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Indonesia and China: Friends or Foes?

Quality Competition and Firm Productivity

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Abstract: We define and measure "firm-product-destination-year-specific export quality" and investigate how quality competition from China affects Indonesian firm productivity in the domestic and export markets. Our results suggest that an increase in Chinese exported product quality by 10 percent will increase the productivity of Indonesian firms by 0.4–0.5 percent in Indonesia's domestic market, and increase Indonesian exporters' productivity by 2 percent in the export market. Where we limit our sample to exporters only, an increase in Chinese exported product quality will increase Indonesian firm productivity in the export market, but not in the domestic market. Our findings broaden the horizon through which firms could benefit from opening up to trade.

Keywords: Quality, productivity, competition, firm-level study, China, Indonesia
JEL Classification: F1, F12, F13, F14

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1. Introduction

Opening up to trade can benefit a home country for various economic reasons. Recent micro-level empirical evidence suggests that substantial gains from trade originate from firm-level responses to trade policy transitions. One of the most prevalent findings across different countries is that import tariff reductions can improve firm productivity in the home country.

Two mechanisms are well discussed when understanding how import tariff reductions can affect individual firm productivity in a home country. The first mechanism is the 'pro-competitive effect' induced by output tariff reductions. When output tariffs decrease, domestic firms are faced with tougher competition in the domestic product market from foreign competitors. The intensified competition therefore forces domestic firms to reduce inefficiencies and generates a productivity gain. The second mechanism is the 'input-facilitation effect' induced by input tariff reductions. When input tariffs decrease, domestic firms can have access to intermediate inputs either at lower prices or of higher quality, especially for domestic firms in developing countries. Better access to inputs also facilitates increases in domestic firm productivity.

Our paper specifies a particular pro-competitive effect, namely 'quality competition' induced by foreign competitors, to generate new empirical insights in understanding productivity gains from trade. Previous studies generally use import tariff reductions as identification strategies to study their effects on firm productivity. However, this treatment fails to capture distinct dimensions of increased competition triggered by trade policy transitions. Import tariff reductions may cause more competitors to enter the market, higher-quality competitors to enter the market, or both. Understating contributions of different margins is hence key to quantifying the possible effects of trade policy reform. In contrast, using a novel way of measuring disaggregated trade quality from one country to another that is applicable to micro-level data, we are able to disentangle the variation in quality competition and directly investigate its effect on firm productivity in the home country. Our argument is that as the product quality of foreign competitors increases, domestic firms are faced with tougher competition in terms of quality and therefore exhibit larger productivity gains due to the larger pro-competitive effect.

Combining micro-level datasets for Indonesia and China, we are able to accurately measure average export quality at the Harmonized System (HS) 6-digit level from China to Indonesia by using a new approach applied to Chinese micro-level production and trade data. We then construct firm-specific quality competition indices, which measure the quality competition intensities induced by Chinese competitors for Indonesian firms in both the domestic and export markets.

The main value added of our study is threefold. First, we specify a clear channel through which trade can affect firm productivity. We join the strand of empirical literature that uses firm-level data to study the effect of trade. Amiti and Konings (2007) find that trade liberalisation—output and input tariff reductions—increased Indonesian firm productivity. Topalova and Khandelwal (2011) confirm this finding with Indian data using firm-specific tariff measures. Amiti and Khandelwal (2013) also find that import competition helps to facilitate quality upgrading for products close to the quality frontier, but depresses quality upgrading for products far from the quality frontier. Goldberg, *et al.* (2009) claim that input tariff reductions cause the importation of more input varieties and therefore facilitate importing firm productivity growth. By directly measuring quality competition, we present evidence that the increased import product quality and the intensified quality competition will have effects on firm productivity, investigating a specific channel that is not yet well discussed, through which trade contributes to productivity growth.

Second, we adopt a new approach in measuring product quality. Unit value is used as a proxy for product quality in many studies (Hallak, 2006; Schott, 2004; Manova and Zhang, 2012; Alessandria and Kaboski, 2011; and other studies). Khandelwal

(2010) incorporates quality as a demand shifter in a nested-logit utility function, and generates a demand-side empirical specification to estimate import product quality using United States import trade data on quantity and price, with the intuition that conditional on price, variety with a higher market share should be assigned a higher quality. Hallak and Schott (2011) follow a similar intuition that exports from countries with trade surpluses should be assigned higher quality. Khandelwal, *et al.* (2013) incorporate quality as a demand shifter in a constant elasticity of substitution (CES) utility function and estimate export product quality conditional on destination, year, and product. Feenstra and Romalis (2014) jointly consider supply and demand, and generate an aggregate quality index for each country and product, which is comparable across countries. We implement a new approach to estimate micro-level export product quality, which conceptually follows Feenstra and Romalis (2014) but is empirically different. We generate micro-level export product quality comparable across destinations and over time. More importantly, our approach can be readily applied to a standard micro-level production and trade dataset.

Third, our study also helps to understand South-South trade and how it affects firm productivity. Since its accession to the World Trade Organization (WTO) in 2001, China has become the largest trading country in the world. A large number of studies analyse North-South trade and its consequences: among others, Xu (2003); Ing (2009); Autor, *et al.* (2013); and Bloom, *et al.* (2016). On one hand, we are interested to see whether an increase in import quality from China to Indonesia would have any competition effect for the productivity of Indonesian firms. On the other hand, we also study whether an increase in import quality from China to other countries, where Indonesian exporters compete with Chinese exporters, would yield any competition effect for the productivity of Indonesian exporters. Our study therefore broadens the horizons on how South-South trade will affect the South's productivity via quality competition.

The rest of the paper is organised as follows. Section 2 describes a theoretical framework on export quality and how this will affect productivity. Section 3 describes the estimation strategy. Section 4 explains the firm-level and product-level datasets used in our study, which consist of Indonesian and Chinese data. Section 5 presents our empirical results. Section 6 concludes.

2. A Framework to Measure Micro-level Export Quality

As quality is unobservable in the real data, we need to rely on a theoretical framework to quantify quality in consumer preferences. This section presents a simple framework upon which we build our empirical methodology for measuring micro-level quality.

We follow Feenstra and Romalis (2014) to derive the expression of micro-level export product quality and use firm-level and product-level data together with estimates of structural parameters to construct firm-product-destination-year level export quality.

On the demand side, a consumer's utility depends on both the quantity and quality of the product she consumes. A consumer in destination j faces a continuum of differentiated goods, ω, within each product category, g. The consumer's preference is characterised by an expenditure function as indicated in (2.1):

$$E_{jg} = U_{jg}\left[\int_{\omega} \left(\frac{p_{\omega j}}{\left(z_{\omega j}\right)^{\alpha_{jg}}}\right)^{(1-\sigma_g)} d\omega\right]^{\frac{1}{1-\sigma_g}} \qquad (2.1)$$

with utility $U_{jg} > 0$ and $\alpha_{jg} = 1 + \gamma_g ln(U_{jg})$. $p_{\omega j}$ and $z_{\omega j}$ are the cost, insurance, and freight (CIF) price and quality of variety, ω, sold in destination j, respectively. α_{jg} is a parameter that describes the consumer's 'preference for quality' in destination j for product category g. As the preferences for quality depend on the utility, this implies that the utility function is non-homothetic. σ_g is the elasticity of substitution between different varieties within product category g, and α_{jg} depends on the utility. The demand function can be derived as (2.2):

$$q_{\omega j} = \frac{\partial E_{jg}}{\partial p_{\omega j}} = E_{jg} \cdot P_{jg}{}^{\sigma_g - 1} \cdot p_{\omega j}{}^{-\sigma_g} \cdot z_{\omega j}{}^{\alpha_{jg}(\sigma_g - 1)} \qquad (2.2)$$

where $P_{jg} = \left[\int_\omega \left(\frac{p_{\omega j}}{z_{\omega j}{}^{\alpha_{jg}}} \right)^{(1-\sigma_g)} d\omega \right]^{\frac{1}{1-\sigma_g}}$ is the quality-adjusted CES price index in country j for product category g. Demand for a particular variety is increasing in its quality and decreasing in its CIF price.

We proceed to consider supply side behaviour to endogenise quality. Firms compete in a monopolistic competitive market and simultaneously decide on the free on board (FOB) price and quality. For firm i selling a variety in product category g and destination j, $p_{ijg}{}^*$ is the FOB price and z_{ijg} is the quality at which the firm decides to produce. Firm i's maximisation problem is therefore (2.3):

$$\underset{p_{ijg};\, z_{ijg}}{Max} \left[\left(p_{ijg}{}^* - c_i(z_{ijg}, w) \right) \right] \cdot \frac{\tau_{ijg} q_{ijg}}{tar_{jg}} \qquad (2.3)$$

where $c_i(z_{ijg}, w)$ is the unit production cost dependent on product quality z_{ijg} and cost rate w, and q_{ijg} is the quantity firm i sells to j. tar_{jg} is the tariff of product category g in destination j. As we know, a consumer in destination j faces CIF price p_{ijg}. There are two types of trade cost: the ad valorem trade cost, τ_{ijg}, and the per-unit trade cost, T_{ijg}.[1] The CIF price, p_{ijg}, and FOB price, $p_{ijg}{}^*$, satisfy (2.4):

$$p_{ijg} = \left(p_{ijg}{}^* + T_{ijg} \right) \tau_{ijg} \qquad (2.4)$$

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[1] The ad valorem trade cost refers to costs that are proportionate in value to the value of the goods being traded. For example, if the ad valorem trade cost is 20 percent, then a good with an FOB value of US$10 will be subject to an ad valorem trade cost worth US$2 (20 percent of US$10), regardless of the quantity being shipped. In contrast, a per-unit trade cost is based on quantity, regardless of the value of the goods being traded.

Following Feenstra and Romalis (2014), we assume the unit cost, $c_i(z_{ijg}, w)$:

$$c_i(z_{ijg}, w) = \frac{w(z_{ijg})^{\frac{1}{\theta_g}}}{\varphi_i} \qquad (2.5)$$

The cost rate, w, is the price of one unit of 'effective' input.[2] If a firm wants to produce output with quality z_{ijg}, then for one physical unit of output, $(z_{ijg})^{\frac{1}{\theta_g}}/\varphi_i$ units of effective input are needed. φ_i is firm *i*'s productivity. Given z_{ijg}, a firm with higher productivity requires a smaller amount of effective inputs to produce one unit of output. Moreover, given φ_i, higher quality requires a higher unit cost.

We assume that quality upgrading is subject to decreasing returns to scale. Under the assumption that $0 < \theta_g < 1$, as θ_g moves from 0 to 1, the unit cost function becomes less convex with respect to z_{ijg}. This means that given the same quality level, z_{ijg}, a lower θ_g raises the marginal cost of upgrading quality.

From equation (2.3) we can note that a firm faces a trade-off when choosing a level of quality for its product. On one hand, a higher quality raises a consumer's demand for the product and results in more sales, which increases the firm's total profits. On the other hand, a higher quality raises the unit cost of production and suppresses per-unit profit, which decreases its total profits. A firm, therefore, chooses the optimal level of quality z_{ijg} when marginal revenue equals marginal cost. The firm's profit optimisation yields

$$\frac{w(z_{ijg})^{\frac{1}{\theta_g}}}{\varphi_i \theta_g} = \left[p_{ijg}{}^* - \frac{w(z_{ijg})^{\frac{1}{\theta_g}}}{\varphi_i} \right] \cdot [\alpha_{jg}(\sigma_g - 1)] \qquad (2.6)$$

which can be rewritten as

$$ln(z_{ijg}) = \theta_g \left[ln(\kappa_{1jg} p_{ijg}{}^*) - ln\left(\frac{w}{\varphi_i}\right) \right] \qquad (2.7)$$

[2] Effective inputs are inputs with an identical quality and unit. Using effective inputs is a way to transform inputs with different qualities into inputs with identical qualities but different quantities, so that it is easier to illustrate how the unit cost of physical output depends on quality.

where $\kappa_{1jg} = \alpha_{jg}\theta_g(\sigma_g - 1)/[1 + \alpha_{jg}\theta_g(\sigma_g - 1)]$. For a different year, t, we can therefore have (2.8):

$$ln(z_{ijgt}) = \theta_g\left[ln(\kappa_{1jg}) + ln(p_{ijgt}{}^{*}) + ln(\varphi_{it}) - ln(w_t)\right] \quad (2.8)$$

Several observations emerge from equation (2.8). First, quality is positively correlated with productivity; second, quality is positively correlated with unit value; third, quality is negatively correlated with costs. To estimate quality, several input variables need to be constructed. These variables include the FOB price (or unit value), $p_{ijgt}{}^{*}$, firm productivity, φ_{it}, cost rate, w_t, and a number of structural parameters, α_{jg}, θ_g, and σ_g.

3. Estimation Strategy

In this section, we introduce measures of our four key variables: Chinese exported product quality, the Chinese firm's productivity, the Indonesian firm's productivity, and a firm-level index measuring the intensity of quality competition from China. We then discuss the empirical specifications we use to observe the effects of quality competition from China on Indonesian firms' productivity.

3.1. Export quality of Chinese firms

Recall equation (2.8) to estimate the firm-destination-product-year-level export quality:

$$ln(z_{ijgt}) = \theta_g\left[ln(\kappa_{1jg}) + ln(p_{ijgt}{}^{*}) + ln(\varphi_{it}) - ln(w_t)\right] \quad (2.8)$$

We construct the FOB price, $p_{ijgt}{}^{*}$, by using the Chinese Customs (CC) dataset. Specifically, we aggregate the FOB export value and quantity for each firm–HS-6–

destination–year pair and divide the value by the quantity to obtain an FOB unit value. Our sample includes ordinary exports, since processing exports feature a significant difference in production procedure. The FOB unit values are converted to yuan and deflated using the corresponding industry-level output deflators.

For firm productivity, φ_{it}, we use the Olley-Pakes algorithm, following Yu (2015), to construct firm-level productivity using the Chinese manufacturing dataset under a Cobb-Douglas production function. The detailed procedure to estimate productivity is described in Section 3.2.

We define the cost rate, w_t, as in equation (3.1):

$$ln(w_t) = \alpha' \, ln({w^L}_t) + \beta' \, ln({w^K}_t) \qquad (3.1)$$

As indicated in equation (3.1), the cost rate consists of labour cost ${w^L}_t$ and capital cost ${w^K}_t$, with their shares being α' and β', respectively. We use the average level of wages in the manufacturing sector to measure ${w^L}_t$. ${w^K}_t$ is measured as the ratio of total depreciation over total net fixed assets in each China Industrial Classification (CIC) at the 2-digit industry level. Using the standard Cobb-Douglas production function, equation (3.1) results in:

$$\alpha' = \frac{\alpha}{\alpha+\beta} \qquad (3.1')$$

$$\beta' = \frac{\beta}{\alpha+\beta}$$

α and β are directly obtained when one estimates the production function and productivity.

For the structural parameters of α_{jg}, θ_g and σ_g, we rely on the estimated parameter values from Feenstra and Romalis (2014) to calculate the export quality based on equation (2.8).[3] Feenstra and Romalis (2014) provide the estimated values of α_{jg}, θ_g and σ_g for each country and each SITC rev2 4-digit product in each year.

[3] Feenstra and Romalis (2014) calibrate the structural parameters α_{jg}, θ_g, and σ_g using bilateral trade flow data. See Feenstra and Romalis (2014) for detailed procedure of the calibration. The values of the estimated parameters are available on Feenstra's personal website (http://www.robertfeenstra.info/data/).

We concord the SITC rev2 classifications to their HS-6 classifications and map their estimated parameters to each HS-6 product or HS-6–destination pair. To maximise the number of observations in our sample, for those HS-6 product categories with missing parameter estimates in the corresponding SITC 4-digit product, we instead use the average values of the parameters for the corresponding SITC 3-digit product. The use of the parameters described in equation (2.8), rather than destination, product, or year fixed effects as used by Khandelwal, *et al.* (2013) and Fan, *et al.* (2015), ensures our measured quality is comparable across destinations and years.

Equipped with these variables and parameter values, we can then use equation (2.8) to calculate the firm–destination–HS-6–year–level export quality from China. To ensure comparability of this measured quality across products, we normalise $ln(z_{ijgt})$ by subtracting its 10-th percentile value in the corresponding HS 6-digit product category in the sample period, namely:

$$qual_{ijgt} = ln(z_{ijgt}) - ln\left(z_{10\%_g}\right) \qquad (3.2)$$

$qual_{ijgt}$ is, therefore, comparable across different g as it measures how far a particular variety is from its 10-th percentile value in the quality distribution.

Now, we can obtain the average Chinese export quality, $qual_{jgt}$, to each destination, j, in each year, t, for each HS 6-digit product, g, by taking the simple average of $qual_{ijgt}$ across different firms, i.

3.2. Productivity measures

We need to measure the total factor productivity (TFP) of Chinese and Indonesian firms. First, we want to see how the increased quality competition from China will affect productivity in Indonesian firms. Second, we need to calculate the Chinese export quality, which requires Chinese firms' TFP. We use TFP to measure firm-level productivity. In this subsection we describe how we measure a firm's TFP using the Olley-Pakes algorithm, which mitigates the potential simultaneity and selection biases in the traditional ordinary least squares (OLS) and fixed effects estimations, using the Indonesian firm dataset and the Chinese firm dataset, respectively.

3.2.1. Indonesian TFP measures

Following Amiti and Konings (2007), we specify a gross-output Cobb-Douglas production function:

$$ln(Y_{it}) = ln(\varphi_{it}) + \alpha\, ln(K_{it}) + \beta\, ln(L_{it}) + \gamma\, ln(M_{it}) \qquad (3.3)$$

Y_{it} is the real output measured by nominal output deflated by output deflators. To construct the output deflators, we first manually concord the Wholesale Price Index (WPI) with the International Standard of Industrial Classification Revision 3 (ISIC rev3) at the 2-digit industry level. We then average the WPI within each ISIC rev3 at the 2-digit industry level to generate industry-specific output deflators following Amiti and Konings (2007), where the WPI price indices are obtained from the CEIC database.

M_{it} is the real cost of intermediate inputs measured by the expenses on domestic raw materials deflated by the domestic input deflators, plus the expenses on imported raw materials deflated by the imported input deflators. We obtain each industry's own domestic input shares as well as the shares from other industries using Indonesia's input-output table. We then construct the domestic input deflators for a particular industry by weighting all industries' output deflators with their cost shares as intermediate inputs in the particular industry. The weighted deflators are therefore industry-level domestic input deflators. We generate imported input deflators through a similar procedure, assuming the input-output structure is identical for domestic and imported inputs, since information on input-output linkages is not available for imported goods. Industry-level imported price indices are obtained from CEIC's Premium database.

K_{it} is the real capital measured by the estimated value of fixed capital, deflated by a capital deflator, where the capital deflator is a value-weighted WPI price index of construction materials, vehicles, and machineries. L_{it} is the number of employees.

We implement the Olley-Pakes algorithm to estimate equation (3.3) separately for each 2-digit industry defined according to ISIC rev3 at the 2-digit level. We also control for a firm being an exporter or importer, which affects a firm's productivity, and for the global financial crisis in 2008 and 2009, which affected productivity by reducing world demand.[4]

We hence obtain the estimated values of α, β, and γ for each ISIC rev3 2-digit industry level. Table A1 reports the estimation results of the production function. We can therefore construct an Indonesian firm's TFP as:

$$ln(TFP_{it}) = ln(\varphi_{it}) = ln(Y_{it}) - \hat{\alpha}\, ln(K_{it}) - \hat{\beta}\, ln(L_{it}) - \hat{\gamma}\, ln(M_{it}) \qquad (3.4)$$

3.2.2. Chinese TFP measures

Similarly, we also construct firm-level TFP as a measure of the productivity of Chinese firms before using equation (2.8) to calculate micro-level export quality using the Olley-Pakes algorithm. However, we adopt the value added Cobb-Douglas production function when we use the Chinese manufacturing dataset:

$$ln(VA_{it}) = ln(\varphi_{it}) + \alpha\, ln(K_{it}) + \beta\, ln(L_{it}) \qquad (3.5)$$

where VA_{it} is the real value added, measured by nominal value added deflated by the output deflators. The CIC 2-digit output deflators come from the National Bureau of Statistics. As the Chinese manufacturing dataset does not report the value of capital, K_{it} is constructed using a permanent inventory method proposed by Brandt, *et al.* (2012). L_{it} is the number of employees.

The reason why we choose the value added specification in equation (3.5) is due to a lack of intermediate input data in 2008 and 2009. To cope with this problem, first, we calculate the firm-level value added for observations with non-missing

[4] Following Amiti and Konings (2007), we allow for the possibility that export or import status may affect firm productivity by including an export dummy and an import dummy into the estimation of the control function in the first stage of the Olley-Pakes algorithm. In addition, we also include a dummy that equals 1 in 2008 and 2009 and 0 otherwise, to account for the possibility that the financial crisis may also affect firm productivity by cutting global demand.

intermediate inputs for the sample from 1998–2007 and 2010. We then calculate the median ratio of the value added over gross output for each CIC 2-digit industry in each year. We take the medians of these median ratios over time to generate the value added ratios for each CIC 2-digit industry. We use the value added ratios to impute the value added for observations in 2008 and 2009. After imputing the value added for each firm, we continue to estimate equation (3.5) using the Olley-Pakes algorithm.

Following Yu (2015), we augment the Olley-Pakes algorithm to adapt to China's circumstances and estimate the production function separately for each CIC 2-digit industry. We include an export dummy, a State Owned Enterprise (SOE) dummy and a WTO dummy to control for the possibility that export status, state ownership, and China's accession to the WTO may have impacts on a firm's productivity when estimating the control function in the first stage of the Olley-Pakes algorithm.

Now we can obtain the estimated values of α and β for each CIC 2-digit industry. We report the estimated values in Table A2. We can, therefore, construct a Chinese firm's TFP as:

$$ln(TFP_{it}) = ln(\varphi_{it}) = ln(VA_{it}) - \hat{\alpha}\, ln(K_{it}) - \hat{\beta}\, ln(L_{it}) \qquad (3.6)$$

3.3. Firm-specific quality competition index

A firm can sell multiple products in the domestic market and, therefore, the competition from China is from the various products that China exports to Indonesia. To capture this effect, we consider a firm-level weighted quality competition index, $DQC1_{it}$, in the domestic market as follows:

$$DQC1_{it} = \sum_{g} \left(\frac{Dom\ Sale_{igt}}{\sum_g Dom\ Sale_{igt}} \right) qual_{jgt}\text{, where } j = \text{Indonesia} \qquad (3.7)$$

where $Dom\ Sale_{igt}$ is firm *i*'s revenue from selling product g in the domestic market in year *t*. This indicator reflects the intensity of quality competition from China faced by an Indonesian firm in the domestic market. However, one concern is that a domestic firm may change (i.e. reduce or increase) the shares of output of products when facing more intense quality competition, therefore $DQC1_{it}$ does not perfectly reflect the actual intensity of quality competition. To mitigate this potential bias, we follow Topalova and Khandelwal (2011) and Yu (2015) by using the initial share to construct firm-level tariffs, which enables us to construct a firm-level domestic weighted quality competition index, $DQC2_{it}$, using the initial share as follows:

$$DQC2_{it} = \sum_{g} \left(\frac{Dom\ Sale_{ig,initial_{year}}}{\sum_g Dom\ Sale_{ig,initial_{year}}} \right) qual_{jgt}\text{, where } j = \text{Indonesia} \qquad (3.7')$$

The initial year is defined as the year when firm *i* first appears in the sample. Therefore, the changes in $DQC2_{it}$ purely stem from changes in the average export quality from China at the HS 6-digit product category, rather than changes in composition across different products.

We also measure the quality competition from China that Indonesian firms face in the export market. We then construct a firm-level weighted quality competition index in the export market, $EQC1_{it}$, as follows:

$$EQC1_{it} = \sum_{j} \sum_{g} \left(\frac{Exp\ Sale_{ijgt}}{\sum_j \sum_g Exp\ Sale_{ijgt}} \right) qual_{jgt} \qquad (3.8)$$

where $Exp\ Sale_{ijgt}$ is firm *i*'s revenue from selling product *g* in destination market *j* in year *t*. This indicator reflects the intensity of quality competition from China that an Indonesian exporter faces in all of Indonesia's export markets. Similarly, we can construct $EQC2_{it}$ using the export shares in the initial year:

$$EQC2_{it} = \sum_{j} \sum_{g} \left(\frac{Exp\ Sale_{ijg,initial\_year}}{\sum_j \sum_g Exp\ Sale_{ijg,initial\_year}} \right) qual_{jgt} \qquad (3.8')$$

Table 1 presents the evolution of the firm-level quality competition index in both the domestic and export markets, using the sales in the current and initial year to construct weights, respectively.

Table 1. Quality Competition Indices from China

	$DQC1_{it}$		$DQC2_{it}$		$EQC1_{it}$		$EQC2_{it}$	
Year	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2008	0.881	0.694	0.881	0.694	0.789	0.540	0.789	0.540
2009	1.055	0.729	0.828	0.764	0.891	0.551	0.749	0.569
2010	0.832	0.796	0.601	0.766	0.695	0.613	0.504	0.558

Note: The table presents the evolution of Indonesian firm-specific indices measuring the intensities of quality competition from Chinese competitors over time. $DQC1_{it}$ and $DQC2_{it}$ measure the intensities of quality competition from Chinese competitors faced by Indonesian firms in the Indonesian domestic market, while $EQC1_{it}$ and $EQC2_{it}$ measure the intensities of quality competition from Chinese competitors faced by Indonesian firms in other countries, namely in the export market.
Source: Authors.

3.4. Empirical specification

To investigate the effects of quality competition from China on Indonesian firm productivity in Indonesia's domestic market, we set up the following specification:

$$ln(TFP_{it}) = \beta_1 \times DQC1_{it} + \theta X_{it} + \mu_i + \delta_t + \epsilon_{it} \qquad (3.9)$$

where $ln(\varphi_{it})$ is the TFP of Indonesian firms measured using the Olley-Pakes algorithm. $DQC1_{it}$ is the quality competition index of Chinese products faced by an Indonesian firm *i* in year *t* in the domestic market, as constructed in equation (3.7). A positive estimated value of β_1 is consistent with the pro-competitive effect induced by the quality upgrading of imports from China in Indonesia's domestic market. To mitigate a possible bias induced by the interaction between quality competition and market share, we also test this with $DQC2_{it}$ in the empirical analysis.

In addition, we also include a series of control variables, X_{it}, that might also exert an effect on a firm's TFP. First, we include two dummies indicating whether a firm is an exporter (FX_{it}) or an importer (FM_{it}) to control for the possible 'learning by exporting' or 'learning by importing' effects. Second, we also control for the log of the capital-labour ratio, kl_{it}, to account for the fact that capital-intensive firms tend to be more productive. Last, the error term is composed of three components: (i) a firm-specific fixed effect, μ_i, that captures time-invariant unobservable variables affecting productivity; (ii) a year-specific fixed effect, δ_t, that captures overall variation of productivity; (iii) an idiosyncratic effect, ϵ_{it}, which is independently distributed.

Similarly, we also test the hypothesis that quality competition from China in the export market could yield effects on the productivity of Indonesian exporters. The specification is:

$$ln(TFP_{it}) = \beta_1 \times EQC1_{it} + \theta X_{it} + \mu_i + \delta_t + \epsilon_{it} \qquad (3.10)$$

Compared with equation (3.9), the only difference in (3.10) is that we replace the quality competition index in the domestic market, $DQC1_{it}$, with the quality competition index in the export market, $EQC1_{it}$. Equation (3.9) is used to estimate for all manufacturing firms, while equation (3.10) is used to estimate the sample of exporters only. We can also replace $EQC2_{it}$ with $EQC1_{it}$ to mitigate the potential bias.[5]

Finally, we combine the quality competition from China in Indonesia's domestic and export markets to assess the relative magnitude of domestic and export competition in affecting a firm's productivity. We set up the following specification:

$$ln(TFP_{it}) = \beta_1 \times DQC1_{it} + \beta_2 \times EQC1_{it} + \theta X_{it} + \mu_i + \delta_t + \epsilon_{it} \qquad (3.11)$$

Equation (3.11) presents the significance and magnitudes of β_1 and β_2 to assess the relative importance of quality competition in the domestic and export markets, respectively.

Before conducting regression analyses, it is worth checking the simple correlations between quality competition measures and firm productivity. It is clearly observed in Table 2 that firm productivity exhibits a significant and consistent correlation with the quality competition index. Moreover, the correlation between productivity and export quality competition is stronger than domestic quality competition. The quality competition indices in the domestic and export markets are also significantly positively correlated.

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[5] Recall equations (3.8) and (3.8′).

Table 2. Correlation between Firm Productivity and the Firm-specific Quality Competition Index

	$\boldsymbol{DQC1_{it}}$	$\boldsymbol{DQC2_{it}}$	$\boldsymbol{EQC1_{it}}$	$\boldsymbol{EQC2_{it}}$
Firm TFP	0.077***	0.081***	0.110***	0.101***
$DQC1_{it}$		0.790***	0.117***	0.088***
$DQC2_{it}$			0.068***	0.079***
$EQC1_{it}$				0.808***

Note: The table presents a simple correlation between firm productivity and firm-specific quality competition indices in the domestic and export markets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.
Source: Authors.

4. Data and Data Sources

To investigate the effects of quality competition on firm productivity, we use comprehensive and disaggregated datasets from Indonesia and China to construct the variables of interest.

We use Indonesian firm-level production data to calculate the productivity of Indonesian firms, which is the key dependent variable in our analysis. We use Chinese firm-level production data combined with Chinese product-level trade data to calculate China's firm-product-year-level export quality to Indonesia. We then aggregate these quality indices to generate average export quality from China to Indonesia at the HS 6-digit level. This average export quality index is then used to construct a firm-specific index of the quality competition from China faced by Indonesian firms, both in the domestic and export markets.

4.1. Indonesian firm-level production data and customs export-import data

The Indonesian firm-level production data are from the Manufacturing Survey of Large and Medium-sized Firms (Survey Industry, or SI), issued by Statistics Indonesia

(*Badan Pusat Statistik*, or BPS). We call it the Indonesian firm dataset (IFD). The survey is conducted every year and covers all manufacturers in Indonesia with over 20 employees. The data span from 2000 to 2010.[6] The SI dataset contains firm-level information on output; expenses on domestic raw materials and imported materials; capital expenses; the number of employees; domestic sales; export and import status, the shares of exports and imports; and other firm characteristics that are essential for us to construct the measure of productivity of the Indonesian firms.

We use merged data of SI and customs firm-level data on exports and imports provided by Statistics Indonesia, which provides each firm's domestic and export sales at the HS 10-digit product level from 2008 to 2010.[7] This comprehensive information enables us to construct a firm-specific domestic quality competition index that measures the quality competition from China in the domestic market faced by Indonesian firms. In the empirical analysis, we combine the average export quality from China to Indonesia with Indonesian firms' shares of domestic (and export) sales to generate firm-specific quality competition indices for the domestic market. Since the HS 6-digit level is the most disaggregated product level compatible across countries, we aggregate each firm's domestic sales to the HS 2007 6-digit level before constructing the quality competition index.[8]

To construct a firm-specific export quality competition index, we turn to product-level trade data, as discussed in Section 4.2.

4.2. Indonesian product-level trade data

Indonesian product-level trade data are also available from 2008 to 2010. This dataset is also provided by Statistics Indonesia, which records information on the

[6] This dataset is used by Amiti and Konings (2007) to study how trade liberalisation affects Indonesian firms' TFP, via both output tariff and input tariff reductions.
[7] Statistics Indonesia merges the SI data and customs firm-level data by using a combination of the firm ID number (PSID), tax number, phone number, and address.
[8] We also aggregate product-level export data to the HS 2007 6-digit level for the same compatibility concern.

dollar export value, export volume, destination, and product category up to the HS 10-digit level for each exporter in each year. We aggregate each firm's dollar export value and volume to the HS 2007 6-digit level for each destination and year before constructing the quality competition index in the export market.

One important note is that the firms' identity numbers in the Indonesian product-level trade data are of the same coding system as those in the SI dataset. Therefore, we can readily match the export information with the SI dataset using the firm identity number (*Kode Identitas Pendirian Usaha*, PSID).

4.3. Chinese firm-level production data

The Chinese firm-level production data is collected and maintained by China's National Bureau of Statistics. We call it the Chinese firm dataset (CFD). The dataset covers all state-owned industrial firms and all non-state-owned industrial firms with annual sales exceeding CNY5 million. Therefore, the CFD consists of large and medium-sized enterprises. The dataset records comprehensive production information (gross output, material inputs, employment, export sales, and other firm characteristics) and financial information (assets, fixed assets, and other variables). Yu (2015) uses the CFD to study how the effect of output tariffs and input tariffs on firm TFP substantially differ for processing firms and non-processing firms. The dataset spans from 1998 to 2010, and we use this dataset to construct Chinese firm productivity, which is needed to calculate the Chinese export quality (see Section 3.1 for the detailed calculation procedure).

We acknowledge the shortcomings of the CFD, according to Brandt, Van Biesebroeck, and Zhang (2012) and Feenstra, *et al.* (2014). A part of the sample in the CFD suffers from missing or misleading information. Hence we conduct a data filtering procedure before using the data. Following Yu (2015), we specifically omit the observations that: have missing values for assets, the net value of fixed assets, sales, gross output, or firm identity number; have a greater value of current assets than total assets; have a greater value of fixed assets than total assets; have a greater value of net value of fixed assets than total assets; or have an establishment month that is less than 1 or greater than 12.

The filtered CFD dataset is then used to construct the Chinese firm-level productivity measures.

4.4. Chinese product-level trade data

The Chinese product-level trade dataset comes from the General Administration of Customs of China (Chinese Customs (CC) dataset). The CC dataset records information on the dollar export value, export volume, destination, product category up to the HS 8-digit level, and export mode for each exporter. The time span we use is from 2008 to 2010. As noted by Yu (2015) and Dai, *et al.* (2016), in China, processing exports possess entirely different production features from ordinary exports.[9] To avoid unnecessary complications induced by the mixture of export mode, we keep only ordinary exports in our sample. We then combine each firm's export value and volume at the HS 2007 6-digit level to each destination in each year before constructing a measure of the firm-product-year-level export quality to Indonesia.

One point worth noting is that the CC dataset and CFD dataset have different coding systems for the firm identity numbers. We therefore follow Yu (2015) and Dai, *et al.* (2016) to match these two datasets using each firm's Chinese name, as well as the zip code and the last seven digits of the phone number.

[9] Processing trade refers to the production activity in which the firm imports intermediate inputs, processes these inputs to produce outputs, and exports these outputs to other countries. Therefore, imported inputs (exported outputs) related to processing trade as defined as processing imports (exports). In contrast, inputs used mainly for the production of ordinary exports are mainly from the domestic market.

5. Estimation Results

5.1. Quality competition in the domestic market

First, we examine how the quality competition from China in Indonesia's domestic market affects Indonesian firm productivity. Table 3 presents the estimation results of equation (3.9) with various specifications. Column 1 presents the regression results of the impact of quality competition on firm productivity in Indonesia's domestic market, controlling only for year-specific fixed effects. In column 2, we further include firm-specific fixed effects to capture the time-invariant unobservable variable, within firm variation, that may affect firm productivity. Quality competition from China significantly affects Indonesian firm productivity in Indonesia's domestic market.

We further control for the firm-level variables in Table 3, columns 3, 4, and 5 by including firm exporter and importer dummies to capture potential 'learning by exporting' or 'learning by importing' effects that could improve firm productivity; and also control for the firm log capital-labour ratio to allow for the possibility that firm-level capital intensity might also exert some effect on firm productivity. Columns 3, 4, and 5 show consistent estimates for the coefficient of $DQC1_{it}$, in terms of both significance and magnitude. Tougher quality competition from China in the domestic market is positively associated with firm productivity; an increase of 10 percent in quality competition will increase an Indonesian firm's productivity in Indonesia's domestic market by about 0.5 percent.

Firms might shift the share among products due to different degrees of quality competition. One concern is that $DQC1_{it}$ may result in biased estimations. To mitigate this potential concern, we replace $DQC1_{it}$ with $DQC2_{it}$ in Table 3, column 6. The estimation yields a positive coefficient of 0.036, significant at the 10 percent level. As Indonesia is a large, archipelagic country, one may argue that Indonesian firms located in different islands may have different productivity trends.[10] We

[10] An additional concern is that firms from different provinces may have different time trends.

therefore further include province-year-specific fixed effects in Table 3, columns 7 and 8, to control for the potential province-specific time trend, where $DQC1_{it}$ and $DQC2_{it}$ are used separately. Our results show that by controlling for a province-specific time trend, the quality competition from China robustly improves Indonesian firm productivity; an increase of 10 percent in quality competition will improve an Indonesian firm's productivity by around 0.5 percent in Indonesia's domestic market.

Table 3. Quality Competition and Firm Productivity in the Domestic Market

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	$ln(TFP_{it})$	$ln(TFP_{it})$	$ln(TFP_{it})$	$ln(TFP_{it})$	$ln(TFP_{it})$	$ln(TFP_{it})$	$ln(TFP_{it})$	$ln(TFP_{it})$
$DQC1_{it}$	0.079***	0.052***	0.057***	0.052***	0.056***		0.054***	
	(7.044)	(2.997)	(2.917)	(3.000)	(2.914)		(2.893)	
$DQC2_{it}$						0.036*		0.045**
						(1.911)		(2.416)
FX_{it}			0.031		0.031	0.016	0.023	0.009
			(0.744)		(0.748)	(0.395)	(0.559)	(0.229)
FM_{it}			-0.064		-0.063	-0.065	-0.088	-0.089
			(-0.761)		(-0.742)	(-0.761)	(-1.141)	(-1.141)
kl_{it}				0.020	-0.008	-0.008	-0.009	-0.008
				(1.074)	(-0.409)	(-0.403)	(-0.473)	(-0.463)
Firm-specific FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-specific FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year-specific FE	No	No	No	No	No	No	Yes	Yes
Observations	12,084	12,084	10,537	12,084	10,537	10,537	10,537	10,537
R^2	0.022	0.070	0.137	0.071	0.138	0.136	0.220	0.219

Note: The table reports the estimation results of equation (3.9) and its variants. The t-values corrected for clustering at the firm level are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Authors.

As revealed by Amiti and Konings (2007), Topalova and Khandelwal (2011), and Yu (2015), a reduction in import tariffs could also yield sizeable effects on domestic firm productivity. We, thus, additionally control for this potential omitted variable. Specifically, we construct firm-specific output (input) tariffs by weighting Indonesia's import tariffs at the HS 6-digit product level by using domestic output shares (input shares) within each firm.[11] [12] The output and input tariffs can be measured as:

$$FOT_{it} = \sum_{g} \left(\frac{Dom\ Sale_{igt}}{\sum_g Dom\ Sale_{igt}} \right) tariff_{gt} \qquad (5.1)$$

$$FIT_{it} = \sum_{g} \left(\frac{Input_{igt}}{\sum_g Input_{igt}} \right) tariff_{gt} \qquad (5.2)$$

Table 4 presents the results where we include the firm-specific output tariff, FOT_{it}, and input tariff, FIT_{it}, firm-specific control variables, and firm-specific, year-specific, and province-year fixed effects. The results are consistent with the previous findings that higher quality competition from China will improve Indonesian firm productivity in Indonesia's domestic market and that an increase of 10 percent of competition quality will increase an Indonesian firm's productivity by 0.4–0.5 percent in Indonesia's domestic market.

5.2. Quality competition in the export market

This section investigates whether quality competition from China in Indonesia's export market will also improve Indonesian firm productivity. Table 5 presents the results of various specifications based on equation (3.10). The sample size reduces to around 3,000 firms since we now only include Indonesian exporters in the sample by definition of the specification. Columns 1 and 2 report the simple regressions of the impacts of quality competition on firm productivity. The results show that higher quality competition from China in Indonesia's export market also significantly and positively increases the productivity of Indonesian firms.

[11] The import tariff data are derived from the Trade Analysis and Information System (TRAINS).
[12] Firm-level output and input information at the HS 10-digit level is available from the SI dataset.

In columns 3–8, we control for more firm-level variables, such as importer status, the log of the capital-labour ratio, and the input tariff.[13] We also experiment with different measures of quality competition from China in Indonesia's export market, $EQC1_{it}$ and $EQC2_{it}$. We obtain consistent results. Quality competition from China in Indonesia's export market significantly improves Indonesian exporter productivity. In the full specification included in column 7, where importer status, the capital-labour ratio, and the input tariff are all controlled for, an increase of 10 percent in quality competition in Indonesia's export market will increase Indonesian firm productivity by 2 percent. When we replace $EQC1_{it}$ with $EQC2_{it}$ in column 8, the effect is reduced to 0.94 percent.

Table 4. Quality Competition and Firm Productivity in the Domestic Market: Controlling for Output and Input Tariffs

	(1) $ln(TFP_{it})$	(2) $ln(TFP_{it})$	(3) $ln(TFP_{it})$	(4) $ln(TFP_{it})$
$DQC1_{it}$	0.044**	0.044**		
	(2.263)	(2.263)		
$DQC2_{it}$			0.045**	0.045**
			(2.431)	(2.416)
FOT_{it}	0.007***	0.007***	0.009***	0.009***
	(2.647)	(2.645)	(3.320)	(3.320)
FIT_{it}	0.002	0.002	0.002	0.002
	(0.961)	(0.973)	(0.911)	(0.921)
FX_{it}	0.041	0.041	0.036	0.036
	(0.988)	(0.990)	(0.861)	(0.863)
FM_{it}	-0.093	-0.092	-0.092	-0.091
	(-1.203)	(-1.185)	(-1.186)	(-1.169)
kl_{it}		-0.008		-0.008
		(-0.447)		(-0.424)
Firm-specific FE	Yes	Yes	Yes	Yes
Year-specific FE	Yes	Yes	Yes	Yes
Province-Year-specific FE	Yes	Yes	Yes	Yes
Observations	10,537	10,537	10,537	10,537
R^2	0.221	0.221	0.221	0.222

Notes: The table reports the estimation results of equation (3.9) and its variants, controlling for firm-level output and input tariffs. The t-values corrected for clustering at the firm level are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.
Source: Authors.

[13] We only include the input tariff as a control variable, as the output tariff in the home market is supposed to be less relevant for competition in foreign markets. In contrast, the input tariff in the home market might still play an important role in affecting firm TFP.

Table 5. Quality Competition and Firm Productivity in the Export Market

Dependent Variable	(1) $ln(TFP_{it})$	(2) $ln(TFP_{it})$	(3) $ln(TFP_{it})$	(4) $ln(TFP_{it})$	(5) $ln(TFP_{it})$	(6) $ln(TFP_{it})$	(7) $ln(TFP_{it})$	(8) $ln(TFP_{it})$
$EQC1_{it}$	0.173***	0.202***	0.206***		0.206***		0.206***	
	(3.703)	(3.390)	(3.436)		(3.441)		(3.449)	
$EQC2_{it}$				0.098*		0.095*		0.094*
				(1.792)		(1.747)		(1.735)
FIT_{it}							0.010	0.009
							(1.131)	(1.066)
FM_{it}			-0.180*	-0.171*	-0.188**	-0.179*	-0.186*	-0.176*
			(-1.893)	(-1.764)	(-1.962)	(-1.825)	(-1.938)	(-1.802)
kl_{it}					0.023	0.021	0.023	0.021
					(0.893)	(0.837)	(0.909)	(0.852)
Firm-specific FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-specific FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-Year-specific FE	No	No	No	No	No	No	Yes	Yes
Observations	3,008	3,008	3,008	3,008	3,008	3,008	3,006	3,006
R^2	0.041	0.094	0.095	0.090	0.096	0.091	0.097	0.091

Notes: The table reports the estimation results of equation (3.10) and its variants, controlling for the firm-level input tariff. The t-values corrected for clustering at the firm level are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Source: Authors.

We then combine quality competition from China, both in the domestic and export markets, to examine the relative importance of these two for Indonesian exporters. We estimate equation (3.11) and compare the significances and magnitudes of the coefficients on $DQC1_{it}$ and $EQC1_{it}$. Table 6 presents the results. We observe that in almost all specifications, $DQC1_{it}$ and $EQC1_{it}$ have significantly positive impacts on productivity. For magnitude, quality competition in the export market is found to be more pronounced than in the domestic market. For example, column 4 shows the results when we control for importer status and the log of the capital-labour ratio. Quality competition in both the domestic and export markets significantly increases firm productivity. An increase of 10 percent in quality competition in the domestic market is associated with a 0.85 percent increase in an Indonesian firm's productivity in Indonesia's domestic market, while an increase of 10 percent in quality competition in the export market will raise an Indonesian firm's productivity by 1.68 percent in Indonesia's export market—almost a doubling effect. This pattern still preserves when we further control for firm-specific output and input tariffs in column 5. We find that the effect of quality competition in the domestic market becomes insignificant, while the effect of quality competition in the export market remains significantly positive. Therefore, for Indonesian exporters, quality competition in the export market yields a larger impact on firm productivity than quality competition in the domestic market.

6. Concluding Remarks

Understanding how trade contributes to firm productivity is important for evaluating the effects of trade policy reforms and transitions. In this paper, we propose a specific channel through which domestic firms can benefit from trade competition. We argue that an increase in quality of imported products could increase a domestic firm's productivity, both in the domestic and export markets, through a 'pro-competitive effect'.

Table 6. Quality Competition and Firm Productivity in the Domestic and Export Markets

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	$ln(TFP_{it})$	$ln(TFP_{it})$	$ln(TFP_{it})$	$ln(TFP_{it})$	$ln(TFP_{it})$
$DQC1_{it}$	0.068**	0.092*	0.094*	0.085*	0.075
	(2.068)	(1.813)	(1.836)	(1.663)	(1.265)
$EQC1_{it}$	0.217***	0.172*	0.170*	0.168*	0.166*
	(3.958)	(1.847)	(1.830)	(1.801)	(1.791)
FOT_{it}					0.004
					(0.416)
FIT_{it}					-0.000
					(-0.022)
FM_{it}				-0.208	-0.211
				(-1.004)	(-1.010)
kl_{it}			0.058	0.060	0.060
			(1.317)	(1.363)	(1.371)
Firm-specific FE	No	Yes	Yes	Yes	Yes
Year-specific FE	Yes	Yes	Yes	Yes	Yes
Observations	1,446	1,446	1,446	1,446	1,446
R^2	0.034	0.065	0.070	0.072	0.072

Notes: The table reports the estimation results of equation (3.11) and its variants, controlling for firm-level output tariff and input tariff. The t-values corrected for clustering at the firm level are in parentheses.
*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.
Source: Authors.

We are able to accurately measure the average export quality at the HS 6-digit product level from China to Indonesia using a new approach applied to Chinese micro-level production and trade data. We carefully construct firm-specific quality competition indices, which measure the quality competition intensities induced by Chinese competitors for Indonesian firms, both in the domestic and export markets. Our results suggest that an increase in Chinese exported product quality in Indonesia's domestic market by 10 percent will increase Indonesian firm productivity by 0.4–0.5 percent. For Indonesian exporters, an increase in Chinese exported product quality in the export market by 10 percent will increase Indonesian firm productivity by 1.7 percent, but not so for the same amount of quality increase in the domestic market. Our results suggest a new dimension through which firms and the home country can benefit from opening up to trade.

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Appendix

A.1. Derivation

a. Derivation from equation (2.1) to equation (2.2)

We start from (2.1):

$$E_{jg} = U_{jg}\left[\int_{\omega}\left(\frac{p_{\omega j}}{\left(z_{\omega j}\right)^{\alpha_{jg}}}\right)^{(1-\sigma_g)} d\omega\right]^{\frac{1}{1-\sigma_g}} \qquad (2.1)$$

We also define the quality-adjusted price index P_{jg}:

$$P_{jg} \equiv \left[\int_{\omega}\left(\frac{p_{\omega j}}{z_{\omega j}{}^{\alpha_{jg}}}\right)^{(1-\sigma_g)} d\omega\right]^{\frac{1}{1-\sigma_g}}$$

To derive the demand function for variety s selling at country j, we simply take the partial derivative of E_{jg} with respective to p_{sj}:

$$q_{sj} = \frac{\partial E_{jg}}{\partial p_{sj}} = \frac{U_{jg}}{1-\sigma_g}\cdot\left[\int_{\omega}\left(\frac{p_{\omega j}}{\left(z_{\omega j}\right)^{\alpha_{jg}}}\right)^{(1-\sigma_g)} d\omega\right]^{\frac{1}{1-\sigma_g}-1}\cdot\frac{(1-\sigma_g)}{\left(z_{sj}\right)^{\alpha_{jg}}}\cdot\left(\frac{p_{sj}}{\left(z_{sj}\right)^{\alpha_{jg}}}\right)^{-\sigma_g}$$

We use the result that $U_{jg} = E_{jg}/P_{jg}$ from (2.1) and the expression of the price index P_{jg}, then

$$q_{sj} = \frac{E_{jg}}{P_{jg}}\cdot P_{jg}{}^{\sigma_g}\cdot\left(\frac{p_{sj}}{\left(z_{sj}\right)^{\alpha_{jg}}}\right)^{-\sigma_g}\cdot\frac{1}{\left(z_{sj}\right)^{\alpha_{jg}}} = E_{jg}\cdot P_{jg}{}^{\sigma_g-1}\cdot p_{sj}{}^{-\sigma_g}\cdot z_{\omega j}{}^{\alpha_{jg}(\sigma_g-1)}$$

b. Derivation from equation (2.6) to equation (2.8)

We solve the following profit maximisation problem (2.3):

$$\underset{p_{ijg};\, z_{ijg}}{Max}\left[\left(p_{ijg}{}^{*} - c_i\left(z_{ijg}, w\right)\right)\right]\cdot\frac{\tau_{ijg} q_{ijg}}{tar_{jg}} \qquad (2.3)$$

Notice that

$$c_i(z_{ijg}, w) = \frac{w\left(z_{ijg}\right)^{\frac{1}{\theta_g}}}{\varphi_i}$$

$$q_{ijg} = E_{jg}\cdot P_{jg}{}^{\sigma_g-1}\cdot p_{ijg}{}^{-\sigma_g}\cdot z_{ijg}{}^{\alpha_{jg}(\sigma_g-1)}$$

$$p_{ijg} = (p_{ijg}{}^{*} + T_{ijg})\tau_{ijg}$$

Plugging the expressions above into the firm's maximisation problem (2.3), the problem becomes:

$$\underset{p_{ijg};\, z_{ijg}}{Max} \left[p_{ijg}{}^{*} - \frac{w(z_{ijg})^{\frac{1}{\theta_g}}}{\varphi_i} \right] \cdot \frac{\tau_{ijg}}{tar_{jg}} \cdot E_{jg} \cdot P_{jg}{}^{\sigma_g - 1} \cdot \left[(p_{ijg}{}^{*} + T_{ijg}) \tau_{ijg} \right]^{-\sigma_g} \cdot z_{ijg}{}^{\alpha_{jg}(\sigma_g - 1)}$$

The first order condition with respect to z_{ijg} is therefore:

$$\left[p_{ijg}{}^{*} - \frac{w(z_{ijg})^{\frac{1}{\theta_g}}}{\varphi_i} \right] \cdot \alpha_{jg}(\sigma_g - 1) z_{ijg}{}^{\alpha_{jg}(\sigma_g - 1) - 1} - \frac{1}{\theta_g} \cdot \frac{w(z_{ijg})^{\frac{1}{\theta_g} - 1}}{\varphi_i} \cdot z_{ijg}{}^{\alpha_{jg}(\sigma_g - 1)} = 0$$

$$\frac{1}{\theta_g} \cdot \frac{w(z_{ijg})^{\frac{1}{\theta_g}}}{\varphi_i} = \left[p_{ijg}{}^{*} - \frac{w(z_{ijg})^{\frac{1}{\theta_g}}}{\varphi_i} \right] \cdot \alpha_{jg}(\sigma_g - 1)$$

$$\left[\frac{1}{\theta_g} + \alpha_{jg}(\sigma_g - 1) \right] \cdot \frac{w(z_{ijg})^{\frac{1}{\theta_g}}}{\varphi_i} = \alpha_{jg}(\sigma_g - 1) p_{ijg}{}^{*}$$

$$(z_{ijg})^{\frac{1}{\theta_g}} = \frac{\theta_g \alpha_{jg}(\sigma_g - 1)}{1 + \theta_g \alpha_{jg}(\sigma_g - 1)} \cdot p_{ijg}{}^{*} \cdot \frac{\varphi_i}{w}$$

Taking logs gives

$$\ln(z_{ijg}) = \theta_g \left[\ln(\kappa_{1jg} p_{ijg}{}^{*}) - \ln\left(\frac{w}{\varphi_i}\right) \right] \qquad (2.7)$$

where

$$\kappa_{1jg} = \frac{\theta_g \alpha_{jg}(\sigma_g - 1)}{1 + \theta_g \alpha_{jg}(\sigma_g - 1)}$$

By adding subscript *t*, we have equation (2.8)

$$\ln(z_{ijgt}) = \theta_g \left[\ln(\kappa_{1jg}) + \ln(p_{ijgt}{}^{*}) + \ln(\varphi_{it}) - \ln(w_t) \right] \quad (2.8)$$

A.2. Results of the Production Function Estimation

Table A1. Production Function of Indonesian Manufacturers

ISIC code	Industry	Labour	Materials	Capital
15	Food Products and Beverages	0.316	0.648	0.092
16	Tobacco Products	0.177	0.908	0.064
17	Textiles	0.347	0.660	0.076
18	Apparel	0.431	0.594	0.087
19	Tanning and Dressing of Leather	0.290	0.704	0.008
20	Wood and Products of Wood and Cork	0.281	0.684	0.067
21	Paper and Paper Products	0.311	0.690	0.033
22	Publishing, Printing, and Reproduction of Recorded Media	0.474	0.615	0.026
23	Coke, Refined Petroleum Products, and Nuclear Fuel	0.407	0.698	0.022
24	Chemicals and Chemical Products	0.312	0.707	0.060
25	Rubber and Plastics Products	0.296	0.678	0.037
26	Other Non-metallic Mineral Products	0.428	0.575	0.053
27	Basic Metals	0.177	0.775	0.128
28	Fabricated Metal Products, except Machinery and Equipment	0.288	0.715	0.072
29	Machinery and Equipment N.E.C.	0.352	0.643	0.182
31	Electrical Machinery and Apparatus nec.	0.274	0.705	0.017
32	Radio, Television, Communication Equipment, and Apparatus	0.375	0.583	0.125
34	Motor Vehicles, Trailers, and Semi-trailers	0.348	0.665	0.065
35	Other Transport Equipment	0.261	0.711	0.169
36	Furniture; Manufacturing N.E.C.	0.348	0.647	0.036

Note: The production functions of Indonesian manufacturers are estimated using the gross-output production function.

Table A2. Production Function of Chinese Manufacturers

CIC code	Industry	Labour	Capital
13	Processing of Foods	0.458	0.347
14	Manufacture of Foods	0.476	0.349
15	Beverages	0.513	0.348
17	Textiles	0.414	0.323
18	Apparel	0.519	0.297
19	Leather	0.439	0.273
20	Timber	0.404	0.335
21	Furniture	0.566	0.287
22	Paper	0.437	0.303
23	Printing	0.440	0.320
24	Article of Culture and Sports	0.490	0.271
26	Raw Chemicals	0.342	0.390
27	Medicines	0.492	0.376
28	Chemical Fibres	0.449	0.397
29	Rubber	0.370	0.397
30	Plastics	0.403	0.328
31	Non-metallic Minerals	0.312	0.398
32	Smelting of Ferrous Metals	0.437	0.393
33	Smelting of Non-ferrous Metals	0.392	0.344
34	Metal	0.388	0.327
35	General Machinery	0.422	0.378
36	Special Machinery	0.444	0.392
37	Transport Equipment	0.491	0.387
39	Electrical Machinery	0.447	0.397
40	Communication Equipment	0.539	0.307
41	Measuring Instruments	0.445	0.286
42	Artwork and Miscellaneous	0.427	0.305

Note: Production functions of Chinese manufacturers are estimated using value-added production function.

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