tau_{lh}^o [\zeta\Theta_l]^{-1/\theta}}{[\zeta\Theta_h]^{-1/\theta}}\right]^{-k}}{1 - (\tau_{lh}^o \tau_{hl}^o)^{-k}} \tag{14}$$

$$\varphi_{hh}^{-k-2} = \frac{2\gamma(k+1)(k+2)\varphi_{\min}^{-k} f_e}{\Omega L_h [\zeta\Theta_h]^{-2/\theta}} \frac{1 - \left[\frac{\tau_{hl}^o [\zeta\Theta_h]^{-1/\theta}}{[\zeta\Theta_l]^{-1/\theta}}\right]^{-k}}{1 - (\tau_{lh}^o \tau_{hl}^o)^{-k}} \tag{15}$$

From (13), (14), and (15), we have:

$$\varphi_{lh}^{-k-2} = \frac{2\gamma(k+1)(k+2)[\zeta\Theta_l]^{2/\theta} f_e}{\Omega L_h (\tau_{lh}^o)^2 \varphi_{\min}^k} \frac{\left[\frac{\tau_{lh}^o [\zeta\Theta_l]^{-1/\theta}}{[\zeta\Theta_h]^{-1/\theta}}\right]^{-k} - (\tau_{lh}^o \tau_{hl}^o)^{-k}}{1 - (\tau_{lh}^o \tau_{hl}^o)^{-k}} \tag{16}$$

$$\varphi_{hl}^{-k-2} = \frac{2\gamma(k+1)(k+2)[\zeta\Theta_h]^{2/\theta} f_e}{\Omega L_h (\tau_{hl}^o)^2 \varphi_{\min}^k} \frac{\left[\frac{\tau_{hl}^o [\zeta\Theta_h]^{-1/\theta}}{[\zeta\Theta_l]^{-1/\theta}}\right]^{-k} - (\tau_{lh}^o \tau_{hl}^o)^{-k}}{1 - (\tau_{lh}^o \tau_{hl}^o)^{-k}} \tag{17}$$

Note that the sufficient condition to have $\varphi_{ll} > 0$, $\varphi_{hh} > 0$, $\varphi_{lh} > 0$ and $\varphi_{hl} > 0$ is $(\tau_{lh}^o \tau_{hl}^o)^{-k} < \left[\frac{\tau_{lh}^o [\zeta\Theta_l]^{-1/\theta}}{[\zeta\Theta_h]^{-1/\theta}}\right]^{-k} < 1$ and $(\tau_{lh}^o \tau_{hl}^o)^{-k} < \left[\frac{\tau_{hl}^o [\zeta\Theta_h]^{-1/\theta}}{[\zeta\Theta_l]^{-1/\theta}}\right]^{-k} < 1$. The following assumption guarantees this sufficient condition:

Assumption 1. $\tau_{hl}^o > \frac{[\zeta\Theta_l]^{-1/\theta}}{[\zeta\Theta_h]^{-1/\theta}} > (\tau_{lh}^o)^{-1}$

This assumption is a mild condition. Indeed, note that $\Theta_l = T_l + T_h (\tau_{hl}^i)^{-\theta}$ and $\Theta_h = T_h + T_l (\tau_{lh}^i)^{-\theta}$. Therefore, we can rewrite Assumption 1 as:

$$\tau_{hl}^o > \left(\frac{T_l + T_h (\tau_{hl}^i)^{-\theta}}{T_h + T_l (\tau_{lh}^i)^{-\theta}}\right)^{-1/\theta} > (\tau_{lh}^o)^{-1}$$

When $T_l = T_h$ and $\tau_{hl}^i = \tau_{lh}^i$, Assumption 1 is equivalent to $\tau_{hl}^o > 1 > (\tau_{lh}^o)^{-1}$, which is always satisfied.

3.4 The Effects of Trade Liberalization

In what follows, we will analyze how a reduction in the imported-input tariff τ_{hl}^i and a reduction in the imported-output tariff τ_{hl}^o affect the export productivity cutoff φ_{lh} of the firms in country l. We assume that the exported-input tariff τ_{lh}^i and exported-output tariff τ_{lh}^o are unchanged. This is because prior to the WTO accession, China was granted

[3] The condition to guarantee $\varphi_{ll} > \varphi_{\min}$ and $\varphi_{hh} > \varphi_{\min}$ is: $\min\left(\left[\frac{2\gamma(k+1)(k+2)f_e}{\Omega L_h[\zeta\Theta_h]^{-2/\theta}} \frac{1-\left(\frac{\tau_{hl}^o[\zeta\Theta_h]^{-1/\theta}}{[\zeta\Theta_l]^{-1/\theta}}\right)^{-k}}{1-(\tau_{lh}^o\tau_{hl}^o)^{-k}}\right]^{-1/2}, \left[\frac{2\gamma(k+1)(k+2)f_e}{\Omega L_l[\zeta\Theta_l]^{-2/\theta}} \frac{1-\left(\frac{\tau_{lh}^o[\zeta\Theta_l]^{-1/\theta}}{[\zeta\Theta_h]^{-1/\theta}}\right)^{-k}}{1-(\tau_{lh}^o\tau_{hl}^o)^{-k}}\right]^{-1/2}\right) > \varphi_{\min}$

the MFN status by many of its important trading partners. As a result, the export tariffs had been low and hardly changed after China's WTO accession.

From Equation (16), we obtain the following:

$$
\begin{aligned}
\Delta \log \varphi_{lh} \quad = \quad & \frac{1}{k+2}\left(2+\frac{k}{1-\left[\frac{\tau^o_{hl}[\zeta\Theta_h]^{-1/\theta}}{[\zeta\Theta_l]^{-1/\theta}}\right]^{-k}}\right)\frac{\Delta \log \tau^i_{hl}}{\frac{T_l}{T_h}\left(\tau^i_{hl}\right)^{\theta}+1} \\
& +\frac{k}{k+2}\left(\frac{\left(\tau^o_{lh}\tau^o_{hl}\right)^{-k}}{1-\left(\tau^o_{lh}\tau^o_{hl}\right)^{-k}}-\frac{\left(\tau^o_{lh}\tau^o_{hl}\right)^{-k}}{\left[\frac{\tau^o_{lh}[\zeta\Theta_l]^{-1/\theta}}{[\zeta\Theta_h]^{-1/\theta}}\right]^{-k}-\left(\tau^o_{lh}\tau^o_{hl}\right)^{-k}}\right)\Delta \log \tau^o_{hl}
\end{aligned}
\tag{18}
$$

In Equation (18), the coefficient of $\Delta \log \tau^i_{hl}$ is positive and the coefficient of $\Delta \log \tau^o_{hl}$ is negative, since $\left[\frac{\tau^o_{lh}[\zeta\Theta_l]^{-1/\theta}}{[\zeta\Theta_h]^{-1/\theta}}\right]^{-k} < 1$ and $\left[\frac{\tau^o_{hl}[\zeta\Theta_h]^{-1/\theta}}{[\zeta\Theta_l]^{-1/\theta}}\right]^{-k} < 1$. Hence, we have the following lemma:

Lemma 1. A reduction in the imported-input tariff will lower the export productivity cutoff φ_{lh}. By contrast, a reduction in the imported-output tariff will increase the export productivity cutoff φ_{lh}.

The intuition is straightforward. Following a reduction in the imported-input tariff, the Home firms' marginal costs fall. Lower marginal costs means that the domestic firms are relatively more competitive in the foreign market. As a result, the Home exporters reallocate their resources away from the core competency. The effect of imported-output tariff reduction heads in the opposite direction. A fall in the imported-output tariff in the domestic market raises the expected profits of foreign firms. The free entry condition implies that the foreign market becomes tougher, which induces Home exporters to skew their exports toward their core competency.

According to Equation (10), a reduction in the imported-input tariff τ^o_{hl} and a reduction in the imported-output tariff τ^i_{hl} result in a change in the export value, which satisfies the following equation:

$$
\begin{aligned}
\Delta \log r_{lh} \quad = \quad & 2\left[1-\left(\frac{1}{k+2}\right)\frac{\varphi_{lh}^{-2}}{\varphi_{lh}^{-2}-\omega^{-2m}\varphi^{-2}}\left(2+\frac{k}{1-\left[\frac{\tau^o_{hl}[\zeta\Theta_h]^{-1/\theta}}{[\zeta\Theta_l]^{-1/\theta}}\right]^{-k}}\right)\right]\frac{\Delta \log \tau^i_{hl}}{\frac{T_l}{T_h}\left(\tau^i_{hl}\right)^{\theta}+1} \\
& -\frac{2\varphi_{lh}^{-2}}{\varphi_{lh}^{-2}-\omega^{-2m}\varphi^{-2}}\left(\frac{k}{k+2}\right)\left(\frac{\left(\tau^o_{lh}\tau^o_{hl}\right)^{-k}}{1-\left(\tau^o_{lh}\tau^o_{hl}\right)^{-k}}-\frac{\left(\tau^o_{lh}\tau^o_{hl}\right)^{-k}}{\left[\frac{\tau^o_{lh}[\zeta\Theta_l]^{-1/\theta}}{[\zeta\Theta_h]^{-1/\theta}}\right]^{-k}-\left(\tau^o_{lh}\tau^o_{hl}\right)^{-k}}\right)\Delta \log \tau^o_{hl}
\end{aligned}
\tag{19}
$$

Note that the coefficient of $\Delta \log \tau^i_{hl}$ in Equation (19) is negative, since $\left[\frac{\tau^o_{hl}[\zeta\Theta_h]^{-1/\theta}}{[\zeta\Theta_l]^{-1/\theta}}\right]^{-k} <$

1. By the same token, the coefficient of $\Delta \log \tau^o_{hl}$ in Equation (19) is positive, since $\left[\frac{\tau^o_{lh}[\zeta\Theta_l]^{-1/\theta}}{[\zeta\Theta_h]^{-1/\theta}}\right]^{-k} < 1$. In other words, the reduction in the imported-input tariff leads to increases in the values of exported products. In contrast, the reduction in the imported-output tariff leads to decreases in the values of exported products. The strength of this effect rises with the distance from the core competency. This is because $\frac{\varphi_{lh}^{-2}}{\varphi_{lh}^{-2} - \omega^{-2m}\varphi^{-2}}$ increases as m increases. Hence, we have the following testable proposition:

Proposition 1 (Export Value and Import Tariff)**.** A reduction in the imported-input tariff will cause a higher percentage increase in the export revenue for the products that are further away from the firm's core competency; a reduction in the imported-output tariff will cause a higher percentage reduction in the export revenue for the products that are further away from the firm's core competency.

4 Empirical Specification, Data, and Measurement

4.1 Empirical Specification

Our theory predicts that import tariff cuts induce the firm to reallocate its resources across products within the firm(-country). In particular, cutting imported-input tariffs results in more resources reallocated toward the peripheral products. In contrast, cutting imported-output tariffs results in more resources reallocated away from the peripheral products. To test this hypothesis, we consider the following reduced-form regression:

$$\begin{aligned} \Delta \log V_{fp(c)t} \;=\; & \alpha_0 \Delta Input\_tariff_{it} + \alpha_1 \Delta Input\_tariff_{it} \times Rank_{fp(c)t} \\ & + \beta_0 \Delta Output\_tariff_{it} + \beta_1 \Delta Output\_tariff_{it} \times Rank_{fp(c)t} \\ & + Rank_{fp(c)t} + \gamma \Delta \mathbf{X}_{ft} + \varphi_t + \varphi_{f(c)} (+\varphi_c) + \epsilon_{f(c)t} \end{aligned} \tag{20}$$

which represents several specifications. Here, Δ denotes a year-on-year change in any variable; $V_{fp(c)t}$ represents either V_{fpt} or V_{fpct}. The variable V_{fpct} is the export value of Harmonized System (HS) 6-digit product p exported by a firm f to a destination country c. In an alternative specification, the left hand side uses the variable V_{fpt}, which is the corresponding variable with the destination being the whole world. $Input\_tariff_{it}$ and $Output\_tariff_{it}$ are the imported-input and imported-output tariffs at the 4-digit Chinese Industry Classification (CIC) for industry i at year t, respectively. $Rank_{fp(c)t}$ represents either $Rank_{fpt}$ or $Rank_{fpct}$. Each of them is the log of product rank. The rank is increasing from the most successful product in terms of sales (the core product) to the least successful product (the most peripheral one). When products are defined at the HS 6-digit level, the variable $Rank_{fpt}$ is defined as the log rank of each product within a firm according to its total export value to the whole world, with the best performing product being ranked as 1. In an alternative specification, a product is defined as an HS 6-digit-country combination. In this case, the variable $Rank_{fpct}$ is defined as the log rank of each product within firm f according to its export value to destination country c, with the best performing product being ranked as 1.

To control for the time-varying firm attributes that might have an effect on the resource allocation across products, we include the vector $X_{f,t}$ which contains firm productivity (TFP), firm size (measured by employment), factor intensity (capital-labor ratio), and wage. In all the specifications of the benchmark case, the year fixed effect φ_t and the firm fixed effect φ_f are added to control for the time-variant and firm-specific characteristics. When products are defined as a HS 6-digit-country combination, we replace the firm fixed effect φ_f by the firm-destination fixed effect φ_{fc}. In the alternative specification, we add the country fixed effect φ_c. The error term $\epsilon_{f(c)t}$ includes all unobserved factors that may affect the dependent variables.

The variables of interest are the two interaction terms, $Input\_tariff_{it} \times Rank_{fp(c)t}$ and $Output\_tariff_{it} \times Rank_{fp(c)t}$. We expect $\alpha_1 < 0$ and $\beta_1 > 0$. More precisely, we expect the Chinese exporter to raise its export values, especially those of the high ranks (peripheral products) following the imported-input tariff reduction. Similarly, we expect the exporter to lower the export values of the peripheral products following imported-output tariff cuts. It is important to note that as the key variables, $Input\_tariff_{it}$ and $Output\_tariff_{it}$, are constructed at the 4-digit CIC industry level, we cluster the error terms at the same level to address the potential correlation of errors within each industry over time.

As explained by Bernard et al. (2014), there could be an entry issue when we use the annual customs data. Firms could enter the same market in different months, which leads to an upwardly biased growth rate between the year of entry and the following year.[4] Hence, we need to be aware of the timing issue when we compare the values of exports. To correct for this timing bias, we do not consider the products that were just exported. Instead, we require them to be exported at least in the previous year to make sure that the value growth of exports indeed indicates the products performance. In addition, to ensure our results are not driven by outliers, we delete products with rank higher than 50, which reduces the number of observations by 0.5 percent.

[4]For instance, a firm started to export product A and B in the same year, say 2002. However, for some reason (e.g., paper work), product A was started several months earlier. To make the issue simpler, suppose these two products performed identically in the export market. As product A started earlier, records in the year 2002 should show that product A has better sales. In the next year (2003), both products had the same amount of months of export. With their similar performance, they would have the same export value in 2003. But because product A started earlier and, hence, was "better" in 2002, we would conclude wrongly that product A grew slower than product B.

4.2 Data Description

To take the theory to the data, we need three sets of information. First, we need firm-product-level customs data, obtained from China's General Administration of Customs. Second, we need the import tariff data, which are taken from the WTO and the trade analysis and information system (TRAINS).[5] And finally, we need the information on the firm's characteristics, which is captured by the firm-level manufacturing survey data from the National Bureau of Statistics of China (NBSC). Our data sets cover the period 2000-2006.

China's General Administration of Customs provides us with the universe of all Chinese trade transactions by importing and exporting firms at the HS 8-digit level, covering the universe of all Chinese exports and imports in 2000-2006. It records detailed information for each trade transaction, including import and export values, quantities, product name, source or destination countries, contact information of the firm (e.g., company name, telephone, zip code, contact person), type of enterprise (e.g., state owned, domestic private firms, foreign invested, and joint ventures), and customs regime (e.g. "Processing and Assembling"and "Processing with Imported Materials"). As firms under the processing trade regime are not subject to tariffs, we focus only on firms under the ordinary trade regime.[6]

As the customs data are recorded on a monthly basis, we aggregated the data to the annual level to eliminate seasonal variations. Products that are recorded at the HS 8-digit level are aggregated to the HS 6-digit level so as to enable consistent comparison of data over time, as China changed the HS 8-digit codes in 2002, and the concordance between the old and new HS 8-digit codes (before and after 2002) is not available. To ensure the consistency of the product categorization over time (2000-2006), we adopt HS 6-digit codes maintained by the World Customs Organization and use the conversion table from UN Comtrade to convert the HS 2002 codes into the HS 1996 codes. We only focus on manufacturing products to be consistent with the second database, namely the NBSC manufacturing firm production data.[7]

To characterize firms' attributes, such as TFP and capital intensity, we also use the NBSC firm-level production data from the annual surveys of Chinese manufacturing firms, covering all state-owned enterprises (SOEs), and non-SOEs with annual sales of at least 5 million renminbi (the Chinese currency). The NBSC database contains detailed firm-level information on manufacturing enterprises in China, such as employment, capital stock,

[5] The tariff data are available at http://tariffdata.wto.org/ReportersAndProducts.aspx.

[6] As imports under the ordinary trade regime include final goods and intermediate goods, we use the Broad Economic Categories classification to distinguish final goods and intermediate goods.

[7] See http://unstats.un.org/unsd/tradekb/Knowledgebase/HS-Classification-by-Section. There are originally 20 sectors in the UN list for HS product classification. We delete sectors 1-3, agricultural sectors; sector 5, a mining sector; and sector 19, Arms and Ammunition.

gross output, value added, firm identification (e.g., company name, telephone number, zip code, contact person, etc.), and complete information on the three major accounting statements (i.e., balance sheets, profit & loss accounts, and cash flow statements).[8] Due to mis-reporting by some firms, we use the following rules to delete unsatisfactory observations and construct our sample, following Cai and Liu (2009) and the General Accepted Accounting Principles: (i) the total assets must be greater than the liquid assets; (ii) the total assets must be greater than the total fixed assets; (iii) the total assets must be greater than the net value of the fixed assets; (iv) a firm's identification number cannot be missing and must be unique; and (v) the established time must be valid.

Then we match the firm-product-level trade data between the Chinese Customs Database and the NBSC database, according to the contact information of manufacturing firms, as there is no consistent coding system of firm identity between these two databases.[9] Our matching procedure is done in three steps: (1) by company name, (2) by telephone number and zip code, and (3) by telephone number and contact person name together (see detailed description of the matching process in Fan, Lai and Li 2015). Compared with the exporting and importing firms reported by the Customs database,[10] the matching rate of our sample (in terms of the number of firms) covers 45.3 percent of exporters and 40.2 percent of importers, corresponding to 52.4 percent of total export value and 42 percent of total import value reported by the Customs database.[11]

Table 1 shows the descriptive statistics for our sample. In addition to the number of employees and value-added per worker, which proxy for the size and the productivity of the firm, respectively, we also report the statistics for the export product mix. In particular, an average Chinese exporter exports 12 products (at the HS 6-digit level) to 11 countries. The average number of country-product pairs is 48. If we define the main product as the most successful product sold in one country, its average value is US$4 million, although it is driven by some very large firms (the median is than one-tenth of the mean). During the period 2000-2006, Chinese firms experienced significant export growth. The value of the main product grew at an annual rate of 7 percent on average.

[8]The firm identification information will be used to match the NBSC database with the customs database.

[9]In the NBSC database, firms are identified by their corporate representative codes and contact information. In the customs database, firms are identified by their corporate custom codes and contact information. These two coding systems are neither consistent nor transferable with each other.

[10]As we merge the Customs database with the manufacturing firms in the NBSC database, we exclude all intermediary firms or trading companies from the customs database.

[11]We do not compare our sample with the NBSC database because it does not contain any information on firms' import status.

Table 1: Descriptive Statistics

Variables	Obs	Mean	Median	Std.Dev.
#employees	3,800,926	874.5	320	2,407.2
Value added/worker (thousand RMB)	3,795,691	96.2	44.5	451.6
#destinations	3,800,931	11	7	13
#products	3,800,931	12	5	34
#product-destination	3,800,931	48	17	126
Main product				
value (USD)	1,489,488	4,375	353	69,101.8
relative value	607,287	535.2	3.6	35,813.8
growth in value (%)	542,456	6.8	5.4	133.5
growth in relative value(%)	155,528	-2.9	-1.6	164
log(product rank)	956,866	1.55	1.60	1.05
log(product-country rank)	2,715,457	0.76	0.69	0.89

Note: The main product is defined as the most successful product of a firm in a certain country-time pair.

4.3 Measurement

Tariffs — To construct the tariffs, we first draw the tariff lines from the WTO and TRAINS. To be consistent with the Input-Output (IO) table that we will use later, we then map the HS 8-digit level tariffs onto the 3-digit IO code. Our 3-digit output tariff, then, is the simple average of the tariffs in the HS 8-digit codes within each 3-digit IO industry code.

To compute the input tariff, we use an input cost-weighted average of output tariffs where:

$$\tau_{it}^{input} = \sum_{k} a_{ki} \tau_{kt}^{output}$$

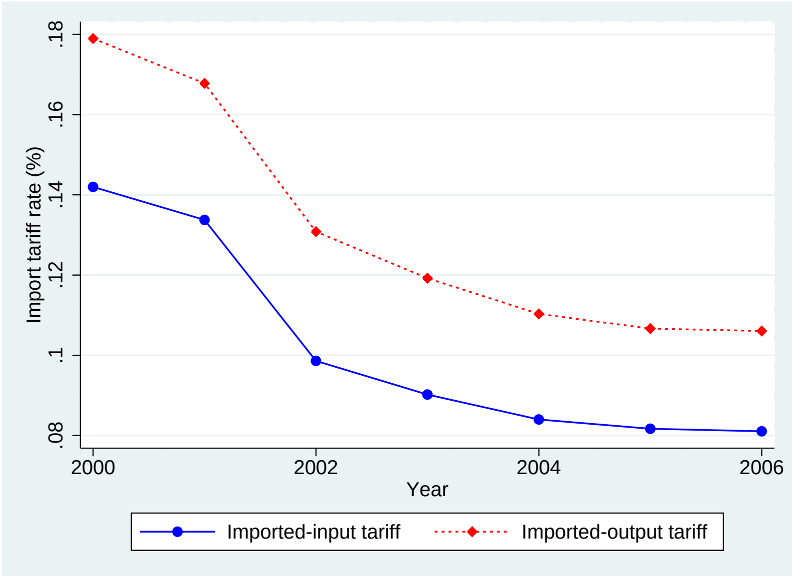
where τ_{kt}^{output} is the tariff on industry k at time t, and a_{ki} is the weight of industry k in the input cost of industry i. For instance, if industry i incurs 80 percent of its costs in steel and 20 percent of its costs in rubber, then steel tariffs receive an 80 percent weight in our calculation of input tariffs in industry i, while rubber tariffs receive a 20 percent weight. These weights are taken from the IO table issued in 2002.[12]

Since our production data utilize the CIC 4-digit code, we then map the IO 3-digit imported-input and imported-output tariffs onto the CIC 4-digit industry code. This procedure then yields a set of imported-input and imported-output tariffs at the CIC 4-digit code. Figure 1 presents the imported-input and imported-output tariff levels in China during 2000-2006. It shows that there was a drastic reduction of tariff rates since China joined the WTO in 2001.

Productivity — To control for the change in firm productivity in some of our regres-

[12]We also used the IO table issued in 2007 and received similar results

Figure 1: Imported-input tariffs and imported-output tariffs in China (2000-2006)



sions, we estimate TFP. Our primary TFP measure is based on the augmented Olley and Pakes (1996) measure.[13] The augmentation takes into account a number of additional firm-level decisions. For instance, we include the firm's trade status in the TFP realization, as in Amiti and Konings (2007), by including two trade-status dummy variables — an export dummy (equal to one for exports and zero otherwise) and an import dummy (equal to one for imports and zero otherwise). Finally, we include a WTO dummy (i.e., one for a year in or after 2002 and zero for before) in the Olley and Pakes (1996) estimation, as accession to the WTO represents a positive demand shock for China's exports. We use value-added to measure production output, and deflate firms' inputs (e.g., capital) and value-added, using the input-price deflators and output-price deflators from Brandt et al. (2012).[14] Then we construct the real investment variable by adopting the perpetual inventory method to investigate the law of motion for real capital and real investment. To measure the depreciation rate, we use each firm's real depreciation rate provided by the NBSC firm-production database.

[13] Our results are robust to different approaches in estimating TFP, including the OLS method, the Levinsohn and Petrin (2003) method, and the Ackerberg, Caves and Frazer (2006) augmented O-P and L-P methods. These results are available upon request.

[14] The output deflators are constructed using "reference price" information from China's Statistical Yearbooks, and the input deflators are constructed based on output deflators and China's national input-output table (2002). The data can be accessed via http://www.econ.kuleuven.be/public/N07057/CHINA/appendix/.

5 Main Results

In this section, we use the merged database to analyze the effect of trade liberalization on export value across products and the number of exported products within firms.

5.1 Effect of Trade Liberalization on Export Value across Products

Table 2 reports our results based on estimation of Equation (20). As predicted by our theory, imported-input tariff cuts result in a shift of production resources toward the peripheral products, and hence reduce the variance in export value among products. In contrast, reduction in imported-output tariffs has the exact opposite effect. This means that a product further away from the core product would be more affected by imported-input tariff reductions and enjoy a larger percentage increase in export value. At the same time, a product further away from the core product would be more affected by imported-output tariff reductions and suffer a larger percentage decrease in export value.

A product, measured at HS 6-digit level, can be defined as a variety. Alternatively, a product-country pair can also be seen as a variety. In columns 1 and 2 of Table 2, the dependent variables are firm-product level export value. We add the firm fixed effect to exploit the export value adjustment across products within-firm. In columns 3 to 6, the dependent variables are firm-product-destination level export value. To investigate the export value adjustment within firms and destination, we add the firm fixed effect and the country fixed effect in columns 3 and 4. Alternatively, we add the firm-destination fixed effect in column 5 and 6. Columns 1, 3, and 5 reports the results without firm-level controls, while columns 2, 4, and 6 report the results with firm-level controls. As predicted, the coefficient of ΔInput_tariff$\times$Rank, α_1, is significantly negative. More precisely, a one standard deviation increase in the log rank was associated with a 2 to 3 percent increase in the export value following a 1 percent fall in the imported-input tariff. The coefficient of ΔOutput_tariff$\times$Rank is positive as we expected. After a 1 percent fall in the imported-output tariff, a one standard deviation increase in the log rank was associated with a 0.5 to 0.7 percent fall in the export value. However, the coefficient is not always significant. Of the six specifications reported in Table 2, only two (columns 3 and 4) display significant results.

Important trading partners — The insignificance of the imported-output tariff effect is not surprising. Indeed, the imported output tariff reductions affect relative export sales to the extent that the Home country's import policy can have an impact on how competitive the foreign market is. This obviously depends on the importance of Chinese exported

Table 2: Effect of Trade Liberalization on Export Value across Products

Dependent variable: changes in log export value.						
	(1)	(2)	(3)	(4)	(5)	(6)
ΔInput_tariff	2.202*	2.287**	2.104**	2.143**	1.943*	1.968*
	(1.135)	(1.159)	(0.851)	(0.855)	(1.021)	(1.026)
ΔInput_tariff $\times$ Rank	-2.400***	-2.437***	-2.661***	-2.646***	-1.653**	-1.644**
	(0.617)	(0.623)	(0.569)	(0.582)	(0.705)	(0.704)
ΔOutput_tariff	0.082	0.072	-0.471	-0.500	-0.645	-0.672
	(0.603)	(0.590)	(0.442)	(0.446)	(0.497)	(0.502)
ΔOutput_tariff $\times$ Rank	0.486	0.554	0.781**	0.807**	0.575	0.602
	(0.436)	(0.429)	(0.358)	(0.363)	(0.408)	(0.404)
Rank	0.418***	0.419***	0.414***	0.415***	0.511***	0.511***
	(0.025)	(0.025)	(0.015)	(0.015)	(0.016)	(0.016)
Δ(TFP)		0.077***		0.047***		0.044***
		(0.011)		(0.008)		(0.010)
Δ(Labor)		0.212***		0.134***		0.134***
		(0.025)		(0.024)		(0.030)
Δ(Capital/Labor)		0.030***		0.029***		0.032***
		(0.011)		(0.008)		(0.010)
Δ(Wage)		0.058***		0.047***		0.051***
		(0.014)		(0.011)		(0.014)
Year fixed effect	yes	yes	yes	yes	yes	yes
Firm-Destination fixed effect	no	no	no	no	yes	yes
Firm fixed effect	yes	yes	yes	yes	no	no
Destination fixed effect	no	no	yes	yes	no	no
Observations	157,960	157,862	341,795	341,627	341,795	341,627
R-squared	0.200	0.202	0.124	0.124	0.347	0.347
R-squared adj.	0.058	0.060	0.061	0.062	0.019	0.020

Notes: Robust standard errors are clustered at the industry level. * $p < 0.1$, **$p < 0.05$, *** $p < 0.01$. In columns 1-2, the dependent variable is the firm-product export value, in columns 3-6 the dependent variable is the firm-product-country export value.

outputs in the foreign market. Similarly, the impact of imported-input tariff reductions depends on the importance of the Chinese market for the intermediate goods exported from the foreign country. Consequently, we can further test our theory by restricting our sample to countries that trade intensively with China. We expect our results to be more significant, statistically and economically, by focusing on trade with only these countries.

In Table 3, we re-run the specification in column 6 in Table 2 by using only a subsample of countries that are important exporters and/or importers. More precisely, for each Chinese trading partner, for instance the United States, we compute the share of goods exported to China in U.S. exports. We use this share to rank the Chinese trading partners. A country is called type-1A important trading partner if the share associated with this country is above the median value. A country is called type-1B important trading partner if the associated share is above the 75 percentile. Type 1 importance measures the export-dependence of the country on China.

In addition to the shares mentioned above, we compute the share of Chinese goods among all the imported goods in a market where Chinese exporters are present. We then rank this share across all the trading partners of China. A country is called a type-2A important trading partner if the share is above the median. We call this country a type-2B important trading partner if the share is above the 75 percentile in the ranking. Type 2 importance measures the import-dependence of the country on China.

Finally, a country that is both a type-1A and a type-2A important trading partner is called a type-3A important trading partner. Similarly, a country is called a type-3B important trading partner if it is both a type-1B and a type-2B important trading partner. Type 3 importance measures the overall trade-dependence of the country on China. In columns 1 to 6 we make use of the subsample that contain the type-1A, type-1B, type-2A, type-2B, type-3A and type-3B important trading partners, respectively.

Consistent with our conjecture, the coefficient of the interaction term of imported-output tariffs and log product rank becomes more significant statistically and economically. Moreover, the coefficient of the interaction term of imported-input tariffs and log product rank becomes larger as well. In Table 3 , we can see that a one standard deviation increase in the log product rank was associated with a 3 to 6 percent rise in the export value (compared to 1.6 percent in column 6 in Table 2) after a 1 percent imported-input tariff cut. In addition, a one standard deviation increase in the log product rank was associated with a 1 to 3 percent drop in the export value (compared with the non-significant, less than 1 percent drop in column 6 in Table 2) following a 1 percent imported-output tariff reduction. Moreover, the magnitude of the coefficients of interest rises as we focus on trading partners that are more trade-dependent on China.

As the mechanisms on which our theory is based depends crucially on the extent to which the changes in import policy affect the foreign market, we have to take into

Table 3: Effect of Trade Liberalization with Important Exporting/Importing Countries

Dependent variable: changes in log export value.						
	(1)	(2)	(3)	(4)	(5)	(6)
ΔInput_tariff	3.270**	4.992**	4.205***	6.804***	4.566***	7.685***
	(1.519)	(2.106)	(1.404)	(1.884)	(1.622)	(2.459)
ΔInput_tariff $\times$ Rank	-2.667**	-6.157***	-4.015***	-5.274***	-4.413***	-5.809***
	(1.086)	(1.370)	(1.048)	(1.365)	(1.113)	(1.432)
ΔOutput_tariff	-1.295**	-2.040**	-1.584**	-2.235**	-1.700**	-2.432**
	(0.618)	(0.971)	(0.690)	(1.113)	(0.672)	(1.160)
ΔOutput_tariff $\times$ Rank	1.272**	2.823***	1.523**	2.084**	1.775***	2.214**
	(0.576)	(0.867)	(0.650)	(0.890)	(0.632)	(0.962)
Rank	0.499***	0.509***	0.509***	0.511***	0.507***	0.501***
	(0.019)	(0.022)	(0.018)	(0.024)	(0.019)	(0.023)
Δ(TFP)	0.047***	0.044**	0.045***	0.050***	0.048***	0.050**
	(0.013)	(0.017)	(0.014)	(0.016)	(0.015)	(0.021)
Δ(Labor)	0.138***	0.077*	0.122***	0.111***	0.118***	0.107**
	(0.033)	(0.043)	(0.035)	(0.042)	(0.034)	(0.046)
Δ(Capital/Labor)	0.030**	0.029	0.028*	0.023	0.032**	0.028
	(0.015)	(0.020)	(0.016)	(0.021)	(0.016)	(0.023)
Δ(Wage)	0.049***	0.047*	0.042**	0.046*	0.033	0.055*
	(0.019)	(0.027)	(0.021)	(0.027)	(0.023)	(0.030)
Year fixed effect	yes	yes	yes	yes	yes	yes
Firm-Destination fixed effect	yes	yes	yes	yes	yes	yes
Observations	162,310	65,061	152,932	74244	121,857	51,566
R-squared	0.327	0.328	0.344	0.356	0.334	0.333
R-squared adj.	0.024	0.025	0.027	0.028	0.031	0.033

Notes: Robust standard errors are clustered at the industry level. * $p < 0.1$, **$p < 0.05$, *** $p < 0.01$. In columns 1-6 we make use of the subsample that contain the type-1A, type-1B, type-2A, type-2B, type-3A and type-3B important trading partners, respectively.

account the economic size of the foreign market. In contrast to the shares used in Table 3, when we construct a fraction to take into account the economic size of a trading partner, the denominator is no longer the total value of imported goods in the trading partner (for type-1A and type-1B) or the total value of exported goods from the trading partner (for type-2A and type-2B), but the GDP of this trading partner. Thus, based on this principle, we construct another set of shares indicating trade-dependence of trading partners on China which takes into account the economic size of the trading partner. With the new shares we rank the trading partners and define type-4A, type-4B, type-5A, type-5B, type-6A and type-6B in a similar manner as type-1A, type-1B, type-2A, type-2B, type-3A and type-3B.

The shares calculated are highly correlated, as reported by Table 13 in the Appendix. Like Table 3, Table 4 reruns the specifications in column 6 in Table 2 with the new shares. In columns 1 to 6 we make use of the subsample that contain the type-4A, type-4B, type-5A, type-5B, type-6A and type-6B important trading partners, respectively. Similar to what Table 3 reports, the coefficient of the interaction term between the output tariff and the log rank is positive and significant. Moreover, the coefficients of interest have a larger magnitude than those in column 6 in Table 2.

In the specifications above, we do not control for industry characteristics. To test our effects within a particular industry, we add the 2-digit CIC industry fixed effect to the baseline regressions and find similar results, which are reported in Table 14 in the Appendix. All the results in Table 14 confirm that adding industry fixed effect would not affect our results. A concern with the ranking system we use in the baseline regression is measurement errors. A product might be reported with erroneous sale value that affects its rank. We try another ranking variable by creating a dummy that takes on the value 1 if the product belongs to the top half (in terms of export value) of the ranking and 0 otherwise, and find similar results, which are reported in Table 15 in the Appendix. In Tables 14 and 15, we use our whole sample in column 1. We make use of the subsample that contain the type-1A, type-1B, type-2A, type-2B, type-3A and type-3B important trading partners in columns 2 to 7. Again, the results are more significant economically when we use the subsample of important trading partners with China (columns 2 to 7).

5.2 Effect of Trade Liberalization: Extension

The number of products— In the previous sections, we mainly discussed how trade liberalization affected the export value of a product, or the intensive margin. Our model can be naturally extended to the extensive margin, i.e., the number of products exported by each firm. Recall the number of products exported in our model is given by:

Table 4: Large Imports/GDP Ratio and/or Exports/GDP Ratio

Dependent variable: changes in log export value.						
	(1)	(2)	(3)	(4)	(5)	(6)
ΔInput_tariff	4.335***	5.757***	3.816***	6.073***	4.926***	6.879***
	(1.324)	(2.102)	(1.408)	(1.907)	(1.444)	(2.223)
ΔInput_tariff × Rank	-4.066***	-4.108**	-3.829***	-4.335**	-5.006***	-4.903***
	(1.152)	(1.626)	(1.305)	(1.691)	(1.153)	(1.675)
ΔOutput_tariff	-1.756***	-2.795**	-1.519**	-2.448**	-2.039***	-2.939**
	(0.661)	(1.091)	(0.711)	(1.119)	(0.747)	(1.177)
ΔOutput_tariff × Rank	1.764**	2.237**	1.689**	2.325**	2.139***	2.690***
	(0.734)	(1.005)	(0.704)	(1.015)	(0.696)	(1.011)
Rank	0.522***	0.525***	0.511***	0.514***	0.516***	0.517***
	(0.018)	(0.023)	(0.017)	(0.023)	(0.019)	(0.027)
Δ(TFP)	0.036***	0.039**	0.034***	0.029*	0.037**	0.025
	(0.012)	(0.018)	(0.013)	(0.016)	(0.014)	(0.020)
Δ(Labor)	0.126***	0.137***	0.127***	0.152***	0.130***	0.149***
	(0.034)	(0.044)	(0.037)	(0.048)	(0.037)	(0.051)
Δ(Capital/Labour)	0.022	0.011	0.038**	0.017	0.032*	0.010
	(0.014)	(0.019)	(0.015)	(0.022)	(0.016)	(0.026)
Δ(Wage)	0.066***	0.064**	0.060***	0.064**	0.066***	0.064**
	(0.019)	(0.028)	(0.020)	(0.025)	(0.021)	(0.032)
Year fixed effect	yes	yes	yes	yes	yes	yes
Firm-Destination fixed effect	yes	yes	yes	yes	yes	yes
Observations	148,554	76,500	158,039	75,228	119,965	52,145
R-squared	.361	.38	.356	.367	.354	.359
R-squared adj.	.0225	.0307	.0212	.0298	.023	.0368

Notes: Robust standard errors are clustered at the industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. In columns 1-6 we make use of the subsample that contain type-4A, type-4B, type-5A, type-5B, type-6A and type-6B important trading partners, respectively

$$M_{lh}(\varphi)=\begin{cases}0 & \text{if } \varphi<\varphi_{lh}\\ \max\{m|\varphi\geq\omega^{-m}\varphi_{lh}\}+1 & \text{if } \varphi\geq\varphi_{lh}\end{cases}$$

Given productivity, a firm exports more varieties when the export productivity cutoff φ_{lh} falls. Our model shows that this cutoff falls with imported-input tariff reduction and rises with imported-output tariff reduction. Consequently, the firm expands its export product scope in response to trade liberalization in imported-intermediate goods while it shrinks its export product scope following trade liberalization in imported-final goods. To test these predictions, we run the following reduced-form regression:

$$\Delta\left(M_{f(c)t}\right)=\alpha\Delta Input\_tariff_{it}+\beta\Delta Output\_tariff_{it}+\gamma\Delta\mathbf{X}_{ft}+\varphi_t(+\varphi_c)+\epsilon_{f(c)t} \quad (21)$$

which represents several specifications. Here, $M_{f(c)t}$ represents either M_{ft} or M_{fct}. The variable M_{fct} is the number of products (at the HS 6-digit level) exported by firm f to country c at time t. In an alternative specification, the variable M_{ft} refers to the firm's number of exported products over all destinations. When we consider the firm's number of exported products over all destinations, we only include the year fixed effect φ_t. In an alternative specification, when we consider the firm's number of exported products within each destination, we also add the country fixed effect φ_c. Our theory predicts that $\alpha<0$ and $\beta>0$, indicating that trade liberalization in imported-final goods leads the firm to contract its export product scope, while trade liberalization in imported-intermediate goods induces the firm to expand its export product scope.

Table 5 shows the result of our regression, which generally supports our predictions. In column 1, the dependent variable is M_{ft} and in columns 2 to 6, the dependent variable is M_{fct}. The year fixed effect is included in all columns while the destination fixed effect is included in columns 3 to 6. Columns 1 to 3 make use of the whole sample of our data, while columns 4, 5 and 6 make use of the subsamples that contain the type-1A, type-2A and type-3A important trading partners, respectively. As predicted, the coefficient α is significantly negative while the coefficient β is positive, and significant when China is an important trading partner (see columns 4 to 6).[15]

Entropy— We can replace the number of products in Equation (21) by an alternative measure of product diversification, namely the entropy statistic that was first introduced by Jacquemin and Berry (1979) and later used in Baldwin and Gu (2009) and Bernard, Redding and Schott (2011). This statistic is constructed as $\sum_k s_{fkt}\log(1/s_{fkt})$ where s_{fkt} is the share of product k in firm f at time t. This entropy statistic measures the concentration of sales at the product level, and captures the extent to which a firm's

[15]In all the specifications above, single-product firms are included. Excluding them in the sample will not change our results.

Table 5: Effect of Trade Liberalization on the Number of Exported Products

Depedent variable: changes in the number of exported products						
	(1)	(2)	(3)	(4)	(5)	(6)
ΔInput_tariff	-10.996***	-4.089***	-4.132***	-4.340***	-3.836***	-4.309**
	(4.111)	(1.437)	(1.443)	(1.572)	(1.378)	(1.676)
ΔOutput_tariff	2.909**	0.601	0.626	0.989**	0.773*	1.035*
	(1.124)	(0.444)	(0.443)	(0.462)	(0.463)	(0.536)
Δ(TFP)	0.236***	0.077***	0.077***	0.086***	0.081***	0.085***
	(0.057)	(0.019)	(0.019)	(0.023)	(0.023)	(0.027)
Δ(Labor)	0.907***	0.275***	0.277***	0.335***	0.325***	0.355***
	(0.166)	(0.039)	(0.039)	(0.054)	(0.053)	(0.063)
Δ(Capital/Labor)	0.249***	0.087***	0.087***	0.100***	0.093***	0.102***
	(0.062)	(0.017)	(0.017)	(0.019)	(0.020)	(0.023)
Δ(Wage)	0.191***	0.061***	0.062***	0.080***	0.080***	0.090***
	(0.046)	(0.013)	(0.013)	(0.018)	(0.017)	(0.020)
Year fixed effect	yes	yes	yes	yes	yes	yes
Country fixed effect	no	no	yes	yes	yes	yes
Observations	95,693	515,730	515,730	263,411	260,096	207,636
R-squared	0.005	0.002	0.004	0.004	0.004	0.004
R-squared adj.	0.004	0.002	0.003	0.004	0.003	0.004

Notes: Robust standard errors are clustered at the industry level. * $p < 0.1$, **$p < 0.05$, *** $p < 0.01$. In column 1, the dependent variable is the number of firm's export products; in columns 2 to 6, the dependent variable is the number of firm's export products within each destination. In columns 1 to 3, we use the whole sample; in columns 4,5 and 6 we use the subsample that contain the type-1A, type-2A and type-3A important trading partners respectively.

output is skewed toward its core product. When the firm's sales are evenly spread out over all N products that it can possibly sell, the entropy statistic takes on the maximum value $\log(N)$; when the firm's sales are concentrated in one single product, the entropy statistic takes on the value zero. In other words, the higher is the entropy statistic, the more diverse are the sales of the firm. As a result, we expect a fall in the entropy statistic following a cut in the imported-input tariffs and a rise in the entropy statistic after a cut in the imported-output tariffs.

Table 6 presents our results. We rerun the same specifications as in Table 5 but with the dependent variable changed to the entropy statistic. The results are still consistent with our predictions: the coefficient α is significantly negative and the coefficient β is significantly positive except in column 2.

Table 6: Effect of Trade Liberalization on the Entropy Statistic

Depedent variable: changes in the entropy statistic	(1)	(2)	(3)	(4)	(5)	(6)
ΔInput_tariff	-0.799***	-0.466***	-0.492***	-0.414**	-0.384**	-0.366**
	(0.280)	(0.168)	(0.176)	(0.166)	(0.153)	(0.175)
ΔOutput_tariff	0.250***	0.107	0.113*	0.140**	0.125*	0.123*
	(0.093)	(0.066)	(0.067)	(0.065)	(0.066)	(0.071)
Δ(TFP)	0.007***	0.008***	0.008***	0.009***	0.008***	0.008***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Δ(Labor)	0.048***	0.042***	0.041***	0.044***	0.041***	0.044***
	(0.008)	(0.003)	(0.003)	(0.004)	(0.005)	(0.005)
Δ(Capital/Labor)	0.015***	0.012***	0.012***	0.014***	0.012***	0.013***
	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Δ(Wage)	0.011***	0.008***	0.008***	0.008***	0.008***	0.009***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Year fixed effect	yes	yes	yes	yes	yes	yes
Country fixed effect	no	no	yes	yes	yes	yes
Observations	95,693	515,730	515,730	263,411	260,096	207,636
R-squared	0.002	0.002	0.002	0.002	0.002	0.002
R-squared adj.	0.002	0.002	0.002	0.002	0.002	0.002

Notes: Robust standard errors are clustered at the industry level. * $p < 0.1$, **$p < 0.05$, *** $p < 0.01$. In column 1, the dependent variable is the number of firm's export products; in columns 2-6, the dependent variable is the number of firm's export products within each destination. In columns 1-3, we use the wholesample; in columns 4,5 and 6 we make use of the subsample that contain the type-1A, type-2A and type-3A important trading partners respectively.

6 Robustness Checks

In this section we run a battery of robustness checks to see if our results continue to hold across various types of alternative specifications.

6.1 Endogeneity

One of the problems when studying the impact of trade liberalization is that tariff changes are possibly not set exogenously. To take this issue seriously and address it appropriately, we rely on the history of trade protection to find the appropriate instruments for policy changes. Based on the observation that there is a strong correlation between tariff changes and the pre-reform tariff levels, Goldberg and Pavcnik (2005) suggest to use the latter as instrumental variables. The history of trade protection in China displays a similar pattern. In particular, tariff cuts were higher in heavily protected industries (see Liu et al. 2015). As our sample is for 2000-2006, we select the input and output tariff levels in 1999 in our simple set of instruments (columns 1 to 4 in Table 7). In an alternative set of instruments, we use the previous-year's level of tariffs to instrument the changes in tariffs (columns 5 to 8 in Table 7). Consistent with the other specifications, we first test using the whole sample (columns 1 and 5). Columns 2 and 6 make use of the subsamples that contain the type-1A important trading partners, columns 3 and 7 make use of the subsamples that contain the type-2A important trading partners. Finally columns 4 and 8 make use of the subsample that contain the type-3A important trading partners .[16]

Our results are robust to adopting the instrumental variables approach. In particular, when we use past tariffs as instruments, the coefficient of ΔInput_tariff$\times$Rank is significantly negative and the coefficient of ΔOutput_tariff$\times$Rank is positive, although slightly insignificant in some specifications (columns 1 to 4). When the previous-year's tariffs are chosen as instruments, all the coefficients of interest have the correct signs and are statistically significant (columns 5 to 8). In addition, the same pattern arises as in Table 3. The magnitude of the coefficients of interest is amplified from columns 1 and 5 (with the whole sample) to columns 2 to 4 and 6 to 8 (important trading partners), respectively.

One concern with the instrumental variables approach is the weak instrument. Our first-stage tests reveal that our instruments explain 28-53 percent of the imported-input tariff variation, 33-49 percent of the imported-output tariff variation, 6-62 percent of the ΔInput_tariff$\times$Rank, and 12-31 percent of the ΔOutput_tariff$\times$Rank variation, even after excluding the other exogenous variables for the sample of ordinary trade. The values of the F-statistics are high. In addition, we conduct additional tests to analyze the strength of our instruments. The usual canonical correlation likelihood ratio test (Anderson 1984) might not be appropriate here if we assume heteroskedasticity. In this case, the Kleibergen and Paap (2006) rk statistics are often used. The Kleibergen-Paap rk Lagrange Multiplier (LM) statistic reveals that our model passes the under-identification

[16] To save space, here we only report the results with the subsample using the type-A important trading partners that correspond to the 50 percentile. All the results are preserved with the type-B important trading partners that correspond to the 75 percentile.

test. Moreover, the Kleibergen and Paap (2006) rk Wald F-statistic is way above the Stock and Yogo (2005) critical value (if we accept the i.i.d. assumption that the closely related Cragg and Donald (1993) Wald test displays an F-statistic that is way above the Stock and Yogo (2005) critical value). All these results suggest that we can reject the weak instrument hypothesis.

We also perform additional diagnostic tests to see if any particular endogenous regressors are unidentified. The Angrist and Pischke (2009) first-stage chi-squared and F statistics suggest that none of our endogenous regressor is weakly identified. Among all four of our potentially endogenous regressors, ΔOutput_tariff×Rank is our weakest link. The Angrist and Pischke (2009) chi-squared and F statistics corresponding to this regressor are only one-third of those of the next weak link (ΔInput_tariff×Rank). This explains why the coefficients of this variable are insignificant in some specifications (in particular in columns 1 and 3).

To test for the significance of the endogenous regressors, we run two more tests. The first one is the Anderson and Rubin (1949) test, which provides the chi-squared and the F-statistics. The second test, which is closely related, is proposed by J.H. Stock and J.H. Wright (2000), which yields the S statistics. The high values of these statistics suggest that our model passes these tests.

6.2 Customs Data

In the benchmark case, our database merges the customs data and the manufacturing survey data. This merged data set allows us to incorporate firm characteristics in the observations, such as its productivity, its size, etc. The drawback of this database is that it only covers large non-SOEs firms with annual sales of at least 5 million RMB (approximately equivalent to US$800,000).[17] In other words, some small exporters are unaccounted for, which may result in a selection bias problem. In this section, we test our theory using only the customs data to cover the whole universe of exporters.

Since there is no industry classification in customs data, we map the IO 3-digit imported-input and imported-output tariffs onto the HS 6-digit level instead of the 4-digit CIC industry. This procedure yields a set of imported-input and imported-output tariffs at the HS 6-digit level. Hence, we cluster error terms at this level to address the potential correlation of errors within each HS 6-digit category over time.

In Table 8, we make use of our whole sample in column 1; and we use the subsample that contain type-1A, type-1B, type-2A, type-2B, type-3A and type-3B important trading partners in columns 2 to 7. Table 8 shows that the results are not that different from the ones obtained when we use the merged database. In particular, all the coefficients of

[17]All the SOEs are included in our database.

Table 7: Effect of Trade Liberalization using Instrumental Variables

Dependent variable: changes in log export value								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Instrumented by the past year tariff				Instrumented by the previous year tariff			
ΔInput_tariff	6.519***	10.229***	10.187***	12.074***	3.202***	6.244***	5.574***	6.702***
	(1.419)	(2.395)	(2.549)	(3.002)	(0.872)	(1.385)	(1.421)	(1.636)
ΔInput_tariff $\times$ Rank	-7.987***	-12.713***	-14.054***	-15.888***	-2.910***	-4.758***	-6.021***	-6.249***
	(1.599)	(2.594)	(3.211)	(3.643)	(0.759)	(1.197)	(1.323)	(1.458)
ΔOutput_tariff	-1.294*	-2.381**	-2.272**	-2.888**	-1.688***	-2.703***	-3.149***	-3.112***
	(0.723)	(1.085)	(1.121)	(1.298)	(0.561)	(0.882)	(0.927)	(1.072)
ΔOutput_tariff $\times$ Rank	1.026	2.275*	2.173	2.570	1.298*	2.484**	3.020**	2.843**
	(0.978)	(1.273)	(1.461)	(1.584)	(0.785)	(1.101)	(1.265)	(1.392)
Rank	0.462***	0.432***	0.443***	0.434***	0.507***	0.494***	0.508***	0.504***
	(0.010)	(0.016)	(0.020)	(0.022)	(0.006)	(0.009)	(0.009)	(0.010)
Δ(TFP)	0.044***	0.046***	0.045***	0.049***	0.044***	0.047***	0.045***	0.048***
	(0.005)	(0.007)	(0.007)	(0.008)	(0.005)	(0.007)	(0.007)	(0.008)
Δ(Labour)	0.132***	0.135***	0.119***	0.114***	0.135***	0.138***	0.123***	0.118***
	(0.012)	(0.019)	(0.019)	(0.022)	(0.012)	(0.018)	(0.019)	(0.022)
Δ(Capital/Labour)	0.032***	0.031***	0.030**	0.035***	0.032***	0.030***	0.029**	0.033**
	(0.007)	(0.011)	(0.012)	(0.013)	(0.007)	(0.011)	(0.012)	(0.013)
Δ(Wage)	0.052***	0.049***	0.043***	0.034**	0.051***	0.049***	0.042***	0.033**
	(0.008)	(0.012)	(0.012)	(0.013)	(0.008)	(0.012)	(0.012)	(0.013)
Ho: coefficient on input tariff equals 0								
Partial R-squared	0.3204	0.3060	0.2997	0.2883	0.5129	0.5187	0.5257	0.5195
Ho: coefficient on output tariff equals 0								
Partial R-squared	0.336	0.336	0.332	0.330	0.482	0.480	0.477	0.470
Ho: coefficient on input tariff*log(rank) equals 0								
Partial R-squared	0.103	0.094	0.063	0.062	0.616	0.559	0.548	0.541
Ho: coefficient on output tariff*log(rank) equals 0								
Partial R-squared	0.146	0.158	0.122	0.128	0.295	0.302	0.285	0.279
Kleibergen-Paap rk LM $\chi^2(1)$	4,746.05	1,797.47	940.58	755.93	3,003.13	1,545.30	1,290.10	1,041.56
Kleibergen-Paap Wald rk F-statistic	1,458.52	506.00	257.58	206.05	950.62	487.08	397.61	320.18
Anderson-Rubin Wald F-statistic	9.27	6.55	4.99	5.02	6.59	6.06	7.19	6.94
Anderson-Rubin Wald $\chi^2(4)$	37.08	26.22	19.97	20.10	26.35	24.24	28.76	27.75
Stock-Wright LM $\chi^2(4)$	37.05	26.20	19.97	20.08	26.27	24.11	28.57	27.54
Observations	341,627	162,310	152,932	121,857	341,627	162,310	152,932	121857

Notes: Robust standard errors are reported. * $p < 0.1$, **$p < 0.05$, *** $p < 0.01$. The whole sample are used in columns 1 and 5, the Columns 2 and 6 use the subsample that contain type-1A important trading partners, columns 3 and 7 use the subsample that contain the type-2A important trading partners. Finally columns 4 and 8 use the subsample that contain type-3A important trading partners . All the tests reject the corresponding null hypothesis.

interest have the predicted signs and their magnitudes rise as we switch from using the whole sample to using the subsample of important trading partners.

Table 8: Effect of Trade Liberalization based on Customs Data Sample

Dependent variable: changes in log export value							
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔInput_tariff	-0.026	0.710	1.844	1.388	2.488*	1.934*	2.267
	(0.719)	(1.056)	(1.410)	(1.014)	(1.269)	(1.097)	(1.518)
ΔInput_tariff × Rank	-0.915***	-1.100***	-1.674***	-1.296***	-1.825***	-1.525***	-1.806***
	(0.277)	(0.361)	(0.506)	(0.350)	(0.469)	(0.394)	(0.537)
ΔOutput_tariff	-0.871	-1.514*	-2.205*	-1.955**	-2.689**	-2.212**	-2.691**
	(0.584)	(0.833)	(1.175)	(0.812)	(1.160)	(0.894)	(1.324)
ΔOutput_tariff × Rank	0.095	0.425	0.924**	0.536	1.207***	0.671*	1.131**
	(0.268)	(0.341)	(0.447)	(0.333)	(0.438)	(0.379)	(0.491)
Rank	0.447***	0.435***	0.432***	0.438***	0.449***	0.434***	0.446***
	(0.006)	(0.006)	(0.007)	(0.006)	(0.007)	(0.006)	(0.008)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes
Firm-Destination fixed effect	yes	yes	yes	yes	yes	yes	yes
Observations	1,809,185	840,468	341,934	815,022	377,712	633,888	245,102
R-squared	0.275	0.288	0.313	0.295	0.319	0.293	0.306
R-squared adj.	0.084	0.090	0.100	0.089	0.091	0.094	0.103

Notes: Robust standard errors are clustered at the industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The rank here is a dummy variable that takes the value 1 if the product-level value belongs to the top 50 percentile. We make use of our whole sample in column 1, we use the subsample that contain type-1A, type-1B, type-2A, type-2B, type-3A and type-3B important trading partners in columns 2 to 7.

6.3 Placebo Test

A prevalent feature of Chinese trading activities is the presence of processing trade (Manova and Yu 2014, Fan et al. 2015, Yu forthcoming). A Chinese firm could obtain inputs from its trading partners, use them to assemble the final good, and export it back to its trading partners. This type of trading activity is recorded as processing with supplied inputs in the customs documents. Alternatively, firms could pay for the imported-inputs from foreign suppliers, assemble the final good and export all the processed goods. This practice is documented as processing with imported inputs. The processing-trade regime allows the firms to enjoy duty-free imports. As such, we expect that there is no impact from the changes in imported-input tariffs on their export performance. In other words, the processing-trade firms in China can be used as a control group in our study.

The construction of Table 9, which displays the results of this placebo test, is similar to Table 8. The impacts of imported-input tariffs and imported-output tariffs are hardly significant (column 1), even when we limit our sample to the important trading partners of China (columns 2 to 7 use type-1A, type-1B, type-2A, type-2B, type-3A and type-3B important trading partners, respectively). Hence, the use of the processing-trade regime as the control group provides additional evidence to support our results.

Table 9: Effect of Trade Liberalization using the Processing Trade Data

Dependent variable: changes in log export value	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔInput_tariff	0.591	1.459	0.334	1.090	0.484	1.660	0.037
	(0.952)	(1.054)	(1.675)	(1.185)	(1.777)	(1.155)	(2.181)
ΔInput_tariff × Rank	0.374	0.222	-0.154	0.385	0.539	0.245	0.695
	(0.411)	(1.022)	(1.595)	(0.928)	(1.694)	(1.122)	(2.093)
ΔOutput_tariff	0.172	-0.039	-0.238	0.320	0.323	-0.227	-0.232
	(0.348)	(0.383)	(0.890)	(0.440)	(0.813)	(0.433)	(1.046)
ΔOutput_tariff × Rank	0.159	0.158	0.121	0.019	-0.291	0.119	-0.701
	(0.404)	(0.563)	(0.807)	(0.528)	(0.959)	(0.656)	(1.170)
Rank	0.367***	0.313***	0.310***	0.341***	0.363***	0.319***	0.324***
	(0.023)	(0.021)	(0.025)	(0.025)	(0.027)	(0.022)	(0.023)
Δ(TFP)	0.060***	0.069***	0.062***	0.065***	0.062***	0.071***	0.071***
	(0.010)	(0.013)	(0.018)	(0.014)	(0.017)	(0.016)	(0.020)
Δ(Labor)	0.203***	0.216***	0.196***	0.202***	0.199***	0.206***	0.218***
	(0.028)	(0.032)	(0.053)	(0.035)	(0.048)	(0.034)	(0.059)
Δ(Capital/Labor)	0.013	0.004	-0.002	0.015	0.025	0.014	-0.002
	(0.018)	(0.018)	(0.029)	(0.019)	(0.024)	(0.020)	(0.033)
Δ(Wage)	0.060***	0.052***	0.028	0.041**	0.020	0.036**	0.023
	(0.016)	(0.017)	(0.025)	(0.019)	(0.026)	(0.017)	(0.031)
Observations	221,219	96,284	38,734	96,762	38,366	75,460	26,455
R-squared	0.291	0.272	0.284	0.284	0.286	0.263	0.277
R-squared adj.	0.034	0.028	0.043	0.034	0.040	0.031	0.050

Notes: Robust standard errors are clustered at the industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Column 1 employs the whole sample; columns 2-7 use the type-1A, type-1B,type-2A, type-2B, type-3A and type-3B important trading partners respectively.

6.4 Long Difference

In our benchmark case, we employ a one-year difference estimator. We find that our results do not change when we take longer difference estimators. In Table 10, we use a two-year difference estimator in Columns 1 to 3, a three-year difference estimator in columns 4 to 6 and a four-year difference estimator in columns 7 to 9. For each of these three-column clusters, the first column uses to the whole sample, the second column uses to the sub-sample with type-3A important trading partners and the third column uses the subsample that contains type-3B important trading partners. Consistent with our predictions, the coefficients of our variables of interest all have the predicted signs, namely negative for ΔInput_tariff × Rank and positive for ΔOutput_tariff × Rank. One exception is the specification in column 4 when the coefficient of ΔOutput_tariff × Rank is negative but insignificant. Interestingly, with all the estimators (two-year difference, three-year difference and four-year difference) we see a clear pattern that the magnitude of the coefficients of interest rises from left to right, i.e., from using the whole sample to using the smaller subsample of large trading partners.

6.5 Other Mechanisms

There may exist other mechanisms that could potentially affect the reallocation of outputs across products within a destination country. One may be concerned that this

Table 10: Effect of Trade Liberalization using Long Difference Estimators

Dependent variable: changes in log export value	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Two-year difference			Three-year difference			Four-year difference		
ΔInput_tariff	1.631	4.894**	7.399**	-0.706	1.744	1.664	-2.061	-0.140	-3.048
	(1.340)	(2.247)	(3.150)	(2.262)	(3.574)	(3.974)	(2.665)	(5.411)	(5.723)
ΔInput_tariff × Rank	-1.692**	-3.428**	-3.858*	-1.179	-3.393*	-4.227**	-1.688	-4.381**	-6.863***
	(0.720)	(1.467)	(2.008)	(0.853)	(1.845)	(1.860)	(1.280)	(2.172)	(2.556)
ΔOutput_tariff	-1.194*	-2.607**	-3.535**	-1.222	-0.871	0.073	0.458	0.724	1.431
	(0.682)	(1.181)	(1.711)	(1.277)	(2.006)	(2.251)	(1.715)	(2.486)	(3.382)
ΔOutput_tariff × Rank	0.465	1.475	1.539	-0.314	0.774	1.200	1.265	2.810	6.268**
	(0.634)	(1.083)	(1.434)	(0.727)	(1.305)	(1.486)	(1.539)	(1.726)	(2.611)
Rank	0.677***	0.685***	0.659***	0.800***	0.791***	0.728***	0.940***	0.874***	0.910***
	(0.029)	(0.032)	(0.041)	(0.043)	(0.049)	(0.059)	(0.083)	(0.092)	(0.120)
Δ(TFP)	0.049**	0.049**	0.054*	0.076**	0.101***	0.101**	0.113***	0.211***	0.143
	(0.019)	(0.022)	(0.032)	(0.032)	(0.033)	(0.050)	(0.036)	(0.060)	(0.098)
Δ(Labor)	0.148**	0.149***	0.176***	0.219**	0.131	0.109	0.243**	0.160	-0.018
	(0.061)	(0.051)	(0.067)	(0.091)	(0.094)	(0.118)	(0.101)	(0.141)	(0.224)
Δ(Capital/Labor)	0.037**	0.044	0.044	0.081**	0.076*	0.058	0.111*	0.130	0.142
	(0.018)	(0.028)	(0.042)	(0.035)	(0.044)	(0.074)	(0.067)	(0.103)	(0.139)
Δ(Wage)	0.048**	0.058*	0.039	0.055*	0.031	0.011	0.094	-0.016	0.002
	(0.021)	(0.033)	(0.049)	(0.033)	(0.051)	(0.061)	(0.070)	(0.101)	(0.114)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm-Destination fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	173,246	56,531	25,864	91,531	29,428	13,500	42,713	13,494	6,556
R squared	0.459	0.448	0.439	0.568	0.551	0.535	0.655	0.640	0.633
R squared adj.	0.156	0.148	0.153	0.261	0.238	0.244	0.305	0.283	0.305

Notes: Robust standard errors are clustered at the industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The whole sample is used in columns 1, 4, and 7. The subsample of type-3A important trading partners is used incolumns 2, 5, and 8. The subsample of type-3B important trading partners is used in columns 3, 6 and 9.

reallocation across products within firm-destination is partially due to the appreciation of the renminbi. In late 2005, China adopted the floating regime and allowed the RMB to appreciate. This policy clearly could have an effect on the import/export decisions of Chinese firms. One solution to this problem is to use the pre-2005 database to separate the effect of this policy from that of the trade reforms (columns 1 to 4 in Table 11).

Another concern one might have is the issue of policy uncertainty. Prior to WTO accession, China already enjoyed the MFN status from the United States and the European Union, among other countries, which granted low tariffs to Chinese exports. However, this status was subject to annual review in some countries, notably the United States. It is therefore natural to suspect that the effect of China's WTO accession was the reduction of the policy uncertainty that Chinese exporters faced. Pierce and Schott (2013) find that most of the uncertainty faced by Chinese exporters actually came from the United States. Based on this observation, we address this policy uncertainty issue by removing the U.S. transactions in our sample (columns 5 to 8 in Table 11).

In Table 11, all the transactions to and from the United States are removed in columns 5 to 8. In columns 2 and 6, we use only the subsample containing the type-1A important trading partners; in columns 3 and 7, the type-2A important trading partners; in columns 4 and 8, the type-3A important trading partners.

Again, as predicted by our theory, the coefficient of the interaction term between imported-input tariff and log rank is negative and the coefficient of the interaction term between imported-output tariff and log rank is positive. When we limit our sample to the important trade partners with China, the coefficients of the interaction terms become larger in magnitude and more significant.[18]

Table 11: Effects of Other Mechanisms

Dependent variable: changes in log export value								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Exchange rate				Policy uncertainty			
ΔInput_tariff	1.529	1.524	3.000**	2.865*	2.137*	3.961**	4.143***	4.505***
	(1.095)	(1.522)	(1.397)	(1.622)	(1.090)	(1.620)	(1.420)	(1.635)
ΔInput_tariff × Rank	-1.480*	-2.662**	-4.278***	-4.734***	-1.491*	-2.789**	-4.095***	-4.556***
	(0.819)	(1.336)	(1.397)	(1.453)	(0.804)	(1.332)	(1.111)	(1.181)
ΔOutput_tariff	-0.398	-0.916	-1.231*	-1.442**	-0.648	-1.568**	-1.521**	-1.624**
	(0.495)	(0.613)	(0.659)	(0.693)	(0.524)	(0.686)	(0.708)	(0.691)
ΔOutput_tariff × Rank	0.355	1.056*	1.267*	1.589**	0.500	1.273*	1.562**	1.859***
	(0.422)	(0.596)	(0.734)	(0.720)	(0.448)	(0.720)	(0.704)	(0.689)
Rank	0.525***	0.515***	0.522***	0.521***	0.523***	0.519***	0.515***	0.514***
	(0.020)	(0.021)	(0.023)	(0.023)	(0.017)	(0.019)	(0.018)	(0.019)
Δ(TFP)	0.036***	0.044***	0.037**	0.045***	0.042***	0.044***	0.038***	0.040***
	(0.013)	(0.015)	(0.017)	(0.017)	(0.010)	(0.015)	(0.014)	(0.015)
Δ(Labor)	0.105***	0.118***	0.103**	0.107**	0.121***	0.113***	0.107***	0.097***
	(0.036)	(0.040)	(0.046)	(0.046)	(0.030)	(0.034)	(0.034)	(0.033)
Δ(Capital/Labor)	0.022	0.020	0.019	0.020	0.034***	0.026	0.026	0.030*
	(0.016)	(0.020)	(0.024)	(0.025)	(0.010)	(0.016)	(0.016)	(0.017)
Δ(Wage)	0.044***	0.048**	0.047**	0.039	0.048***	0.045**	0.045**	0.036
	(0.015)	(0.020)	(0.022)	(0.025)	(0.016)	(0.021)	(0.022)	(0.025)
Observations	224,374	104,959	98,470	77,453	304,893	131,129	141,963	110,888
R-squared	0.355	0.341	0.362	0.356	0.358	0.341	0.348	0.338
R-squared adj.	0.025	0.032	0.034	0.041	0.021	0.024	0.027	0.031

Notes: Robust standard errors are clustered at the industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All the transactions to and from the United States are removed in columns 5-8. Columns 2 and 6 employ the type-1A important trading partners, columns 3 and 7 employ the type-2A important trading partners, columns 4 and 8 employ the type-3A important trading partners.

7 Calibration

To run the quantitative analysis, we need to estimate the following sets of parameters: (i) the variability of productivity draws θ; (ii) the labor supply $L_l(l = H, F)$; (iii) the elasticity of substitution $1/(1-\rho)$; (iv) the degree of product differentiation γ; (v) the Pareto shape parameter k and Pareto scale parameter $\varphi_{\min}$; (vi) the sourcing capabilities Θ; (vii) the entry cost f_e; (viii); and the customization cost ω. We choose standard values for these parameters based on the existing empirical literature and the moments of U.S.-China trade data in 2000. In particular, we choose the variability of productivity draws $\theta = 8.28$, which is the preferred value in Eaton and Kortum (2002). The total labor

[18] To save space, we only report the results with the subsample using the 50 percentile threshold. Using the subsample with the 75 percentile threshold yields similar results.

force is calculated from the Penn World Table.[19] To be consistent with the estimates in Bernard et al. (2003) we set $\rho = 0.8$, which corresponds to an elasticity of substitution between intermediate goods of $\sigma = 4$.

The degree of product differentiation γ is taken from Broda, Greenfield and Weinstein (2006). We choose the Pareto shape parameter k and the scale parameter φ_{min} to match the shape of the right tail of the productivity distribution. Since our productivity estimates are calculated at the 2-digit CIC industry level, the Pareto shape parameters are estimated at the same level.

Since only the relative sourcing of capabilities $\frac{\Theta_l}{\Theta_h}$ matters, we can always normalize by setting $\Theta_h = 1$. Hence, we have:

$$\Theta_l = \frac{\Theta_l}{\Theta_h} = \left[\left(\tau_{hl}^o\right)^{-k} + \frac{\left(\tau_{lh}^o\right)^k + \left(\tau_{hl}^o\right)^{-k}}{1 + \frac{L_l}{L_h}\left(\frac{\varphi_{ll}}{\varphi_{lh}}\right)^{-(k+2)}} \right]^{\frac{\theta}{k}}$$

The firm-level survey data provides the information about firm's export value. Using the firm-level NBSC survey, we measure the average export revenue $\overline{r}$, and the probability of exporting $\left(\frac{\varphi_{ll}}{\varphi_{lh}}\right)^k$. The probability of exporting $\left(\frac{\varphi_{ll}}{\varphi_{lh}}\right)^k$ is then used to calibrate the sourcing capabilities Θ_l. The free-entry cost f_e is chosen to match the average firm's export revenue and the probability of exporting, according to the following formula:

$$\begin{aligned} \overline{r} &= \int_{\varphi_{lh}}^{\infty} \sum_{m=0}^{M_{lh}(\varphi)} r_{lh}\left(\phi\left(m,\varphi\right)\right) dG\left(\varphi\right) \\ &= \left(k+1\right) f_e \frac{L_h}{L_l} \left(\frac{\varphi_{ll}}{\varphi_{lh}}\right)^{k+2} \end{aligned}$$

When the productivity for the core product is Pareto distributed, so are those of all the produced varieties. In particular, if we denote the mass of entrants by N_e and the normalized measure of varieties per mass of entrants by $H(c)$, then:

$$H(c) = \sum_{m=0}^{\infty} G\left(\omega^m c\right) = \Omega G\left(c\right)$$

Moreover, the average number of products produced by a firm is given by:

$$\frac{H\left(c_{ll}\right) N_e}{G\left(c_{ll}\right) N_e} = \Omega$$

[19]We can find in the Penn Wolrd Table the population, *pop* as well as the GDP per capita *rgdpch* and the GDP per worker *rgdpwok*. The total labor force is then defined as $L_h = 1000 * pop_h * rgdpch_h / rgdpwok_h$.

As a result, the multi-product flexibility Ω can be estimated from the average number of products an exporter supplies to the foreign market. The customization costs then can be estimated from the multi-product flexibility and the Pareto shape parameter:

$$\omega = \left(1 - \frac{1}{\Omega}\right)^{\frac{1}{k}}$$

The selected parameters are presented in Table 12. We then use these parameters to quantify the effects of import tariff cuts in China on the two indicators of Chinese export performance in the U.S. market: the export productivity cut-off and the export value. Figure 2 shows that while imported-input tariff reduction reduced the export productivity cutoffs, enabling more Chinese firms to enter the U.S. market, cutting imported-output tariffs raised the export productivity cutoffs, making it more difficult to penetrate the U.S. market. The effects were strong at the beginning of the trade reforms and became milder in the subsequent years. For instance, in 2001 the reduction in imported-input tariffs lowered the export productivity cutoff by 3 percent, on average and the reduction of imported-output tariffs raised the export productivity cutoff by 3 percent. Both effects converged to 0 in 2005, the last year in our sample.

As predicted by our theory, the effect of trade liberalization in imported-intermediate goods was to increase the export value, and more so for peripheral products. At the same time, the effect of trade liberalization in imported-final goods was to reduce the export value, again more so for peripheral products. In particular, Figure 3 shows that from 2001 to 2006, the export value of core products rose by approximately 2 percent thanks to the reduction in imported-input tariffs, but dropped by approximately 1.5 percent due to the fall in imported-output tariffs. The magnitudes of these effects rose by a further 1 percent when we consider the effect on the fourth-ranked product instead of the core product.

8 Conclusion

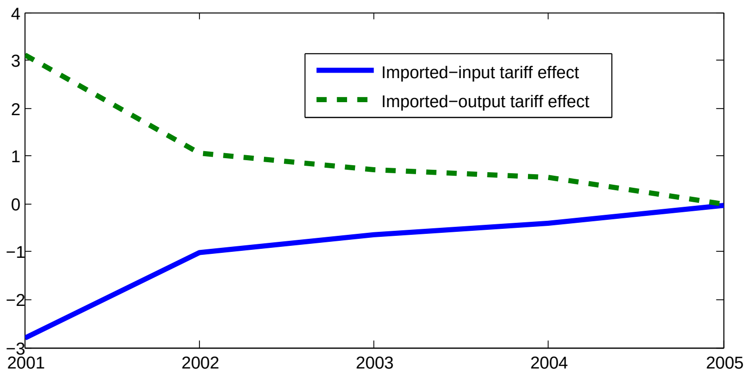
Economists have long been preoccupied with the question of how best to allocate limited resources. The existing literature has focused on plant or firm entry and exit, together with the changes in the composition of output across plants and firms, as the main avenues of resource reallocation. Recently, there has been a surge of interest in investigating the reallocation of resources across products within firms. In this paper, we develop a model that incorporates import capabilities into a firm's decisions concerning the allocation of resources among the products, the product mix and export values. Our tractable framework generates several interesting implications. A reduction of tariffs on imported-intermediate goods induces the firm to increase the export sales of a periph-

Table 12: Calibrated Parameters

Parameters	Mean	Std	Min	Max
k	1.40	0.13	1.11	1.54
ω	0.78	0.12	0.59	0.96
Θ_{China}	0.64	0.14	0.27	1
T_{China}	0.31	0.44	0.001	2

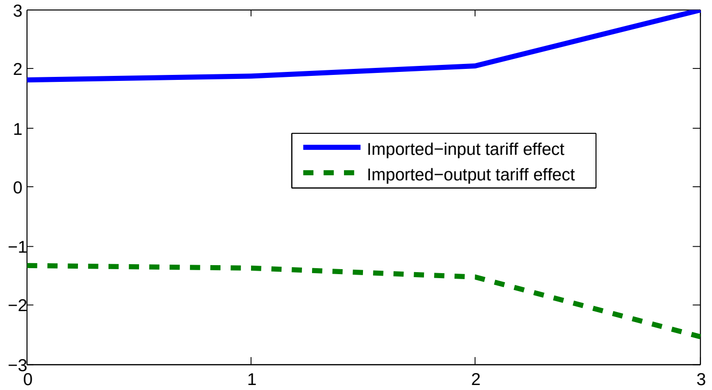
Notes: The parameters are calibrated to match the moments of the U.S-China trade data in 2000. The sourcing capabilities and the state of technology in the United States are normalized to be 1.

Figure 2: The effects of import tariff cuts on U.S.-China export productivity cutoffs..



Note: The changes in export productivity cutoffs, in percentage, are indicated on the vertical axis.

Figure 3: The effects of import tariff cuts on Chinese export value in the U.S. market.



Note: The product ranks are indicated on the horizontal axis, with 0 being the core competency. The changes in export value, in percentage, are indicated on the vertical axis.

eral product by a larger percentage than the core product. Conversely, a reduction of tariffs on imported-final goods induces the firm to reallocate resources away from the peripheral products towards the core product. As a result, the firm diversifies its product line more after trade liberalization in imported-intermediate goods, but concentrates its production in the core products in response to imported-output tariff cuts. Using a detailed and highly disaggregated data set for China for the period 2000-2006, we carry out empirical tests and provide evidence to support our theoretical predictions. We also use the U.S.-China trade data to calibrate the parameters of our model and quantify the impacts of imported-output tariff and imported-input tariff reductions on two important variables in the export market: the export productivity cutoff which indicates the export probability, and the export values across different products within firms.

Our study contributes to a vibrant literature that links improved access to imported intermediate inputs to superior firm performance, as well as the literatures that analyzes multi-product firms, that examines the impact of trade reforms on resource allocation across products within firms, and that distinguishes the effects between trade reforms in the final goods market and in the intermediate goods market. It would be interesting to decompose the effect on each export value into that on export quantity and on export price and assess how each adjusts across products within firms in reponse to trade liberalization. It would be also interesting to explore how export values adjust across products for different types of firms during trade liberalization. For instance, one might investigate how credit constraints faced by firms affect the export values adjustments across products within firms. These are interesing areas for future research.

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Appendix: Tables

Table 13: The correlation coefficients among the indexes

	Impshare	Expshare	CHNimp/GDP	CHNexp/GDP
Impshare	1.000			
Expshare	0.6419	1.000		
CHNimp/GDP	0.8540	0.5495	1.000	
CHNexp/GDP	0.4944	0.8474	0.5878	1.000

Note: Impshare denotes the share of imported goods from China; Expshare denotes the share of exported goods to China; CHNimp/GDP denotes the share of imported goods from China in the country's GDP; CHNexp/GDP denotes the share of exported goods to China in the country's GDP

Table 14: The Effect of Trade Liberalization using Industry Fixed Effect

Dependent variable: changes in log export value.							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔInput_tariff	1.471	2.865	3.907	3.670**	6.528***	3.896**	7.905***
	(1.256)	(1.762)	(2.435)	(1.564)	(2.117)	(1.877)	(2.784)
ΔInput_tariff × Rank	-1.591**	-2.590**	-6.094***	-3.910***	-5.251***	-4.351***	-5.756***
	(0.702)	(1.097)	(1.345)	(1.058)	(1.352)	(1.116)	(1.412)
ΔOutput_tariff	-0.500	-1.010	-1.512	-1.211*	-1.934	-1.370*	-1.977
	(0.544)	(0.663)	(1.029)	(0.714)	(1.190)	(0.732)	(1.215)
ΔOutput_tariff × Rank	0.611	1.253**	2.859***	1.563**	2.064**	1.815***	2.167**
	(0.409)	(0.582)	(0.865)	(0.647)	(0.892)	(0.633)	(0.965)
Rank	0.512***	0.499***	0.510***	0.511***	0.512***	0.509***	0.501***
	(0.016)	(0.018)	(0.022)	(0.018)	(0.024)	(0.018)	(0.023)
Δ(TFP)	0.046***	0.050***	0.045**	0.048***	0.055***	0.050***	0.052**
	(0.010)	(0.014)	(0.018)	(0.014)	(0.016)	(0.016)	(0.021)
Δ(Labour)	0.134***	0.138***	0.078*	0.121***	0.113***	0.117***	0.109**
	(0.030)	(0.032)	(0.043)	(0.035)	(0.042)	(0.034)	(0.046)
Δ(Capital/Labour)	0.031***	0.030**	0.028	0.027*	0.023	0.032**	0.028
	(0.010)	(0.015)	(0.020)	(0.015)	(0.021)	(0.016)	(0.023)
Δ(Wage)	0.049***	0.048**	0.047*	0.040*	0.046*	0.031	0.055*
	(0.014)	(0.019)	(0.027)	(0.021)	(0.027)	(0.023)	(0.030)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes
Firm fixed effect	no	no	no	no	no	no	no
Destination fixed effect	no	no	no	no	no	no	no
Firm-Destination fixed effect	yes	yes	yes	yes	yes	yes	yes
Industry fixed effect	yes	yes	yes	yes	yes	yes	yes
Observations	341,627	162,310	65,061	152,932	74,244	121,857	51,566
R-squared	.348	.328	.328	.344	.357	.334	.333
R-squared adj.	.0205	.0235	.025	.0267	.0281	.0307	.0324

Notes: Robust standard errors are clustered at the industry level. * $p < 0.1$, **$p < 0.05$, *** $p < 0.01$.
In Column 1 we make use of the whole sample; in columns 2-7 we make use of the subsample that contain type-1A, type-1B, type-2A, type-2B, type-3A and type-3B important trading partners respectively

Table 15: The Effect of Trade Liberalization using Alternative Measure of Rank

Dependent variable: changes in log export value.							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔInput_tariff	2.556**	3.398**	3.374**	3.578**	3.417	5.885***	6.476***
	(1.289)	(1.594)	(1.396)	(1.634)	(2.193)	(1.851)	(2.471)
ΔInput_tariff × Rank	-4.335**	-5.214***	-5.648***	-6.253***	-8.535***	-8.649***	-9.101***
	(1.868)	(1.865)	(1.804)	(2.054)	(2.716)	(2.352)	(2.808)
ΔOutput_tariff	-0.740	-1.220**	-1.268*	-1.327**	-0.995	-1.490	-1.657
	(0.522)	(0.557)	(0.658)	(0.630)	(0.930)	(1.085)	(1.117)
ΔOutput_tariff × Rank	1.428**	2.649***	2.551***	2.940***	3.276***	2.365*	2.564*
	(0.726)	(0.862)	(0.899)	(1.007)	(1.160)	(1.285)	(1.363)
Rank	0.507***	0.520***	0.518***	0.527***	0.489***	0.499***	0.488***
	(0.031)	(0.035)	(0.036)	(0.039)	(0.031)	(0.036)	(0.036)
Δ(TFP)	0.043***	0.047***	0.045***	0.048***	0.044**	0.051***	0.051**
	(0.010)	(0.014)	(0.014)	(0.015)	(0.017)	(0.016)	(0.021)
Δ(Labour)	0.133***	0.139***	0.125***	0.120***	0.072*	0.107**	0.100**
	(0.030)	(0.033)	(0.036)	(0.035)	(0.043)	(0.043)	(0.047)
Δ(Capital/Labour)	0.031***	0.031**	0.030*	0.034**	0.029	0.024	0.027
	(0.010)	(0.015)	(0.016)	(0.016)	(0.020)	(0.022)	(0.023)
Δ(Wage)	0.049***	0.045**	0.040*	0.030	0.043	0.044	0.052*
	(0.014)	(0.019)	(0.021)	(0.023)	(0.027)	(0.027)	(0.031)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes
Firm-Destination fixed effect	yes	yes	yes	yes	yes	yes	yes
Observations	341,627	162,310	152,932	121,857	65,061	74,244	51,566
R-squared	0.336	0.316	0.331	0.321	0.314	0.344	0.320
R-squared adj.	0.004	0.007	0.008	0.012	0.005	0.010	0.013

Notes: Robust standard errors are clustered at the industry level. * $p < 0.1$, **$p < 0.05$, *** $p < 0.01$. The rank here is a dummy variable that takes the value 1 if the product-level value belongs to the top 50 percentile.
In Column 1 we make use of the whole sample; in columns 2-7 we make use of the subsample that contain type-1A, type-1B, type-2A, type-2B, type-3A and type-3B important trading partners respectively