Imported Intermediate Inputs, Export Prices, and Trade Liberalization[*]

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Abstract

This paper examines how trade liberalization affects unit value export prices via firms' import decisions on input quality and the number of imported varieties. The paper extends Melitz's (2003) model of trade with heterogeneous firms by introducing endogenous quality and endogenous number of imported varieties. The key predictions are as follows. First, an increase in productivity or a reduction in import tariff induces firms to spend more on each import variety, and choose to import higher-quality inputs (the "*quality effect*"). Second, higher-productivity firms or firms facing lower import tariff tend to import more varieties (the "*variety effect*"). Third, more importantly, due to the quality effect and the variety effect, there is a clear pattern of "***quality ladder***": firms importing more varieties or with higher productivity set higher export prices; trade liberalization further ***raises*** export prices set by firms. However, if one adopts the alternative assumption that quality is exogenous across firms, then completely opposite results would be expected: import tariff reduction would **decrease** export prices, and firms importing more varieties or with higher productivity set lower export prices. We test two competing theories using the merged Chinese firm-product trade data and the tariff data at the HS8 level by computing firm specific tariff. Our empirical results strongly support all the predictions of the endogenous-quality model, validate the mechanisms of the quality effect and the variety effect, and therefore confirm the pattern of the "quality ladder". Moreover, we find evidence to support the exogenous-quality model using quality-adjusted price estimates and the subsample of the goods with more homogeneity of quality.

JEL: F1, D2, G2, L1

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1. Introduction

Understanding firms' responses to trade liberalization is one of the major challenges in international trade. A large body of prior literature has devoted to examining the role of imported intermediate inputs in trade liberalization by exploring productivity effect (Pavcnik, 2002; Fernandes, 2007; Amiti and Konings, 2007, among others),[1] or the impacts of tariff change on firms' attributes such as domestic product scope, export value, and export scope (e.g., Goldberg, Khandelwal, Pavcnik, and Topalova, 2010; Bas, 2012; Feng, Li and Swenson, 2012). Despite the prominence of the large literature on imported intermediate inputs and trade liberalization, we have surprisingly few studies on the impacts of trade liberalization on firms' export prices. However, it is important to investigate the effect of trade liberalization on export prices as unit value export prices are typically used as proxies for countries' export quality. Hence, this paper aims to fill the gap in the literature by examining how trade liberalization affects export prices via firms' import decisions on input quality and the number of imported inputs.

We extend Melitz's (2003) model of trade with heterogeneous firms by introducing endogenous input quality, endogenous number of imported varieties, and fixed costs of importing. Firms choose optimal prices of their outputs and optimal quality of domestic and/or imported intermediate inputs. After deriving the equilibrium prices and quality choices, we examine how the number of imported varieties is affected by firm productivity and import tariff.

Our model predicts the following propositions. First, an increase in productivity or a reduction in import tariff induces firms to spend more on each imported variety, and choose to import higher-quality inputs (the "*quality effect*"). Second, higher-productivity firms or firms facing lower import tariff tend to import more varieties (the "*variety effect*"). Third, more importantly, due to the existence of both the quality effect and the variety effect, there is a clear pattern of "***quality ladder***": firms importing more varieties or with higher productivity set higher export prices for their products; trade liberalization further ***raises*** export prices set by firms. The propositions of our model regarding the relationship between productivity and prices are consistent with the recent quality-and-trade literature as more productive firms tend to choose higher-quality inputs, which yield higher export prices.[2]

[1] Another branch of literature relates imported intermediate inputs and firm TFP or aggregate productivity but does not empirically investigate trade liberalization, such as Kasahara and Rodrigue (2008), Gopinath and Neiman (2011), and Halpern, Koren and Szeidl (2011).

[2] See Verhoogen (2008), Kugler and Verhoogen (forthcoming), Hallak (2010), Hallak and Sivadasan (2011), Gervais (2011), Johnson (2012), Manova and Zhang (2012), Fan, Lai and Li (2012), among others.

Meanwhile, we provide another competing theory about the impacts of trade liberalization on export prices when quality is exogenous.[3] We find that this case predicts exactly opposite patterns: import tariff reduction would decrease export prices, and firms importing more varieties or with higher productivity set lower export prices. The intuition is that without quality adjustment mechanism, the impact of trade liberalization goes through lower marginal costs, which in turn induces lower export prices.

Next, we test two competing theories, with endogenous quality and exogenous quality, respectively, using the model-based estimation equation. We employ the applied MFN tariff for Chinese imports at the HS 8-digit level from the WTO with a matched Chinese firm-product level dataset. There are three distinct advantages of our sample based on the matched database: First, it contains information on unit value prices of both imports and exports at the product-firm-country level.[4] Second, all products in our sample are the most disaggregated trade data available for Chinese imports and exports at HS 8-digit level. Third, as we have firm-level information over the whole sample period, we can estimate and, therefore, track the evolution of firms' TFP and control for other firms' attributes such as capital intensity and wage.

We use Chinese data to test our theories because China presents a good setting to study the impacts of trade liberalization. China's accession to the WTO since December 2001 leads to an important unilateral trade liberalization, associated with a series of significant reductions in China's import tariff and very little corresponding changes in China's trade partners' import barriers against China.[5] To compute input tariff, we compute firm specific tariff rather than the conventional industry-level input tariff. The major reason for constructing firm specific tariff measure is the huge variation of tariff change across products within the same industry subsequent to trade liberalization.[6] So it is important to properly measure effective tariff levels faced by firms when they import different bundles of intermediate inputs, while the average industry-level tariff ignores the variations of tariff within the industry (see Ge et al., 2011, and Section 3.3. in this paper for more detailed discussion). Thus, we use three different ways to construct a firm specific tariff

[3]We prove this case in the appendix.

[4]With the information on destination country of exports and source country of imports, we are able to obtain the most precise information on variety. By the Armington (1969) assumption, an HS-8 product supplied by one country is regarded as a different variety from the same product supplied by any other country.

[5]Before China joined the WTO, many trade partners had already offered China MFN treatment.

[6]For example, the Input-Output sector, automobile manufacturing (Chinese I-O classification code 37074), includes the HS4 products, "motor cars & vehicles for transporting persons" (HS4 code 8703), and "special purpose motor vehicles" (HS4 code 8705). Within the same I-O sector, some products enjoyed substantial import tariff reduction from 80% in 2001 to 28% in 2006 (e.g., HS8 product "other vehicles", code 87033390), while others remain the same tariff level at 3% between 2001-2006 (e.g., HS8 product "fire fighting vehicles", code 87033390).

measure: (i) weighted by import value, (ii) weighted across the imported inputs within the same HS 2-digit category,[7] and (iii) weighted by input-output relation. To estimate TFP, we employ the augmented Olley-Pakes (1996) approach, which alleviates simultaneity bias and selection bias, and the De Lecker (2011) approach to further eliminate the price effect due to the unavailable physical output data in our study.

We test two competing theories regarding the impacts of trade liberalization on (i) import values, varieties, and prices, and (ii) export prices. The empirical results based on the whole sample support all the predictions of the endogenous quality model, and there is a clear, significant pattern of "quality ladder" due to the existence of the quality effect and the variety effect: firms importing more varieties or with higher productivity set higher export prices for their products, and trade liberalization further increases export prices set by firms. The mechanisms of our model that the effects of trade liberalization on export prices go through the firm's import decisions on input quality and the set of import variety are confirmed by different specifications of estimations. Our results regarding import values and varieties using Chinese data are consistent with the findings in Goldberg et al. (2010) based on Indian data.[8] Our results of the *quality ladder* via firms' import decisions on input quality (i.e., the quality effect) and the set of import variety (i.e., the variety effect) are novel in the literature to our knowledge.

Interestingly, we also find evidence to support the model with exogenous quality using quality-adjusted prices and the subsample of products with very little variation of quality. First, we estimate quality-adjusted prices and regress them on tariff, TFP, and import variety. The effect of trade liberalization on quality-adjusted prices are fully consistent with the predictions of the exogenous-quality model. Second, we divide the whole sample into two subsamples: differentiated products and homogeneous products, according to Rauch's (1999) classification. We find that in the differentiate product group, all effects of trade liberalization and productivity on export prices become significantly larger than the baseline estimation results, validating the mechanism of quality. In the homogenous product group, the effects of TFP on export prices becomes significantly negative, consistent with the predictions of the exogenous-quality model, while the effects of import tariff become insignificant. Third, we measure the heterogeneity of product quality by computing the variance of export prices across HS8-destination varieties by firm within each HS-6 category

[7]Manova and Zhang (2011) use the similar method by focusing on foreign inputs in the same broad industry classification as the output product. We adopt their method so as to distinguish what imported goods should be calculated as inputs to produce the exported goods.

[8]Our results on the effect of trade liberalization on import prices are different from Goldberg et al. (2010) because our import prices are at fob price.

as greater price variation implies more heterogeneity of product quality.[9] For products with more homogeneity of quality (i.e., lower price variation), tariff reduction would decrease export prices, consistent with the exogenous-quality case. However, moving from the products with more homogeneity of quality to those with more heterogeneity of quality, the effects of tariff reduction gradually become to increase export prices, consistent with the endogenous-quality model. This further validates the mechanism of quality in our model.

The main contribution of this paper is that it offers both theory and the empirical evidence on the impacts of trade liberalization (via firms' decisions on imported intermediate inputs) on export prices, adding to the emerging literature on the role of imported inputs in international trade. To the best of our knowledge, this paper provides the first compelling analysis of the impacts of trade liberalization on export prices through the *quality effect* and the *variety effect* and hence, the pattern of the *quality ladder*, under a heterogeneous-firm framework. The comparison of testing two competing theories and of providing evidence to support the endogenous-quality model and the exogenous-quality model is also new in the literature. We position our paper in the relevant literature through the following four aspects.

First, this paper is related to the literature examining the effect of imported inputs on productivity, such as Feenstra, Markusen and Zeile (1992), Muendler (2004), Kasahara and Rodrigue (2008), and Halpern, Koren, and Szeidl (2011). However, it should be noted that these studies are not related to the effects of trade liberalization.

Second, this paper joins the literature exploring the effect of trade liberalization on productivity, for example, Bernard and Jensen (2004) for the US and Trefler (2004) for Canada. Except these studies testing data on developed countries, more evidence has been found in developing countries, such as Bustos (2009) for Argentina, Schor (2004) for Brazil, Tybout et al. (1991) and Pavcnik (2002) for Chile, Fernandes for Columbia (2007), Krishna and Mitra (1998) and Topalova and Khandelwal (2010) for India, Amiti and Konings (2007) for Indonesia, Iscan (1998) for Mexico and Levinsohn (2003) for Turkey. These studies find that lower output tariffs have boosted productivity due to "import competition" effects, whereas cheaper imported inputs can raise productivity via learning, variety, and quality effects. Our paper highlights the channel through import variety and quality effect.

Third, this paper also complements the large quality-and-trade literature in confirming the prevalence of product quality heterogeneity at the firm level and the mechanism of quality in

[9] In the main results, we treat the same HS8 product with different destination country as different varieties. Computing the price variation according to HS8 product solely does not alter the results.

the presence of trade liberalization. Our finding of a positive relationship between firm productivity and export prices is consistent with the findings of the literature on product quality (e.g., Verhoogen, 2008; Kugler and Verhoogen, 2012; Hallak, 2010; Johnson, 2012; and Hallak and Sivadasan, 2011). What distinguishes our paper from the literature, however, is that we emphasize that the impacts of trade liberalization on optimal prices act through the optimal adjustment of import quality and import variety by the firm. We also provide evidence that exogenous-quality model can also generates reasonable predictions for products with more homogeneity of quality.

Lastly, this paper complements the empirical literature by affirming the effects of imported intermediate inputs on firms' attributes such as domestic product scope, export value, and export scope, for example, Goldberg et al. (2010) find that the use of imported inputs increases product scope for Indian firms.

The remainder of the paper is organized as follows. Section 2 presents a trade model with heterogeneous firms, featuring endogenous product quality and endogenous set of import variety to illustrate the impacts of import tariff on export prices via firms' import decisions on input quality and import variety.[10] Section 3 describes the data and introduces the strategy of the empirical analysis. Section 4 presents the empirical results and Section 5 provides some robustness checks. Section 6 concludes.

2. A Model of Export Price and Imported Intermediate Inputs

In this section we build a model of trade with heterogeneous firms where each firm uses both domestic and imported intermediate inputs for production to study how import tariff reduction impacts unit value export prices across firms. We extend Melitz's (2003) model of the monopolistic competition framework by introducing endogenous quality and endogenous number of imported varieties. Now, firms choose not only the optimal price but also the optimal quality of products as well as the optimal set of imported intermediate goods. Goods are differentiated, and each good is produced by a firm.

2.1. Preference and the Market Structure

The source country and the destination country are denoted by i and j, respectively, where $i, j \in \{1, ..., n\}$. Country j is populated by a continuum of consumers who have access to a potentially

[10] We prove the case of the exogenous-quality model and its propositions in the appendix.

different set of goods Ω_j. In each source country i, there is a continuum of firms that ex ante differ in their productivity level, ϕ. We assume that a representative consumer in country j has the constant-elasticity-of-substitution (CES) utility function when she consumes a variety ω in the product set Ω_j:

$$U_j = \left[\int_{\omega \in \Omega_j} (q_{ij}(\omega) x_{ij}(\omega))^{\frac{\sigma-1}{\sigma}} \, d\omega \right]^{\frac{\sigma}{\sigma-1}}$$

where ω indexes variety in the product set Ω_j, $q_{ij}(\omega)$ represents quality of variety ω from country i, $x_{ij}(\omega)$ is the quantity demanded of variety ω from country i, and $\sigma > 1$ is the elasticity of substitution between varieties.[11] Then, consumer optimization yields the following demand for variety ω:

$$x_{ij}(\omega) = (q_{ij}(\omega))^{\sigma-1} \frac{(p_{ij}(\omega))^{-\sigma}}{P_j^{1-\sigma}} Y_j \tag{1}$$

where $P_j = \left[\int_{\omega \in \Omega_j} (p_{ij}(\omega) / q_{ij}(\omega))^{1-\sigma} \, d\omega \right]^{\frac{1}{1-\sigma}}$ is an aggregate price index (adjusted by quality), $p_{ij}(\omega)$ is the (net quality) price of variety ω from country i in country j, and Y_j represents the total expenditure of country j. Given the same price, higher-quality products attract a larger demand. To simplify notation, the indices for varieties and the subscripts for sources and destinations are suppressed hereafter.

2.2. Production Technology

Firms use a Cobb-Douglas production function to produce output with productivity ϕ:

$$Y = \phi K^a L^b \prod_{m=1}^{M} X_m^{\gamma_m},$$

where K and L denote capital and labor employed in production, X_m denotes intermediate input m, and ϕ is the exogenous technology of the firm drawn from a common distribution. The Cobb-Douglas weight γ_m measures the importance of intermediate input m in production and we allow γ_m to be different for different input bundle m. The production technology is assumed to be constant returns to scale, so $a + b + \sum_{m=1}^{M} \gamma_m = 1$. Each firm chooses K and L given the rental price of capital r and the price of labor w. Each intermediate input X_m is potentially produced from a combination of a domestic variety, $X_{m,H}$, and a foreign variety, $X_{m,F}$, according to the CES

[11] $q_{ij}(\omega) x_{ij}(\omega)$ captures the quantity of each variety consumed, which is implicitly measured in units of utility.

aggregator:[12]

$$X_m = \begin{cases} \left(X_{m,H}^{\frac{\theta-1}{\theta}} + X_{m,F}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} & \text{, if intermediate input } m \text{ uses foreign inputs} \\ X_{m,H} & \text{, if intermediate input } m \text{ uses domestic inputs only} \end{cases}$$

where $X_{m,F}$ and $X_{m,H}$ are the quantity of foreign and domestic inputs, respectively, and $\theta > 1$ is the elasticity of substitution between the two input bundles. The prices (net quality) of the domestic and foreign varieties are denoted by $p_{m,H}$ and $p_{m,F}$, which are assumed to be given in the model. Then the prices of the domestic and foreign varieties are denoted by $p_{m,H}q_{m,H}^{\alpha}$ and $p_{m,F}q_{m,F}^{\alpha}$, where $q_{m,H} \in (0, +\infty)$ and $q_{m,F} \in (0, +\infty)$ are the quality of domestic and imported intermediate goods, respectively, and $\alpha \in (0, 1)$. Following the production function, the quality of the final good is assumed to be $q = \prod_{m=1}^{M} q_m^{\gamma_m}$, where q_m is the quality of the intermediate input m, which is assumed to be the potential combination of the quality of domestic input and the quality of foreign input according to CES aggregator:

$$q_m = \begin{cases} \left(q_{m,H}^{\frac{\theta-1}{\theta}} + q_{m,F}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} & \text{, if intermediate input } m \text{ uses foreign inputs} \\ q_{m,H} & \text{, if intermediate input } m \text{ uses domestic inputs only} \end{cases}$$

where $\theta > 1$ is the elasticity of substitution between the quality of foreign inputs and the quality of domestic inputs.[13]

We assume that importing each variety incurs a fixed cost f_m, which is constant across imported products within a firm. The presence of the fixed importing cost is consistent with the empirical evidence in Bernard, Jensen, and Schott (2009), Halpern, Koren, and Szeidl (2011), and Gopinath and Neiman (2011). There are two additional fixed costs: the fixed exporting cost f_x and the fixed production cost $f_d q^{\beta}$ ($\beta > 0$), which represents fixed investments in employing the higher-quality inputs, where f_d denotes the fixed production cost without quality adjustment and $1/\beta$ measures the effectiveness of fixed expenditures in raising quality. In addition, we assume that all these fixed costs are due every period.

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[12]Halpern, Koren and Szeidl (2011) and Goldberg, Khandelwal, Pavcnik and Topalova (2010) use a similar production structure.

[13]For simplification, we assume that the elasticity of substitution between the quality of foreign inputs and the quality of domestic inputs is equal to the elasticity of substitution between foreign and domestic input bundles. Assuming different elasticities of substitution for quality and for input bundles does not alter the following analysis and the model predictions.

2.3. Firm Behavior

To characterize firm behavior, we first compute the optimal quality of domestic and imported intermediate goods employed by firms and hence their optimal pricing rule given the set of imported goods. After we obtain the equilibrium prices and quality choices, we will further examine how a firm's productivity and import tariff affect the set of imported goods.

Let F denote the imported product set. Then, marginal cost, MC, satisfies

$$MC = \frac{r^a w^b \prod_{m \in F} \left(\left[\left(p_{m,H} q_{m,H}^{\alpha}\right)^{1-\theta} + \left(\tau p_{m,F} q_{m,F}^{\alpha}\right)^{1-\theta} \right]^{\frac{1}{1-\theta}} \right)^{\gamma_m} \prod_{m \notin F} \left(p_{m,H} q_{m,H}^{\alpha}\right)^{\gamma_m}}{\phi a^a b^b \prod_{m \in F} \gamma_m^{\gamma_m}}$$

where τ is the import tariff imposed by domestic country.

Given the imported product set F, a firm's profit optimization problem now becomes:

$$\max_{p; q_{m,H}; q_{m,F}} \quad (p - MC)\, q^{\sigma-1} \frac{p^{-\sigma}}{P^{1-\sigma}} Y - f_x - f_d q^{\beta} \tag{2}$$

Here, we ignore the variable trade cost.[14] Solving this optimization problem with respect to price p, quality of foreign input $q_{m,F}$, and quality of domestic input $q_{m,H}$ yields

$$p = \frac{\sigma}{\sigma - 1} MC \tag{3}$$

$$\left(\frac{\sigma - 1}{\sigma} q^{\sigma-1} \frac{p^{1-\sigma}}{P^{1-\sigma}} Y - \beta f_d q^{\beta} \right) \frac{\partial \ln q}{\partial \ln q_{m,F}} = \frac{\sigma - 1}{\sigma} q^{\sigma-1} \frac{p^{1-\sigma}}{P^{1-\sigma}} Y \frac{\partial \ln p}{\partial \ln q_{m,F}}, m \in F \tag{4}$$

$$\left(\frac{\sigma - 1}{\sigma} q^{\sigma-1} \frac{p^{1-\sigma}}{P^{1-\sigma}} Y - \beta f_d q^{\beta} \right) \frac{\partial \ln q}{\partial \ln q_{m,H}} = \frac{\sigma - 1}{\sigma} q^{\sigma-1} \frac{p^{1-\sigma}}{P^{1-\sigma}} Y \frac{\partial \ln p}{\partial \ln q_{m,H}}, m \in F \tag{5}$$

$$q^{\sigma-1} \frac{p^{1-\sigma}}{P^{1-\sigma}} Y = \Lambda q^{\beta}, m \notin F \tag{6}$$

where $\Lambda \equiv \frac{\sigma \beta f_d}{(\sigma-1)(1-\alpha)}$. Equations (5) and (4) yield that, if $m \in F$, the relative quality between the domestic variety and foreign variety satisfies:

$$\frac{\partial \ln q}{\partial \ln q_{m,H}} \Big/ \frac{\partial \ln q}{\partial \ln q_{m,F}} = \frac{\partial \ln p}{\partial \ln q_{m,H}} \Big/ \frac{\partial \ln p}{\partial \ln q_{m,F}} \Leftrightarrow \frac{q_{m,F}}{q_{m,H}} = \Delta_m$$

where $\Delta_m \equiv \left(\frac{p_{m,H}}{\tau p_{m,F}} \right)^{\theta/(\alpha\theta+1)}$ reflects the relative price of domestic vs. foreign goods. It is worth noting that Δ_m contains import tariff, τ, which reflects the degree of trade liberalization. Then, we

[14] Adding the variable trade cost does not change our proposition and derivation.

have:

$$\frac{\partial \ln q}{\partial \ln q_{m,H}} = \frac{1}{1+\Delta_m^{\frac{\theta-1}{\theta}}} = \frac{1}{\alpha}\frac{\partial \ln p}{\partial \ln q_{m,H}} \tag{7}$$

Substituting the previous equation (7) into equation (5), we obtain

$$q^{\sigma-1}\frac{p^{1-\sigma}}{P^{1-\sigma}}Y = \Lambda q^{\beta}, m \in \{1, ..., M\} \tag{8}$$

Meanwhile, marginal cost, MC, can be rewritten as:

$$MC = \frac{r^a w^b \prod_{m\in F}\left(1+\Delta_m^{\frac{\theta-1}{\theta}}\right)^{\frac{(\alpha\theta+1)\gamma_m}{1-\theta}} \prod_{m=1}^{M} p_{m,H}^{\gamma_m}}{\phi a^a b^b \prod_{m\in F}\gamma_m^{\gamma_m}} q^{\alpha}$$

The above equation, together with equations (3) and (8), imply that the optimal quality chosen by firms satisfies the following equation:

$$q^{\beta-(\sigma-1)(1-\alpha)} = \frac{1}{\Lambda}\left(\frac{\sigma r^a w^b \prod_{m\in F}\left(1+\Delta_m^{\frac{\theta-1}{\theta}}\right)^{\frac{(\alpha\theta+1)\gamma_m}{1-\theta}} \prod_{m=1}^{M} p_{m,H}^{\gamma_m}}{(\sigma-1)\,\phi a^a b^b \prod_{m\in F}\gamma_m^{\gamma_m}}\right)^{1-\sigma} \frac{Y}{P^{1-\sigma}} \tag{9}$$

Under the condition (i), given by $\beta > (1-\alpha)(\sigma-1)$, there is a positive correlation between firm productivity ϕ and quality q. This suggests that a more productive firm chooses higher quality. Equation (9) also suggests that tariff affects the choice of quality q via the relative price of domestic vs. foreign inputs Δ_m: a reduction in tariff τ increases Δ_m, and in turn raises quality q. We call the above mechanism the "***quality effect***" in which higher productivity or lower tariff induces firms to choose higher quality. Combining equations (9) and (3), the optimal price in this case is given by

$$p = \Lambda^{-\Psi}\left(\frac{\sigma r^a w^b \prod_{m\in F}\left(1+\Delta_m^{\frac{\theta-1}{\theta}}\right)^{\frac{(\alpha\theta+1)\gamma_m}{1-\theta}} \prod_{m=1}^{M} p_{m,H}^{\gamma_m}}{(\sigma-1)\,\phi a^a b^b \prod_{m\in F}\gamma_m^{\gamma_m}}\right)^{1+(1-\sigma)\Psi} \left(\frac{Y}{P^{1-\sigma}}\right)^{\Psi} \tag{10}$$

where $\Psi \equiv \frac{\alpha}{\beta-(\sigma-1)(1-\alpha)} > 0$. If the condition (ii), given by $\beta < \sigma - 1$, also holds, then a firm's optimal price is positively correlated with firm productivity as conditions (i) and (ii) together imply that $1 + (1-\sigma)\Psi < 0$. When conditions (i) and (ii) hold, higher-productivity firms set higher optimal prices because they use higher-quality inputs, and this proposition is consistent with the recent quality-and-trade literature.[15]

Next, we analyze different factors which can affect export prices and, in particular, how import tariff reduction affects export prices through import decisions and derive five testable propositions under conditions (i) and (ii).

2.3.1. The Prices of Exports

An increase in productivity or a reduction in import tariff induces firms to choose higher quality due to the quality effect and hence set higher export prices, according to equations (9) and (10). Hence, we have the following proposition:

Proposition 1 *Export prices increase when firms have higher productivity or face lower import tariff.*

It should be noted that if we do not assume endogenous quality chosen by a firm, then higher-productivity firms or firms facing lower import tariff will set lower prices because an increase in productivity or a reduction in import tariff decreases firms' marginal costs when quality adjustment does not exist. The intuition behind this exogenous quality case is straightforward: a more productive firm or a firm facing a lower import tariff enjoys lower marginal costs, and hence sets lower price to attract more consumers. We analyze the exogenous-quality case in the appendix.

2.3.2. The Values, Prices, and Varieties of Imports

We now characterize the firm's importing behavior. The revenue of a firm with productivity ϕ is given by:

$$R = \Lambda^{1-\frac{\beta}{\alpha}\Psi} \left(\frac{\sigma r^a w^b \prod_{m \in F} \left(1 + \Delta_m^{\frac{\theta-1}{\theta}}\right)^{\frac{(\alpha\theta+1)\gamma_m}{1-\theta}} \prod_{m=1}^{M} p_{m,H}^{\gamma_m}}{(\sigma-1)\,\phi a^a b^b \prod_{m \in F} \gamma_m^{\gamma_m}} \right)^{-\frac{\beta(\sigma-1)}{\alpha}\Psi} \left(\frac{Y}{P^{1-\sigma}}\right)^{\frac{\beta}{\alpha}\Psi} \tag{11}$$

Then, the optimal expenditure on the input variety $m \in F$, E_m, can be derived as:

$$E_m = \frac{\Delta_m^{\frac{\theta-1}{\theta}}}{1+\Delta_m^{\frac{\theta-1}{\theta}}} \gamma_m \frac{\sigma-1}{\sigma} R \tag{12}$$

[15]See Verhoogen (2008), Kugler and Verhoogen (forthcoming), Hallak (2010), Hallak and Sivadasan (2011), Gervais (2009), Johnson (2012), Manova and Zhang (forthcoming), Fan, Lai, and Li (2012), among others.

Expression (12) illustrates that the optimal expenditure on the imported variety m increases in γ_m and Δ_m. Therefore, a firm importing intermediate inputs will choose to import those goods with the highest γ or Δ. Intuitively speaking, a firm will first choose to import products with the highest expenditure share or the lowest relative imported-input price. Equations (11) and (12) imply that E_m increases in productivity ϕ, which suggests that the firm with higher productivity will spend more on each imported variety. As a reduction in import tariff τ leads to an increase in Δ_m, it further implies that an import tariff reduction is associated with higher value of imports on each variety according to equation (12).

As the set of imported varieties is denoted by F, we use F^* to denote the optimal set of imported varieties. The optimal import decision of the firm is then to maximize profits net of the cost of importing varieties:

$$F^* = \arg\max_{F} \left\{ \Pi\left(F, \phi, \tau\right) - f_m \left|F\right| \right\}$$

where $\Pi\left(F, \phi, \tau\right)$ are profits gross of importing fixed costs, and $\left|F\right|$ denote the number of imported varieties. It can be shown that F^* is non-decreasing in ϕ and non-increasing in τ: firms with higher productivity import a greater number of varieties, and a reduction in import tariff can induce firms to import more varieties as well.[16] We call this mechanism the "***variety effect***". This is consistent with the previous discussion that higher-productivity firms or firms facing a lower import tariff spend more on imported inputs, so they are more likely to cover the fixed importing cost and therefore to expand the set of imported goods. Put in other words, as the expenditure on each imported variety increases, more varieties will be imported by the firm. Meanwhile, based on equation (9), as discussed earlier we know that there is a positive relationship between firm productivity and the choice of quality q, where q is positively related to imported input quality $q_{m,F}$. Hence, higher-productivity firms choose the higher-quality intermediate inputs, reflected by higher (quality-adjusted) prices of imported intermediate inputs. Then, again, based on equation (9), we know that a reduction in import tariff τ induces the firm to choose the higher-quality inputs. Therefore, we have the following proposition regarding the effects of productivity and trade liberalization on a firm's import decisions:[17]

Proposition 2 *The firms with higher productivity or the firms facing lower import tariff (i) spend more on*

[16]This is because firms will compare the changes in profits with the fixed importing cost if they decide to import additional variety. If the increase in profits is greater than extra fixed importing cost, that variety will be added into the optimal import set F^*. Based on equation (11), it can be shown that the profit gap between $\Pi\left(F, \phi, t\right)$ and $\Pi\left(\widetilde{F}, \phi, t\right)$ is non-decreasing in productivity ϕ, but non-increasing in tariff t, where $\left|\widetilde{F}\right| = \left|F\right| + 1$.

[17]Halpern, Koren, and Szeidl (2011) derive a property of their model that firms with lower fixed costs import a greater number of varieties.

each imported variety, (ii) tend to import more varieties, and (iii) tend to choose those imported inputs with higher quality.

2.3.3. The Impacts of Import Decision on Export Prices

The earlier discussions of Propositions 1-2 imply that firms which import a greater number of varieties (i.e., the set of F expands) set higher export prices, according to equation (10).[18] Thus, the two parallel mechanisms-the quality effect and the variety effect-yields the pattern of the "***quality ladder***":

Proposition 3 *Firms importing more varieties set higher export prices.*

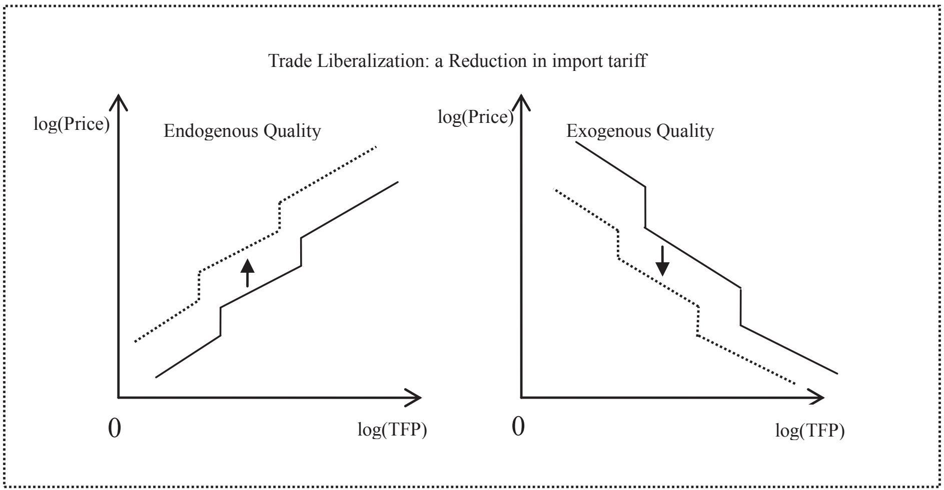
However, if we shut down the choice of quality and consider a model with exogenous quality across firms, we derive the opposite result: firms importing more varieties set lower export prices (see appendix for derivation of the exogenous-quality model).

We summarize the impacts of a firm's import decision on its export price as well as the relationship between export price and firm productivity in Figure 1. The graph in the left panel of Figure 1 illustrates the relationship between prices, productivity, and import tariff reduction when we assume endogenous quality across firms: the solid line corresponds to the scenario with higher import tariff, and the dashed line captures the scenario with import tariff reduction. Under the endogenous-quality assumption, export prices are positively related to firm productivity and import tariff reduction shifts up the solid line based on Proposition 1 due to the existence of the quality effect. The stepped shape of the two lines corresponds to the increase in the number of imported varieties associated with the increase in productivity and tariff reduction according to Propositions 2-3 due to the existence of the variety effect.[19] This shows that export price presents the "***quality ladder***" pattern: more productive firms tend to import more intermediate inputs, to use higher-quality inputs, and therefore to charge higher prices of their exports; given productivity, tariff reduction leads to the scenario that firms to tend to import more varieties, to use higher-quality inputs, and to charge higher export prices. The quality ladder pattern results from the combination of the quality effect and the variety effect. The right panel of Figure 1 illustrates

[18]It is easy to see that $\left(1+\Delta_m^{\frac{\theta-1}{\theta}}\right)^{\frac{(\alpha\theta+1)\gamma_m}{1-\theta}} < 1$. Then under conditions (i) and (ii), export prices increase in the number of varieties in F.

[19]It should be noted that based on equation (10), the increase in the number of imported varieties in the set F only affects the intercept, but does not affect the slope of the lines in Figure 1 when we take log of the relationship between export prices and productivity.

Figure 1: The Quality Ladder - Export Prices, Productivity, and # of Imported Varieties



the case of exogenous quality model: more productive firms set lower export prices due to lower marginal costs and they also import a greater number of imported intermediate inputs; import tariff reduction further lowers export prices (see appendix for derivation).

3. Empirical Specification, Data and Measurement

3.1. Empirical Specification

The above propositions imply that export prices are a function of firm productivity and will be affected by trade liberalization. Meanwhile, a firm's decision on how many varieties to import also affects its export price. Therefore, we use a model-based empirical equation to test the proposed propositions:

$$\log price_{fpct} = c + c_1 \log(TFP_{ft}) + c_2\tau_{ft} + c_3X_{ft} + c_4N_{ft} + \varphi_{pc} + \varphi_t + \epsilon_{fpct} \quad (13)$$

where $price_{fpct}$ represents the unit value export price of product p (disaggregated at the HS 8-digit level) exported by firm f to destination country c in year t; TFP_{ft} denotes a firm f's productivity in year t; τ_{ft} is import tariff faced by firm f at year t;[20] X_{ft} is a vector of time-varying firm attributes of firm f in year t; N_{ft} is the number of imported varieties by firm f in year t; φ_{pc} is

[20]As firms import different intermediate inputs, the effective import tariff is various across firms depending on their imported product sets.

product-destination fixed effects;[21] φ_t is the year fixed effects; ϵ_{fpct} is the error term that includes all unobserved factors that may affect export prices. The vector of time-varying firm attributes X_{ft} includes capital intensity and wage to control for production technique beyond the measured TFP: capital intensity is measured by capital-labor ratio, K/L; wage is measured by average payment for each worker.[22]

3.2. Firm-Product-level Trade Data and Firm-level Production Data

To test our propositions, we need to use both firm-level information to measure firm attributes such as TFP, and product-level trade data on export prices and characteristics of imports. Therefore we use a merged dataset based on the two databases: (1) the firm-product-level trade data of each transaction from Chinese customs, and (2) the firm-level production data, collected and maintained by the National Bureau of Statistics of China (NBSC). Our sample period is between 2001 and 2006.[23]

The main database we use is the Chinese trade data at the transaction level, provided by China's General Administration of Customs. The transaction-level trade data provide information of exporting or importing firm and the product information at the HS 8-digit level, covering the universe of all Chinese exports and imports in 2001-2006. It records detailed information of each trade transactions, including import and export values, quantities, products, source or destination countries, contact information of the firm (e.g., company name, telephone, zip code, contact person), type of enterprises (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 processing trade regime are not subject to tariffs, we focus on firms under ordinary trade regime.[24] Then we aggregate transaction-level data to firm-product-level trade data. For each HS 8-digit product, we use import and export values and quantities to compute unit value price of imported inputs and exports by each firm.[25]

[21]We test two different specifications. One is the baseline equation (13), treating the same product shipped to different destination country as different varieties of the product and thus using the product-country fixed effects. Another is treating the same product at HS 8-digit level as one product and only including product fixed effects. Two specifications generate similar results.

[22]We expect that the effects of capital intensity and wage on export prices are consistent with the effect of TFP on export prices.

[23]We do not include the data in the year of 2000 because the tariff data at HS 8-digit level from the WTO are not available for 2000.

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

[25]For exported goods, we use two measures to compute their unit value export prices: (1) the export prices of the HS 8-digit goods by each firm, and (2) the export prices of the HS 8-digit goods shipped to different destination country by

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-state-owned enterprises with annual sales of at least 5 million RMB (Chinese currency). The NBSC database contains detailed firm-level information of manufacturing enterprises in China, such as employment, capital stock, 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).[26] Due to mis-reporting by some firms, we use the following rules to delete the unsatisfactory observations and construct our sample, according to Cai and Liu (2009) and the General Accepted Accounting Principles: (i) the total assets must be higher than the liquid assets; (ii) the total assets must be larger than the total fixed assets; (iii) the total assets must be larger 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 from the Chinese Customs Database to the NBSC Database, according to the contact information of manufacturing firms, because there is no consistent coding system of firm identity between these two databases.[27] 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, 2012). Compared with the exporting and importing firms reported by the Customs Database,[28] the matching rate of our sample (in terms of the number of firms) covers 45.3% of exporters and 40.2% of importers, corresponding to 52.4% of total export value and 42% of total import value reported by the Customs Database.[29]

3.3. Tariff

Chinese import tariff data are obtained from the World Trade Organization (WTO), and available as MFN (most-favored nation) applied tariff at the most disaggregated level, the HS 8-digit level,

each firm, i.e., we view the same HS 8-digit goods exported to different destination countries as "different" varieties. In the main tests, we report our results based on the second measure, but we also report the results based on the first measure as robustness check. The results remain the same.

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

[27]In the NBSC Database, firms are identified by their corporate representative codes and contact information. While 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.

[28]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.

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

for the period 2001-2006.[30] As the main interest of this paper is to explore the effect of trade liberalization on export prices through firms' import decisions on quality and variety, it is important to properly measure effective tariff levels faced by firms when they import different bundles of intermediate inputs. Hence, we need to compute a firm specific import tariff to measure trade liberalization faced by firms.

The firm specific tariff measure has distinct advantages over the conventional industry-level tariff measure. While the prior studies usually use the industry-level input tariff reduction as the measure of trade liberalization (Amiti and Konings, 2007; Goldberg et al., 2010; Topalova and Khandelwal, 2011, among others), the industry-level measure may not reflect actual tariff reduction faced by the importers (Ge et al., 2011). Consider two firms that produce the same HS 8-digit product, but they may import different intermediate inputs, according to their own import decisions on different input varieties. A firm needs to upgrade its products may need to import some generic inputs such as computers and machinery. Using an industry-level measure of tariff would assign the same tariff to these two firms, but apparently the effective import tariff faced by these two firms would be different if they have different bundles of imported inputs. Thus, the average industry-level tariff ignores the variations of tariff within the industry, and possibly underestimates the tariff change (Ge et al., 2011), while the firm specific tariff measure can better reflect the heterogeneity of tariff within the industry. Besides being a direct measure of tariff faced by the firm, an additional advantage of this firm-level tariff measure is that its construction avoids the potential bias created by the multiple links procedure in the industry-level tariff construction (Ge et al., 2011). Next, we use four different ways to compute tariff of imported inputs faced by firms as firm specific measure of trade liberalization.

First, we construct a firm specific import tariff, computed as import value weighted average ad valorem duty across imported products within each firm. In the merged firm-product-level trade data, we have information on what inputs (8-digit HS) are imported by each importer. Therefore, the firm-level input tariff is measured by $\tau_{ft} = \sum_{p \in F_t} w_{pt} \tau_{pt}$, where τ_{pt} is the import tariff rate for the imported product p in year t, F_t is the set of imported varieties in year t, and w_{pt} is the weight, defined as the share of import value of product p in total import value by firm f in year t. This firm specific input tariff can reflect the changes in effective tariff rate faced by firm due to its responses to trade liberalization when the firm alters its input bundles over time.[31]

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

[31] Our firm specific input tariff measure is different with the one in Ge et al. (2011). In their paper, they fix the total number of imported varieties over the whole sample period and focus on the pure changes in tariff reduction rather than the changes in input bundles. In our paper, we focus on the changes in measured tariff rate due to the changes

Second, we follow Manova and Zhang (2011) to focus on foreign inputs in the same broad industry classification as the output product. For example, if a firm buys brakes and safety seat belts and sells cars, both its exports and imports would be recorded in the motor vehicles industry. The average ad valorem duty of its imported inputs such as brakes and safety seat belts would proxy the import tariff faced by the firm that produces cars. If the company also manufactures cell phones, tariff reduction in SIM cards would enter the measure of import tariff of its cell phones but not that of its cars. Therefore, for each exported product by a particular firm, we construct the weighted average tariff across all the inputs imported by the firm (e.g. brakes, safety seat belts) in a given HS2 category (e.g. motor vehicle). We then assign this average tariff to all products exported by this firm in the same HS2 category (e.g. cars and potentially trucks). Therefore, using this method we eventually compute firm-product specific tariff τ_{fpt} for each product p exported by firm f in year t.[32]

Third, to take into account the input-output relation between imported intermediate inputs and exported goods, we construct a firm specific tariff measure using the benchmark 122-industry Input-Output (I-O) Table of China (2002) released by the NBSC. According to a concordance made by the NBSC, we match each HS8 product to a certain input-output industry. For any given product exported by a firm, we construct the firm-product specific tariff τ_{fpt}, but now the weight of each imported input is the input industry's share of the output industry's total input value from the industries of those imported inputs, computed based on the input-output tables.[33]

Lastly, we acknowledge that there may exist the endogeneity issue of firm specific import tariff since a firm will endogenously change its import decision when facing trade liberalization. To overcome this issue, we also adopt another measure of firm specific tariff which fixes the set of imported inputs, $\tau_{ft} = \sum_{p \in F} \frac{\tau_{pt}}{|F|}$, where F is the total set of imported varieties during the sample period, and $|F|$ denotes the total number of imported inputs by importing firm f over the whole sample period (see Ge et al., 2011). By fixing the total number of imported varieties over the sample period, this measure focuses on the pure changes in tariff reduction rather than the changes

in input bundles, which capture the firm's response to trade liberalization. Hence, we do not fix the total number of imported varieties over time in our main estimation results. However, we also report the results based on the measure by Ge et al. (2011) in the robustness checks and all results remain to be true using different measures of firm specific tariff.

[32]We also compute this tariff measure at HS4 level by assigning the average tariff across all the imported inputs in a given HS4 category to all products exported by the same firm within the same HS4 category and it yields the similar results.

[33]As in the I-O table each output industry uses inputs from almost all input industries including service and non-tradable industries, we only use the input industries actually containing the imported intermediate inputs of the firm to compute the firm-product specific tariff.

in input bundles.

We report the results based on the first measure, import value weighted average tariff, in the main results in Section 4., and the results based on the other three measure in the robustness checks in Section 5..[34] Changing the methods of computing firm specific tariff does not alter the results.

3.4. TFP

To capture firms' productivity, we compute total factor productivity (TFP) using various methods, including the augmented Olley-Pakes (1996) method and the De Loecker (2011) approach. The augmented O-P method is employed to deal with the simultaneity bias and selection bias in measured TFP, while the recent advance by De Loecker (2011) is used to separate out the associated price and productivity effects, given unobservable physical output. We report the results based on the O-P method in main estimation results and the results based on the De Loecker method and other approaches in robustness checks.

Our O-P estimation approach is based on the recent development in the application of the O-P method, for example, Amiti and Konings (2007), Feenstra et al. (2011), and Yu (2011), among others. The production function we use is a Cobb-Douglas production function:

$$Y_{ft} = \phi_{ft} L_{ft}^{a} K_{ft}^{b} \prod_{m_t=1}^{M_t} X_{m_t}^{\gamma_{m_t}}$$

where production output of firm f at year t, Y_{ft}, is a function of labor, L_{ft}, and capital, K_{ft}; ϕ_{ft} captures firm f's TFP in year t.

We use deflated firm's value-added to measure production output. We do not include intermediate inputs (materials) as one of input factors in our main results because the prices of imported intermediate inputs are different from those of domestic intermediate inputs.

To measure real terms of firm's inputs (labor and capital) and value added, we use different input price deflators and output price deflators from Brandt, Van Biesebroeck, and Zhang (2012).[35] 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). 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

[34]We also compute the unweighted average tariff measure using the first three methods, and they all yield the similar empirical results to support Propositions 1-3.

[35]The data can be accessed via http://www.econ.kuleuven.be/public/N07057/CHINA/appendix/.

capture the depreciation rate, we use each firm's real depreciation rate provided by the Chinese firm-level data.

To take into account firm's trade status in the TFP realization, following Amiti and Konings (2007) we include 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). Furthermore, to capture the pre- and post-period of China's accession to WTO, we include a WTO dummy (i.e., one for a year since 2002 and zero for before) in the Olley-Pakes estimation as the accession to WTO represents a positive demand shock for China's exports.

One caveat in computing TFP using the O-P method is worth noting. To estimate TFP, the usual practice to derive the real output is deflating revenues by the industry price index as the information of the quantity of firm-level output is not available. This usual practice may affect the level of the estimated TFP through making it include the information regarding the differences on prices across firms. To avoid this omitted price variable problem, we also compute firm's TFP by following De Loecker (2011) to correct for unobserved firm-level prices and demand shocks as robustness check (see Section 5.3.).

4. Results

In this section, we present the estimation results for firms conducting ordinary trade. We do not include the firms falling into "processing trade" regime since the government usually offers import tariff exemption on the processing of intermediate goods in order to encourage processing trade. Hence, trade liberalization via import tariff reduction induces importer competition for those processing firms, and this competition effect is out of the scope of the current mechanism in our model. In our model, the key mechanism of the effects of trade liberalization on export price is via quality choice of imported inputs. The quality mechanism is more profound for firms conducting ordinary trade: import tariff reduction, net the competition effect, implies that the imported inputs become cheaper, and hence encourages ordinary traders to choose more higher-quality imported varieties as inputs. Therefore, our sample excludes firms conducting processing trade and we focus on ordinary trading firms.

Next, we report our results on imports and then on the effects of import decisions on export price. All the estimation results are cluster-robust standard error estimators, clustering at firm level to take into account any potential correlation in error terms within each firm.

4.1. Import Values, Prices, and Varieties

We first test Proposition 2 on the relationship between productivity, tariff reduction, and import values, prices, and varieties using the following estimation equations:

$$\log IM\_price_{fpct} = c + c_1 \log(TFP_{ft}) + c_2\tau_{pt} + c_3 X_{ft} + \varphi_{pc} + \varphi_t + \epsilon_{fpct} \tag{14}$$

$$\log IM\_value_{fpct} = c + c_1 \log(TFP_{ft}) + c_2\tau_{pt} + c_3 X_{ft} + \varphi_{pc} + \varphi_t + \epsilon_{fpct} \tag{15}$$

$$\log IM\_variety_{fpt} = c + c_1 \log(TFP_{ft}) + +c_2\tau_{pt} + c_3 X_{ft} + \varphi_p + \varphi_t + \epsilon_{fpt} \tag{16}$$

where, in equation (14) and (15), the subscript p denotes the imported product p at the HS 8-digit level, τ_{pt} is the import tariff for imported product p in year t, and the subscript c denote the import source country. In equation (16), we slightly change the meaning of subscript p to let it denote the imported product at the HS 6-digit level, so we can count the number of varieties within each HS 6-digit category. So τ_{pt} in equation (16) is the weighted average import tariff of each variety for the same HS-6 product.

According to Proposition 2, higher productivity or tariff reduction can induce firms to import more expensive inputs and a greater number of varieties, yielding higher import value. So we expect to see positive coefficients on TFP and negative coefficients on import tariff. The results in Table 1 support those propositions, and all estimates are significant at 1 percent significance level.

Column 1 reports the estimation result of equation (14), suggesting that higher productivity or lower import tariff raises import prices of HS8 products from different countries for each firm.[36] Column 2 reports the estimation result of equation (15), confirming that higher productivity or lower tariff also increases import values of HS8 products from different countries for each firm. Column 3 reports the result of the alternative specification of testing import value at firm level, where we regress firm-level total import value, $\log IM\_value_{ft}$, on firm specific import tariff, τ_{ft}, and the result is consistent with the product-level result as in column 2.

The remaining columns of Table 1 report estimates of equation (16), and confirm that higher-productivity firms or import tariff reductions can induce firms to import more varieties. The difference between column 4 and 5 is the way we count the number of imported varieties: in column 4, we count the number of imported varieties by HS-8 category and source country together, i.e., we view the same HS-8 good from different source country as different variety, while in column 5, we count the number of varieties only by HS-8 category. Column 6 is the firm-level estimation ver-

[36]Here we consider the same HS8 product from different source country as different varieties.

sion of equation (16), where we regress the number of imported variety by firm, $\log IM\_variety_{ft}$, on firm specific import tariff, τ_{ft}. Our results regarding import values, and varieties using Chinese data are consistent with the findings in Goldberg et al. (2010) based on Indian data.[37]

4.2. Effects of Trade Liberalization and Import Decision on Export Prices

In this section, we test Propositions 1 and 3 to examine the effects of import tariff reduction and import decisions on export prices. Our results support all these propositions, indicating that import tariff reduction indeed induces firms to import more expensive varieties, to import a greater number of varieties, and in turn to raise export prices.

4.2.1. Baseline Regression

Table 2 reports the baseline regression results according to equation (13). Column 1 presents the result of regressing export prices on import tariff; column 2 adds TFP into the key regressors; columns 3 and 4 add more control variables regarding firm attributes, capital intensity and average wage; columns 5-8 further add the number of import varieties into regressions using different methods to compute the number of import varieties. Column 5 uses the (relative) number of import variety defined as the ratio of the import variety mass to the export variety mass, where both import and export varieties are counted by HS-8 code; column 6 is analogous to column 5 except for computing import and export variety mass by HS-8 code and source/destination country.[38] Column 7 directly counts the number of imported varieties by HS-8 code; column 8 counts the number of imported varieties by HS-8 category and source country.

In all specifications, the coefficients on TFP is significantly positive, indicating that higher-productivity firms charge higher export prices, which is consistent with the recent quality-and-trade literature. The coefficients on import tariff are all negative, and significant in columns 1-4. Once we add on the number of import varieties in columns 5-8, the coefficients on import tariff are still negative but no longer significant, implying that the effects of tariff reduction on export prices indeed go through the import decision on the number of import varieties. The firm sets higher export prices once it decides to import more varieties due to import tariff reduction. The coefficients on wage and capital intensity are also positive, because they partially capture the effect

[37] Our result on import price is different with Goldberg et al. (2010) because we use fob price, while import prices in their paper include import tariff.

[38] We compute the ratio of the import variety mass to the export variety mass as the (relative) number of import varieties because it is difficult to know what inputs are used to produce what outputs.

of real productivity which may not be fully represented by the measured TFP.[39]

There are two important and interesting patterns in Table 2 worth noting. First, there is a clear pattern of "*quality ladder*". As we show in Figure 1, with the increase in firm productivity, firms choose to import more intermediate inputs, and in turn further to increase their export prices. So we expect to see that given the positive relationship between productivity and export prices, firms importing more varieties also charge higher export prices. We test this ladder shape by including three dummy variables of the status of import variety, D_{25th_50th}, D_{50th_75th}, and D_{75th_100th}, into the regression. To define the dummy variable, we rank all firms according to the number of import varieties and divide them into four intervals: below 25th percentile, 25th-50th percentile, 50th-75th percentile, and above 75th percentile. D_{25th_50th} is equal to 1 if the firm falls into the 25th-50th percentile, and zero otherwise. The other two dummy variables are defined analogously. If the *quality ladder* is true, we expect to observe the *variety effect* and therefore the coefficients on all the three dummy variables are expected to be positive, and the magnitude of those coefficients are expected to increase when the firm moves from the bottom percentile to top percentile regarding the number of import varieties. Columns 5-8 clearly shows this increasing pattern that firms importing more varieties also charge higher export prices, and all coefficients on the import variety dummy variables are significant at 1 percent significance level.

Second, beside the vertical pattern regarding the coefficients on the dummy variables of different import variety ranges, there is a horizontal pattern due to the quality effect. In our model, an increase in productivity or a reduction in tariff raises export prices because higher-productivity firms or firms facing lower tariff increase the input quality. Therefore, when we control for more factors that contribute to product quality, the magnitude of the effects of those factors on export prices is excepted to become smaller due to the quality effect. When we compare the results from column 1 to column 5 (and treat columns 6-8 as variants of column 5), it is easy to find that the magnitude of the effects of regressors on export price is apparently decreasing. In particular, the effects of import tariff and TFP on export prices are consistently decreasing once we add more firm attributes and the import decision variables of the number of import varieties as regressors. Moreover, this horizontally decreasing effects hold for capital intensity and wage as these two factors capture the production technique beyond the measured TFP, because capital intensity, wage, and measured TFP all represent all represent the technology advancement of the firm that contribute to product quality of the firm. The horizontal pattern of coefficients on the independent variables

[39]In columns 5-8, the coefficients on capital intensity are insignificant.

in Table 2 confirms the existence of the quality effect.

To sum up, these two patterns, the horizontal pattern and the vertical pattern, validate the mechanisms of our model that the effects of trade liberalization on export prices go through the firm's import decisions on *quality* (columns 1-4) and *variety* (columns 5-8). Table 3 replicates the baseline regressions with imports of only intermediate goods. All patterns in Table 2 hold in Table 3, and the only difference is that all the effects of duty and of import variety on export prices are more profound with imports of only intermediate goods.

4.2.2. Quality and Quality-Adjusted Prices

It is not easy to directly measure quality, but we can infer quality from observed prices and demand. We estimate export "quality" of product p shipped to destination country c by firm f in year t, q_{fpct}, via the following empirical demand equation based on equation (1) of the demand in our model:

$$x_{fpct} = q_{fpct}^{\sigma-1} p_{fpct}^{-\sigma} P_{ct}^{\sigma-1} Y_{ct} \tag{17}$$

where x_{fpct} denotes the demand for a particular firm's export of product p in destination country c. Following Khandelwal, Schott, and Wei (2011), we take logs of the above equation, and then use the residual from the following OLS regression to infer quality:

$$\log x_{fpct} + \sigma \log p_{fpct} = \varphi_p + \varphi_{ct} + \epsilon_{fpct} \tag{18}$$

where $\hat{q}_{fpct} \equiv \hat{\epsilon}_{fpct} / (\sigma - 1)$; the country-year fixed effect φ_{ct} collects both the destination price index P_{ct} and income Y_{ct}; the product fixed effect φ_p captures the difference in prices and quantities across product categories due to the inherent characteristics of products. The intuition behind this approach is that conditional on price, a variety with a higher quantity is assigned higher quality.[40] Given the certain value of the elasticity of substitution σ, we are able to estimate quality from equation (18). In our estimation, we use $\sigma = 5$ and $\sigma = 10$.[41] Then the quality-adjusted price is the observed log price less estimated quality, which is also in logs.

According to our model with endogenous quality, trade liberalization leads to an increase in unit value export prices, which can represent the quality upgrading of exports. Therefore, we expect that the estimated quality presents the same pattern as the export prices do: quality rises

[40] See Khandelwal, Schott, and Wei (2011) for detailed review of this approach.
[41] Khandelwal, Schott, and Wei (2011) use $\sigma = 4$.

when tariff reduces, productivity increases, and the set of imported inputs expands. We replicate the baseline regressions (column 1-5 in Table 2) by replacing export prices with the estimated quality as dependent variable, and present the results in columns 1-5 in Table 4. The top panel uses $\sigma = 5$ and the bottom panel uses $\sigma = 10$. The results are consistent with the predictions of our model, and, in particular, the "quality ladder" remains its upgrading pattern at the one percent significance level (see column 5).

Columns 6-10 in Table 4 present the estimation results with quality-adjusted prices as dependent variable. It is expected that quality-adjusted prices follow the predictions of the exogenous-quality model, in which the (quality-adjusted) export prices are positively correlated with import tariff but negatively correlated with firm productivity. Meanwhile, there is a ladder pattern of the quality downgrading: (quality-adjusted) export prices decline when the number of imported varieties increases. The results in columns 6-10 in Table 4 confirm the above expectation: the coefficients on tariff become significantly positive; the coefficients on TFP become negative yet insignificant; all coefficients on the dummy variables of the range of import variety, D_{25th_50th}, D_{50th_75th}, and D_{75th_100th}, become negative.

4.2.3. Heterogeneity of Product Quality

In our model, we show that endogenous quality is the key mechanism through which trade liberalization impacts export prices as firms choose to import higher-quality, thus more expensive inputs when they face lower import tariff. It is natural to think that more differentiated products usually present greater heterogeneity of quality. Therefore, we use a subsample of differentiated export products, defined based on Rauch's (1999) classification, to redo the baseline estimations as in columns 1-5 of Table 2. We present the corresponding results for differentiated goods in columns 1-5 in Table 5. As expected, the effects of productivity and tariff reduction on export prices are stronger for more differentiated goods. More importantly, the effects of the *"quality ladder"* due to the increase in the number of import variety are also stronger for more differentiated products. This suggests that the endogenous quality mechanism in our model is correct because of the empirical evidence that the effects of trade liberalization, import decision, and productivity on export prices are indeed stronger for products with more heterogeneity of quality.

We also test Proposition 4 in the exogenous quality case (see Appendix) using the subsample with homogeneous goods, again defined based on Rauch's (1999) classification, in the same specifications as in columns 1-5. We report the results based homogeneous goods in columns 6-10.

According to Proposition 4 as illustrated in the right panel of Figure 1, if no variation of quality choice across firms, we expect to see the positive sign of coefficients on import tariff and negative sign of coefficients on TFP. We find that the effects of TFP on export prices indeed become significantly negative for homogeneous goods, while the effects of import tariff become insignificant. While we cannot obtain significantly positive coefficients on tariff to exactly prove Proposition 4 in this case, the results in columns 6-10 are highly suggestive.

Besides the Rauch's (1999) classification, we adopt an alternative method to measure the heterogeneity of product quality by computing the variance of export prices across HS-8 product-destination varieties by firm within each HS-6 category. Greater price variation implies more heterogeneity of product quality. Hence, we rank export (HS8-destination) products according to the price variation at the HS-6 category they belong and generate four groups of observations with: (i) very low price variation (below the 25th percentile of price variance), (ii) low price variation (below the 50th percentile), (iii) medium price variation (below the 75th percentile), and (iv) the whole sample. We report the estimation results of groups (i)-(iv) in columns 1-4 in Table 6. It is worth noting that from group (i) to group (iv), the effects of import tariff on export prices start with positive signs and gradually become negative. It implies that for goods with more homogeneity of quality (i.e., lower price variation such as goods in group (i)), tariff reduction would decrease export prices, as we derive in the Proposition 4 in the exogenous quality case (see Appendix) and illustrate in the right panel of Figure 1. Once the goods present more heterogeneity of quality, the effect of tariff reduction on export prices would become negative, as we seen in the whole sample in group (iv). The coefficients on TFP for goods with homogeneity of quality (groups (i) and (ii)) are not significant, but the magnitude of them becomes more profound and significantly positive when we move to the cases with more heterogeneity of quality (groups (iii) and (iv)). Therefore, Table 6 confirms both the exogenous quality and endogenous quality cases, but the former is rejected in favor of the latter in the whole sample, indicating the prevalence of heterogeneity of product quality across firms in the reality. This further validates the mechanism of quality in our model.

4.2.4. Firms' Dependence on Imported Inputs

As the effect of trade liberalization on export price goes through the import decision by firm, we expect that firms relying little on imported intermediates for their total intermediate input usages should be less affected by the tariff reduction, while firms relying heavily on imported inputs should be more affected by tariff reduction. To confirm this pattern, we present regression results in Table 7 by ranking firms based on two import shares: one is the ratio of the import value to total value of material inputs of each firm (see columns 1-4); another is the ratio of the number of import variety to the number of export variety of each firm (see columns 5-8). We divide the total sample into four subsamples according to firms' import shares and present a 25-percentile bin by ascending order in each column. For example, column (1) denotes firms importing very little inputs (with import share below the bottom 25th percentile), while column (4) represents firms heavily importing inputs (with import share above the top 25th percentile). The coefficients on import tariff confirm the previous conjecture. Indeed, firms relying heavily on imported inputs are more affected by trade liberalization. Firms relying little on imported inputs are less impacted by tariff reduction, and the effect of trade liberalization on those firms are often insignificant.

4.3. Difference-in-difference Estimator

Although our estimation equation (13) is a model-based equation, strictly speaking, the empirical implication of the previous results is correlation rather than causality regarding the effects of trade liberalization on export prices. To further address this issue, we use difference-in-difference (DID) estimation by regressing $(t+3)-t$ change in log export prices, $\triangle \log price_{(t+3)-t}$, on $(t+3)-t$ changes in regressors including import tariff, TFP, and other firm attributes. We report DID estimation results in Table 8. Columns 1-4 report the DID estimates using HS8 product shipped to different countries as different varieties, and columns 5-8 report the DID estimates based on HS8 product category only. Table 8 presents two panels of results: Panel A without firm fixed effects and Panel B with firm fixed effects. By adding firm fixed effects, we difference out the effect on export prices due to inherent characteristics of firms. It should be worth noting that firm fixed-effect term captures the choice of quality by firm at a certain point of time to some extent, and therefore, it often dominates the quality effect, and makes the impact of trade liberalization less significant. However, the change in quality cannot be captured by firm fixed effects, and hence, the effect on export prices due to the change in quality would not emerge until enough time difference is allowed. The reason is that price adjustment is slow due to contract enforcement issues, menu costs, and so on. That is why we add firm fixed effects in difference-in-difference estimation with 3-year interval but not in the previous baseline regressions. All DID results confirm the negative sign of coefficients on import tariff and positive sign of coefficients on TFP. This, again, validates our theoretical propositions that export price is affected by trade liberalization via the quality effect.

To further confirm the pattern that firms relying more heavily on imported inputs are more affected by trade liberalization, we present the DID estimation results in Table 9 using the interaction term of $\triangle Duty_{(t+3)-t}$ and a dummy variable which equals one if the firm belongs to heavily-relying-on-imports group and zero otherwise. To differentiate firms' dependence on imports, we again use the ratio of import value to total value of material inputs (in columns 1-4), and the ratio of the number of import variety to the number of export variety (in columns 5-8). If a firm's import share is above the 50th percentile, we assign it the dummy variable one. As the coefficient on $\triangle Duty_{(t+3)-t}$ is predicted to be negative, we expect that the coefficient on the interaction term is also negative if firms relying more heavily on imports are indeed more affected by tariff reduction. Different columns present different specifications such as with and without firm fixed effects, with product fixed effects, or with product-destination fixed effects. The results in Table 9 show that the coefficients on the interaction term in all specifications are negative, which are consistent with our expectation.

Moreover, we present another set of DID results in columns 9-12 in Table 9 to show that firms that were induced to import higher priced inputs by the tariff reduction subsequently raised the measured quality (here unit value export price) of their output relative to firms that were not induced to import higher priced inputs. In columns 9-12, we group firms based on the weighted $\triangle ImportPrice_{(t+3)-t}$, where the weight is the ratio of import value to total value of material inputs. If a firm has a bigger change in its import price, we assign it a dummy variable one and expect it to subsequently increase unit value export price of its outputs more. Therefore, our interest of variable is still the interaction term. Again, the coefficients on the interaction term are negative in all specifications in columns 9-12, and this further validates the mechanism of our model: trade liberalization impacts export price through import decision, and quality upgrading pattern exists.

5. Robustness

In addition to the estimation results in Tables 1-4, we test a number of alternative specifications that yield the same results regarding the effect of trade liberalization on export prices via import decisions on quality and variety. Our robustness checks include using product rather than product-destination to distinguish export goods, employing two alternative methods to compute firm specific import tariff, and adopting different specifications for productivity estimation. Except for the previous estimation specifications, we also use difference-in-difference estimation to confirm the causality between tariff reduction and export prices. In all robustness checks, we still use cluster-robust standard error estimators, clustering at firm level. We report the robustness checks in Tables 10-8.

5.1. Export Prices across Products

The baseline regression results in Table 2 estimate equation (13), where export price is measured by using the unit value export price for each product p shipped to destination country c and produced by firm f in year t, $price_{fpct}$. Now we suppress the destination country and use export price $price_{fpt}$ in estimation. Table 10 reports the results.[42] All seven columns correspond to the seven columns in Table 2 of the baseline regression results. Clearly, all negative coefficients on tariff and positive coefficients on TFP remain the same. More importantly, the pattern of the quality ladder as shown in columns 5-7 are still preserved at 1 percent significance level. Like Table 2, we also observe both the increasing vertical pattern (regarding the coefficients on the dummy variables of different import variety ranges) due to the variety effect and the decreasing horizontal pattern (regarding the coefficients on TFP, tariff, wage, and capital intensity) due to the quality effect.

5.2. Alternative Measures of Tariff

As discussed in Section 3.3., we use four different methods to compute firm specific import tariff. The results based on the first measure are presented in previous tables as main results. Table 11 reports the results based the second measure and the third measure. Columns 1-5 present the estimation results of specifications 1-5 in the baseline regression in Table 2, using the weighted average tariff across the imported inputs within the same HS 2-digit category. Columns 6-10 report the results based on the average tariff weighted by input-output relation. It is worth noting three features of Table 11. First, in all specifications, the coefficients on import tariff are significantly negative, while the coefficients on TFP are significantly positive, further confirming that export prices increase in productivity and trade liberalization. Second, the pattern of quality ladder is also clear that the positive effects of import variety on export prices increase with the number of import variety, as shown by the coefficients on three dummy variables D_{25th_50th}, D_{50th_75th}, and D_{75th_100th} in columns 5 and 10. Third, the magnitude of the effects of regressors on export

[42] Accordingly, we use product fixed effects φ_p instead of product-country fixed effects φ_{pc}.

price is decreasing from column 1 to column 5 and from column 6 to column 10. This pattern is consistent with the one in the baseline regressions in Table 2, indicating that the effects of trade liberalization on export prices go through the firm's import decisions on input quality and the number of imported varieties.

To address the endogeneity of the firm specific import tariff, we also re-estimate the baseline regressions using the last measure of tariff, which controls the common set of imported products during the whole sample period. Therefore, using the last measure avoids the endogenous, firm-specific import tariff resulting from the change in the firm's import decisions. We report the results in Table 12. All the previous patterns still hold: First, there exists a vertical pattern of the increased effects of import variety on export prices through coefficients on the dummy variables of import variety (D_{25th_50th}, D_{50th_75th}, and D_{75th_100th}) in columns 5-8. Second, the effect of import duty on export prices presents a clear horizontal pattern: the magnitude of the coefficients on duty reduces when we move from column 1 to columns 5-8.

5.3. Alternative Estimation of Productivity: Correcting for Price Effect

The productivity measures are typically recovered after estimating a production function where output is replaced by sales, because physical output is usually not observed. The standard solution in the literature has been to deflate firm-level sales by industrywide producer price index in the hope to eliminate price effects (De Loecker, 2011). That is what we have estimated using the O-P method. However, this standard practice will potentially generate biased estimates of coefficients of the production function due to the omitted price variable problem. Furthermore, the TFP estimates obtained by using the revenue data may contain price and demand variation, and therefore, may be poor measures of true efficiency (Katayama, Lu, and Tybout, 2009; De Loecker, 2011, among others).

To resolve this issue, we estimate TFP by following the recent development in De Loecker (2011) to correct for the price effect. The production function is still a standard Cobb-Douglas production function where a firm f produces a unit of output at time t using labor, intermediate inputs, and capital.[43] In addition to the various inputs, production depends on a firm-specific productivity shock and idiosyncratic shocks to production. To obtain consistent estimates of the revenue production function, we control for both unobserved productivity shocks and unobserved demand shocks, by estimating equation (11) in De Loecker (2011). This approach allows us to com-

[43]We use material here and the value of material inputs are directly from the NBSC database.

pute the modified TFP estimates from the O-P method, the Levinsohn and Petrin (2003) method, and the Ackerberg-Caves-Frazer (2006) method, after correcting for price effect.

Using the modified estimates of TFP from the various previous approaches, such as the O-P, L-P, and ACF methods, does not change our empirical results. To keep consistency with our previous discussion, we report the baseline estimation results using the modified De Loecker-OP estimates of TFP in columns 1-5 in Table 13. Apparently, all the main results, including the quality ladder patterns, are preserved.[44]

In addition, as productivity serves only as a control variable when we test the effects of trade liberalization on export prices, we estimate the baseline regression, Equation (13), without controlling for productivity (see columns 6-8 in Table 13). By dropping productivity, we can directly observe the impact of tariff reduction on export prices. Again, the results support the predictions from the endogenous-quality model: trade liberalization via import tariff reduction increases export prices through the firm's import decisions on import quality and variety, and export prices increase in the number of imported varieties.

6. Conclusion

In this paper, we extend Melitz's (2003) model of trade with heterogeneous firms by introducing endogenous input quality and endogenous number of imported varieties. In order to analyze how quality effect and variety effect of trade liberalization affect export prices, this paper provides two competing theories: endogenous-quality model and exogenous-quality model. When the quality is endogenous, my model predicts the following propositions. First, an increase in productivity or a reduction in import tariff induces firms to spend more on each imported variety, tend to choose higher-quality imported inputs (the "*quality effect*"), and tend to import more varieties (the "*variety effect*"). Second, more importantly, due to the existence of both the quality effect and the variety effect, there is a clear pattern of "***quality ladder***": firms importing more varieties or with higher productivity set higher export prices for their products; trade liberalization further ***raises*** export prices set by firms. When the quality is exogenous, our model predicts exactly opposite patterns: import tariff reduction would decrease export prices, and firms importing more varieties or with higher productivity set lower export prices.

[44]Although using the De Loecker's method corrects for the output price effect, the measured TFP also includes the quality elements. As Amiti and Konings (2007) point out, it is not possible to separately identify differences in quality from differences in measured productivity.

In order to test these two competing theories, with endogenous quality and exogenous quality, respectively, using the model-based estimation equation, we employ the applied MFN tariff for Chinese imports at the HS8 level from the WTO with a matched Chinese firm-product data set. The empirical results based on the whole sample support all the predictions of the endogenous quality model, and there is a clear, significant pattern of "quality ladder" due to the existence of the quality effect and the variety effect: firms importing more varieties or with higher productivity set higher export prices for their products, and trade liberalization further increases export prices set by firms. Interestingly, we also find evidence to support the model with exogenous quality using quality-adjusted prices and the subsample of products with very little variation of quality.

Therefore, quality effect and variety effect are indeed two channels of the impacts of trade liberalization on export prices via the imported intermediate inputs. Consequently, we expect that the firms depending more on imported intermediate inputs should be more affected by the tariff reduction. In order to further test this story, we divide firms into four intervals according to two indicators of firm's reliance on imported inputs: one is the ratio of the import value to total value of material inputs of each firm; another is the ratio of the number of import variety to the number of export variety of each firm. The empirical results strongly confirm the previous conjecture: firms relying heavily on imported inputs are more affected by trade liberalization; firms relying little on imported inputs are less impacted by tariff reduction.

There are undoubtedly some limitations to our present study. Like De Locker, Goldberg, Khandelwal and Pavcnik (2012), price is multiplication of markup and marginal cost. Hence, it is noteworthy to analyze how trade liberalization affects markup and marginal cost when markup is endogenous. The quality effect of trade liberalization on export price can come from two different sources. On one hand, higher-quality product induces higher markup due to its own larger market power. On the other hand, higher-quality product also incurs higher marginal cost. Then, which one accounts more in explaining the quality effect of trade liberalization on export price? It would be interesting to further decompose the quality effect into the change in markup and the change in marginal cost, which is left for future research.

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A Appendix: Proof of Propositions (When Quality Is Exogenous)

When quality is exogenous, the marginal cost, MC, becomes:

$$MC = \frac{r^a w^b \prod_{m \in F} \left[(p_{m,H})^{1-\theta} + (\tau p_{m,F})^{1-\theta} \right]^{\gamma_m/(1-\theta)} \prod_{m \notin F} (p_{m,H})^{\gamma_m}}{\phi a^a b^b \prod_{m \in F} \gamma_m^{\gamma_m}} \tag{19}$$

Meanwhile, the firm's profit maximization implies that the optimal price, p, equals to:

$$p = \frac{\sigma}{\sigma - 1} MC = \frac{\sigma r^a w^b \prod_{m \in F} \left[(p_{m,H})^{1-\theta} + (\tau p_{m,F})^{1-\theta} \right]^{\gamma_m/(1-\theta)} \prod_{m \notin F} (p_{m,H})^{\gamma_m}}{(\sigma - 1) \phi a^a b^b \prod_{m \in F} \gamma_m^{\gamma_m}} \tag{20}$$

According to equation (20), we have:

Proposition 4 *Export price decreases in firm productivity. In addition, a reduction in import tariff decreases export price.*

The intuition behind Proposition 4 is that an increase in productivity or a reduction in import tariff decreases a firm's marginal cost; and hence lowers the optimal export price.

Now, the revenue of a firm with productivity ϕ is given by:

$$R = \left(\frac{\sigma r^a w^b \prod_{m \in F} \left[(p_{m,H})^{1-\theta} + (\tau p_{m,F})^{1-\theta} \right]^{\gamma_m/(1-\theta)} \prod_{m \notin F} (p_{m,H})^{\gamma_m}}{(\sigma - 1) \phi a^a b^b \prod_{m \in F} \gamma_m^{\gamma_m}} \right)^{1-\sigma} \frac{Y}{P^{1-\sigma}} \tag{21}$$

Then, the optimal expenditure on the imported intermediate input variety $m \in F$, E_m, can be derived as:

$$E_m = \frac{(\tau p_{m,F})^{1-\theta}}{(p_{m,H})^{1-\theta} + (\tau p_{m,F})^{1-\theta}} \gamma_m \frac{\sigma - 1}{\sigma} R \tag{22}$$

Expressions (21) and (22) illustrate that the optimal expenditure on the imported variety m, E_m, increases in productivity ϕ, which suggests that the firm with higher productivity will spend more on each imported variety. In addition, a lower import tariff will increase the optimal expenditure on each imported input variety.

Correspondingly, the optimal set of imported varieties, $\mathcal{F}^*$, is non-decreasing in ϕ and non-increasing in τ, where

$$\mathcal{F}^* = \arg\max_{\mathcal{F}} \left\{ \Pi\left(\mathcal{F}, \phi, \tau\right) - f_m \left|\mathcal{F}\right| \right\}$$

Hence, firms with higher productivity tend to import a greater number of varieties, and a reduction in import tariff tends to induce firms to import more varieties as well. Then we have the following proposition:

Proposition 5 *The firms with higher productivity spend more on each imported variety and tend to import more varieties. In addition, a reduction in import tariff increases the expenditure on each imported variety, and tend to induce firms to import a greater number of varieties.*

The effective price of a composite good X_m equals to $p_{m,H}$ if only domestic input is used. If the firm also uses foreign inputs, the effective price is $\left[(p_{m,H})^{1-\theta} + (\tau p_{m,F})^{1-\theta}\right]^{\frac{1}{1-\theta}}$, which is less than $p_{m,H}$. Hence, equation (20) also implies the following proposition:

Proposition 6 *Firms importing more varieties set lower export prices.*

Table 1: Import Price, Value, and Variety

	Dependent Variable					
	Price	Value	Value	Variety	Variety	Variety
Regressor:	(1)	(2)	(3)	(4)	(5)	(6)
Duty	-1.189 ***	-0.954 ***	-7.906 ***	-0.101 ***	-0.037 ***	-1.539 ***
	(0.097)	(0.149)	(0.365)	(0.025)	(0.009)	(0.095)
log(TFP)	0.077 ***	0.205 ***	0.678 ***	0.041 ***	0.005 ***	0.193 ***
	(0.008)	(0.010)	(0.013)	(0.002)	(0.000)	(0.006)
log(Capital/Labor)	0.145 ***	0.143 ***	0.760 ***	0.007 ***	0.002 ***	0.169 ***
	(0.006)	(0.008)	(0.011)	(0.002)	(0.000)	(0.005)
log(Wage)	0.051 ***	0.115 ***	0.640 ***	0.040 ***	0.004 ***	0.546 ***
	(0.017)	(0.016)	(0.022)	(0.004)	(0.001)	(0.011)
Year fixed effects	yes	yes	yes	yes	yes	yes
Product-source fixed effects	yes	yes	no	no	no	no
Product fixed effects	no	no	no	yes	yes	no
constant	yes	yes	yes	yes	yes	yes
Observations	1620580	1620580	94800	1206712	1206712	94800
Adjusted R^2	0.636	0.301	0.272	0.115	0.146	0.177

Notes: Cluster-robust standard errors in parentheses. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Baseline Estimation: Export Prices across Product and Destination

Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Duty	-0.517***	-0.470***	-0.401***	-0.280**	-0.109	-0.087	-0.119	-0.125
	(0.113)	(0.118)	(0.125)	(0.113)	(0.103)	(0.104)	(0.115)	(0.115)
log(TFP)		0.092***	0.083***	0.040***	0.035***	0.037***	0.021**	0.020**
		(0.010)	(0.010)	(0.009)	(0.008)	(0.008)	(0.009)	(0.009)
log(Capital/Labor)			0.058***	0.019***	-0.000	-0.001	-0.001	-0.000
			(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
log(Wage)				0.275***	0.235***	0.224***	0.240***	0.239***
				(0.016)	(0.015)	(0.015)	(0.016)	(0.016)
D_{25th_50th}					0.070***	0.095***	0.050***	0.042***
					(0.017)	(0.017)	(0.013)	(0.012)
D_{50th_75th}					0.189***	0.220***	0.116***	0.108***
					(0.019)	(0.019)	(0.016)	(0.016)
D_{75th_100th}					0.439***	0.512***	0.309***	0.312***
					(0.023)	(0.023)	(0.027)	(0.027)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Product-destination fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
constant	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1439745	1439745	1439745	1439745	1439745	1439745	1439745	1439745
Adjusted R^2	0.711	0.713	0.714	0.717	0.721	0.722	0.719	0.719

Notes: Cluster-robust standard errors in parentheses. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Export Prices across Product and Destination (with Imported Intermediate Inputs)

Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Duty	-0.647***	-0.579***	-0.511***	-0.377***	-0.279***	-0.270***	-0.259**	-0.277**
	(0.112)	(0.113)	(0.114)	(0.110)	(0.101)	(0.101)	(0.114)	(0.115)
log(TFP)		0.100***	0.0919***	0.0476***	0.0433***	0.0448***	0.0304***	0.0302***
		(0.011)	(0.011)	(0.010)	(0.009)	(0.009)	(0.010)	(0.010)
log(Capital/Labor)			0.0539***	0.0134*	-0.00632	-0.00740	-0.00527	-0.00483
			(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
log(Wage)				0.275***	0.238***	0.222***	0.243***	0.243***
				(0.017)	(0.016)	(0.017)	(0.017)	(0.017)
D_{25th_50th}					0.166***	0.201***	0.0274**	0.0119
					(0.018)	(0.017)	(0.013)	(0.013)
D_{50th_75th}					0.349***	0.418***	0.108***	0.0983***
					(0.024)	(0.025)	(0.016)	(0.016)
D_{75th_100th}					0.420***	0.546***	0.282***	0.267***
					(0.027)	(0.030)	(0.027)	(0.028)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Product-destination fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
constant	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1212550	1212550	1212550	1212550	1212550	1212550	1212550	1212550
Adjusted R^2	0.712	0.713	0.714	0.718	0.721	0.722	0.719	0.719

Notes: Cluster-robust standard errors in parentheses. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Quality and Quality-Adjusted Export Prices across Product and Destination

	Dependent Variable									
Panel A: $\sigma = 5$	Quality					Quality-Adjusted Export Prices				
Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Duty	-0.592***	-0.545***	-0.469***	-0.356***	-0.186	0.075**	0.075**	0.068*	0.076**	0.077**
	(0.120)	(0.124)	(0.131)	(0.121)	(0.112)	(0.036)	(0.035)	(0.036)	(0.036)	(0.036)
log(TFP)		0.093***	0.083***	0.043***	0.038***		-0.001	-0.000	-0.003	-0.004
		(0.012)	(0.012)	(0.011)	(0.010)		(0.004)	(0.004)	(0.004)	(0.005)
log(Capital/Labor)			0.064***	0.028***	0.009			-0.006**	-0.008***	-0.009***
			(0.008)	(0.007)	(0.007)			(0.003)	(0.002)	(0.002)
log(Wage)				0.255***	0.216***				0.020***	0.019***
				(0.017)	(0.017)				(0.005)	(0.005)
D_{25th_50th}					0.088***					-0.018***
					(0.017)					(0.005)
D_{50th_75th}					0.197***					-0.007
					(0.020)					(0.007)
D_{75th_100th}					0.435***					0.003
					(0.026)					(0.009)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Product-destination fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
constant	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1439745	1439745	1439745	1439745	1439745	1439745	1439745	1439745	1439745	1439745
Adjusted R^2	0.061	0.065	0.067	0.075	0.083	0.916	0.916	0.916	0.916	0.916
Panel B: $\sigma = 10$										
Duty	-0.553***	-0.506***	-0.434***	-0.317***	-0.146	0.036**	0.036**	0.033**	0.037**	0.038**
	(0.114)	(0.119)	(0.126)	(0.115)	(0.105)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
log(TFP)		0.092***	0.083***	0.041***	0.036***		-0.000	0.000	-0.001	-0.001
		(0.011)	(0.011)	(0.010)	(0.009)		(0.002)	(0.002)	(0.002)	(0.002)
log(Capital/Labor)			0.060***	0.023***	0.004			-0.002**	-0.004***	-0.004***
			(0.007)	(0.007)	(0.007)			(0.001)	(0.001)	(0.001)
log(Wage)				0.266***	0.227***				0.009***	0.008***
				(0.017)	(0.016)				(0.002)	(0.002)
D_{25th_50th}					0.078***					-0.008***
					(0.017)					(0.002)
D_{50th_75th}					0.192***					-0.003
					(0.019)					(0.003)
D_{75th_100th}					0.437***					0.002
					(0.024)					(0.004)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Product-destination fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
constant	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1439745	1439745	1439745	1439745	1439745	1439745	1439745	1439745	1439745	1439745
Adjusted R^2	0.065	0.069	0.072	0.082	0.092	0.982	0.982	0.982	0.982	0.982

Notes: Cluster-robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 5: Export Prices: Products with More Heterogeneity vs. More Homogeneity of Quality

	Differentiated Goods					Homogeneous Goods				
Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Duty	-0.593***	-0.543***	-0.463***	-0.327**	-0.135	-0.121	-0.129	-0.125	-0.101	-0.101
	(0.124)	(0.131)	(0.141)	(0.127)	(0.115)	(0.109)	(0.108)	(0.107)	(0.107)	(0.107)
log(TFP)		0.098***	0.089***	0.045***	0.040***		-0.035***	-0.035***	-0.056***	-0.056***
		(0.010)	(0.010)	(0.009)	(0.009)		(0.009)	(0.009)	(0.010)	(0.010)
log(Capital/Labor)			0.059***	0.023***	0.003			0.008	-0.019**	-0.020**
			(0.007)	(0.008)	(0.007)			(0.009)	(0.010)	(0.009)
log(Wage)				0.275***	0.230***				0.157***	0.155***
				(0.018)	(0.016)				(0.018)	(0.019)
D_{25th_50th}					0.078***					-0.004
					(0.018)					(0.025)
D_{50th_75th}					0.203***					-0.006
					(0.020)					(0.034)
D_{75th_100th}					0.490***					0.012
					(0.026)					(0.035)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Product-destination fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
constant	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1148018	1148018	1148018	1148018	1148018	161645	161645	161645	161645	161645
Adjusted R^2	0.720	0.722	0.723	0.726	0.730	0.639	0.640	0.640	0.642	0.642

Notes: Cluster-robust standard errors in parentheses. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Export Prices: Products with Less vs. Greater Variation of Quality

Regressor:	(1)	(2)	(3)	(4)
Duty	0.125 **	0.120	-0.013	-0.280 **
	(0.063)	(0.077)	(0.091)	(0.113)
log(TFP)	0.007	0.009	0.013 **	0.040 ***
	(0.005)	(0.006)	(0.006)	(0.009)
log(Capital/Labor)	-0.001	-0.004	0.001	0.019 ***
	(0.005)	(0.005)	(0.005)	(0.007)
log(Wage)	0.093 ***	0.119 ***	0.158 ***	0.275 ***
	(0.010)	(0.010)	(0.011)	(0.016)
Year fixed effects	yes	yes	yes	yes
Product-destination fixed effects	yes	yes	yes	yes
constant	yes	yes	yes	yes
Observations	360001	719976	1080004	1439745
Adjusted R^2	0.919	0.855	0.785	0.717

Notes: Cluster-robust standard errors in parentheses. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Export Prices by Firms with Different Dependence on Imports

	Grouped by import-to-material ratio				Grouped by import-to-export-variety ratio			
Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Duty	0.173	-0.0943	-0.198*	-0.280**	0.0388	-0.0261	-0.212*	-0.280**
	(0.131)	(0.132)	(0.105)	(0.113)	(0.117)	(0.105)	(0.111)	(0.113)
log(TFP)	0.00679	0.00830	0.0211***	0.0401***	-0.0191*	-0.00683	0.0279***	0.0401***
	(0.011)	(0.008)	(0.008)	(0.009)	(0.010)	(0.008)	(0.010)	(0.009)
log(Capital/Labor)	0.0378***	0.0312***	0.0264***	0.0194***	0.00426	0.00874	0.0140*	0.0194***
	(0.007)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
log(Wage)	0.107***	0.154***	0.198***	0.275***	0.132***	0.170***	0.249***	0.275***
	(0.017)	(0.016)	(0.015)	(0.016)	(0.018)	(0.016)	(0.018)	(0.016)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Product-destination fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
constant	yes	yes	yes	yes	yes	yes	yes	yes
Observations	444278	817081	1146749	1439745	717970	1035397	1277428	1439745
Adjusted R^2	0.733	0.723	0.723	0.717	0.724	0.726	0.721	0.717

Notes: Cluster-robust standard errors in parentheses. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Difference-in-Difference Estimation

Panel A: without firm fixed effects								
Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Duty	-0.027	-0.027	-0.023	-0.022	-0.182 *	-0.181 *	-0.179 *	-0.179 *
	(0.104)	(0.104)	(0.104)	(0.104)	(0.104)	(0.104)	(0.103)	(0.103)
log(TFP)		0.001	0.001	0.000		0.008	0.008	0.008
		(0.009)	(0.009)	(0.009)		(0.007)	(0.007)	(0.008)
log(Capital/Labor)			-0.008	-0.009			-0.010	-0.010
			(0.008)	(0.008)			(0.009)	(0.009)
log(Wage)				0.003				-0.004
				(0.012)				(0.012)
Year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Product-destination fixed effects	yes	yes	yes	yes	no	no	no	no
Product fixed effects	no	no	no	no	yes	yes	yes	yes
constant	yes	yes	yes	yes	yes	yes	yes	yes
Observations	51257	51257	51257	51257	24057	24057	24057	24057
Adjusted R^2	0.093	0.093	0.093	0.093	0.031	0.031	0.031	0.031
Panel B: with firm fixed effects								
Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Duty	-0.081	-0.078	-0.084	-0.082	-0.067	-0.067	-0.069	-0.068
	(0.104)	(0.104)	(0.104)	(0.104)	(0.149)	(0.149)	(0.149)	(0.149)
log(TFP)		0.005	0.006	0.005		0.000	0.001	0.001
		(0.007)	(0.007)	(0.007)		(0.009)	(0.009)	(0.009)
log(Capital/Labor)			0.007	0.006			0.005	0.006
			(0.008)	(0.008)			(0.011)	(0.011)
log(Wage)				0.006				-0.003
				(0.010)				(0.014)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Product-destination fixed effect	yes	yes	yes	yes	no	no	no	no
Product fixed effects	no	no	no	no	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
constant	yes	yes	yes	yes	yes	yes	yes	yes
Observations	51257	51257	51257	51257	24057	24057	24057	24057
Adjusted R^2	0.333	0.333	0.333	0.333	0.350	0.350	0.350	0.350

Notes: Cluster-robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Table 9: Difference-in-Difference Estimation: Grouping Firms by Import Share

Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ΔDuty	-0.00812	0.0377	-0.165	-0.00187	0.0149	-0.0133	-0.0949	0.0399	0.0304	-0.0367	-0.00580	-0.00232
	(0.115)	(0.210)	(0.123)	(0.244)	(0.106)	(0.186)	(0.104)	(0.222)	(0.145)	(0.291)	(0.131)	(0.313)
ΔDuty $\times$ Dummy	-0.0728	-0.377	-0.0521	-0.211	-0.305	-0.418	-0.595**	-0.529	-0.123	-0.0832	-0.405**	-0.123
	(0.219)	(0.336)	(0.206)	(0.395)	(0.290)	(0.485)	(0.287)	(0.512)	(0.190)	(0.340)	(0.182)	(0.368)
Year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Product-destination fixed effects	yes	yes	no	no	yes	yes	no	no	yes	yes	no	no
Product fixed effects	no	no	yes	yes	no	no	yes	yes	no	no	yes	yes
Firm fixed effects	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
Constant	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	51257	51257	24057	24057	51257	51257	24057	24057	51257	51257	24057	24057
Adjusted R^2	0.093	0.333	0.031	0.350	0.093	0.333	0.031	0.350	0.093	0.333	0.031	0.350

Notes: Cluster-robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Table 10: Robustness: Export Prices across Products

Regressor:	(1)	(2)	(3)	(4)	(5)	(6)
Duty	-0.576***	-0.524***	-0.458***	-0.328**	-0.124	-0.174
	(0.134)	(0.139)	(0.144)	(0.136)	(0.124)	(0.124)
log(TFP)		0.089***	0.081***	0.039***	0.033***	0.019***
		(0.009)	(0.009)	(0.009)	(0.008)	(0.008)
log(Capital/Labor)			0.049***	0.010	-0.013*	-0.010*
			(0.007)	(0.007)	(0.007)	(0.007)
log(Wage)				0.285***	0.227***	0.242***
				(0.015)	(0.014)	(0.014)
D_{25th_50th}					0.085***	0.044***
					(0.018)	(0.018)
D_{50th_75th}					0.243***	0.144***
					(0.020)	(0.020)
D_{75th_100th}					0.512***	0.348***
					(0.024)	(0.024)
Year fixed effect	yes	yes	yes	yes	yes	yes
Product fixed effect	yes	yes	yes	yes	yes	yes
constant	yes	yes	yes	yes	yes	yes
Observations	527377	527377	527377	527377	527377	527377
Adjusted R^2	0.616	0.618	0.619	0.624	0.630	0.627

Notes: Cluster-robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Table 11: Robustness: Different Measures of Tariff (Measure 2 and Measure 3)

Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Duty	-0.631***	-0.633***	-0.567***	-0.400**	-0.244	-0.486***	-0.453***	-0.350**	-0.318**	-0.181
	(0.189)	(0.204)	(0.200)	(0.180)	(0.164)	(0.150)	(0.159)	(0.162)	(0.154)	(0.143)
log(TFP)		0.120***	0.108***	0.050***	0.040***		0.092***	0.083***	0.040***	0.035***
		(0.015)	(0.015)	(0.013)	(0.012)		(0.010)	(0.010)	(0.009)	(0.008)
log(Capital/Labor)			0.081***	0.027**	0.008			0.057***	0.019***	-0.001
			(0.011)	(0.011)	(0.010)			(0.007)	(0.007)	(0.007)
log(Wage)				0.334***	0.291***				0.273***	0.232***
				(0.023)	(0.021)				(0.016)	(0.015)
D_{25th_50th}					0.116***					0.073***
					(0.019)					(0.017)
D_{50th_75th}					0.247***					0.195***
					(0.024)					(0.019)
D_{75th_100th}					0.503***					0.446***
					(0.033)					(0.023)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Product-destination fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
constant	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	780633	780633	780633	780633	780633	1382781	1382781	1382781	1382781	1382781
Adjusted R^2	0.715	0.717	0.718	0.723	0.726	0.707	.708	0.709	0.713	0.716

Notes: Cluster-robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Table 12: Robustness: Different Measures of Tariff (Measure 4)

Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Duty	-0.847***	-0.777***	-0.603***	-0.551***	-0.304*	-0.322*	-0.466***	-0.456**
	(0.164)	(0.170)	(0.174)	(0.176)	(0.166)	(0.166)	(0.181)	(0.181)
log(TFP)		0.0918***	0.0831***	0.0400***	0.0331***	0.0337***	0.0223**	0.0212**
		(0.011)	(0.010)	(0.009)	(0.008)	(0.008)	(0.009)	(0.009)
log(Capital/Labor)			0.0575***	0.0187***	-0.00311	-0.00408	-0.0000528	-0.000297
			(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
log(Wage)				0.275***	0.231***	0.218***	0.243***	0.241***
				(0.016)	(0.015)	(0.015)	(0.016)	(0.016)
D_{25th_50th}					0.134***	0.190***	0.0333***	0.0404***
					(0.014)	(0.014)	(0.013)	(0.012)
D_{50th_75th}					0.339***	0.401***	0.0929***	0.0915***
					(0.022)	(0.022)	(0.016)	(0.015)
D_{75th_100th}					0.479***	0.622***	0.284***	0.289***
					(0.026)	(0.029)	(0.024)	(0.024)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Product-destination fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
constant	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1439745	1439745	1439745	1439745	1439745	1439745	1439745	1439745
Adjusted R^2	0.711	0.713	0.714	0.717	0.721	0.722	0.719	0.719

Notes: Cluster-robust standard errors in parentheses. $^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 13: Robustness: Measured TFP after Correcting Price Effect and Non TFP Specification

Regressor:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Duty	-0.518***	-0.515***	-0.428***	-0.291***	-0.120	-0.431***	-0.286***	-0.115
	(0.113)	(0.113)	(0.119)	(0.110)	(0.101)	(0.119)	(0.110)	(0.102)
log(TFP)		0.221***	0.224***	0.130***	0.113***			
		(0.025)	(0.025)	(0.023)	(0.021)			
log(Capital/Labor)			0.068***	0.023***	0.002	0.067***	0.021***	0.000
			(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
log(Wage)				0.283***	0.242***		0.296***	0.252***
				(0.017)	(0.017)		(0.017)	(0.016)
D_{25th_50th}					0.069***			0.069***
					(0.016)			(0.016)
D_{50th_75th}					0.186***			0.187***
					(0.019)			(0.019)
D_{75th_100th}					0.439***			0.442***
					(0.023)			(0.023)
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Product-destination fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
constant	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1437958	1437958	1437958	1437958	1437958	1437958	1437958	1437958
Adjusted R^2	0.711	0.712	0.713	0.717	0.721	0.712	0.717	0.721

Notes: Cluster-robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$