The Margins of Intermediate Goods Trade: Theory and Evidence*

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Abstract

This paper develops a heterogeneous-firm model in which firms in asymmetric countries in terms of sizes and trade costs export and import intermediate goods subject to selection. We show that the elasticity with respect to variable trade costs is greater for intermediate goods than for final goods, mainly due to the extensive margin. Using China Customs data with tariff-gravity data, we empirically assess the impact of tariffs as well as distances on China's imports and find empirical evidence in support of our prediction of the model.

Keywords: Intermediate goods trade, gravity equation, extensive margin, intensive margin
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1 Introduction

Intermediate goods are a large and growing share of international trade relative to final goods. It is often argued that the advancement in information and communication technology allows firms organizing production on a global scale to fragment production processes by "outsourcing" or "offshoring," which is a key factor in increasing trade flows of intermediate goods. In fact, there are a lot of studies suggesting that the distinction between intermediate goods trade and final goods trade is crucial. For example, Johnson and Noguera (2012) show that intermediate goods account for approximately two thirds of international trade; Yi (2003, 2010) shows that vertical specialization in intermediate goods amplifies the effect of trade liberalization on trade in final goods. Despite the stylized facts, few papers have theoretically and empirically explored a distinctive feature of intermediate goods trade that is absent in final goods trade.

We develop a heterogeneous-firm model in which firms in asymmetric countries in terms of sizes and trade costs export and import intermediate goods subject to selection. Each industry is composed of the upstream and downstream sectors, where firms in the former (latter) sector can export (import) intermediate goods. While firms in the upstream sector incur fixed costs to export their intermediate goods, firms in the downstream sector also incur fixed costs to source imported intermediate goods (see Kasahara and Lapham (2013) and Halpern et al. (2015) for empirical evidence on such fixed costs). Consequently, firms self-select not only into the export market in the upstream sector but also into the import market in the downstream sector, which allows us to capture empirical patterns that, just as in exporters, importers are larger and more productive than non-importers within the same industries (Bernard et al., 2007, 2012, 2018a). In this setting, we derive a gravity equation of intermediate goods to explore the difference in the trade elasticities between intermediate goods and final goods.

In our model, the value of intermediate goods trade between country i and country j is

$$Trade^I_{ij} = \frac{GDP_i^{\alpha} \times GDP_j^{\beta}}{(Trade\ barriers_{ij})^{\varepsilon^I}}.$$

This is similar to a gravity equation of final goods in that the value of trade is positively affected by sizes of trading countries but is negatively affected by trade barriers between them. In that sense, the gravity equation also holds for intermediate goods let alone final goods. However, when comparing the trade elasticities of the gravity equation of final goods $Trade^F_{ij}$, we find that the trade elasticities with respect to trade barriers are *endogenously* greater for intermediate goods than for final goods, i.e., $|\varepsilon^I| > |\varepsilon^F|$. The difference arises through which trade barriers on final goods affect selection into only the downstream sector, but trade barriers on intermediate goods affect selection into both the upstream and downstream sectors. This means that there is an extra adjustment in the set of firms (extensive margin) in intermediate goods trade that is absent in final goods trade, thereby raising the trade elasticities of intermediate goods. The finding could help us obtain a better understanding about rapidly rising trade in intermediate goods relative to final goods as reviewed above.

To empirically assess this theoretical prediction, we explore the impact of tariffs as well as distances on China's imports combining China Customs data with tariff-gravity data. We first estimate the gravity equation with full samples without distinguishing between final goods and intermediate goods. Not surprisingly, we find that both distances and tariffs have a negative impact on trade flows while GDPs have a positive impact on these trade flows. Further, when the total imports are decomposed into the extensive and intensive margins, these relationships are explained relatively more by the extensive margin than the intensive margin, conforming well with the results in the existing empirical literature. We then estimate the gravity equation with samples distinguishing between the two types of goods. In this case, several differences arise between them. We find that the two variable trade costs have a negative impact on trade flows for final goods and intermediate goods, but the estimated coefficients on these trade costs are significantly greater for intermediate goods than for final goods. In addition, a large part of differences in the trade elasticities is significantly explained by differences in the extensive margin, which is consistent with our theory that the differences come mainly from the extensive margin. In sum, we find empirical evidence on the elasticity with respect to variable trade costs in support of our theoretical prediction of the model.

This paper contributes to large literatures of the gravity equation with heterogeneous firms. In terms of theoretical perspectives, our paper is particularly close to Chaney (2008). As in his work that applies to final goods trade, the extensive margin plays a key role in developing the gravity equation of heterogeneous firms in intermediate goods trade as well. In contrast to his work, we show that intermediate goods trade has an extra adjustment through the extensive margin, which is not only absent in final goods trade but is also indispensable in understanding why the trade elasticities are greater for intermediate goods than for final goods. Like ours, several papers have explored a distinctive feature of intermediate goods trade theoretically and empirically. Antràs et al. (2017), Bernard et al. (2018b) and Melitz and Redding (2014b) are especially close to our work among others. This paper is different from theirs, however, because we pay attention to two-sided heterogeneity in which selection into the export (import) market operates through paying fixed trade costs in the upstream (downstream) sector.

In terms of empirical perspectives, besides the gravity literature that studies the impact of distances (e.g., Bernard et al., 2007, 2011; Eaton et al., 2004, 2011; Helpman et al., 2008), this paper is closely related to the emerging literature that tries to identify the impact of tariffs on the extensive and intensive margins (e.g., Debaere and Mostashari, 2010; Buono and Lalanne, 2012). One of the most crucial differences from these papers is that we make a clear distinction between final goods and intermediate goods, and show that the trade elasticities with respect to tariffs as well as distances are significantly greater for intermediate goods than for final goods, mainly through the extensive margin. We also tackle the well-known problem in interpreting distances as a proxy of variable trade costs, i.e., we cannot control for country fixed effects along with distances (see Buono and Lalanne (2012) for detailed discussions). Noticing the fact that tariffs vary not only along product and country but also along time, we conduct a different set of specifications and confirm that the result is robust to them.

The current paper is most closely related to Ara (2019). The main difference from Ara (2019) is that, allowing for country asymmetry, we can examine the asymmetric impact of reductions in trade costs on liberalizing and non-liberalizing countries and aggregate trade flows between these trading countries (Ara (2019) considers only a symmetric-country setup). Exploiting this model property, we then empirically test the trade elasticity difference between different types of goods and provide empirical evidence in support of our prediction of the model.

2 Theory

We extend a model setup in Ara (2019) to a multiple-industry, asymmetric-country framework, which guides us to estimate the gravity equation derived from the model in the next section. We show that the trade elasticities are greater for intermediate goods than for final goods.

2.1 Setup

There are two potentially asymmetric countries. Each country has $S+1$ industries where $s=0$ is a homogeneous good, and the remaining $s \geq 1$ industries produce differentiated goods. Labor is only a factor of production and country i is endowed with $\bar{L}_i$ units of labor. The homogeneous good is produced with one unit of labor and freely tradable, and is chosen as a numeraire of the model. In contrast, each of the differentiated goods industries is composed of the upstream and downstream sectors that are monopolistically competitive.

Firm behavior is similar to Melitz (2003). Upon paying fixed entry costs f_{is}^E in country i, intermediate goods firms draw productivity ϕ from a distribution $G_{is}^I(\phi)$; final goods firms draw productivity φ from a distribution $G_{is}^F(\varphi)$. When exporting inputs from country j to country i, intermediate goods firms incur variable trade costs τ_{jis}^I and fixed trade costs f_{jis}^I where $\tau_{jjs}^I = 1$ and $(\tau_{jis}^I)^{\sigma_s-1} f_{jis}^I > f_{jjs}^I$. In contrast, when importing inputs from country j to country i, final goods firms incur fixed trade costs f_{jis}^F where $(\tau_{jis}^I)^{\sigma_s-1} f_{jis}^F > f_{iis}^F$. This means that final goods firms using only domestic inputs in country i incur only f_{iis}^F, while those using both domestic inputs in country i and imported inputs from country j incur both f_{iis}^F and f_{jis}^F. Hereafter the former (latter) firms are referred to as *domestic-sourcing* (*foreign-sourcing*) firms. Though final goods firms can also export by incurring variable trade costs τ_{jis}^F and fixed trade costs f_{jis}^F where $\tau_{jjs}^F = 1$ and $(\tau_{jis}^F)^{\sigma_s-1} f_{jis}^F > f_{jjs}^F$, we first assume that intermediate goods are only tradable and final goods are prohibitively costly to trade across borders by setting $\tau_{jis}^I < \infty$ and $\tau_{jis}^F = \infty$.

Following Helpman et al. (2008) and Melitz and Redding (2014a), it is useful to define

$$J_{is}^h(a^*) = \int_{a^*}^{\infty} \left[\left(\frac{a}{a^*} \right)^{\sigma_s - 1} - 1 \right] dG_{is}^h(a),$$
$$V_{is}^h(a^*) = \int_{a^*}^{\infty} a^{\sigma_s-1} dG_{is}^h(a),$$

where $J_{is}^h(a^*)$ and $V_{is}^h(a^*)$ are strictly decreasing in a^* for $h \in \{F, I\}$.

2.2 Consumers

The preferences of consumers are defined as Cobb-Douglas across industries:

$$U_i = \sum_{s=0}^{S} \beta_s \ln Q_{is}, \qquad \sum_{s=0}^{S} \beta_s = 1,\ \beta_s \geq 0.$$

As noted above, industry $s = 0$ is the freely-tradable homogeneous good. In the analysis below, we require that β_0 is large enough that all countries produce the homogeneous good. For each of the differentiated goods industry $s \geq 1$, consumers' preferences are given by a standard C.E.S. Dixit-Stiglitz form:

$$Q_{is} = \left(\int_0^{M_{iis}} q_{iis}(\omega)^{\frac{\sigma_s - 1}{\sigma_s}} d\omega + \int_0^{\tilde{M}_{iis}} \tilde{q}_{iis}(\omega)^{\frac{\sigma_s - 1}{\sigma_s}} d\omega \right)^{\frac{\sigma_s}{\sigma_s - 1}}, \quad \sigma_s > 1,$$

where $q_{iis}(\omega)$ and $\tilde{q}_{iis}(\omega)$ are respectively final goods produced by domestic-sourcing firms and foreign-sourcing firms, while M_{iis} and $\tilde{M}_{iis}$ are the masses of these firms in country i.

Utility maximization yields the demand functions for final goods:

$$\begin{aligned} q_{iis}(\omega) &= R^F_{iis} P^{\sigma_s - 1}_{iis} p_{iis}(\omega)^{-\sigma_s}, \\ \tilde{q}_{iis}(\omega) &= R^F_{iis} P^{\sigma_s - 1}_{iis} \tilde{p}_{iis}(\omega)^{-\sigma_s}, \end{aligned}$$

where

$$P_{is} = \left(\int_0^{M_{iis}} p_{iis}(\omega)^{1-\sigma_s} d\omega + \int_0^{\tilde{M}_{iis}} \tilde{p}_{iis}(\omega)^{1-\sigma_s} d\omega \right)^{\frac{1}{1-\sigma_s}}$$

is the price index of final goods. The Cobb-Douglas upper tier of utility implies that consumers spend $R^F_{is} = \beta_s \bar{L}_i$ on goods produced by industry s (as aggregate income of country i is $\bar{L}_i$ due to free entry).

2.3 Final goods firms

Final goods firms' technologies are also given by a C.E.S. production function with elasticity σ_s:

$$\begin{aligned} q_{iis} &= \varphi \left(\int_0^{N_{iis}} x_{iis}(v)^{\frac{\sigma_s - 1}{\sigma_s}} dv \right)^{\frac{\sigma_s}{\sigma_s - 1}}, \\ \tilde{q}_{iis} &= \varphi \left(\int_0^{N_{iis}} \tilde{x}_{iis}(v)^{\frac{\sigma_s - 1}{\sigma_s}} dv + \int_0^{N_{jis}} \tilde{x}_{jis}(v)^{\frac{\sigma_s - 1}{\sigma_s}} dv \right)^{\frac{\sigma_s}{\sigma_s - 1}}, \end{aligned} \tag{1}$$

where $x_{iis}(v)$, $\tilde{x}_{iis}(v)$ and $\tilde{x}_{jis}(v)$ are respectively domestic inputs and imported inputs used by domestic-sourcing firms and foreign-sourcing firms, while N_{iis} and N_{jis} are the masses of intermediate goods firms that produce in country i and export from country j to country i. To facilitate the analysis below, we follow Bernard et al. (2018b) in assuming that the elasticity of substitution between intermediate goods is identical with the elasticity of substitution between final goods, but this would not affect the qualitative results of the paper. The expenditures of these firms are given by

$$
\begin{aligned}
e_{iis} &= \int_0^{N_{iis}} \gamma_{iis}(v) x_{iis}(v) dv, \\
\tilde{e}_{iis} &= \int_0^{N_{iis}} \tilde{\gamma}_{iis}(v) \tilde{x}_{iis}(v) dv + \int_0^{N_{jis}} \tilde{\gamma}_{jis}(v) \tilde{x}_{jis}(v) dv,
\end{aligned}
$$

where $\gamma_{iis}(v)$, $\tilde{\gamma}_{iis}(v)$ and $\tilde{\gamma}_{jis}(v)$ are respectively domestic input prices and imported input prices faced by domestic-sourcing firms and foreign-sourcing firms. These input prices satisfy

$$
\tilde{\gamma}_{jis}(v) = \tau_{jis}^I \tilde{\gamma}_{iis}(v) = \tau_{jis}^I \gamma_{iis}(v). \tag{2}
$$

Cost minimization yields the demand functions for intermediate goods:

$$
\begin{aligned}
x_{iis}(v) &= e_{iis} \Gamma_{is}^{\sigma_s - 1} \gamma_{iis}(v)^{-\sigma_s}, \\
\tilde{x}_{iis}(v) &= \tilde{e}_{iis} \tilde{\Gamma}_{is}^{\sigma_s - 1} \tilde{\gamma}_{iis}(v)^{-\sigma_s}, \\
\tilde{x}_{jis}(v) &= (\tau_{jis}^I)^{-\sigma_s} \tilde{x}_{iis}(v),
\end{aligned} \tag{3}
$$

where Γ_{is} and $\tilde{\Gamma}_{is}$ are the unit cost functions for final goods production for each type of firms:

$$
\begin{aligned}
\Gamma_{is} &= \left(\int_0^{N_{iis}} \gamma_{iis}(v)^{1-\sigma_s} dv \right)^{\frac{1}{1-\sigma_s}}, \\
\tilde{\Gamma}_{is} &= \left(\int_0^{N_{iis}} \tilde{\gamma}_{iis}(v)^{1-\sigma_s} dv + \int_0^{N_{jis}} \tilde{\gamma}_{jis}(v)^{1-\sigma_s} dv \right)^{\frac{1}{1-\sigma_s}}.
\end{aligned}
$$

As will become clear later, these unit cost functions satisfy

$$
\tilde{\Gamma}_{is}^{1-\sigma_s} = \left[1 + (\tau_{jis}^I)^{1-\sigma_s} \Lambda_{jis}^I \right] \Gamma_{is}^{1-\sigma_s}, \tag{4}
$$

where Λ_{jis}^I is the (endogenous) market share of intermediate goods exporters from country j to country i. To understand this, suppose that τ_{jis}^I is sufficiently large that no intermediate goods firm exports ($\Lambda_{jis}^I = 0$), which makes the unit cost the same across firms. Evidence suggests, however, that not all firms access imported inputs and firms using both domestic and imported inputs have a cost advantage over firms using only domestic inputs (e.g., Halpern et al., 2015). Thus we restrict attention to the range of τ_{jis}^I that allows for selection into the export market in the upstream sector ($\Lambda_{jis}^I < 1$), which makes the unit cost lower for firms using imported inputs. Intuitively, foreign-sourcing firms using both domestic and imported inputs can exploit a "love-of-variety" effect and raise their production efficiency.

For now, we will focus on a particular industry $s \geq 1$ and drop the s subscript from relevant variables for notational simplicity.

Substituting (3) into (1) yields

$$q_{ii} = \varphi \frac{e_{ii}}{\Gamma_i} \iff e_{ii} = \frac{\Gamma_i}{\varphi} q_{ii},$$
$$\tilde{q}_{ii} = \varphi \frac{\tilde{e}_{ii}}{\tilde{\Gamma}_i} \iff \tilde{e}_{ii} = \frac{\tilde{\Gamma}_i}{\varphi} \tilde{q}_{ii}.$$

The profits of the two types of firms are then

$$\pi_{ii}^F = p_{ii} q_{ii} - \frac{\Gamma_i}{\varphi} q_{ii} - f_{ii}^F,$$
$$\tilde{\pi}_{ii}^F = \tilde{p}_{ii} \tilde{q}_{ii} - \frac{\tilde{\Gamma}_i}{\varphi} \tilde{q}_{ii} - f_{ii}^F - f_{ji}^F.$$

The pricing rules are given by

$$p_{ii}(\varphi) = \frac{\sigma}{\sigma - 1} \frac{\Gamma_i}{\varphi},$$
$$\tilde{p}_{ii}(\varphi) = \frac{\sigma}{\sigma - 1} \frac{\tilde{\Gamma}_i}{\varphi}.$$

As usual, the pricing rules are a constant markup over marginal cost. Since the unit cost differs between the two types of firms, however, the equilibrium price is lower for foreign-sourcing firms than domestic-sourcing firms for a given productivity level:

$$\tilde{\Gamma}_i < \Gamma_i \implies \tilde{p}_{ii}(\varphi) < p_{ii}(\varphi).$$

Using (4), the equilibrium revenues of the two types of firms are

$$r_{ii}^F(\varphi) = \sigma \Gamma_i^{1-\sigma} B_i^F \varphi^{\sigma-1},$$
$$\tilde{r}_{ii}^F(\varphi) = \sigma \tilde{\Gamma}_i^{1-\sigma} B_i^F \varphi^{\sigma-1},$$

where

$$B_i^F = \frac{(\sigma - 1)^{\sigma-1}}{\sigma^\sigma} R_i^F P_i^{\sigma-1}$$

is the index of final goods market demand in country i. Using these equilibrium revenues, we obtain the equilibrium profits:

$$\pi_{ii}^F(\varphi) = \frac{r_{ii}^F(\varphi)}{\sigma} - f_{ii}^F = \Gamma_i^{1-\sigma} B_i^F \varphi^{\sigma-1} - f_{ii}^F,$$
$$\tilde{\pi}_{ii}^F(\varphi) = \frac{\tilde{r}_{ii}^F(\varphi)}{\sigma} - f_{ii}^F - f_{ji}^F = \tilde{\Gamma}_i^{1-\sigma} B_i^F \varphi^{\sigma-1} - f_{ii}^F - f_{ji}^F.$$

To characterize the equilibrium of the downstream sector, we identify productivity cutoffs that realize zero profit for both domestic-sourcing firms and foreign-sourcing firms. While this cutoff satisfies $\pi_{ii}^F(\varphi_{ii}^*) = 0$ for domestic-sourcing firms, the cutoff satisfies $\pi_{ii}^F(\tilde{\varphi}_{ii}^*) = \tilde{\pi}_{ii}^F(\tilde{\varphi}_{ii}^*)$ for foreign-sourcing firms at which firms are indifferent about whether to use imported inputs:

$$\Gamma_i^{1-\sigma} B_i^F (\varphi_{ii}^*)^{\sigma-1} = f_{ii}^F, \tag{5}$$

$$\Lambda_{ji}^I (\tau_{ji}^I)^{1-\sigma} \Gamma_i^{1-\sigma} B_i^F (\tilde{\varphi}_{ii}^*)^{\sigma-1} = f_{ji}^F, \tag{6}$$

which implies that

$$\left(\frac{\tilde{\varphi}_{ii}^*}{\varphi_{ii}^*}\right)^{\sigma-1} = \frac{1}{\Lambda_{ji}^I} \frac{(\tau_{ji}^I)^{\sigma-1} f_{ji}^F}{f_{ii}^F} > 1. \tag{7}$$

In addition, we also need to impose the free entry condition for final goods firms, which is given by $\int_{\varphi_{ii}^*}^{\tilde{\varphi}_{ii}^*} \pi_{ii}^F(\phi) dG_i^F(\varphi) + \int_{\tilde{\varphi}_{ii}^*}^{\infty} \tilde{\pi}_{ii}^F(\varphi) dG_i(\varphi) = f_i^E$. Using the definition of $J_i^F(\cdot)$ in section 2.1, this condition is rewritten as

$$f_{ii}^F J_i^F(\varphi_{ii}^*) + f_{ji}^F J_i^F(\tilde{\varphi}_{ii}^*) = f_i^E. \tag{8}$$

It is important to note that conditions (5), (6), and (8) cannot characterize the equilibrium of the downstream sector. As shown by (7), the productivity cutoffs are affected by the market share of input exporters Λ_{ji}^I that is endogenously pinned down in the upstream sector. Therefore, any changes in Λ_{ji}^I have a critical impact on selection in the downstream sector.

Aggregate expenditure of consumers is $R_i^F = M_i^E \int_{\varphi_{ii}^*}^{\tilde{\varphi}_{ii}^*} r_{ii}^F(\varphi) dG_i^F(\varphi) + M_i^E \int_{\tilde{\varphi}_{ii}^*}^{\infty} \tilde{r}_{ii}^F(\varphi) dG_i^F(\varphi)$ where M_i^E is the mass of entrants in the downstream sector. Using the definition of $V_i^F(\cdot)$,

$$R_i^F = \sigma B_i^F M_i^E \Gamma_i^{1-\sigma} V_i^F(\varphi_{ii}^*) \left[1 + (\tau_{ji}^I)^{1-\sigma} \tilde{\Lambda}_{ji}^F \Lambda_{ji}^I\right], \tag{9}$$

where

$$\tilde{\Lambda}_{ji}^F = \frac{V_i^F(\tilde{\varphi}_{ii}^*)}{V_i^F(\varphi_{ii}^*)}$$

is the (endogenous) market share of foreign-sourcing firms in country i, which is a counterpart to Λ_{ji}^I in (4). On the other hand, aggregate amount of labor (aggregate labor income from $w_i = 1$) of final goods firms is $L_i^F = M_i^E f_i^E + M_i^E \int_{\varphi_{ii}^*}^{\varphi_{ii}^*} f_{ii}^F dG_i^F(\varphi) + M_i^E \int_{\varphi_{ii}^*}^{\infty} (f_{ii}^F + f_{ji}^F) dG_i^F(\varphi)$, where these firms buy intermediate goods from the market and labor is used for fixed costs only. Using (8),

$$L_i^F = R_i^F - E_i,$$

where $E_i = M_i^E \int_{\varphi_{ii}^*}^{\tilde{\varphi}_{ii}^*} e_{ii}(\varphi) dG_i^F(\varphi) + M_i^E \int_{\tilde{\varphi}_{ii}^*}^{\infty} \tilde{e}_{ii}(\varphi) dG_i^F(\varphi)$ is aggregate expenditure of final goods firms, which is simplified to

$$E_i = (\sigma - 1) B_i^F M_i^E \Gamma_i^{1-\sigma} V_i^F(\varphi_{ii}^*) \left[1 + (\tau_{ji}^I)^{1-\sigma} \tilde{\Lambda}_{ji}^F \Lambda_{ji}^I\right]. \tag{10}$$

From (9), it follows that (10) is a fraction of aggregate expenditure of consumers:

$$E_i = \left(\frac{\sigma - 1}{\sigma}\right) R_i^F.$$

2.4 Intermediate goods firms

Intermediate goods firms' technologies are represented by a linear cost function of inputs. The cost function needs to reflect the fact that only a fraction of final goods firms source domestic and foreign inputs among entrants: the productivity levels for final goods firms who source domestic (foreign) inputs must be greater than φ_{ii}^* ($\tilde{\varphi}_{ii}^*$) among M_i^E entrants. Thus the amounts of labor used for domestic production and exporting by intermediate goods firms are

$$l_{ii}^I = f_{ii}^I + M_i^E \int_{\varphi_{ii}^*}^{\infty} \frac{x_{ii}(\varphi, \phi)}{\phi} dG_i^F(\varphi),$$
$$l_{ji}^I = f_{ji}^I + M_i^E \int_{\tilde{\varphi}_{ii}^*}^{\infty} \frac{\tau_{ji}^I \tilde{x}_{ji}(\varphi, \phi)}{\phi} dG_i^F(\varphi),$$

where $x_{ii}(\varphi, \phi)$ and $\tilde{x}_{ji}(\varphi, \phi)$ are intermediate goods demands by domestic-sourcing firms and foreign-sourcing firms respectively (note that $x_{ii}(\varphi, \phi) = \tilde{x}_{ii}(\varphi, \phi)$ in equilibrium). The profits of the two types of firms are then

$$\pi_{ii}^I = M_i^E \int_{\varphi_{ii}^*}^{\infty} \gamma_{ii} x_{ii}(\varphi, \phi) dG_i^F(\varphi) - M_i^E \int_{\varphi_{ii}^*}^{\infty} \frac{x_{ii}(\varphi, \phi)}{\phi} dG_i^F(\varphi) - f_{ii}^I,$$
$$\pi_{ji}^I = M_i^E \int_{\tilde{\varphi}_{ii}^*}^{\infty} \tilde{\gamma}_{ji} \tilde{x}_{ji}(\varphi, \phi) dG_i^F(\varphi) - M_i^E \int_{\tilde{\varphi}_{ii}^*}^{\infty} \frac{\tau_{ji}^I \tilde{x}_{ji}(\varphi, \phi)}{\phi} dG_i^F(\varphi) - f_{ji}^I.$$

The pricing rules are given by

$$\gamma_{ii}(\phi) = \tilde{\gamma}_{ii}(\phi) = \frac{\sigma}{\sigma - 1} \frac{1}{\phi},$$
$$\tilde{\gamma}_{ji}(\phi) = \frac{\sigma}{\sigma - 1} \frac{\tau_{ji}^I}{\phi}.$$

Thus the pricing rules satisfy (2) for a given productivity level ϕ. Substituting the pricing rules into (3), we obtain intermediate goods demands by domestic-sourcing firms and foreign-sourcing firms that appear in the intermediate goods firms' technologies:

$$x_{ii}(\varphi, \phi) = \tilde{x}_{ii}(\varphi, \phi) = (\sigma - 1) \left(\frac{\sigma - 1}{\sigma} \right)^{\sigma} B_i^F \varphi^{\sigma - 1} \phi^{\sigma},$$
$$\tilde{x}_{ji}(\varphi, \phi) = (\sigma - 1) \left(\frac{\sigma - 1}{\sigma} \right)^{\sigma} (\tau_{ji}^I)^{1-\sigma} B_i^F \varphi^{\sigma - 1} \phi^{\sigma}.$$

Then the equilibrium revenues of the two types of firms are

$$r_{ii}^I(\phi) = M_i^E \int_{\varphi_{ii}^*}^{\infty} \gamma_{ii}(\phi) x_{ii}(\varphi, \phi) dG_i^F(\varphi) = M_i^E \sigma \left(\frac{\sigma - 1}{\sigma} \right)^{\sigma} B_i^F V_i^F(\varphi_{ii}^*) \phi^{\sigma - 1},$$
$$r_{ji}^I(\phi) = M_i^E \int_{\tilde{\varphi}_{ii}^*}^{\infty} \tilde{\gamma}_{ji}(\phi) \tilde{x}_{ji}(\varphi, \phi) dG_i^F(\varphi) = M_i^E \sigma \left(\frac{\sigma - 1}{\sigma} \right)^{\sigma} (\tau_{ji}^I)^{1-\sigma} B_i^F V_i^F(\tilde{\varphi}_{ii}^*) \phi^{\sigma - 1}.$$

These revenues can be expressed in terms of intermediate goods market demand. To show this, note that aggregate revenue of intermediate goods firms R_i^I must equal aggregate expenditure of final goods firms E_i in (10) in equilibrium:

$$R_i^I = E_i \quad \Longleftrightarrow \quad R_i^I = \left(\frac{\sigma-1}{\sigma}\right) R_i^F,$$

where aggregate expenditure of consumers R_i^F is given in (9). Substituting (9) into the above equality and rearranging, the equilibrium revenues are expressed as

$$\begin{aligned} r_{ii}^I(\phi) &= \sigma B_i^I \phi^{\sigma-1}, \\ r_{ji}^I(\phi) &= \sigma \tilde{\Lambda}_{ji}^F (\tau_{ji}^I)^{1-\sigma} B_i^I \phi^{\sigma-1}, \end{aligned}$$

where

$$B_i^I = \frac{(\sigma-1)^{\sigma-1}}{\sigma^\sigma} \lambda_{ii}^I R_i^I \Gamma_i^{\sigma-1}$$

is the index of intermediate goods market demand and λ_{ii}^I is the domestic expenditure share of intermediate goods defined later. The equilibrium profits are then given by

$$\begin{aligned} \pi_{ii}^I(\phi) &= \frac{r_{ii}^I(\phi)}{\sigma} - f_{ii}^I = B_i^I \phi^{\sigma-1} - f_{ii}^I, \\ \pi_{ji}^I(\phi) &= \frac{r_{ji}^I(\phi)}{\sigma} - f_{ji}^I = \tilde{\Lambda}_{ji}^F (\tau_{ji}^I)^{1-\sigma} B_i^I \phi^{\sigma-1} - f_{ji}^I. \end{aligned}$$

To characterize the equilibrium of the upstream sector, we again consider the zero profit cutoff conditions for domestic firms and exporting firms. The productivity cutoffs that satisfy $\pi_{ii}^I(\phi_{ii}^*) = 0$ and $\pi_{ji}^I(\phi_{ji}^*) = 0$ are respectively given by

$$B_i^I (\phi_{ii}^*)^{\sigma-1} = f_{ii}^I, \tag{11}$$

$$\tilde{\Lambda}_{ji}^F (\tau_{ji}^I)^{1-\sigma} B_i^I (\phi_{ji}^*)^{\sigma-1} = f_{ji}^I, \tag{12}$$

which implies that

$$\left(\frac{\phi_{ji}^*}{\phi_{ii}^*}\right)^{\sigma-1} = \frac{1}{\tilde{\Lambda}_{ji}^F} \frac{(\tau_{ji}^I)^{\sigma-1} f_{ji}^I}{f_{ii}^I} > 1. \tag{13}$$

Note importantly the similarity between (7) and (13). Whereas (7) imposes selection into the import market in the downstream sector, (13) imposes selection into the export market in the upstream sector.

In addition, we also need to impose the free entry condition for intermediate goods firms, which is given by $\int_{\varphi_{ii}^*}^\infty \pi_{ii}^I(\phi) dG_i^I(\phi) + \int_{\phi_{ij}^*}^\infty \pi_{ij}^I(\phi) dG_i^I(\phi) = f_i^E$. Using the definition of $J_i^I(\cdot)$ in section 2.1, we can rewrite this condition as

$$f_{ii}^I J_i^I(\phi_{ii}^*) + f_{ij}^I J_i^I(\phi_{ij}^*) = f_i^E. \tag{14}$$

Note as in the downstream sector that conditions (11), (12) and (14) cannot solely characterize the equilibrium in the upstream sector. As shown by (13), the productivity cutoffs are affected by the market share of foreign-sourcing firms $\tilde{\Lambda}_{ji}^F$ that is endogenously pinned down in the downstream sector. Thus, selection into the export/import markets is interdependent through this channel.

Aggregate expenditure of final goods firms is $R_i^I = N_i^E \int_{\phi_{ii}^*}^{\infty} r_{ii}^I(\phi) dG_i^I(\phi) + N_j^E \int_{\phi_{ji}^*}^{\infty} r_{ji}^I(\phi) dG_j^I(\phi)$, where N_i^E is the mass of entrants in the upstream sector. Note that the first (second) subscript denotes the exporting (importing) country and R_i^I consists of expenditure on domestic inputs in country i and imported inputs from country j. Using the definition of $V_i^I(\cdot)$,

$$R_i^I = \sigma B_i^I N_i^E V_i^I(\phi_{ii}^*) \left[1 + (\tau_{ji}^I)^{1-\sigma} \tilde{\Lambda}_{ji}^F \Lambda_{ji}^I\right], \tag{15}$$

where

$$\Lambda_{ji}^I = \frac{N_j^E}{N_i^E} \frac{V_j^I(\phi_{ji}^*)}{V_i^I(\phi_{ii}^*)}$$

is the (endogenous) market share of exporters in the domestic market in (4). Further, from (15), the domestic expenditure share of intermediate goods in the definition of B_i^I is given by

$$\lambda_{ii}^I = \frac{N_i^E \int_{\phi_{ii}^*}^{\infty} r_{ii}^I(\phi) dG_i^I(\phi)}{R_i^I} = \frac{1}{1 + (\tau_{ji}^I)^{1-\sigma} \tilde{\Lambda}_{ji}^F \Lambda_{ji}^I}. \tag{16}$$

The domestic share in (16) proves to be useful for calculating the trade elasticity of intermediate goods in our model. On the other hand, aggregate amount of labor (aggregate labor income from $w_i = 1$) of intermediate goods firms is $L_i^I = N_i^E \int_{\phi_{ii}^*}^{\infty} r_{ii}^I(\phi) dG_i^I(\phi) + N_i^E \int_{\phi_{ij}^*}^{\infty} r_{ij}^I(\phi) dG_i^I(\phi)$, which consists of revenues earned by domestic firms and exporting firms of country i. As with (15), we can simplify this expression as follows:

$$L_i^I = \sigma N_i^E [B_i^I V_i^I(\phi_{ii}^*) + \tilde{\Lambda}_{ij}^F (\tau_{ij}^I)^{1-\sigma} B_j^I V_i^I(\phi_{ij}^*)]. \tag{17}$$

Finally, we express the unit costs in terms of the productivity cutoffs. On the one hand, the unit cost of domestic-sourcing firms is $\Gamma_i^{1-\sigma} = N_i^E \int_{\phi_{ii}^*}^{\infty} (\gamma_{ii}(\phi))^{1-\sigma} dG_i^I(\phi)$, which is expressed as

$$\Gamma_i^{1-\sigma} = \left(\frac{\sigma}{\sigma - 1}\right)^{1-\sigma} N_i^E V_i^I(\phi_{ii}^*). \tag{18}$$

On the other hand, the unit cost of foreign-sourcing firms is $\tilde{\Gamma}_i^{1-\sigma} = N_i^E \int_{\phi_{ii}^*}^{\infty} (\tilde{\gamma}_{ii}(\phi))^{1-\sigma} dG_i^I(\phi) + N_j^E \int_{\phi_{ji}^*}^{\infty} (\tilde{\gamma}_{ji}(\phi))^{1-\sigma} dG_j^I(\varphi)$. Using Λ_{ji}^I defined above, we have (4).

This completes the characterization of the model. To show that the trade elasticity is greater for intermediate goods than for final goods, the next section explores the impact of input trade liberalization on the equilibrium variables and aggregate trade flows. These results cannot be obtained without the endogenous interaction between the vertically-related sectors.

2.5 Equilibrium

Having described the equilibrium conditions in the two production sectors, we now characterize the key variables of our model. Since there are the twelve equations ((5), (6), (8), (11), (12) and (14) that hold in countries i and j), these conditions jointly provide implicit solutions for the following twelve unknowns:

$$\varphi_{ii}^*, \ \varphi_{jj}^*, \ \tilde{\varphi}_{ii}^*, \ \tilde{\varphi}_{jj}^*, \ \phi_{ii}^*, \ \phi_{jj}^*, \ \phi_{ij}^*, \ \phi_{ji}^* \ B_i^F, \ B_j^F, \ B_i^I, \ B_j^I.$$

The labor market clearing condition is omitted by the presence of a freely-tradable outside good where a common wage is measured by the price of that good. The other equilibrium variables, including the mass of entrants M_i^E, N_i^E and the domestic share λ_{ii}^I, can be written as a function of these twelve unknowns.

In what follows, we focus on trade liberalization of intermediate goods because final goods are assumed to be non-tradable. In particular, we study reductions in variable trade costs τ_{ji}^I, which arises when country i unilaterally reduces its variable trade costs of importing from country j. Although the equilibrium characterizations thus far apply to general distributions, we will restrict our attention to a Pareto distribution in the following analysis in order to obtain the closed-form solutions:

$$G_i^F(\varphi) = 1 - \left(\frac{\varphi_{\min}}{\varphi}\right)^k, \quad G_i^I(\phi) = 1 - \left(\frac{\phi_{\min}}{\phi}\right)^k,$$

where $\varphi \geq \varphi_{\min} > 0$ and $\phi \geq \phi_{\min} > 0$. For simplicity, we assume a common shape parameter of the distribution k but different lower bounds $\varphi_{\min}, \phi_{\min}$. Regarding the shape parameter k, in addition to $k > \sigma - 1$ that is usually imposed in the literature, we also restrict the range within which k is not too large (i.e., productivity dispersion is not too small).

Assumption 1 The shape parameter of the Pareto distribution k is not too large.

$$\sigma - 1 < k < 2(\sigma - 1). \tag{19}$$

While the intensive margin elasticity is $\sigma - 1$, the extensive margin elasticity is $k - (\sigma - 1)$ in the downstream and upstream sectors under the distribution. Hence Assumption 1 requires that the extensive margin elasticity is not too large relative to the intensive margin elasticity, which is assumed in the analysis below. (Without this assumption, the signs of the equilibrium variables in Lemmas 1–3 are opposite and trade liberalization reduces aggregate trade flows, which are less likely in reality.)

Solving the system of the twelve equations simultaneously within the range of Assumption 1 leads to the following lemma regarding the productivity cutoffs of intermediate goods firms (see Appendix for proof):

Lemma 1 *Reductions in τ_{ji}^{I} give rise to the following impacts on the productivity cutoffs of intermediate goods firms in the upstream sector:*

$$\frac{\partial \phi_{ii}^{*}}{\partial \tau_{ji}^{I}} > 0, \quad \frac{\partial \phi_{ij}^{*}}{\partial \tau_{ji}^{I}} < 0, \quad \frac{\partial \phi_{jj}^{*}}{\partial \tau_{ji}^{I}} < 0, \quad \frac{\partial \phi_{ji}^{*}}{\partial \tau_{ji}^{I}} > 0.$$

Liberalization in country i makes country j a better export base and induces the additional entry of intermediate goods firms in country j, which allows country j to enjoy a home market effect in the upstream sector and specialize in differentiated intermediate goods. In contrast, country i suffers from increased competition from country j and faces a decline in the entry of intermediate goods firms, and instead specializes in a homogeneous good. This effect – known as firm delocation – has been explored in the recent trade literature assuming the outside good (see, e.g., Demidova, 2008; Demidova and Rodríguez-Clare, 2013; Melitz and Ottaviano, 2008). We show that the effect also arises by input trade liberalization in the upstream sector.

Taking account of this impact on the downstream sector (see (7)), we also have the following lemma regarding the productivity cutoffs of final goods firms:

Lemma 2 *Reductions in τ_{ji}^{I} simultaneously induce changes in the productivity cutoffs of final goods firms in the downstream sector:*

$$\frac{\partial \varphi_{ii}^{*}}{\partial \tau_{ji}^{I}} < 0, \quad \frac{\partial \tilde{\varphi}_{ii}^{*}}{\partial \tau_{ji}^{I}} > 0, \quad \frac{\partial \varphi_{jj}^{*}}{\partial \tau_{ji}^{I}} = \frac{\partial \tilde{\varphi}_{jj}^{*}}{\partial \tau_{ji}^{I}} = 0.$$

Liberalization in country i makes country i a better import base and induces the additional entry of final goods firms in country i, which allows country i to enjoy a home market effect in the downstream sector and specialize also in differentiated final goods. In contrast, there is no impact on entry of downstream firms in country j because the positive effect of the upstream sector (i.e., more firms export which raises final goods demand) is exactly offset by the negative effect in the downstream sector (i.e., less firms import inputs which reduces productivity). One of the key welfare implications is that, even in the presence of the outside good that induces firm delocation, a liberalizing country does not always lose from unilateral trade liberalization, because liberalization in country i raises φ_{ii}^{*} which is one of sufficient statistics of welfare. Thus welfare in the liberalizing country is more nuanced in the multiple-stage production relative to the single-stage production.

Finally, noting that the aggregate market demands are functions of the productivity cutoffs in Lemmas 1 and 2, the following lemma is obtained from the characterization above.

Lemma 3 *Reductions in τ_{ji}^{I} also induce changes in aggregate market demands in both sectors:*

$$\frac{\partial B_{i}^{I}}{\partial \tau_{ji}^{I}} < 0, \quad \frac{\partial B_{j}^{I}}{\partial \tau_{ji}^{I}} > 0, \quad \frac{\partial B_{i}^{F}}{\partial \tau_{ji}^{I}} > 0, \quad \frac{\partial B_{j}^{F}}{\partial \tau_{ji}^{I}} < 0.$$

Liberalization in country i allows country j (country i) to specialize in intermediate goods (final goods), leading to more intense competition of the upstream (downstream) sector in the respective country. Since the aggregate market demands are proportional to the price indices in each production sector, B_j^I and B_i^F must fall as a result of such liberalization. This intuition also helps to explain why the opposite is true for B_i^I and B_j^F.

Having shown the impact of variable trade costs on the equilibrium variables, we next turn to the impact on aggregate trade flows from country j to country i: $R_{ji}^I = N_j^E \int_{\phi_{ji}^*}^{\infty} r_{ji}^I(\phi) dG_j^I(\phi)$. Following Arkolakis et al. (2008), we can decompose these trade flows into

$$R_{ji}^I = \underbrace{\frac{k\sigma}{k-(\sigma-1)} f_{ji}^I}_{\text{Average sales per firm}} \times \underbrace{\left(\frac{\phi_{\min}}{\phi_{ji}^*}\right)^k N_j^E}_{\text{Firms}}.$$

Thus, conditional on positive trade flows, the average sales per firm are independent of variable trade costs, and reductions in these costs increase aggregate trade flows only through the mass of firms. It is important to note that the mass of entrants in the upstream sector N_j^E in country j, in general, depends not only on the sector labor supply for intermediate goods production L_j^I in country j but also on the productivity cutoff ϕ_{jn}^* in country $n = i, j$, which in turn depends on sector expenditure R_n^I in country n (see (12)). Clearly, this applies to the mass of entrants in the downstream sector M_j^E in country j. Under the Pareto distribution, however, the dependence of the productivity cutoffs is eliminated and the masses of entrants in the two production sectors depend only on the sector aggregates R_j^F, L_j^I in country j (see Appendix for proof):

$$M_j^E = \frac{\sigma-1}{k\sigma}\frac{R_j^F}{f_j^E}, \quad N_j^E = \frac{\sigma-1}{k\sigma}\frac{L_j^I}{f_j^E}, \tag{20}$$

We are interested in trade elasticity differences between final goods and intermediate goods. To examine this most sharply, suppose completely the opposite situation where final goods are only tradable but intermediate goods are prohibitively costly by setting $\tau_{ji}^F < \infty$ and $\tau_{ji}^I = \infty$. Then, aggregate trade flows from country j to country i is expressed as

$$R_{ji}^F = \frac{k\sigma}{k-(\sigma-1)} f_{ji}^F \times \left(\frac{\varphi_{\min}}{\varphi_{ji}^*}\right)^k M_j^E.$$

Consequently, the impact of variable trade costs on the average sales per firm and the mass of firms is similar between final goods trade and intermediate goods trade, so long as the Pareto distribution is imposed to the two production sectors. We find, however, that critical differences emerge between these two types of trade when deriving the trade elasticities.

The decompositions under the Pareto distribution allow us to express aggregate trade flows as a gravity equation form. Substituting ϕ_{ji}^* from (12) into N_j^E in (20) and φ_{ji}^* into M_j^E gives us the following proposition.

Proposition 1

(i) *If $\tau^F_{ji} = \infty$, aggregate trade flows of intermediate goods from country j to country i are*

$$R^I_{ji} = \frac{L^I_j}{\Xi^I_j}(B^I_i)^{\frac{k}{\sigma-1}}(\tau^I_{ji})^{-k}(f^I_{ji})^{1-\frac{k}{\sigma-1}}(\tilde{\Lambda}^F_{ji})^{\frac{k}{\sigma-1}}, \tag{21}$$

$$\Xi^I_j = \sum_{n=i,j}(B^I_n)^{\frac{k}{\sigma-1}}(\tau^I_{jn})^{-k}(f^I_{jn})^{1-\frac{k}{\sigma-1}}(\tilde{\Lambda}^F_{jn})^{\frac{k}{\sigma-1}}.$$

(ii) *If $\tau^I_{ji} = \infty$, aggregate trade flows of final goods from country j to country i are*

$$R^F_{ji} = \frac{L^F_j}{\Xi^F_j}(B^F_i)^{\frac{k}{\sigma-1}}(\tau^F_{ji})^{-k}(f^F_{ji})^{1-\frac{k}{\sigma-1}}, \tag{22}$$

$$\Xi^F_j = \sum_{n=i,j}(B^F_n)^{\frac{k}{\sigma-1}}(\tau^F_{jn})^{-k}(f^F_{jn})^{1-\frac{k}{\sigma-1}}.$$

As in usual gravity equations, aggregate trade flows in each type of goods R^h_{ji} are a function of exporting country size L^h_j, importing country demand B^h_i, and trade costs, both variable τ^h_{ji} and fixed f^h_{ji}. While the functional forms in (21) and (22) are very similar to the gravity equation in Melitz and Redding (2014a), the difference arises through the (endogenous) market share of foreign-sourcing firms $\tilde{\Lambda}^F_{ji}$ which appears only in (21). Under the Pareto distribution,

$$\left(\tilde{\Lambda}^F_{ji}\right)^{\frac{k}{\sigma-1}} = \left(\frac{N^E_j}{N^E_i}(\tau^I_{ji})^{-k}\left(\frac{f^F_{ji}}{f^F_{ii}}\right)^{-1}\left(\frac{f^I_{ji}}{f^I_{ii}}\right)^{-\frac{k-(\sigma-1)}{\sigma-1}}\right)^{\frac{k-(\sigma-1)}{2(\sigma-1)-k}},$$

which is of course negatively affected by both variable and fixed trade costs.

To see the impact of variable trade costs τ^h_{ji} in (21) and (22), we need to use the *partial* trade elasticities that are only empirically observable as these are estimated from gravity equations with origin and destination fixed effects where incomes and price indices are held constant (see Arkolakis et al. (2012) for detailed discussions). This suggests that the market demand B^h_i is held constant in (21) and (22). Substituting $(\tilde{\Lambda}^F_{ji})^{\frac{k}{\sigma-1}}$ into (21), the partial trade elasticities are

$$\zeta^I_o \equiv -\frac{\partial \ln R^I_{ji}}{\partial \ln \tau^I_{ji}} = \frac{k(\sigma-1)}{2(\sigma-1)-k},$$

$$\zeta^F_o \equiv -\frac{\partial \ln R^F_{ji}}{\partial \ln \tau^F_{ji}} = k,$$

where the subscript o is attached to stress "partial." Comparing them under (19) reveals that the trade elasticities are greater for intermediate goods than for final goods. This finding could help understand why intermediate goods trade has been growing faster than final goods trade in the real world (e.g., Hummels et al., 2001; Hanson et al., 2005; Johnson and Noguera, 2012). We summarize the above observation in the next proposition.

Proposition 2 *Under Assumption 1, the partial trade elasticities with respect to variable trade costs are greater for intermediate goods trade than for final goods trade:*

$$\zeta_o^I > \zeta_o^F.$$

The intuition behind the result stems from the impact on the productivity cutoffs in Lemmas 1 and 2. In the case of intermediate goods trade, reductions in variable trade costs τ_{ji}^I induce not only the entry of exporting firms from country j, but also the entry of importing firms in country i by decreasing the export/import productivity cutoffs in the two production sectors. This entry effect through the extensive margin in both production sectors is important to understand why the trade elasticity with respect to variable trade costs is greater for intermediate goods than for final goods. To see this entry effect more formally, following Melitz and Redding (2015) and using (16), let us take the partial derivative of the domestic expenditure share with respect to τ_{ji}^I holding N_i^E, N_j^E constant:

$$\begin{aligned}\zeta_o^I &= -\frac{\partial \ln\left(\frac{1-\lambda_{ii}^I}{\lambda_{ii}^I}\right)}{\partial \ln \tau_{ji}^I} \\ &= (\sigma-1) + \left(-\frac{\partial \ln \tilde{\Lambda}_{ji}^F}{\partial \ln \tau_{ji}^I}\right) + \left(-\frac{\partial \ln \Lambda_{ji}^I}{\partial \ln \tau_{ji}^I}\right).\end{aligned}$$

As in the Krugman model, reductions in variable trade costs increase the average sales with the elasticity of $\sigma-1$, captured by the first term. At the same time, such reductions also decrease the export/import productivity cutoffs and induce new and less productive firms to enter the export/import markets in the two production sectors, captured by the second and third terms. The fact that the entry arises from both production sectors reflects that reductions in variable trade costs increase total imports from country j to country i, not only by allowing intermediate goods firms to export easily in country j but also by allowing final goods firms to import easily in country i (i.e., the market share of foreign-sourcing firms $\tilde{\Lambda}_{ji}^F$ increases with reductions in τ_{ji}^I). Under the Pareto distribution, this decomposition is simplified to

$$\zeta_o^I = \underbrace{(\sigma-1)}_{\text{Intensive margin elasticity}} + \underbrace{\frac{(\sigma-1)[k-(\sigma-1)]}{2(\sigma-1)-k}}_{\substack{\text{Importer extensive margin elasticity} \\ \text{in downstream sector}}} + \underbrace{\frac{(\sigma-1)[k-(\sigma-1)]}{2(\sigma-1)-k}}_{\substack{\text{Exporter extensive margin elasticity} \\ \text{in upstream sector}}},$$

Note that while the extensive margin elasticity is given by $k-(\sigma-1)$ under the distribution, this margin is weighted by $(\sigma-1)/[2(\sigma-1)-k]$ above, which is greater than unity under (19). This means that, due to the co-movement in the export/import productivity cutoffs, the effect on the extensive margin is magnified for intermediate goods trade.

In the case of final goods trade, on the other hand, reductions in τ_{ji}^F induce only the entry of exporting firms in country j (i.e., the productivity cutoff falls only in the downstream sector).

This is because intermediate goods firms do not use final goods for their production, and there is no import productivity cutoff in the upstream sector. The result can be seen from noting that if intermediate goods are prohibitively costly to trade (i.e., $\tau_{ji}^{I} = \infty$), no intermediate goods firm export (i.e., $\phi_{ji}^{*} = \infty$) and the equilibrium conditions corresponding to (11), (12) and (14) are

$$B_i^I (\varphi_{ii}^*)^{\sigma-1} = f_{ii}^I,$$
$$f_{ii}^I J_i(\varphi_{ii}^*) = f_i^E.$$

Variable trade costs do not appear in these conditions, and hence neither the productivity cutoff φ_{ii}^* nor input demand B_i^I is affected by these costs. Since no additional entry of intermediate goods firms is induced by reductions in τ_{ji}^F, the partial trade elasticity is decomposed into

$$\zeta_o^F = \underbrace{(\sigma - 1)}_{\text{Intensive margin elasticity}} + \underbrace{(k - (\sigma - 1))}_{\substack{\text{Exporter extensive margin elasticity} \\ \text{in downstream sector}}},$$

which is the same as that in Chaney's (2008) single-stage production model, though this paper develops the multiple-stage production model. From the two decompositions, it follows that the trade elasticity is greater for intermediate goods trade than for final goods trade. As observed above, even if we confine the extensive margin elasticity in either side of the production sectors, the elasticity is always greater for intermediate goods trade than for final goods trade in (19). This is important because, in practice, we cannot distinguish between the exporter/importer extensive margin elasticities when estimating the trade elasticity from the gravity equation.

It is worth emphasizing that the result in Proposition 2 does *not* rely on a C.E.S. production function where a final good requires a lot of intermediate goods. As is immediate from the two decompositions, our result comes from the difference in the impact of trade liberalization on the extensive margin that would naturally arise in any production function: reductions in variable trade costs induce the entry of firms in a different way. From this reason, we empirically test the theoretical prediction on the elasticity with respect to variable trade costs, paying attention to their impact on the extensive margin in the next section. In so doing, we exploit the fact that our theoretical prediction holds even if we confine the extensive margin elasticity in either side of the production sectors.

While we have focused on variable trade costs τ_{ji}^h, a similar argument applies to fixed trade costs f_{ji}^h. That is, our model predicts that the partial trade elasticity with respect to fixed trade costs is also greater for intermediate goods trade than for final goods trade. From (21) and (22),

$$\xi_o^I \equiv -\frac{\partial \ln R_{ji}^I}{\partial \ln f_{ji}^I} = \frac{\sigma - 1}{2(\sigma - 1) - k} - 1,$$
$$\xi_o^F \equiv -\frac{\partial \ln R_{ji}^F}{\partial \ln f_{ji}^F} = \frac{k}{\sigma - 1} - 1.$$

Comparing them under Assumption 1 establishes the result that $\xi_o^I > \xi_o^F$.

3 Evidence

This section empirically assesses the relevance of one of our theoretical predictions: the trade elasticities with respect to variable trade costs are greater for intermediate goods trade than for final goods trade. We consider both distances and tariffs as a proxy of variable trade costs below. Section 3.1 discusses the data source, section 3.2 presents the regression specifications, section 3.3 reports the estimation results, and section 3.4 makes some discussions on our analysis.

3.1 Data

3.1.1 Data on China's import tariffs

The dataset of China's import tariffs is obtained from the Trade Analysis Information System (TRAINS) database in the World Integrated Trade Solution (WITS) website. For each product at the 6-digit HS level, the tariff dataset provides detailed information on tariff lines, average, minimum and maximum ad-valorem tariffs. Following Buono and Lalanne (2012), we measure the tariffs imposed on exports of China's trading partners using *effectively applied ad-valorem tariffs* at the product-country-time level from the TRAINS database. We restrict the tariff data from 2000 to 2007 in order to eliminate the 2008 global financial crisis. Notice importantly that China joined the WTO in the end of 2001, and the covered time period in our sample begins 2 years before China's WTO accession.

To test the differences in the trade elasticities with respect to tariffs, we divide the TRAINS database into the tariffs imposed on intermediate goods and final goods by applying the Broad Economic Categories (BEC) classification. According to this classification, intermediate goods include industrial supplies not elsewhere specified; fuels and lubricants other than motor spirit; parts and accessories of capital goods; parts and accessories of transport equipment; and food and beverages mainly for an industry. Other goods are defined as final goods.

Table 1 reports the descriptive statistics on the simple-average tariffs imposed on exports of China's trading partners in 2005 for the product level and the destination-product level. The table shows that the tariffs on intermediate goods are relatively smaller than on final goods (in terms of the mean and the standard deviation) for both the product level and the destination-product level. To show that the patterns are not specific to a particular year, Figure 1 reports changes in the simple average of China's effectively applied tariffs on world exports between 2000 and 2010. During these periods, China's import tariffs drastically decreased from 21.3% (14.2%) in 2000 to 10.8% (6.0%) in 2010 for final goods (intermediate goods). As expected, the tariff reductions are sharper particularly after China's WTO accession in 2001.

3.1.2 Data on China's imports

We focus on the import side exploiting the fact that our prediction holds even if we confine the extensive margin elasticity in either side of the production sectors. The dataset used in the

TABLE 1 – Descriptive statistics on China's import tariffs in 2005

Types of imports	No. of obs.	Mean	S.D.	25th	Median	75th
Intermediate goods	$3,118$	8.00	5.31	5.00	6.50	10.00
Final goods	$1,912$	12.34	7.54	8.00	12.00	15.84

(a) Product level

Types of imports	No. of obs.	Mean	S.D.	25th	Median	75th
Intermediate goods	$63,090$	7.98	4.90	5.13	7.50	10.00
Final goods	$37,387$	11.34	7.04	7.50	10.00	16.00

(b) Destination-product level

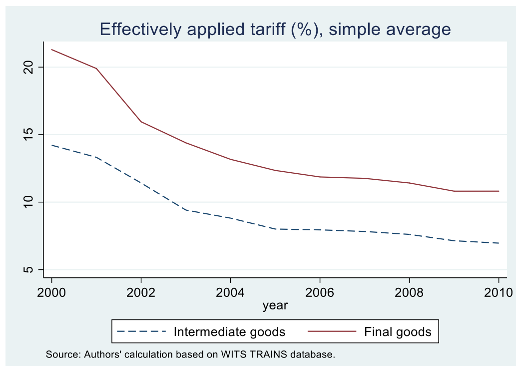


FIGURE 1– China's import tariffs between 2000-2010

estimation is the census of annual firm-level import transactions in China for the periods from 2000 to 2009, collected by China Customs. The dataset contains the information on the trade value and quantity for each trading partner at the 8-digit HS product classification. We use the publicly available concordance tables for the 1997, 2002 and 2007 HS codes to make the product code consistent over time. As noted above, the analysis is restricted to the 2000-2007 data only and the dataset is divided into intermediate goods and final goods by the BEC classification.

To combine the TRAINS database, the original China Customs dataset at the 8-digit HS product level is aggregated into the 6-digit HS product level. As in previous work, we restrict our dataset to manufacturing products, since agricultural products are treated as special cases in tariff setting. Then, for each product imported from each trading partner in each year, the total import values are decomposed into the number of importing firms with positive trade flows (extensive margin) and the average import values conditional on positive trade flows (intensive margin) in terms of thousand U.S. dollar. Formally, this decomposition is given by

$$R^h_{pct} = M^h_{pct} \times \bar{r}^h_{pct}, \tag{23}$$

where R^h_{pct}, M^h_{pct}, and $\bar{r}^h_{pct}$ are respectively the total import values, the extensive margin, and

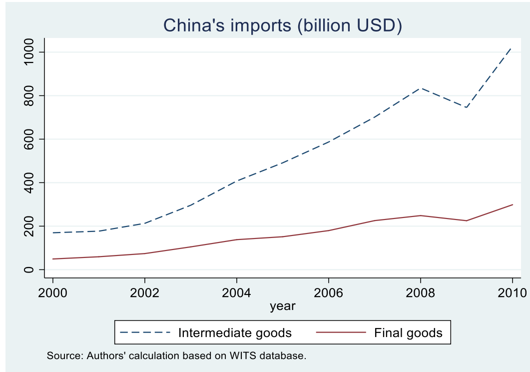


FIGURE 2 – China's imports between 2000-2010

the intensive margin for product p imported from country c in year t, and $h = F$ ($h = I$) denotes final goods (intermediate goods). Note that M^h_{pct} does not include the number of exporting firms. We define $R_{pct} \equiv \sum_{h=F,I} R^h_{pct}$, $M_{pct} \equiv \sum_{h=F,I} M^h_{pct}$, and $\bar{r}_{pct} \equiv R_{pct}/M_{pct}$ for total imports.

The main analysis is devoted to ordinary imports and deletes processing imports, since it is known that processing trade are systematically different from non-processing trade in China (e.g., Dai et al., 2016). Relative to processing imports, however, we find that ordinary imports are a large proportion in terms of the total import values or the number of imported products in total imports. After deleting processing imports, our dataset covers 155 trading countries (see Table A.1 in Appendix for the country list) and roughly 4,000 products, and roughly 70,000 observations in total for intermediate goods and final goods at the 6-digit level in each year.

Figure 2 presents China's imports from trading partners between 2000-2010 for final goods and intermediate goods. As is evident from the figure, intermediate goods imports are a large and growing share relative to final goods imports, which accords well with empirical regularity demonstrated in the literature (e.g., Johnson and Noguera, 2012). Further, the rapid growth is fostered by China's WTO accession in 2001, leading to significant reductions in China's import tariffs as in Figure 1. These tariff reductions have a more prominent impact on intermediate goods imports than on final goods imports.

Table 2 presents the descriptive statics on the import growth rates between 2000 and 2007, decomposing total imports into the extensive and intensive margins. While total imports and both margins grew over time for both intermediate goods and final goods, the contribution of the intensive margin is greater (smaller) than the extensive margin for intermediate goods (final goods). Further, variations in the growth rates are bigger for final goods. These statistics are comparable with those in Buono and Lalanne (2012) for French total exports between 1993 and 2002, though they consider mainly final goods exports which would be a larger share than intermediate goods during their periods.

Finally, Figure 3 plots the log of the total import values, extensive margin, and intensive margin against the log of distances, tariffs and GDPs. For simplicity, each panel of Figure 3 is made without distinguishing between intermediate goods imports and final goods imports.

TABLE 2 – Descriptive statistics on China's import growth rates for 2000-2007

Margin	No. of obs.	Mean	S.D.	25th	Median	75th
Total	$23,705$	14.8%	94.9%	-13.2%	13.6%	41.1%
Extensive	$23,705$	4.6%	32.0%	-7.4%	5.3%	19.3%
Intensive	$23,705$	10.2%	86.4%	-17.1%	7.8%	34.0%

(a) Intermediate goods imports

Margin	No. of obs.	Mean	S.D.	25th	Median	75th
Total	$14,254$	23.2%	116.9%	-19.5%	20.9%	64.7%
Extensive	$14,254$	12.7%	42.8%	-6.9%	10.5%	31.8%
Intensive	$14,254$	10.5%	105.1%	-28.5%	9.6%	47.2%

(b) Final goods imports

As is well-known, variable trade costs such as distances and tariffs have a negative impact on trade flows, whereas country size such as GDPs has a positive impact on these flows, which basically hold not only for the total import values but also for the extensive and intensive margins. The next subsection will investigate these empirical patterns in the gravity equation more carefully by connecting our theoretical prediction with the above datasets.

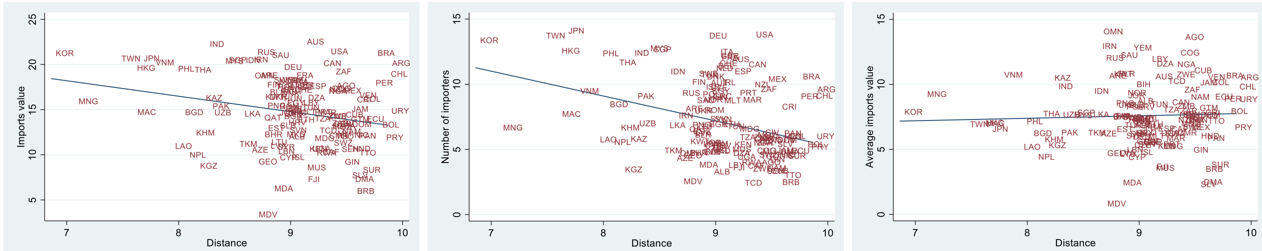
3.2 Specifications

We empirically test the trade elasticities with respect to variable trade costs by estimating the gravity equations of intermediate goods and final goods derived under the Pareto distribution. Holding the importer demand B_i^h and market potential Ξ_j^h constant for $h \in \{F, I\}$, and applying a log-linear approximation to (21) and (22) leads to the following specification:

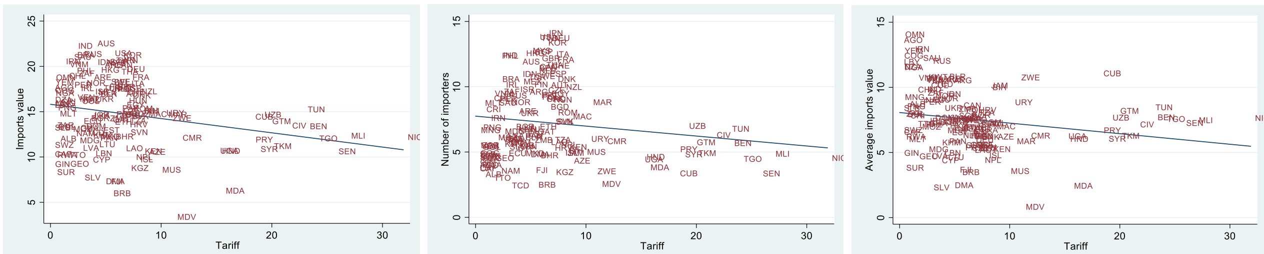
$$\ln R_{pct}^h = \alpha_0^h + \alpha_1^h \ln \tau_{pct}^h + \alpha_2^h \ln L_{ct} + \alpha_3^h X_c + \alpha_4^h Y_{ct} + \theta_p^h + \theta_t^h + \epsilon_{pct}^h. \tag{24}$$

Note that, by taking logs, we are throwing out zero trade flows between China and its trading partner. As usual, the gravity equation includes the variable trade costs τ_{pct}^h and the exporting country size L_{ct}. Following the literature, we first treat the variable trade costs and exporting country size as distances and GDPs, denoted by $dist_c$ and GDP_{ct} respectively. The specification includes sets of country-specific and country-time controls, denoted by X_c and Y_{ct} respectively. The first set of controls contains a border dummy and a language (Chinese) dummy. The second set of controls contains an FTA dummy and a WTO membership dummy, which equals one if country c has FTAs with China and is a member of WTO in year t respectively. Finally, product and year fixed effects are included. Substituting (23) into (24), the specification is expressed as

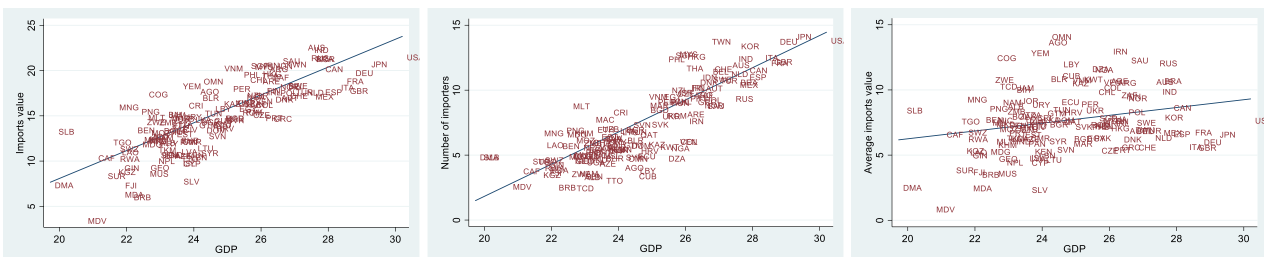
$$\ln Z_{pct}^h = \alpha_0^h + \alpha_1^h \ln dist_c + \alpha_2^h \ln GDP_{ct} + \alpha_3^h X_c + \alpha_4^h Y_{ct} + \theta_p^h + \theta_t^h + \epsilon_{pct}^h, \tag{25}$$



(a) Distances



(b) Tariffs



(c) GDPs

Source: China Customs, CEPII database, TRAINS database and author's calculations.
Note: The left, middle, and right figures in each panel correspond to the total import values, extensive margin and intensive margin respectively.

FIGURE 3 – Total import values, extensive margin, and intensive margin in 2005

where $Z^h_{pct} \in \{R^h_{pct}, M^h_{pct}, \bar{r}^h_{pct}\}$. From the theoretical prediction in Proposition 2, we hypothesize that $|\alpha^I_1| > |\alpha^F_1|$. In fact, from the log-linearization to (21) and (22), we have for $Z^h_{pct} = R^h_{pct}$ that $|\alpha^I_1| = \frac{k(\sigma-1)}{2(\sigma-1)-k}$ and $|\alpha^F_1| = k$. Further, the difference comes mainly from M^h_{pct} rather than $\bar{r}^h_{pct}$.

As pointed out by Buono and Lalanne (2012), the critical problem in interpreting distances as a proxy of variable trade costs is that we cannot control for country fixed effects along with distances: distances may capture some cultural or historical differences across countries, such as consumer tastes. To get rid of these factors and study the impact of trade policy instruments on trade flows, we instead consider tariffs as the measure of variable trade costs. The previous specification introducing tariffs is

$$\ln Z^h_{pct} = \beta^h_0 + \beta^h_1 \ln dist_c + \beta^h_2 \ln tariff^h_{pct} + \beta^h_3 \ln GDP_{ct} + \beta^h_4 X_c + \beta^h_5 Y_{ct} + \theta^h_p + \theta^h_t + \epsilon^h_{pct}, \quad (26)$$

where $tariff^h_{pct} = 1 + t^h_{pct}$ and t^h_{pct} is effectively applied ad-valorem tariffs imposed on product p from country c in year t. Since distances and tariffs are expected to have qualitatively similar effects on trade flows, we hypothesize that $|\beta^I_1| > |\beta^F_1|$ and $|\beta^I_2| > |\beta^F_2|$.

The specification in (26), however, may not correctly capture the trade elasticity differences. As in Figure 1, there are large differences between input tariffs and output tariffs, which would be particularly crucial if the trade elasticities are not constant and vary with the level of tariffs. Note that the problem is relevant to only tariffs because distances are common for intermediate goods and final goods. To adjust differences in the level of tariffs and to obtain reliable results, we report estimates from the regression of the following form:

$$\ln Z^h_{pct} = \gamma^h_0 + \gamma^h_1 \ln dist_c + \gamma^h_2 \ln\left(\frac{tariff^h_{pct}}{\overline{tariff}_{ct}}\right) + \gamma^h_3 \ln GDP_{ct} + \gamma^h_4 X_c + \gamma^h_5 Y_{ct} + \theta^h_p + \theta^h_t + \epsilon^h_{pct}, \quad (27)$$

where $\overline{tariff}_{ct}$ is (weighted) average effectively applied ad-valorem tariffs on all products from country c in year t. It is natural to expect that the theoretical prediction holds in this setting, and we hypothesize that $|\gamma^I_1| > |\gamma^F_1|$ and $|\gamma^I_2| > |\gamma^F_2|$.

We are also interested in checking whether there is a statistically significant difference in the trade elasticities between the two types of imports. Let $\phi^h_{pct} \in \left\{tariff^h_{pct}, \frac{tariff^h_{pct}}{\overline{tariff}_{ct}}\right\}$ denote either non-adjusted or adjusted tariffs. To the above end, we conduct the following regression with an interaction term:

$$\begin{aligned}\ln Z_{pct} = \delta_0 + \delta_1 \ln dist_c + \delta_2 \ln dist_c * inter_p + \delta_3 \ln \phi_{pct} + \delta_4 \ln \phi_{pct} * inter_p \\ + \delta_5 \ln GDP_{ct} + \delta_6 X_c + \delta_7 Y_{ct} + \theta_p + \theta_t + \epsilon_{pct},\end{aligned} \quad (28)$$

where $inter_p$ is a dummy variable which is equal to one if imports are intermediate goods. In regressing (28), we pool our dataset on final goods and intermediate goods together, and then see the coefficients on the variable trade costs for intermediate goods relative to final goods. From this reason, the superscript h should not be attached to the variables of regression (28). In light of Proposition 2, we hypothesize that $\delta_2 < 0$ and $\delta_4 < 0$ for $Z_{pct} \in \{R_{pct}, M_{pct}\}$.

Finally, using the fact that tariffs vary not only along product and country but also along time, we further replace all time-invariant country characteristics by country fixed effects θ^h_c in order to have a closer look at the impact of tariffs:

$$\ln Z^h_{pct} = \eta^h_0 + \eta^h_1 \ln \phi^h_{pct} + \eta^h_2 \ln GDP_{ct} + \eta^h_3 Y_{ct} + \theta^h_c + \theta^h_p + \theta^h_t + \epsilon^h_{pct}. \quad (29)$$

This specification is close to that in Buono and Lalanne (2012). As in (28), we also consider the following specifications with the interaction term:

$$\ln Z_{pct} = \lambda_0 + \lambda_1 \ln \phi_{pct} + \lambda_2 \ln \phi_{pct} * inter_p + \lambda_3 \ln GDP_{ct} + \lambda_4 Y_{ct} + \theta_c + \theta_p + \theta_t + \epsilon_{pct}. \quad (30)$$

In view of Proposition 2, we hypothesize that $|\eta^I_1| > |\eta^F_1|$ and $\lambda_2 < 0$ for $Z_{pct} \in \{R_{pct}, M_{pct}\}$.

3.3 Estimation results

3.3.1 Estimates with the full samples

To compare our results with those in the literature, we first report the estimation results with full samples without distinguishing among final goods and intermediate goods. We then report the estimation results with samples distinguishing among final goods and intermediate goods specified in equations (25)-(30).

The first three columns of Table 3 report the estimation results of (25) with full samples. As in the usual gravity literature, distances have a negative impact on the total import values, while GDPs have a positive impact on the import values. When they are decomposed into the extensive and intensive margins, the negative (positive) relationship between the total import values and distances (GDPs) is explained relatively more by the extensive margin, which fits in well with the findings in the existing literature (Bernard et al. 2007, 2011; Eaton et al. 2004). Having a common language increases China's imports, whereas the WTO membership dummy coefficient is positive and significant, like Helpman et al. (2008) and Buono and Lalanne (2012). In our analysis, we also find that the coefficients of the border and FTA dummies are negative and significant. This would probably be explained by the fact that countries sharing national borders and having FTAs with China are relatively small, developing East Asian countries (see Tables A.2 and A.3 in Appendix for the lists of these countries).

The estimation results of (26) that introduce tariffs are reported in the next three columns. Relative to (25), the number of observations is smaller in (26) because some tariffs are missing in the TRAINS dataset and we drop them from the analysis, as in Buono and Lalanne (2012). While the elasticity of distances does not change much, the elasticity of tariffs is negative and significant at the 1% level. In contrast to distances, however, the negative relationship between the total import values and tariffs is accounted for by the two margins almost equally. Though the impact of tariffs on the two margins is consistent with previous work, the elasticity of tariffs in our analysis is much smaller. For example, Buono and Lalanne (2012) report the estimated coefficients on $\ln R_{pct}$, $\ln M_{pct}$, and $\ln \bar{r}_{pct}$ as -2.87^{***}, -1.73^{***}, and -1.13^{***} respectively, which are nearly ten times greater than ours. One potential reason would be related to some special nature of China's trade policies on its trade flows, e.g., China imports a relatively small amount of products with FTA countries. In contrast, the estimated coefficients of distances are similar to the trade elasticity consensus, including Buono and Lalanne (2012).

Finally, the last three columns show the estimation results of (27) where tariffs are adjusted by taking the (weighted) average of all products. Even in this case, the estimated coefficients of adjusted tariffs on the total import values, extensive margin and intensive margin in (27) are similar with those of (26), which implies that the differences in input tariffs and output tariffs might not have a critical impact on the trade elasticities of tariffs. The elasticity of distances does not change much as before. Overall, the estimated coefficients in the gravity equation are comparable with those in the existing literature, except that the estimated coefficients of tariffs are significantly smaller than them.

Table 3 — Estimates of (25), (26) and (27) with the full samples

	$\ln R_{pct}$	$\ln M_{pct}$	$\ln \bar{r}_{pct}$	$\ln R_{pct}$	$\ln M_{pct}$	$\ln \bar{r}_{pct}$	$\ln R_{pct}$	$\ln M_{pct}$	$\ln \bar{r}_{pct}$
$\ln dist_c$	-0.757^{***}	-0.549^{***}	-0.208^{***}	-0.758^{***}	-0.549^{***}	-0.208^{***}	-0.752^{***}	-0.546^{***}	-2.05
	(0.015)	(0.007)	(0.010)	(0.015)	(0.007)	(0.010)	(0.015)	(0.007)	(0.010)
$\ln tariff_{pct}$				-0.148^{***}	-0.085^{***}	-0.064^{***}			
				(0.018)	(0.007)	(0.014)			
$\ln\left(\frac{tariff_{pct}}{\overline{tariff}_{ct}}\right)$							-0.158^{***}	-0.082^{***}	-0.076^{***}
							(0.020)	(0.008)	(0.014)
$\ln GDP_{ct}$	0.772^{***}	0.481^{***}	0.291^{***}	0.773^{***}	0.481^{***}	0.292^{***}	0.765^{***}	0.477^{***}	0.288^{***}
	(0.012)	(0.006)	(0.006)	(0.012)	(0.006)	(0.006)	(0.012)	(0.006)	(0.006)
$border_c$	-0.689^{***}	-0.461^{***}	0.228^{***}	-0.696^{***}	-0.466^{***}	0.230^{***}	-0.693^{***}	-0.464^{***}	0.229^{***}
	(0.029)	(0.012)	(0.020)	(0.028)	(0.012)	(0.019)	(0.028)	(0.012)	(0.019)
$Chinese_c$	0.713^{***}	0.588^{***}	0.125^{***}	0.715^{***}	0.589^{***}	0.125^{***}	0.704^{***}	0.584^{***}	0.120^{***}
	(0.030)	(0.015)	(0.018)	(0.030)	(0.015)	(0.018)	(0.030)	(0.015)	(0.018)
WTO_{ct}	0.080^{*}	0.047^{***}	0.033	0.078^{*}	0.046^{***}	0.033	0.063	0.038^{**}	0.025
	(0.044)	(0.017)	(0.031)	(0.044)	(0.017)	(0.031)	(0.043)	(0.017)	(0.030)
FTA_{ct}	0.034	-0.113^{***}	0.147^{***}	-0.001	-0.133^{***}	0.132^{***}	0.021	-0.120^{***}	0.141^{***}
	(0.025)	(0.009)	(0.019)	(0.026)	(0.010)	(0.019)	(0.025)	(0.009)	(0.019)
No. of observations	577,056	577,056	577,056	576,509	576,509	576,509	576,509	576,509	576,509
Adj. R^2	0.403	0.497	0.390	0.403	0.498	0.389	0.403	0.498	0.389

Note: Standard errors clustered at product-level are in brackets. Product and year fixed effects are included.

$^{*}p < 0.10,\ ^{**}p < 0.05,\ ^{***}p < 0.01$

3.3.2 Estimates with the subsamples

Table 4 presents the estimation results with the samples distinguishing between intermediate goods and final goods. The estimation results of (26) for intermediate goods are reported in the first three columns, and those for final goods are then reported in the next three columns. While the coefficients of distances on the total import values are negative and significant at the 1% level for both intermediate goods and final goods, the coefficient is greater for intermediate goods than that for final goods. As in the full sample, a large part of the negative relationship is accounted for by the extensive margin, but that margin plays a small role in intermediate goods relative to final goods. We find a similar result for the coefficients of tariffs. Interestingly, the coefficient of the WTO membership dummy is positive and significant only for final goods. The result may indicate that multilateral tariff reductions in WTO were mainly applied to final goods, but not necessarily to intermediate goods in China.

The estimation results of (27) with the same subsamples are reported in the last six columns. Not only do all the coefficient estimates have similar magnitudes and signs with those in (26), but the elasticities of distances and average-adjusted tariffs remain negative and significant at the 1% level. Most importantly, the elasticities of these two variable trade costs are greater for intermediate goods than for final goods in this specification as well.

In Table 5, we also present the estimation results of (28) that includes the interaction term. Note first that, in contrast to (26) and (27), we use the pooled dataset for estimates of (28), and hence the estimated coefficients in Table 5 are almost the same as those in Table 3 except for the interaction term. The coefficients of distances and adjusted-tariffs on the interaction term are negative and significant at the 1% level, which is consistent with our theoretical prediction. (The coefficient of non-adjusted tariffs on the interaction term is not significant, probably due to the differences between input tariffs and output tariffs.) The coefficient of distances on the interaction term further shows that the negative relationship between the total import values and distances is significantly explained only through the extensive margin. In contrast, the coefficient of adjusted tariffs on the interaction term shows that the tariffs have a significant impact on both the margins.

The estimation results of (29) that control for country fixed effects are reported in Table 6. The tariff coefficients – both non-adjusted and adjusted – are still negative and significant at the 1% level. As in Table 4, we find that the elasticities of these two sets of tariffs are greater for intermediate goods than for final goods. In contrast to Table 4, however, once we control for country fixed effects, the coefficient of the WTO membership dummy is positive and significant for intermediate goods rather than final goods. The reason is that the specification in (29) has a different interpretation from that in (26). In (26), the WTO membership dummy means that the WTO membership of existing countries (such as Japan that has already been a member of the WTO during our sample period) increases final goods exports to China. In (29), that dummy means that the WTO accession of new membership countries (such as Vietnam that joined the WTO in 2007) increases intermediate goods exports to China.

Table 4 — Estimates of (26) and (27) with the subsamples

	$\ln R^I_{pct}$	$\ln M^I_{pct}$	$\ln \bar{r}^I_{pct}$	$\ln R^F_{pct}$	$\ln M^F_{pct}$	$\ln \bar{r}^F_{pct}$	$\ln R^I_{pct}$	$\ln M^I_{pct}$	$\ln \bar{r}^I_{pct}$	$\ln R^F_{pct}$	$\ln M^F_{pct}$	$\ln \bar{r}^F_{pct}$
$\ln dist_c$	-0.797^{***}	-0.574^{***}	-0.223^{***}	-0.689^{***}	-0.508^{***}	-0.181^{***}	-0.791^{***}	-0.570^{***}	-0.220^{***}	-0.684^{***}	-0.505^{***}	-0.179^{***}
	(0.020)	(0.009)	(0.013)	(0.023)	(0.010)	(0.016)	(0.020)	(0.009)	(0.013)	(0.023)	(0.010)	(0.016)
$\ln tariff^h_{pct}$	-0.184^{***}	-0.100^{***}	-0.084^{***}	-0.106^{***}	-0.072^{***}	-0.034^{***}						
	(0.029)	(0.011)	(0.023)	(0.022)	(0.008)	(0.016)						
$\ln\left(\frac{tariff^h_{pct}}{\overline{tariff}_{ct}}\right)$							-0.189^{***}	-0.100^{***}	-0.088^{***}	-0.120^{***}	-0.067^{***}	-0.052^{***}
							(0.036)	(0.015)	(0.024)	(0.022)	(0.008)	(0.017)
$\ln GDP_{ct}$	0.820^{***}	0.506^{***}	0.314^{***}	0.704^{***}	0.445^{***}	0.259^{***}	0.811^{***}	0.501^{***}	0.310^{***}	0.698^{***}	0.441^{***}	0.257^{***}
	(0.017)	(0.009)	(0.009)	(0.016)	(0.009)	(0.008)	(0.017)	(0.009)	(0.009)	(0.016)	(0.009)	(0.008)
$border_c$	-0.848^{***}	-0.534^{***}	-0.314^{***}	-0.452^{***}	-0.354^{***}	-0.099^{***}	-0.843^{***}	-0.531^{***}	-0.312^{***}	-0.451^{***}	-0.353^{***}	-0.099^{***}
	(0.037)	(0.015)	(0.026)	(0.043)	(0.019)	(0.029)	(0.037)	(0.015)	(0.026)	(0.043)	(0.019)	(0.029)
$Chinese_c$	0.797^{***}	0.648^{***}	0.149^{***}	0.592^{***}	0.499^{***}	0.093^{***}	0.785^{***}	0.642^{***}	0.143^{***}	0.585^{***}	0.494^{***}	0.090^{***}
	(0.039)	(0.019)	(0.024)	(0.045)	(0.023)	(0.028)	(0.039)	(0.019)	(0.024)	(0.046)	(0.023)	(0.028)
WTO_{ct}	-0.005	0.024	-0.029	0.224^{***}	0.087^{***}	0.137^{***}	-0.022	0.015	-0.037	0.213^{***}	0.081^{***}	0.132^{***}
	(0.062)	(0.023)	(0.043)	(0.053)	(0.022)	(0.038)	(0.062)	(0.023)	(0.043)	(0.053)	(0.022)	(0.038)
FTA_{ct}	-0.098^{***}	-0.179^{***}	0.082^{***}	0.157^{***}	-0.060^{***}	0.217^{***}	-0.070^{**}	-0.164^{***}	0.094^{***}	0.170^{***}	-0.049^{***}	0.218^{***}
	(0.033)	(0.012)	(0.025)	(0.041)	(0.016)	(0.030)	(0.032)	(0.012)	(0.025)	(0.040)	(0.015)	(0.029)
No. of observations	354,976	354,976	354,976	220,693	220,693	220,693	354,976	354,976	354,976	220,693	220,693	220,693
Adj. R^2	0.372	0.510	0.343	0.443	0.478	0.446	0.372	0.510	0.343	0.443	0.478	0.446

Note: Standard errors clustered at product-level are in brackets. Product and year fixed effects are included.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 5 — Estimates of (28) with the interaction term

	$\ln R_{pct}$	$\ln M_{pct}$	$\ln \bar{r}_{pct}$	$\ln R_{pct}$	$\ln M_{pct}$	$\ln \bar{r}_{pct}$
$\ln dist_c$	-0.718^{***}	-0.516^{***}	-0.202^{***}	-0.716^{***}	-0.514^{***}	-2.01^{***}
	(0.022)	(0.010)	(0.015)	(0.023)	(0.010)	(0.015)
$\ln dist_c * inter_c$	-0.064^{**}	-0.054^{***}	-0.010	-0.058^{**}	-0.052^{***}	-0.007
	(0.029)	(0.013)	(0.019)	(0.029)	(0.013)	(0.019)
$\ln tariff_{pct}$	-0.151^{***}	-0.082^{***}	-0.069^{***}			
	(0.022)	(0.008)	(0.017)			
$\ln tariff_{pct} * inter_c$	0.006	-0.010	0.016			
	(0.032)	(0.012)	(0.025)			
$\ln\left(\frac{tariff_{pct}}{\overline{tariff}_{ct}}\right)$				-0.101^{***}	-0.058^{***}	-0.043^{***}
				(0.022)	(0.009)	(0.017)
$\ln\left(\frac{tariff_{pct}}{\overline{tariff}_{ct}}\right) * inter_c$				-0.126^{***}	-0.056^{***}	-0.070^{***}
				(0.042)	(0.019)	(0.028)
$\ln GDP_{ct}$	0.773^{***}	0.481^{***}	0.292^{***}	0.764^{***}	0.477^{***}	0.288^{***}
	(0.012)	(0.006)	(0.006)	(0.012)	(0.006)	(0.006)
$border_c$	-0.695^{***}	-0.465^{***}	0.230^{***}	-0.691^{***}	-0.462^{***}	0.229^{***}
	(0.028)	(0.012)	(0.019)	(0.028)	(0.012)	(0.019)
$Chinese_c$	0.715^{***}	0.589^{***}	0.126^{***}	0.703^{***}	0.583^{***}	0.120^{***}
	(0.030)	(0.015)	(0.018)	(0.030)	(0.015)	(0.018)
WTO_{ct}	0.081^{*}	0.046^{***}	0.033	0.063	0.038^{**}	0.025
	(0.044)	(0.017)	(0.031)	(0.043)	(0.017)	(0.030)
FTA_{ct}	0.001	-0.132^{***}	0.134^{***}	0.026	-0.118^{***}	0.144^{***}
	(0.026)	(0.010)	(0.019)	(0.025)	(0.009)	(0.019)
No. of observations	575,669	575,669	575,669	575,669	575,669	575,669
Adj. R^2	0.403	0.498	0.388	0.403	0.498	0.388

Note: Standard errors clustered at product-level are in brackets. Product and year fixed effects are included.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 6 — Estimates of (29) with the subsamples

	$\ln R^I_{pct}$	$\ln M^I_{pct}$	$\ln \bar{r}^I_{pct}$	$\ln R^F_{pct}$	$\ln M^F_{pct}$	$\ln \bar{r}^F_{pct}$	$\ln R^I_{pct}$	$\ln M^I_{pct}$	$\ln \bar{r}^I_{pct}$	$\ln R^F_{pct}$	$\ln M^F_{pct}$	$\ln \bar{r}^F_{pct}$
$\ln tariff^h_{pct}$	-0.164^{***}	-0.071^{***}	-0.088^{***}	-0.096^{***}	-0.061^{***}	-0.035^{***}						
	(0.028)	(0.011)	(0.022)	(0.022)	(0.008)	(0.017)						
$\ln\left(\frac{tariff^h_{pct}}{tariff_{ct}}\right)$							-0.158^{***}	-0.082^{***}	-0.076^{***}	-0.094^{***}	-0.063^{***}	-0.031^{*}
							(0.026)	(0.010)	(0.021)	(0.022)	(0.008)	(0.017)
$\ln GDP_{ct}$	0.147^{***}	0.147^{***}	0.000	0.664^{***}	0.131^{***}	0.553^{***}	0.141^{***}	0.144^{***}	-0.003	0.660^{***}	0.129^{***}	0.531^{***}
	(0.058)	(0.018)	(0.050)	(0.065)	(0.023)	(0.055)	(0.058)	(0.018)	(0.050)	(0.065)	(0.023)	(0.055)
WTO_{ct}	0.132^{***}	0.040^{***}	0.092^{***}	-0.008	-0.018^{*}	0.009	0.137^{***}	0.043^{***}	0.095^{***}	-0.005	-0.015	0.010
	(0.040)	(0.013)	(0.033)	(0.045)	(0.016)	(0.037)	(0.040)	(0.013)	(0.033)	(0.045)	(0.016)	(0.037)
FTA_{ct}	-0.084^{***}	-0.107^{***}	0.023	-0.023	-0.062^{***}	0.039	-0.055^{**}	-0.094^{***}	0.039^{*}	-0.005	-0.051^{***}	0.046^{*}
	(0.027)	(0.009)	(0.022)	(0.032)	(0.011)	(0.027)	(0.026)	(0.009)	(0.022)	(0.032)	(0.010)	(0.026)
No. of observations	354,976	354,976	354,976	220,693	220,693	220,693	354,976	354,976	354,976	220,693	220,693	220,693
Adj. R^2	0.402	0.568	0.358	0.479	0.543	0.464	0.402	0.568	0.358	0.479	0.543	0.464

Note: Standard errors clustered at product-level are in brackets. Country, product, and year fixed effects are included.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 7 — Estimates of (30) with the interaction term

	$\ln R_{pct}$	$\ln M_{pct}$	$\ln \bar{r}_{pct}$	$\ln R_{pct}$	$\ln M_{pct}$	$\ln \bar{r}_{pct}$
$\ln tariff_{pct}$	-0.132^{***}	-0.064^{***}	-0.068^{***}			
	(0.021)	(0.008)	(0.017)			
$\ln tariff_{pct} * inter_c$	0.006	-0.006	0.012			
	(0.031)	(0.012)	(0.024)			
$\ln \left(\frac{tariff_{pct}}{tariff_{ct}} \right)$				-0.073^{***}	-0.043^{***}	-0.030^{*}
				(0.022)	(0.009)	(0.017)
$\ln \left(\frac{tariff_{pct}}{tariff_{ct}} \right) * inter_c$				-0.123^{***}	-0.061^{***}	-0.062^{**}
				(0.034)	(0.015)	(0.024)
$\ln GDP_{ct}$	0.340^{***}	0.138^{***}	0.202^{***}	0.336^{***}	0.136^{***}	0.200^{***}
	(0.044)	(0.014)	(0.038)	(0.044)	(0.014)	(0.038)
WTO_{ct}	0.079^{***}	0.018^{*}	0.061^{**}	0.085^{***}	0.022^{**}	0.063^{**}
	(0.030)	(0.010)	(0.025)	(0.030)	(0.010)	(0.025)
FTA_{ct}	-0.062^{***}	-0.090^{***}	0.028	-0.035^{*}	-0.076^{***}	0.041^{**}
	(0.021)	(0.007)	(0.017)	(0.021)	(0.007)	(0.017)
No. of observations	575,669	575,669	575,669	575,669	575,669	575,669
Adj. R^2	0.430	0.553	0.401	0.430	0.553	0.401

Note: Standard errors clustered at product-level are in brackets. Country, product, and year fixed effects are included.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Finally, Table 7 reports the estimation results of (30) with the interaction term. As in Table 5, the estimated coefficient of non-adjusted tariffs on the interaction term is not significant, while that coefficient of adjusted-tariffs is negative and significant at the 1% level. In addition, the negative relationship between the total import values and adjusted tariffs operates through the two margins. To interpret the WTO membership dummy, the above claim also applies here: once we control for country fixed effects, the coefficients of WTO membership dummy are still positive and significant but the WTO accession of new membership countries increases their exports to China relatively more through the intensive margin. The results are different with those in Tables 3 and 5 where we compared to non-WTO members, in which case WTO member countries have more trade with China mainly through the extensive margin.

3.4 Discussions

This subsection briefly discusses one extension of our analysis and two potential channels that may affect our results. Detailed estimation results are available upon request to the authors.

3.4.1 Cross-industry difference

Our theory suggests that the trade elasticity of intermediate goods depends on the elasticity of substitution σ, while that elasticity of final goods does not. Because of this, we predict that the difference between the two trade elasticities are greater, the lower the elasticity of substitution. To empirically assess this prediction, we aggregate the 6-digit HS classification into the 2-digit HS classification and examine cross-industry differences in the trade elasticities. For simplicity, we report the results on the machinery industry (HS 84-85) and other industries whose average elasticities of substitution are approximately 2 and 4 respectively.

We find that the coefficients of trade barriers (in particular distances) on the total import values are significantly greater in the machinery industry than those in other industries. The coefficients of trade barriers on the interaction term are also greater in the machinery industry. Moreover, in contrast to the baseline estimations in which the coefficient of non-adjusted tariffs on the interaction term is not significant as shown in Tables 5 and 7, that coefficient is negative and significant in the machinery industry, while keeping the same coefficient insignificant in other industries as before. Overall, we find supportive evidence on our theory in that the trade elasticities are greater for intermediate goods than for final goods, the smaller the elasticity of substitution of the industry.

3.4.2 Zero trade flows

We have ignored the incidence of zero trade flows among China and its trading partner in the main analysis, but the recent literature (e.g., Helpman et al., 2008) shows that controlling for zero trade flows is crucial in the estimation of the gravity equation. To deal with this problem, we run the regressions by including observations that the TRAINS database has tariff records on products but the China Customs database has no import record on them. This does not imply that we can fix the problem of zero trade flows, however, because we have focused on ordinary imports only in our regressions, whereas Chinese firms would import some intermediate goods through processing trade in reality. Consequently, our analysis cannot truely address the issue, even if we employ a Poisson Pseudo-Maximum Likelihood estimation that is frequently used in the existing literature.

Given this caveat, we find that although the elasticities of distances and tariffs are slightly smaller in this estimation than those in the baseline estimation, the key result does not change at all: the trade elasticities are greater for intermediate goods than for final goods, in terms of both distances and tariffs. There are nevertheless some notable differences from the baseline estimations. For example, we found in Table 5 that the negative relationship between the total import values and distances is significantly explained only through the extensive margin. In contrast, the relationship is also significantly explained by the intensive margin as well in this regression. Further the trade elasticity difference between intermediate goods and final goods is smaller and less significant than that in Table 7.

3.4.3 Global value chains

One might wonder to what extent global value chains affect our estimation results. This issue would be of particular importance for analyzing China's imports, because East Asian countries export a lot of intermediate goods that are intensively used for China's final goods production and thereby global value chains help build strong vertical linkages among China and its trading partner. To check this channel, we examine our empirical analysis separately for the East Asian countries (i.e., Bangladesh, Brunei, Cambodia, Hong Kong, Indonesia, Japan, Korea, Rep., Lao PDR, Macao, Malaysia, Philippines, Singapore, Taiwan, Vietnam) and other countries in our dataset. While this treatment allows us to see the impact of global value chains to some extent, the same caveat also applies for the exercise here: the exclusion of processing imports from the whole samples makes the analysis less comprehensive and less comparable with existing work. In particular, it is known that processing trade plays a prominent role in the global production network for Chinese firms (see, e.g., Dai et al., 2016). Our purpose is to provide a big picture of this network effect on our main results.

If we limit the analysis to the East Asian countries, the coefficients of distances and tariffs on the total import values are greater for intermediate goods than for final goods, and hence our prediction continues to hold. For the non-East Asian countries, in contrast, we find that the relation is not so strong and the regional restriction overturns the result in some estimations. This difference between the East Asian and non-East Asian countries may reflect the influence of global value chains within the East Asia, where fragmentation of production contributes to increasing trade flows of intermediate goods relative to final goods. This also may imply that our central result on the trade elasticities deserves further research to assess whether or not the result is specific to China.

4 Conclusion

We presented a heterogeneous-firm model in which firms in asymmetric countries in terms of sizes and trade costs export and import intermediate goods subject to selection. Not only firms in the upstream firms, but firms in the downstream sector also incur fixed trade costs to source intermediate goods, which in turn gives rise to selection into the import market there. In this environment, we derived the gravity equation of intermediate goods in order to demonstrate that the trade elasticities with respect to trade costs, both variable and fixed, are greater for intermediate goods than for final goods. Guided by the theoretical framework, we empirically assessed the difference in the trade elasticities between intermediate goods and final goods, and provided empirical evidence in support of the prediction of the model in China's imports. It is worth noting that, in contrast to distances, tariffs are a policy variable and our result would be useful from policy perspectives. In particular, the fact that the trade elasticities are different between types of trade would help us to better understand the difference in the welfare gains from trade, since these gains depend on whether or not trade liberalization induces more firms to enter the vertically-related sectors (extensive margin), stimulating the Melitz (2003) type resource reallocations across firms. Ara (2019) addresses this point in detail by adopting the sufficient statistics approach developed by Arkolakis et al. (2012).

Much remains to be done however. In theory, we have resorted to a simple two-country setup in which the remoteness of an importing country from the rest of the world has no effect on the gravity equation. As stressed by Chaney (2008), such a "multilateral resistance variable" may play a key role in the impact of firm heterogeneity on the aggregate outcome. The extension to a multiple-country setup also allows us to explore the positive correlation between productivity and the number of source countries in a way that more productive final goods firms import more intermediate goods from a larger number of countries, as in Antràs et al. (2017). In empirics, on the other hand, we have restricted our attention to the standard gravity regressions in which tariffs have an impact on the extensive and intensive margins in the repeated cross-sections. To obtain reliable unbiased estimates of tariffs, we need to control for unobserved heterogeneity of trade flows by exploiting a three-dimensional panel and time-varying tariffs as a measure of variable trade costs. As emphasized by Buono and Lalanne (2012), such a "within regression" is important to take the bias into account, which might drastically change the impact of tariffs on the two margins. In Ara et al. (2020), we have started to study this aspect in China's imports to check whether there still remain statistically significant differences in the trade elasticities between the two types of trade.

Appendix

A.1 Proofs of Lemmas 1, 2 and 3

Taking the log and differentiating (7) and (13) for i, j with respect to τ_{ji}^I gives

$$\left(\frac{\sigma-1}{\tilde{\varphi}_{ii}^*}\right)\frac{\partial \tilde{\varphi}_{ii}^*}{\partial \tau_{ji}^I} - \left(\frac{\sigma-1}{\varphi_{ii}^*}\right)\frac{\partial \varphi_{ii}^*}{\partial \tau_{ji}^I} = -\left(\frac{\theta}{\phi_{ii}^*}\right)\frac{\partial \phi_{ii}^*}{\partial \tau_{ji}^I} + \left(\frac{\theta}{\phi_{ji}^*}\right)\frac{\partial \phi_{ji}^*}{\partial \tau_{ji}^I} + \frac{\sigma-1}{\tau_{ji}^I}, \tag{A.1}$$

$$\left(\frac{\sigma-1}{\tilde{\varphi}_{jj}^*}\right)\frac{\partial \tilde{\varphi}_{jj}^*}{\partial \tau_{ji}^I} - \left(\frac{\sigma-1}{\varphi_{jj}^*}\right)\frac{\partial \varphi_{jj}^*}{\partial \tau_{ji}^I} = -\left(\frac{\theta}{\phi_{jj}^*}\right)\frac{\partial \phi_{jj}^*}{\partial \tau_{ji}^I} + \left(\frac{\theta}{\phi_{ij}^*}\right)\frac{\partial \phi_{ij}^*}{\partial \tau_{ji}^I}, \tag{A.2}$$

$$\left(\frac{\sigma-1}{\phi_{ji}^*}\right)\frac{\partial \phi_{ji}^*}{\partial \tau_{ji}^I} - \left(\frac{\sigma-1}{\phi_{ii}^*}\right)\frac{\partial \phi_{ii}^*}{\partial \tau_{ji}^I} = -\left(\frac{\theta}{\varphi_{ii}^*}\right)\frac{\partial \varphi_{ii}^*}{\partial \tau_{ji}^I} + \left(\frac{\theta}{\tilde{\varphi}_{ii}^*}\right)\frac{\partial \tilde{\varphi}_{ii}^*}{\partial \tau_{ji}^I} + \frac{\sigma-1}{\tau_{ji}^I}, \tag{A.3}$$

$$\left(\frac{\sigma-1}{\phi_{ij}^*}\right)\frac{\partial \phi_{ij}^*}{\partial \tau_{ji}^I} - \left(\frac{\sigma-1}{\phi_{jj}^*}\right)\frac{\partial \phi_{jj}^*}{\partial \tau_{ji}^I} = -\left(\frac{\theta}{\varphi_{jj}^*}\right)\frac{\partial \varphi_{jj}^*}{\partial \tau_{ji}^I} + \left(\frac{\theta}{\tilde{\varphi}_{jj}^*}\right)\frac{\partial \tilde{\varphi}_{jj}^*}{\partial \tau_{ji}^I}, \tag{A.4}$$

where

$$\theta \equiv -\frac{d \ln V_i^h(a^*)}{d \ln a^*} = k - (\sigma - 1) > 0$$

for $a^* \in \{\varphi_{ii}^*, \varphi_{jj}^*, \tilde{\varphi}_{ii}^*, \tilde{\varphi}_{jj}^*, \phi_{ii}^*, \phi_{jj}^*, \phi_{ij}^*, \phi_{ji}^*\}$. θ represents the extensive margin elasticity, which is common for the productivity cutoffs under the Pareto distribution. In (A.1)-(A.2), we take the partial derivative of (7) holding N_i^E, N_j^E in Λ_{ji}^I constant. Differentiating (8) and (14) for i, j with respect to τ_{ji}^I also gives

$$\frac{\partial \tilde{\varphi}_{ii}^*}{\partial \tau_{ji}^I} = -C_{ij}\frac{\partial \varphi_{ii}^*}{\partial \tau_{ji}^I}, \tag{A.5}$$

$$\frac{\partial \tilde{\varphi}_{jj}^*}{\partial \tau_{ji}^I} = -C_{ji}\frac{\partial \varphi_{jj}^*}{\partial \tau_{ji}^I}, \tag{A.6}$$

$$\frac{\partial \phi_{ij}^*}{\partial \tau_{ji}^I} = -D_{ij}\frac{\partial \phi_{ii}^*}{\partial \tau_{ji}^I}, \tag{A.7}$$

$$\frac{\partial \phi_{ji}^*}{\partial \tau_{ji}^I} = -D_{ji}\frac{\partial \phi_{jj}^*}{\partial \tau_{ji}^I}, \tag{A.8}$$

where $C_{ij} \equiv \frac{f_{ii}^F J_i^{F'}(\varphi_{ii}^*)}{f_{ij}^F J_i^{F'}(\tilde{\varphi}_{ii}^*)} > 0$ and $D_{ij} \equiv \frac{f_{ii}^I J_i^{I'}(\phi_{ii}^*)}{f_{ij}^I J_i^{I'}(\phi_{ij}^*)} > 0$. Note that (A.1)-(A.8) are eight equations with eight unknowns ($\frac{\partial \varphi_{ii}^*}{\partial \tau_{ji}^I}, \frac{\partial \varphi_{jj}^*}{\partial \tau_{ji}^I}, \frac{\partial \tilde{\varphi}_{ii}^*}{\partial \tau_{ji}^I}, \frac{\partial \tilde{\varphi}_{jj}^*}{\partial \tau_{ji}^I}, \frac{\partial \phi_{ii}^*}{\partial \tau_{ji}^I}, \frac{\partial \phi_{jj}^*}{\partial \tau_{ji}^I}, \frac{\partial \phi_{ij}^*}{\partial \tau_{ji}^I}, \frac{\partial \phi_{ji}^*}{\partial \tau_{ji}^I}$). Substituting (A.5)-(A.8) into (A.1)-(A.4) and rearranging, (A.1)-(A.4) are expressed as

$$(\sigma-1)\left(\frac{1}{\varphi_{ii}^*} + \frac{C_{ij}}{\tilde{\varphi}_{ii}^*}\right)\frac{\partial \varphi_{ii}^*}{\partial \tau_{ji}^I} - \left(\frac{\theta}{\phi_{ii}^*}\right)\frac{\partial \phi_{ii}^*}{\partial \tau_{ji}^I} - \left(\frac{\theta D_{ji}}{\phi_{ji}^*}\right)\frac{\partial \phi_{jj}^*}{\partial \tau_{ji}^I} = -\left(\frac{\sigma-1}{\tau_{ji}^I}\right), \tag{A.9}$$

$$(\sigma-1)\left(\frac{1}{\varphi_{jj}^*} + \frac{C_{ji}}{\tilde{\varphi}_{jj}^*}\right)\frac{\partial \varphi_{jj}^*}{\partial \tau_{ji}^I} - \left(\frac{\theta}{\phi_{jj}^*}\right)\frac{\partial \phi_{jj}^*}{\partial \tau_{ji}^I} - \left(\frac{\theta D_{ij}}{\phi_{ij}^*}\right)\frac{\partial \phi_{ii}^*}{\partial \tau_{ji}^I} = 0, \tag{A.10}$$

$$-\theta\left(\frac{1}{\varphi_{ii}^*} + \frac{C_{ij}}{\tilde{\varphi}_{ii}^*}\right)\frac{\partial \varphi_{ii}^*}{\partial \tau_{ji}^I} + \left(\frac{\sigma-1}{\phi_{ii}^*}\right)\frac{\partial \phi_{ii}^*}{\partial \tau_{ji}^I} + \left(\frac{(\sigma-1)D_{ji}}{\phi_{ji}^*}\right)\frac{\partial \phi_{jj}^*}{\partial \tau_{ji}^I} = -\left(\frac{\sigma-1}{\tau_{ji}^I}\right), \tag{A.11}$$

$$-\theta\left(\frac{1}{\varphi_{jj}^*} + \frac{C_{ji}}{\tilde{\varphi}_{jj}^*}\right)\frac{\partial \varphi_{jj}^*}{\partial \tau_{ji}^I} + \left(\frac{\sigma-1}{\phi_{jj}^*}\right)\frac{\partial \phi_{jj}^*}{\partial \tau_{ji}^I} + \left(\frac{(\sigma-1)D_{ij}}{\phi_{ij}^*}\right)\frac{\partial \phi_{ii}^*}{\partial \tau_{ji}^I} = 0. \tag{A.12}$$

Note that (A.9)-(A.12) are four equations with four unknowns ($\frac{\partial\varphi^*_{ii}}{\partial\tau^I_{ji}}, \frac{\partial\varphi^*_{jj}}{\partial\tau^I_{ji}}, \frac{\partial\phi^*_{ii}}{\partial\tau^I_{ji}}, \frac{\partial\phi^*_{jj}}{\partial\tau^I_{ji}}$). Multiplying (A.9) and (A.10) by θ and (A.11) and (A.12) by $(\sigma-1)$, and adding (A.9) and (A.11), and (A.10) and (A.12),

$$\frac{1}{\phi^*_{ii}}\frac{\partial\phi^*_{ii}}{\partial\tau^I_{ji}} + \left(\frac{D_{ji}}{\phi^*_{ji}}\right)\frac{\partial\phi^*_{jj}}{\partial\tau^I_{ji}} = -\left(\frac{\sigma-1}{\tau^I_{ji}(2(\sigma-1)-k)}\right), \tag{A.13}$$

$$\left(\frac{D_{ij}}{\phi^*_{ij}}\right)\frac{\partial\phi^*_{ii}}{\partial\tau^I_{ji}} + \left(\frac{1}{\phi^*_{jj}}\right)\frac{\partial\phi^*_{jj}}{\partial\tau^I_{ji}} = 0. \tag{A.14}$$

Note that (A.13) and (A.14) are two equations with two unknowns ($\frac{\partial\phi^*_{ii}}{\partial\tau^I_{ji}}, \frac{\partial\phi^*_{jj}}{\partial\tau^I_{ji}}$), which are solved for

$$\frac{\partial\phi^*_{ii}}{\partial\tau^I_{ji}} = \frac{\left(\frac{\sigma-1}{(2(\sigma-1)-k)\tau^I_{ji}}\right)\frac{1}{\phi^*_{jj}}}{\Delta}, \qquad \frac{\partial\phi^*_{jj}}{\partial\tau^I_{ji}} = -\frac{\left(\frac{\sigma-1}{(2(\sigma-1)-k)\tau^I_{ji}}\right)\frac{D_{ij}}{\phi^*_{ij}}}{\Delta}, \tag{A.15}$$

where

$$\Delta \equiv \frac{1}{\phi^*_{ii}\phi^*_{jj}}\left(\frac{\phi^*_{ii}\phi^*_{jj}}{\phi^*_{ij}\phi^*_{ji}}D_{ij}D_{ji} - 1\right).$$

The sign of (A.15) depends on (19) in Assumption 1 and Δ. From (13) and D_{ij} defined above, $\Delta > 0$ if

$$\frac{J^{I'}_i(\phi^*_{ii})J^{I'}_j(\phi^*_{jj})}{J^{I'}_i(\phi^*_{ij})J^{I'}_j(\phi^*_{ji})} > \tau^I_{ij}\tau^I_{ji}\left(\frac{f^I_{ij}f^I_{ji}}{f^I_{ii}f^I_{jj}}\right)^{\frac{\sigma}{\sigma-1}}\frac{1}{(\tilde{\Lambda}^F_{ij}\tilde{\Lambda}^F_{ji})^{\frac{1}{\sigma-1}}}.$$

Applying Pareto to $J^{I'}_i(\cdot)$,

$$\left(\frac{(\tau^I_{ij}\tau^I_{ji})^{\sigma-1}}{\tilde{\Lambda}^F_{ij}\tilde{\Lambda}^F_{ji}}\right)^k\left(\frac{f^I_{ij}f^I_{ji}}{f^I_{ii}f^I_{jj}}\right)^{k-(\sigma-1)} > 1,$$

which holds true from (7), (13), (19) and $\tilde{\Lambda}^F_{ij} < 1, \tilde{\Lambda}^F_{ji} < 1$. From (A.15) and (19), $\frac{\partial\phi^*_{ii}}{\partial\tau^I_{ji}} > 0, \frac{\partial\phi^*_{jj}}{\partial\tau^I_{ji}} < 0$ and from (A.7) and (A.8), $\frac{\partial\phi^*_{ij}}{\partial\tau^I_{ji}} < 0, \frac{\partial\phi^*_{ji}}{\partial\tau^I_{ji}} > 0$; further substituting (A.15) into (A.1) and (A.2), $\frac{\partial\varphi^*_{ii}}{\partial\tau^I_{ji}} < 0, \frac{\partial\varphi^*_{jj}}{\partial\tau^I_{ji}} = 0$; finally, from (A.5) and (A.6), $\frac{\partial\tilde{\varphi}^*_{ii}}{\partial\tau^I_{ji}} > 0, \frac{\partial\tilde{\varphi}^*_{jj}}{\partial\tau^I_{ji}} = 0$. This completes the proofs of Lemmas 1 and 2.

As for the proof of Lemma 3, taking the log and differentiating (11) for i, j with respect to τ^I_{ji} gives

$$\frac{\partial B^I_i}{\partial\tau^I_{ji}} = -(\sigma-1)\frac{\partial\phi^*_{ii}}{\partial\tau^I_{ji}}, \qquad \frac{\partial B^I_j}{\partial\tau^I_{ji}} = -(\sigma-1)\frac{\partial\phi^*_{jj}}{\partial\tau^I_{ji}}.$$

Noting that $\frac{\partial\phi^*_{ii}}{\partial\tau^I_{ji}} > 0, \frac{\partial\phi^*_{jj}}{\partial\tau^I_{ji}} < 0$, we have $\frac{\partial B^I_i}{\partial\tau^I_{ji}} < 0, \frac{\partial B^I_j}{\partial\tau^I_{ji}} > 0$. Differentiating (4) with respect to τ^I_{ji} also gives

$$\frac{\partial B^F_i}{\partial\tau^I_{ji}} = (\sigma-1)\left(\frac{\partial\Gamma_i}{\partial\tau^I_{ji}} - \frac{\partial\varphi^*_{Ii}}{\partial\tau^I_{ji}}\right), \qquad \frac{\partial B^F_j}{\partial\tau^I_{ji}} = (\sigma-1)\left(\frac{\partial\Gamma_j}{\partial\tau^I_{ji}} - \frac{\partial\varphi^*_{jj}}{\partial\tau^I_{ji}}\right).$$

Further, differentiating (18) with respect to τ^I_{ji} and using the definition of θ, we have

$$\frac{\partial\Gamma_i}{\partial\tau^I_{ji}} = \frac{k-(\sigma-1)}{\sigma-1}\frac{\partial\phi^*_{ii}}{\partial\tau^I_{ji}}, \qquad \frac{\partial\Gamma_j}{\partial\tau^I_{ji}} = \frac{k-(\sigma-1)}{\sigma-1}\frac{\partial\phi^*_{jj}}{\partial\tau^I_{ji}}.$$

Noting that $\frac{\partial\varphi^*_{ii}}{\partial\tau^I_{ji}} < 0, \frac{\partial\varphi^*_{jj}}{\partial\tau^I_{ji}} = 0, \frac{\partial\phi^*_{ii}}{\partial\tau^I_{ji}} > 0, \frac{\partial\phi^*_{jj}}{\partial\tau^I_{ji}} < 0$, we have $\frac{\partial B^F_i}{\partial\tau^I_{ji}} > 0, \frac{\partial B^F_j}{\partial\tau^I_{ji}} < 0$.

A.2 Proof of Proposition 1

We first show (20). Let us rewrite (9) in country j as

$$\begin{aligned}
R_j^F &= \sigma M_j^E[\Gamma_j^{1-\sigma} B_j V_j^F(\varphi_{jj}^*) + \Lambda_{ij}^I(\tau_{ij}^I)^{1-\sigma}\Gamma_j^{1-\sigma} B_j^F V_j^F(\tilde{\varphi}_{jj}^*)] \\
&= \sigma M_j^E \left[(\varphi_{jj}^*)^{1-\sigma} V_j^F(\varphi_{jj}^*) f_{jj}^F + (\tilde{\varphi}_{jj}^*)^{1-\sigma} V_j^F(\tilde{\varphi}_{jj}^*) f_{ji}^F\right] \\
&= \sigma M_j^E \left\{[J_j^F(\varphi_{jj}^*) + 1 - G_j^F(\varphi_{jj}^*)] f_{jj}^F + [J_j^F(\tilde{\varphi}_{jj}^*) + 1 - G_j^F(\tilde{\varphi}_{jj}^*)] f_{ji}^F\right\} \\
&= \sigma M_j^E \{f_j^E + [1 - G_j^F(\varphi_{jj}^*)] f_{jj}^F + [1 - G_j^F(\tilde{\varphi}_{jj}^*) f_{ji}^F]\},
\end{aligned}$$

where the second equality comes from (5) and (6), the third comes from $J_j^h(a^*)+1-G_j^h(a^*) = (a^*)^{1-\sigma} V_j^h(a^*)$, and the last comes from (8). Similarly, from (11), (12) and (14), we can rewrite (17) in country j as

$$L_j^I = \sigma N_j^E \{f_j^E + [1 - G_j^I(\phi_{jj}^*)] f_{jj}^I + [1 - G_j^I(\phi_{ij}^*) f_{ij}^I]\}.$$

Solving these for M_j^E and N_j^E, we have

$$\begin{aligned}
M_j^E &= \frac{R_j^F}{\sigma\{f_i^E + [1 - G_j^F(\varphi_{jj}^*)] f_{jj}^F + [1 - G_j^F(\tilde{\varphi}_{jj}^*)] f_{ij}^F\}}, \\
N_j^E &= \frac{L_j^I}{\sigma\{f_i^E + [1 - G_j^I(\phi_{jj}^*)] f_{jj}^I + [1 - G_j^I(\phi_{ji}^*)] f_{ji}^I\}}.
\end{aligned} \tag{A.16}$$

From (A.16), it follows that the mass of entrants in the upstream sector in country j (N_j^E) depends not only on sector labor supply in country j (L_j^I) but also on the productivity cutoff in country n (ϕ_{jn}^*). Under the Pareto distribution, however, this dependence on the productivity cutoffs is eliminated. To see this, applying the Pareto distribution to (8) and (14) in country j, we have

$$\begin{aligned}
\left(\frac{\sigma-1}{k-(\sigma-1)}\right)\left[\left(\frac{\varphi_{\min}}{\varphi_{jj}^*}\right)^k f_{jj}^F + \left(\frac{\varphi_{\min}}{\tilde{\varphi}_{jj}^*}\right)^k f_{ij}^F\right] &= f_j^E, \\
\left(\frac{\sigma-1}{k-(\sigma-1)}\right)\left[\left(\frac{\phi_{\min}}{\phi_{jj}^*}\right)^k f_{jj}^I + \left(\frac{\phi_{\min}}{\phi_{ji}^*}\right)^k f_{ji}^I\right] &= f_j^E.
\end{aligned}$$

Furthermore, applying the Pareto distribution to (A.16), using the above expressions of (8) and (14), and solving them for M_j^E and N_j^E gives us the expression in (20).

Next, we show (21). Using ϕ_{jj}^* in (11) and ϕ_{ji}^* in (12) in country j, let us express R_{jj}^I and R_{ji}^I as

$$\begin{aligned}
R_{jj}^I &= \left(\frac{k\sigma\phi_{\min}^k}{k-(\sigma-1)}\right) N_j^E (B_j^I)^{\frac{k}{\sigma-1}} (f_{jj}^I)^{1-\frac{k}{\sigma-1}}, \\
R_{ji}^I &= \left(\frac{k\sigma\phi_{\min}^k}{k-(\sigma-1)}\right) N_j^E (B_i^I)^{\frac{k}{\sigma-1}} (\tau_{ji}^I)^{-k} (f_{ji}^I)^{1-\frac{k}{\sigma-1}} (\tilde{\Lambda}_{ji}^F)^{\frac{k}{\sigma-1}}.
\end{aligned} \tag{A.17}$$

Note from (17) that aggregate labor income of intermediate goods firms L_j^I consists of revenues earned by domestic firms and exporting firms of country j and hence L_j^I is expressed as

$$L_j^I = R_{jj}^I + R_{ji}^I = \left(\frac{k\sigma\phi_{\min}^k}{k-(\sigma-1)}\right) N_j^E \Xi_j^I, \tag{A.18}$$

where the expression of Ξ_j^I is given in Proposition 1. Using (A.18), we express (A.17) as shown in (21). Further, using (7) and (13), $\tilde{\Lambda}_{ji}^F$ and Λ_{ji}^I are expressed under the Pareto distribution as

$$\tilde{\Lambda}_{ji}^F = \left(\frac{1}{\Lambda_{ji}^I} \frac{(\tau_{ji}^I)^{\sigma-1} f_{ji}^F}{f_{ii}^F} \right)^{-\frac{k-(\sigma-1)}{\sigma-1}},$$
$$\Lambda_{ji}^I = \frac{N_j^E}{N_i^E} \left(\frac{1}{\tilde{\Lambda}_{ji}^F} \frac{(\tau_{ji}^I)^{\sigma-1} f_{ji}^I}{f_{ii}^I} \right)^{-\frac{k-(\sigma-1)}{\sigma-1}}.$$

Solving these equations for $\tilde{\Lambda}_{ji}^F$ yields

$$\left(\tilde{\Lambda}_{ji}^F\right)^{\frac{k}{\sigma-1}} = \left(\frac{N_j^E}{N_i^E} (\tau_{ji}^I)^{-k} \left(\frac{f_{ji}^F}{f_{ii}^F} \right)^{-1} \left(\frac{f_{ji}^I}{f_{ii}^I} \right)^{-\frac{k-(\sigma-1)}{\sigma-1}} \right)^{\frac{k-(\sigma-1)}{2(\sigma-1)-k}}.$$

The partial trade elasticities with respect to τ_{ji}^I and f_{ji}^I are obtained immediately from substituting this expression of $(\tilde{\Lambda}_{ji}^F)^{\frac{k}{\sigma-1}}$ into R_{ji}^I in (A.17).

Finally, we show (22). If $\tau_{ji}^F < \infty$ and $\tau_{ji}^I = \infty$ so that final goods are only tradable, it is easily shown that the equilibrium revenues of domestic and exporting firms are

$$r_{jj}^F(\varphi) = \Gamma_j^{1-\sigma} B_j^F \varphi^{\sigma-1},$$
$$r_{ji}^F(\varphi) = (\tau_{ji}^F \Gamma_j)^{1-\sigma} B_i^F \varphi^{\sigma-1}.$$

Then, the productivity cutoffs that satisfy $\pi_{jj}^F(\varphi_{jj}^*) = \frac{r_{jj}^F(\varphi)}{\sigma} - f_{jj}^F = 0$ and $\pi_{ji}^F(\varphi_{ji}^*) = \frac{r_{ji}^F(\varphi)}{\sigma} - f_{ji}^F = 0$ are

$$\Gamma_j^{1-\sigma} B_j^F (\varphi_{jj}^*)^{\sigma-1} = f_{jj}^F,$$
$$(\tau_{ji}^F \Gamma_j)^{1-\sigma} B_i^F (\varphi_{ji}^*)^{\sigma-1} = f_{ji}^F,$$

which are counterparts to (5) and (6). Moreover, (20) is expressed as

$$M_j^E = \frac{\sigma-1}{k\sigma} \frac{L_j^F}{f_j^E}, \quad N_j^E = \frac{\sigma-1}{k\sigma} \frac{R_j^I}{f_j^E}.$$

Using φ_{jj}^*, φ_{ji}^* and M_j^E, we can express $R_{jj}^F = M_j^E \int_{\varphi_{jj}^*}^{\infty} r_{jj}^F(\varphi) dG_j^F(\varphi)$ and $R_{ji}^F = M_j^E \int_{\varphi_{ji}^*}^{\infty} r_{ji}^F(\varphi) dG_j^F(\varphi)$ as

$$R_{jj}^F = \left(\frac{k\sigma\varphi_{\min}^k}{k-(\sigma-1)} \right) M_j^E (B_j^F)^{\frac{k}{\sigma-1}} (\Gamma_j)^{-k} (f_{jj}^F)^{1-\frac{k}{\sigma-1}},$$
$$R_{ji}^F = \left(\frac{k\sigma\varphi_{\min}^k}{k-(\sigma-1)} \right) M_j^E (B_i^F)^{\frac{k}{\sigma-1}} (\tau_{ji}^F \Gamma_j)^{-k} (f_{ji}^F)^{1-\frac{k}{\sigma-1}}. \tag{A.19}$$

As above, aggregate labor income of final goods firms is L_j^F consists of revenues earned by domestic firms and exporting firms of country j and hence L_j^F is expressed as

$$L_j^F = R_{jj}^F + R_{ji}^F = \left(\frac{k\sigma\varphi_{\min}^k}{k-(\sigma-1)} \right) M_j^E (\Gamma_j)^{-k} \Xi_j^F, \tag{A.20}$$

where the expression of Ξ_j^F is given in Proposition 1. Using (A.20), we express (A.19) as shown in (22).

A.3 Proof of Proposition 2

We show that the trade elasticity of final goods has only the exporter extensive margin elasticity in the downstream sector. From (A.19), the domestic expenditure share of final goods in country i is

$$\lambda_{ii}^F = \frac{R_{ii}^F}{R_i^F} = \frac{1}{1 + (\tau_{ji}^F)^{1-\sigma}\Lambda_{ji}^F},$$

where $R_i^F (= R_{ii}^F + R_{ji}^F)$ is aggregate final goods expenditure of consumers and

$$\Lambda_{ji}^F = \frac{M_j^E \Gamma_j^{1-\sigma} V_j^F(\varphi_{ji}^*)}{M_i^E \Gamma_i^{1-\sigma} V_i^F(\varphi_{ii}^*)}$$

is the (endogenous) market share of final goods exporters in the domestic market in country i. Following Melitz and Redding (2015), let us take the partial derivative of the domestic share λ_{ii}^F with respect to τ_{ji}^F holding M_i^E, M_j^E constant:

$$\begin{aligned}
\zeta_o^F &= -\frac{\partial \ln\left(\frac{1-\lambda_{ii}^F}{\lambda_{ii}^F}\right)}{\partial \ln \tau_{ji}^F} \\
&= (\sigma - 1) - \frac{\partial \ln \Lambda_{ji}^F}{\partial \ln \tau_{ji}^F},
\end{aligned}$$

where the first term is the intensive margin elasticity and the second term is the exporter extensive margin elasticity in the downstream sector. Noting under the Pareto distribution that the market share of final goods exporters is expressed as

$$\Lambda_{ji}^F = \frac{M_j^E}{M_i^E}(\tau_{ji}^F)^{-(k-(\sigma-1))}\left(\frac{f_{ji}^F}{f_{ii}^F}\right)^{1-\frac{k}{\sigma-1}}\left(\frac{\Gamma_j}{\Gamma_i}\right)^{-k},$$

where Γ_i, Γ_j are not affected by τ_{ji}^F (as N_i^E and ϕ_{ii}^* are both invariant to τ_{ji}^F) in Λ_{ji}^F, we have

$$\zeta_o^F = (\sigma - 1) + (k - (\sigma - 1)).$$

A.4 Additional Tables

Table A.1 — List of countries

Afghanistan	Dominica*	Latvia*	Saudi Arabia*
Albania*	Dominican Republic*	Lebanon	Senegal*
Algeria	Ecuador*	Liberia	Seychelles
Angola*	Egypt*	Libya	Sierra Leone*
Argentina*	El Salvador*	Lithuania*	Singapore*
Armenia*	Equatorial Guinea	Macao*	Slovak Republic*
Australia*	Estonia*	Macedonia, FYR*	Slovenia*
Austria*	Ethiopia (excludes Eritrea)	Madagascar	Solomon Islands*
Azerbaijan	Fiji*	Malaysia*	South Africa*
Bahamas	Finland*	Maldives*	Spain*
Bahrain*	France*	Mali*	Sri Lanka*
Bangladesh*	Gabon*	Malta*	Suriname*
Barbados*	Georgia*	Mauritania*	Swaziland*
Belarus	Germany*	Mauritius*	Sweden*
Belgium*	Ghana*	Mexico*	Switzerland*
Benin*	Greece*	Moldova*	Syrian Arab Republic
Bolivia*	Guatemala*	Mongolia	Taiwan*
Bosnia and Herzegovina	Guinea*	Morocco*	Tajikistan
Brazil*	Guyana*	Mozambique*	Tanzania*
Brunei*	Haiti*	Namibia*	Thailand*
Bulgaria*	Honduras*	Nepal*	Togo*
Burundi*	Hong Kong*	Netherlands*	Trinidad and Tobago*
Cambodia*	Hungary*	New Zealand*	Tunisia*
Cameroon*	Iceland*	Nicaragua*	Turkey*
Canada*	India*	Nigeria*	Turkmenistan
Central African Republic*	Indonesia*	Norway*	Uganda*
Chad*	Iran	Oman*	Ukraine
Chile*	Ireland*	Pakistan*	United Arab Emirates*
Colombia*	Israel*	Panama*	United Kingdom*
Congo, Dem. Rep.*	Italy*	Papua New Guinea*	United States*
Congo, Rep.*	Jamaica*	Paraguay*	Uruguay*
Costa Rica*	Japan*	Peru*	Uzbekistan
Cote d'Ivoire*	Jordan*	Philippines*	Vanuatu
Croatia*	Kazakhstan	Poland*	Venezuela*
Cuba*	Kenya*	Portugal*	Vietnam*
Cyprus*	Korea, Rep.*	Qatar*	Yemen
Czech Republic*	Kuwait*	Romania*	Zambia*
Denmark*	Kyrgyz Republic*	Russian Federation	Zimbabwe*
Djibouti*	Lao PDR	Rwanda*	

Note: * denotes countries that are members of WTO as of 2007.

Table A.2 — List of countries that share borders and a language with China

Borders	Language
Afghanistan	Hong Kong
Hong Kong	Macao
India	Malaysia
Kazakhstan	Singapore
Kyrgyz Republic	Taiwan
Lao PDR	
Macao	
Mongolia	
Nepal	
Pakistan	
Russian Federation	
Tajikistan	
Vietnam	

Source: CEPII database

Table A.3 — List of countries that have FTAs with China

Partner	2000	2001	2002	2003	2004	2005	2006	2007
Brunei						✓	✓	✓
Cambodia						✓	✓	✓
Chile								✓
Hong Kong					✓	✓	✓	✓
Indonesia						✓	✓	✓
Lao PDR						✓	✓	✓
Macao					✓	✓	✓	✓
Malaysia						✓	✓	✓
Philippines						✓	✓	✓
Singapore						✓	✓	✓
Thailand						✓	✓	✓
Vietnam						✓	✓	✓

Source: WTO

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