A Theory of Gains from New Imported Inputs*

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Abstract

This paper analyzes the impact of trade liberalization in an intermediate-good sector on a final-good sector using a general equilibrium model. The model clarifies that the final- and intermediate-good sectors gain from trade through distinct mechanisms. Trade in intermediate-goods leads to tougher competition in the intermediate-good sector, which in turn leads to productivity growth in the sector. Final-good producers benefit from the new entry of foreign suppliers. Moreover, the model shows the economic environment and the channel each sector gains from the most.

JEL Classification: F12, F14, L22

Key words: Trade liberalization, matching, heterogeneous firms, intermediate-goods

1. Introduction

Recent developments in international trade theory have suggested that opening to trade improves the productivity of firms in the economy being liberalized. For example, Melitz’s (2003) seminal paper highlights how new export opportunities and tougher competition generates aggregate productivity gains from trade. In his model, opening to trade enables firms to increase exports and, therefore, profits, resulting in higher aggregate productivity.1) However, recent empirical literature emphasizes that even non-exporting firms gain from trade because of access to new imported inputs and spillovers from productive foreign firms. Motivated by this empirical evidence, this paper develops a general equilibrium model incorporating final-good producers and suppliers to consider how local final-good producers are affected by trade. More specifically, the model considers how final-good producers are
affected by the new entry of foreign intermediate-good suppliers.

In terms of focus, the current paper contributes to a rapidly growing literature on productivity gains from new imported inputs. Previous empirical research on such gains has built new stylized facts in international trade. Amiti and Konings (2007) show that, using Indonesian data, productivity gains from reducing tariffs on imported inputs are at least twice as high as gains from cutting output tariffs. Kasahara and Rodrigue (2008) and Kasahara and Lapham (2008) also show that, using Chilean data, becoming an importer of intermediate-goods improves plant-level productivity. Khandelwal and Topalova (2011) find that, using Indian data, lowering tariffs on intermediate-goods and final-goods increased firm-level productivity. Moreover, their results suggest that productivity gains from new and cheap imported inputs are larger than productivity gains from pro-competitive effects due to cutting tariffs on final-goods. Halpern, Koren, and Szeidl (2011) find that, during 1993–2002, one-third of the productivity growth in Hungary was the result of new imported inputs. Other empirical research on the impact of trade in intermediate-goods includes Kugler and Verhoogen (2009, 2012), Goldberg, Khandelwal, Pavcnik, and Topalova (2010), and Amiti and Davis (2012). However, their focuses were different to ours. We are particularly interested in the impact of trade in intermediate-goods on the productivity of the final- and intermediate-good sectors.

The model developed in this paper clarifies when and how sectors gain most from trade liberalization. The model shows the exact mechanism through which trade improves productivity in the final-good sector and the intermediate-good sector. To distinguish the impact of trade on importing firms (final-good producers) and on exporting firms (suppliers), only intermediate-goods sector is liberalized. The model shows that the final- and intermediate-good sectors benefit from trade through different mechanisms. In the model, final-good producers and suppliers are heterogeneous in terms of productivity and randomly connect with each other. A matched pair of a final-good producer and a supplier jointly operates in the market. Therefore, a final (intermediate)-good producer will generate a higher profit when matched with an intermediate (final)-good producer with a higher productivity. If trade costs of intermediate-goods are reduced, the most productive suppliers begin exporting, which increases competition in the intermediate-good sector. As a result of this pro-competitive effect, the intermediate-good sector experiences productivity growth.

However, opening up to trade also increases the profit of final-good producers because it enables them to match with more productive exporting suppliers. On average, exporters are more productive because they are productive enough to overcome higher fixed and variable trade costs. Therefore, the new import opportunity increases the profit of final-good producers, and so boosts the productivity of the final-good sector. One may interpret this result as technological transfer from foreign productive suppliers to home final-good producers.

1) For empirical investigations related to Melitz’s (2003) theoretical prediction, see, for example, Pavcnik (2002), Kimura and Kiyota (2007), and Amiti and Konings (2007).
2) Kasahara and Lapham (2008) also developed a model that explains their empirical results.
3) Kugler and Verhoogen (2009, 2012) show that larger firms tend to use a greater amount of higher-quality imported inputs. Goldberg, Khandelwal, Pavcnik, and Topalova (2010) emphasize that a channel that lowers tariffs on intermediate inputs fosters the growth of domestic product variety. Amiti and Davis (2012) empirically and theoretically show that a fall in input tariffs increases wages at firms that use imported inputs.
In this sense, this paper is close to Ishikawa (2007) and Horiuchi and Ishikawa (2009). They examine a relationship between tariffs and technological transfer from North to South through trade in intermediate-goods using oligopoly models.

The model suggests that the intermediate-good sector gains more from trade than the final-good sector when fixed exporting costs are low. However, the model suggests that the final-good sector gains more from trade than the intermediate-good sector when fixed exporting costs are high. If fixed exporting costs are sufficiently high, new exporters are more productive, and so significantly contribute to an increase in the profit of final-good producers. As a result, the productivity of the final-good sector increases. However, when fixed exporting costs are sufficiently low, new exporters are less productive, and so they actually reduce the profit of final-good producers. Thus, in this heterogeneous firm model, the extensive margin effect (i.e., the effect of new exporters’ productivity on the importing firms) predominantly determines the impact on final-good producers. These theoretical results may explain the empirical results found in data from Indonesia (Amiti and Konings, 2007) and India (Khandelwal and Topalova, 2011). Here, productivity gains as a result of reducing the tariffs on intermediate-goods are greater than those from reducing the tariffs on final-goods. According to our theory, the fixed export costs required to export to Indonesia and India may be sufficiently high that lowering tariffs on intermediate-goods leads to only those more productive suppliers entering the Indonesian and Indian markets, hence leading to productivity growth in these markets.

In terms of technique, the current paper contributes to current theoretical literature by introducing matching and assignment in an international context. For example, Grossman and Helpman (2002, 2005) consider models in which final-good producers match with suppliers. However, they focus on firms’ organizational form, which is a different focus to ours. In addition, in their model, firms are identical. In our model, firms are heterogeneous in terms of productivity. Other theoretical studies that introduce matching and assignment include Nocke and Yeaple (2007, 2008), Sato (2009), and Costinot, Vogel, and Wang (2012). However, the focus in each of these studies is different to that of this study.

Among the studies that incorporate matching and assignment, that of Sugita (2011) is the closest to this paper in terms of focus. Sugita also introduces heterogeneous importers and exporters to explain the gains from new imported inputs. However, his model is different from our model in two ways. First, in his model, heterogeneous final-good producers and heterogeneous suppliers match with each other in an assortative way, but the matching

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4) If fixed exporting costs are high, a decrease in variable trade costs leads to only those more productive suppliers engaging in exporting.

5) Nocke and Yeaple (2007, 2008) examine the relationship between firm productivity and firm organizational structure, including exporting, greenfield foreign direct investment (FDI), and cross-border mergers and acquisitions (M&A), by introducing matching between immobile firm-intrinsic ability and mobile firm-specific assets. Sato (2009) introduces a model in which managers match with production workers to explain the imperfect relationship between firm productivity and organizational form (such as exporting and FDI) observed in data. In a model developed by Costinot, Vogel, and Wang (2012), heterogeneous countries are endogenously assigned to a number of production stages and they examine, for example, how productivity growth in one country affects other countries.

6) That is, more productive final-good producers match with more productive suppliers, and less productive final-good producers match with less productive suppliers.
pattern is purely random. Second, in his model, there are two distinct intermediate-good sectors. The home supplier has a comparative advantage in producing the one intermediate-good, and the foreign supplier has a comparative advantage in producing the other. Therefore, liberalizing two intermediate-good sectors benefits final-good producers, as it gives them new opportunities to access intermediate-goods produced using better technology. In contrast, our model only contains one intermediate-good sector. Therefore, there are no gains from exploiting comparative advantages, but final-good producers gain from trade as a result of the new entry of foreign productive suppliers.

The rest of the paper is organized as follows. Section 2 describes the setup of the model, and Section 3 characterizes the equilibrium in a closed economy. The model is extended to an open economy in Section 4, and Section 5 concludes the paper.

2. The model

Consider an economy consisting of two symmetric countries, home and foreign. Each country is populated by $L$ units of identical households. Firms in the economy produce a differentiated good using labor as the only input. Now, since the two countries are symmetric, we only focus on the home country.

2.1 Preferences

The utility of a representative consumer is given by a CES utility function over a continuum of varieties, indexed by $\omega$:

$$ U = \left( \int_{\omega \in \Omega} x(\omega)^{\frac{1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1,$$

(1)

where $x(\omega)$ is the consumption of variety $\omega$ of a differentiated food; $\Omega$ is the mass of available varieties; and $\sigma=1/(1-\rho)$ is the elasticity of substitution between any two varieties. Maximizing this utility gives us the demand for variety $\omega$ as:

$$ x(\omega) = \frac{p(\omega)^{\frac{1}{\sigma}} L}{p^{\frac{1}{\sigma-1}}}, $$

(2)

where $P$ is the CES price index dual to the utility function, defined as follows:

$$ P = \left( \int_{\omega \in \Omega} p(\omega)^{\frac{1}{\sigma}} d\omega \right)^{\frac{1}{1-\sigma}}. $$

2.2 Production technology

There are two sectors, namely a final-good sector and an intermediate-good sector. In each sector, there are infinitely many *ex ante* identical final-good producers and suppliers. To enter the market, each type of firm pays fixed entry costs, $f_e > 0$, which we consider to be sunk costs. Then final-good producers and suppliers draw their productivity from the

7) It is assumed that fixed matching costs, $f_e$, are symmetric across the two sectors. However, this assumption does not affect our main results.
Pareto (cumulative) distribution functions \( F(\varphi) = 1 - \varphi^{-k} \) and \( G(\lambda) = 1 - \lambda^{-k} \), respectively, where \( k \) is the shape parameter (assume \( k > \sigma - 1 \)) and each cumulative distribution function has an associated density function denoted as \( f(\varphi) \) and \( g(\lambda) \), respectively. There is a mass, \( N_e \), of entrants in the final-good sector and a mass, \( M_e \), of entrants in the intermediate-good sector. After entry, a final-good producer and a supplier randomly meet with each other and jointly produce a final-good. Mathematically, a final-good (or intermediate-good) producer draws her/his partner’s productivity from the distribution function \( G(\lambda) \) (or \( F(\varphi) \)) by paying a fixed matching cost, \( f \), which we also assume to be a sunk cost. Any pair of firms can be subject to an exogenous shock that induces the pair to exit the market. The probability of such a shock is \( \delta \in (0,1) \).

The cost function for a pair of firms is the sum of the variable production costs, \( x(\omega) / [\varphi(i) \lambda(j)] \), the fixed matching costs paid by final-good producer \( f \), and the fixed matching costs paid by supplier \( f \):

\[
I(\omega) = \frac{x(\omega)}{\varphi(i) \lambda(j)} + f + f,
\]

where \( \varphi(i) \) is the productivity of final-good producer \( i \) and \( \lambda(j) \) is the productivity of supplier \( j \). We assume that the nominal wage is fixed and normalized to unity.

Since, as will be shown later, firms that have the same productivity behave symmetrically, we simply index final-good producers and suppliers by \( \varphi \) and \( \lambda \), respectively. Each pair of firms choose a price so that marginal revenue, \( p(\omega) (1 - 1/\sigma) \), equals marginal costs, \( 1/\varphi \lambda \). From this, the price is given as:

\[
p(\varphi \lambda) = (\rho \varphi \lambda)^{-1}.
\]

The price equation implies that the price of variety \( \omega \) depends only on the product of \( \varphi \) and \( \lambda \), suggesting that varieties can be indexed by \( \varphi \lambda \). Therefore, we henceforth drop the variety index, \( \omega \).

The joint revenue from supplying a product is

\[
r_{\text{joint}}(\varphi \lambda) = p(\varphi \lambda) x(\varphi \lambda).
\]

Substituting (2) and (4) into (5) gives the following joint revenue function:

\[
r_{\text{joint}}(\varphi \lambda) = (\rho \varphi \lambda P)^{\sigma - 1} L.
\]

Using (3) and (5), the joint profit function is now expressed as:

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8) Without this assumption, firms will have infinite profits.
9) The shape parameter, \( k \), is assumed to be symmetric across sectors to avoid a proliferation of parameters. Making \( k \) asymmetric across sectors does not change our main results.
10) It is assumed that fixed matching costs \( f \) are symmetric across two sectors. However, this assumption does not affect our main results.
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\[ \pi_{\text{joint}}(\phi, \lambda) = \left( \frac{\rho \phi \lambda P}{\sigma} \right)^{\gamma - 1} \frac{L}{f} \]  

In this model, neither final-good producers nor suppliers have outside options, and they are assumed to divide joint profits equally, as follows:

\[ \pi_i(\phi, \lambda) = \left( \frac{\rho \phi \lambda P}{2\sigma} \right)^{\gamma - 1} \frac{L}{f}, \quad i = \text{FN, IM}, \]  

where subscripts FN and IM indicate final-good producers and intermediate-good suppliers, respectively. Equation (7) implies that the profit of final-good producer \( \phi \) increases with a corresponding increase in the productivity of supplier \( \lambda \). Similarly, the profit of supplier \( \lambda \) increases with a corresponding increase in the productivity of final-good producer \( \phi \). In other words, the profit function of a firm exhibits complementarity between its own productivity and that of its partner, which plays an important role in deriving the main results of this paper.

3. Closed economy equilibrium

To characterize the equilibrium of the closed-economy model, the profit function of each firm is derived. To simplify analysis, it is assumed that a supplier (final-good producer) matches with only one final-good producer (supplier).\(^1\)

3.1 Final-good producers in the closed economy

Because final-good producers randomly match with suppliers, the expected profit of a final-good producer, \( \phi \), is written as

\[ \pi_{\text{FN}}(\phi) = \int_{\lambda^*}^{\infty} \left( \frac{\rho \phi \lambda P}{2\sigma} \right)^{\gamma - 1} \frac{L}{1 - G(\lambda)} \ dG(\lambda) - f \]  

\[ = f \left[ \phi \left( \frac{\phi}{\phi^*} \right)^{\gamma - 1} - 1 \right], \]  

where

\[ \phi^* = \frac{1}{\rho \lambda^*} \left( \frac{2\sigma f}{\gamma L} \right)^{\gamma/(\gamma - 1)} \]  

with \( \gamma = \frac{k}{k - \sigma + 1} \),

\[ \text{is the cutoff-productivity below which final-good producers make negative profits, and so do not enter the market, and } \lambda^* \text{ is the cutoff-productivity of suppliers, derived later in this section. Equation (9) implies that a higher productivity, } \phi, \text{ increases the expected profit of the firm. By taking an average of (9) with respect to } \phi, \text{ we can determine the expected profit, conditional on entry } (\bar{\pi}_{\text{FN}}), \text{ for final-good producers as follows:} \]

\(^1\) Mathematically, it is assumed that each supplier (and final-good producer) has an increasing matching cost function and that matching with two partners requires infinite matching costs. Hence, they match with only one partner.
This implies that $\bar{\pi}_{FN}$ is increasing for fixed matching costs, $f$, and for the elasticity of substitution, $\sigma$, and is decreasing for the shape parameter, $k$. Intuitively, we interpret this to mean that higher fixed matching costs, $f$, lead to only those more productive final-good producers entering the market, which raises the expected profit (the average profit). A higher elasticity of substitution, $\sigma$, makes the market more competitive, and so induces only those more productive final-good producers to enter the market, also raising the expected profit. A higher shape parameter, $k$, increases the share of less productive final-good producers, which reduces the expected profit.

### 3.2 Suppliers in the closed economy

In the closed-economy setting, suppliers and final-good producers are symmetric. Therefore, suppliers have the same profit as final-good producers, which is

$$\bar{\pi}_{IM} = \frac{\sigma - 1}{k - \sigma + 1},$$

where

$$\lambda^* = \frac{1}{\rho \phi^* P} \left( \frac{2 \sigma f}{\gamma L} \right)^{1/(\sigma - 1)},$$

is the cutoff-productivity below which suppliers make negative profits, and so do not enter the market. The expected profits of final-good producers and suppliers derived here will be compared against those in the open-economy setting in the next section.

### 3.3 Equilibrium

This subsection derives equilibrium cutoff productivities. Free entry in the final-good sector and the intermediate-good sector requires

$$\left[1 - F(\phi^*)\right] \bar{\pi}_{FN} = \delta f, \quad \left[1 - G(\lambda^*)\right] \bar{\pi}_{IM} = \delta f,$$

respectively. Using these equations, (12) and (14), the equilibrium cutoff productivities are expressed as
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\[ \varphi^* = \lambda^* = \left( \frac{f}{\delta f_e} \frac{\sigma - 1}{k - \sigma + 1} \right)^{1/k}. \]

Because two types of firms are symmetric, they have exactly same equilibrium cutoff productivity.

4. Open economy equilibrium

The previous section discussed the closed-economy model and characterized the equilibrium of the model. In this section, the model is extended to an open-economy setting and we again characterize the equilibrium. To simplify the analysis, we assume that a supplier (final-good producer) matches with at most one final-good producer (supplier) in a market.

4.1 Suppliers in the open economy

In an open-economy setting, suppliers are assumed to be able to supply their products to the foreign market in addition to the domestic market. First, we derive the expected profit from operating in the domestic market. A supplier, \( \lambda \), that matches with a domestic final-good producer, \( \varphi \), makes the following profit in the domestic market:

\[ \pi_{d, \lambda}(\varphi, \lambda) = \frac{(\rho \varphi \lambda P)^{\sigma - 1}}{2\sigma} L - f. \] (15)

Since supplier \( \lambda \) randomly matches with a final-good producer, the supplier’s expected profit in the domestic market is:

\[ \int_{\varphi^*}^{\infty} \frac{(\rho \varphi \lambda P)^{\sigma - 1}}{2\sigma} \frac{L}{1 - F(\varphi)} dF(\varphi) = \frac{\gamma (\rho \varphi^* \lambda P)^{\sigma - 1}}{2\sigma} L - f \]

\[ = f \left[ \left( \frac{\lambda}{\lambda^*} \right)^{\sigma - 1} - 1 \right], \] (16)

where

\[ \lambda^* = \frac{1}{\rho \varphi^* P} \left( \frac{2\sigma f}{\gamma L} \right)^{1/(\sigma - 1)} \] (17)

is the cutoff-productivity below which a supplier makes a negative profit if it enters the market and therefore will not enter the market. The value of \( \lambda^* \) depends on the final-good producer’s cutoff-productivity, \( \varphi^* \), which is derived later in this section.

Next, the expected profit from operating in the foreign market is derived. To export one unit of product to the foreign market, the supplier incurs iceberg-type variable trade costs, \( \tau > 1 \). In addition, matching with a foreign final-good producer requires fixed matching costs, \( f_x \), which are assumed to be greater than \( f \), as in Sato (2009). Search activity in the

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12) To simplify the analysis, the exchange rate is assumed to be constant and normalized to one.
foreign market requires higher costs than in the domestic market.\textsuperscript{13)} Henceforth, \( f_i \) is simply referred to as fixed exporting costs.

Supplier \( \lambda \) that matches with foreign final-good producer \( \phi \) makes the following profit from exporting:

\[
\pi_{im} (\phi \lambda) = \frac{\left( \tau^{-1} \rho \phi \lambda P \right)^{\sigma - 1} L}{2\sigma} - f_i .
\]

(19)

Since supplier \( \lambda \) randomly matches with a final-good producer, the supplier’s expected profit from exporting is:

\[
\mathbb{E} \left[ \pi_{im} (\phi \lambda) \right] = \frac{\tau^{-1} \rho \phi \lambda P}{2\sigma} \frac{df(\phi)}{1 - F(\phi')} - f_i = \frac{\gamma \left( \tau^{-1} \rho \phi \lambda P \right)^{\sigma - 1} L}{2\sigma} - f_i
\]

(20)

\[
= f_i \left[ \left( \frac{\lambda}{\lambda_i} \right)^{\sigma - 1} - 1 \right] ,
\]

(21)

where

\[
\hat{\lambda}_i = \frac{\tau}{\rho \phi' P} \left( \frac{2\sigma f_i}{\gamma L} \right)^{1/\sigma - 1} ,
\]

(22)

is the cutoff-productivity below which the supplier makes a negative profit if it enters the export market and therefore will not enter the market. Dividing (22) by (18) gives us following equation:

\[
\frac{\hat{\lambda}_i}{\hat{\lambda}_j} = \tau \left( \frac{f_i}{f_j} \right)^{1/(\sigma - 1)} > 1 \quad \text{since } \tau > 1 \text{ and } f_i > f_j ,
\]

(23)

which implies that only the most productive suppliers engage in exporting. Suppliers that are productive enough to overcome the fixed exporting costs and variable trade costs will export their products to the foreign market.

Using (17) and (21), the expected profit of suppliers in the open-economy setting is expressed as

\[
\pi_{im} = \int \int f \left[ \left( \frac{\lambda}{\hat{\lambda}_i} \right)^{\sigma - 1} - 1 \right] \frac{dG(\hat{\lambda})}{1 - G(\hat{\lambda}_i)} + p_s \int f_i \left[ \left( \frac{\lambda}{\hat{\lambda}_i} \right)^{\sigma - 1} - 1 \right] \frac{dG(\hat{\lambda})}{1 - G(\hat{\lambda}_i)}
\]

\[
= \left( f + p_s f_i \right) \frac{\sigma - 1}{k - \sigma + 1} ,
\]

(24)

(25)

where

\textsuperscript{13)} Sato (2009) considers matching between managers and production workers, and he argues that matches in foreign countries are associated with uncertainty about the quality of managers. Furthermore, in models developed by Melitz (2003) and Helpman, Melitz, and Yeaple (2004), for example, fixed costs required for exporting are assumed to be greater than fixed costs required for domestic operation.
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Figure 1  The impact of trade on the suppliers

Panel A

Panel B

Note: It is assumed that $f = 1.0$, $k = 8.0$, and $\sigma = 6.0$.

\[
    p_e \equiv 1 - \frac{1 - G(\bar{\lambda}_s)}{1 - G(\bar{\lambda}_d)} = \tau^{-k} \left( \frac{f_x}{f_x} \right)^{\lambda/(\sigma-1)},
\]

is the probability of being an exporter.\(^{14}\) Now we can examine impacts of trade liberalization on firms’ expected profit.\(^{15}\)

It is shown that $\frac{\partial \bar{\pi}_{IM}}{\partial \tau} < 0$ and $\frac{\partial \bar{\pi}_{IM}}{\partial f_x} < 0$. In other words, a decrease in variable trade costs, $\tau$, and fixed exporting costs, $f_x$, increases the expected profit of suppliers. The mechanism of gains from trade is the one emphasized in Melitz (2003). A reduction in $\tau$ (or $f_x$) induces the most productive suppliers to start exporting, which increases the expected profit of the most productive suppliers. At the same time, an increase in competition due to trade liberalization reduces the expected profit of the least productive firms, leading them to exit the market. Therefore, the expected profit of suppliers (conditional on entry), $\bar{\pi}_{IM}$, increases.

The impact of trade liberalization in the intermediate-good sector on suppliers’ expected profit $\bar{\pi}_{IM}$ is simulated in Figure 1. Panel A shows the impact of a reduction in $\tau$ on $\bar{\pi}_{IM}$, holding $f_x$ constant. Here we see that a decrease in variable trade costs monotonically increases $\bar{\pi}_{IM}$. Panel B shows the impact of a reduction in $f_x$ on $\bar{\pi}_{IM}$, holding $\tau$ constant. Here, a reduction in $f_x$ monotonically increases $\bar{\pi}_{IM}$. The preceding considerations are summarized as follows.\(^{16}\)

\(^{14}\) To be precise, it is the \textit{ex ante} probability of drawing sufficiently high productivity from the distribution function so as to be an exporter.

\(^{15}\) One might think that we cannot examine the impact of trade on firms’ expected profit until we derive equilibrium of the model. However, the model assumes that firm productivity follows Pareto distribution, which makes it possible to express the expected profit as a function of only exogenous variables. Therefore, we can examine the impact of trade on firms’ expected profit before deriving equilibrium.

\(^{16}\) The proof of Proposition 1 is found in Sasahara (2012).
Proposition 1 (The impact of trade on the suppliers)
A decrease in variable trade costs and fixed exporting costs in the intermediate-good sector unambiguously increases the expected profit of suppliers \((\partial \pi_{IM} / \partial \tau < 0 \text{ and } \partial \pi_{IM} / \partial f_x < 0)\).

4.2 Final-good producers in the open economy
In contrast to suppliers, we do not allow final-good producers to be exporters. This allows us to examine the impact of trade liberalization in the intermediate-good sector on the final-good sector that remains local. However, suppliers randomly match with domestic final-good producers and foreign final-good producers.

4.2.1 Final-good producers who match with domestic suppliers
A final-good producer, \(j\), that matches with domestic supplier \(l\) makes following profit:

\[
\int_{\lambda_d}^{\infty} \left( \frac{\rho \phi \lambda_j P}{2 \sigma} \right)^{\gamma-1} L \frac{dG(\lambda)}{1 - G(\lambda^*_d)} - f = \frac{\gamma \left( \frac{\rho \phi \lambda_j P}{2 \sigma} \right)^{\gamma-1} L}{2 \sigma} - f = f \left[ \left( \frac{\phi}{\phi^*} \right)^{\gamma-1} - 1 \right],
\]

where

\[
\phi^* = \frac{1}{\rho \lambda_d^* P} \left( \frac{2 \sigma f}{\gamma L} \right)^{1/(\gamma-1)},
\]

is the cutoff-productivity for the final-good producer below which entering the market will result in negative profits, and therefore immediately exit the market.\(^{17}\)

4.2.2 Final-good producers who match with foreign suppliers
A final-good producer, \(j\), that matches with foreign supplier \(l\) makes following profit:

\[
\int_{\lambda_d}^{\infty} \left( \frac{\tau^{-1} \rho \phi \lambda_j P}{2 \sigma} \right)^{\gamma-1} L \frac{dG(\lambda)}{1 - G(\lambda^*_d)} - f = \frac{\gamma \left( \frac{\tau^{-1} \rho \phi \lambda_j P}{2 \sigma} \right)^{\gamma-1} L}{2 \sigma} - f
\]

\[
= f \left[ \left( \frac{\tau^{-1} \phi \lambda_j}{\phi^* \lambda_d^*} \right)^{\gamma-1} - 1 \right]
\]

\[
= f \left[ \frac{f_x}{f} \left( \frac{\phi}{\phi^*} \right)^{\gamma-1} - 1 \right],
\]

\(^{17}\) It is implicitly assumed that final-good producers do not expect a reduction of trade costs \(\tau\) and \(f_x\) when they enter the market. That is, final-good producers behave as if there are no foreign suppliers in the domestic market when they enter the market. Without this assumption, determining the cutoff-productivity for final-good producers will be more complicated. This assumption helps clarify the mechanism of gains from trade.
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where inserting (28) into (29) leads to (30), and inserting (23) into (30) leads to (31). Comparing (27) and (31) reveals that matching with a foreign intermediate-producer is more beneficial for a final-good producer than matching with a domestic supplier. Because foreign final-good producers are productive enough to overcome large trade costs, \( f_x \) and \( \tau \), foreign final-good producers are more productive than domestic final-good producers, on average.

4.2.3 The expected profit of final-good producers

To calculate the expected profit for a final-good producer, we derive the probability of matching with a foreign supplier. The probability is expressed as

\[
p_m = \frac{M_x}{M_d + M_x} = \frac{p_x M_d}{M_d + p_x M_d} = \frac{p_x}{1 + p_x},
\]

where \( M_d \) is the mass of domestic suppliers; \( M_x \) is the mass of foreign suppliers; and \( p_x \) is the ratio of exporting suppliers to total suppliers in a country. Using (26) and (32), \( p_m \) is expressed as

\[
p_m = \frac{\tau^{-k} (f / f_x)^{k/(\sigma-1)}}{1 + \tau^{-k} (f / f_x)^{k/(\sigma-1)}}.
\]

Using (27), (31), and (33), the expected profit for a final-good producer is written as

\[
\pi_{FN} = \left(1 - p_m\right) \int_{\varphi^*}^{\infty} f \left(\varphi \bigg/ \varphi^*\right)^{\sigma - 1} \left[ \frac{df(\varphi)}{1 - F(\varphi^*)} + p_m \int_{\varphi^*}^{\infty} f \left(\varphi \bigg/ \varphi^*\right)^{\sigma - 1} \left[ \frac{df(\varphi)}{1 - F(\varphi^*)} \right] \right]
\]

\[
= \left(1 - p_m\right) f \left\{ \frac{\sigma - 1}{k - \sigma + 1} + p_m f \left(\frac{f_x}{f} \bigg/ \frac{k}{k - \sigma + 1} - 1\right) \right\},
\]

where the first term is the expected profit from matching with a domestic supplier and the second term is the expected profit from matching with a foreign supplier.

It follows that \( \partial \pi_{FN} / \partial \tau < 0 \), implying that a decrease in variable trade costs, \( \tau \), increases the expected profits of final-good producers. Three effects are working behind this result. First, lowering \( \tau \) increases exports from individual suppliers, thus increasing the joint profit. Therefore, lowering \( \tau \) increases \( \pi_{FN} \). This effect will be referred to as the intensive margin effect. Second, a decrease in \( \tau \) enables even less productive suppliers to enter the foreign market, reducing the average productivity of exporting suppliers. As a result, a decrease in \( \tau \) reduces the expected profit of final-good producers. This effect will be referred to as the extensive margin effect. Lastly, a decrease of \( \tau \) increases the ratio of foreign suppliers in the

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18) Equation (31) suggests that the expected profit for a final-good producer from matching with a foreign supplier does not depend on variable trade costs, \( \tau \). However, in reality, it does depend on \( \tau \), through two channels. A decrease in \( \tau \) positively affects the expected profit because it increases the demand faced by a pair, therefore increasing the expected profit. However, a decrease in \( \tau \) enables even fewer productive suppliers to begin exporting, reducing the average productivity of exporting suppliers. These opposing effects are in balance in this model. Therefore, equation (31) is independent from variable trade costs.

19) The intensive margin in international trade literature is referred to as exports per firm.

20) The extensive margin in international trade literature is referred to as the number of exporting firms. Chaney (2008), and Helpman, Melitz, and Rubinstein (2008) explicitly explore with the impact of the extensive
market since it leads more suppliers to engage in exporting. As a result, the probability of matching with a foreign productive supplier increases, thus increasing $\bar{\pi}_{FN}$. This effect will be referred to as the matching effect.

To summarize, the intensive margin effect and the matching effect positively affect $\bar{\pi}_{FN}$, but the extensive margin effect negatively affects $\bar{\pi}_{FN}$. The overall impact of a decrease in $\tau$ is determined by the relative magnitude of the three effects. In this model, the positive intensive margin effect is canceled out by the negative extensive margin effect. Therefore, the positive matching effect exclusively determines the overall effect. As a result, a decrease in variable trade costs increases $\bar{\pi}_{FN}$.

The impact of a decrease in fixed exporting costs, $f_x$, differs from the impact of a decrease in variable trade costs, $\tau$. Sasahara (2012) shows that the sign of $\partial \bar{\pi}_{FN} / \partial f_x$ is determined as follows.

$$\frac{\partial \bar{\pi}_{FN}}{\partial f_x} < 0 \iff 1 + \tau^{-k} \left( \frac{f}{f_x} \right)^{\frac{k}{(k-1)}} < \frac{k}{\sigma} - 1 \left( 1 - \frac{f}{f_x} \right),$$  \hspace{1cm} (36)

$$\frac{\partial \bar{\pi}_{FN}}{\partial f_x} > 0 \iff 1 + \tau^{-k} \left( \frac{f}{f_x} \right)^{\frac{k}{(k-1)}} > \frac{k}{\sigma} - 1 \left( 1 - \frac{f}{f_x} \right).$$  \hspace{1cm} (37)

Inequality (36) holds when trade costs $\tau$ and $f_x$ are high; thus, $\partial \bar{\pi}_{FN} / \partial f_x < 0$. This implies that a reduction in $f_x$ increases $\bar{\pi}_{FN}$. However, when $\tau$ and $f_x$ are low, inequality (37) holds. In this case, a decrease in $f_x$ decreases $\bar{\pi}_{FN}$.

The impact of a decrease in $f_x$ on $\bar{\pi}_{FN}$ is determined by two effects: the extensive margin effect and the matching effect. In contrast to variable trade costs, $f_x$ does not affect the amount exported by individual suppliers. Therefore, the intensive margin effect is zero. As in the case of variable trade costs, a decrease in $f_x$ leads to fewer suppliers engaging in exporting, reducing the average productivity of exporting suppliers. This reduces $\bar{\pi}_{FN}$, which is the extensive margin effect. At the same time, a decrease in $f_x$ increases the ratio of foreign suppliers in the market, which increases the probability of matching with a foreign productive supplier. This increases $\bar{\pi}_{FN}$, which is the matching effect.

When $f_x$ is high, a decrease in $f_x$ leads to only those relatively productive suppliers engaging in exporting. Therefore, a decrease in the average productivity of exporting suppliers is small. As a result, the negative extensive margin effect is small. Moreover, since new exporters are productive, an increase in the probability of matching with a foreign supplier significantly increases $\bar{\pi}_{FN}$, implying that the matching effect is greater. As a result, the positive matching effect dominates the negative extensive margin effect.

In contrast, when $f_x$ is low, a decrease in $f_x$ leads to less productive suppliers engaging in exporting, which significantly reduces the average productivity of exporting suppliers. Therefore, the negative extensive margin effect is greater. At the same time, the positive matching effect is small, because new exporters are less productive. Therefore, the negative extensive margin effect dominates the positive matching effect. The preceding consider-
ations are summarized in the following proposition.\textsuperscript{22)}

**Proposition 2 (The impact of trade on the final-good producers)**

A decrease in variable trade costs in the intermediate-good sector unambiguously increases the expected profit of final-good producers ($\frac{\partial \bar{\pi}_{FN}}{\partial \tau_{x}} < 0$). However, a decrease in fixed exporting costs in the intermediate-good sector increases the expected profit of suppliers ($\frac{\partial \bar{\pi}_{FN}}{\partial f_{x}} < 0$) when trade costs $t$ and $f_{x}$ are high, and reduces it ($\frac{\partial \bar{\pi}_{FN}}{\partial f_{x}} > 0$) when trade costs are low.

Figure 2 simulates the impact of trade liberalization on the expected profit of final-good producers, $\bar{\pi}_{FN}$. Panel A shows the impact of a decrease in variable trade costs, $\tau$, holding fixed exporting costs, $f_{x}$, constant. This shows that a decrease in variable trade costs monotonically increases $\bar{\pi}_{FN}$. Panel B shows the impact of a decrease in fixed exporting costs, $f_{x}$, holding variable trade costs, $\tau$, constant. This shows that a decrease of $f_{x}$ first increases $\bar{\pi}_{FN}$, then reduces $\bar{\pi}_{FN}$. Moreover, it suggests that, as $f_{x}$ converges to one ($= f$), the expected profit of suppliers, $\bar{\pi}_{FN}$, converges to an closed-economy level. If $f_{x}$ equals $f$, the expected profit after matching with a domestic supplier is equal to the expected profit after matching with a foreign supplier.\textsuperscript{23)} Therefore, the expected profit equals an autarky level.

### 4.3 Equilibrium in the open economy

In the previous subsection, we derived the expected profit for each type of firm. In this subsection, the equilibrium cutoff productivities are derived using the expected profits. Free entry in each sector gives us the equilibrium cutoff-productivity as:

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{The impact of trade on the final-good producers}
\end{figure}

Note: For parameter values, see the note in Figure 1.

\textsuperscript{22)} The proof of Proposition 2 is found in Sasahara (2012)
Using (23) and \( \lambda^* \) in (38), the equilibrium cutoff-productivity for final-good producers when exporting is expressed as

\[
\lambda^*_x = \left( \frac{\pi_{FN}}{\delta f_x} \right)^{1/k}, \quad \lambda^*_d = \left( \frac{\pi_{IM}}{\delta f_x} \right)^{1/k}.
\]

(39)

It is shown that a decrease in variable trade costs, \( \tau \), raises \( \lambda^*_d \) and lowers \( \lambda^*_x \). A decrease in \( \tau \) enables fewer productive suppliers to export, thus lowering \( \lambda^*_x \). Since the most productive firms start exporting and increasing their profit, in general equilibrium, in which the expected profit is constant, the least efficient suppliers must exit the market. In other words, an increase in competition due to the entry of foreign suppliers induces less productive firms to exit the market. Therefore, a reduction in \( \tau \) raises \( \lambda^*_d \). In addition, it is shown that a decrease of \( \tau \) raises \( \phi^* \). A decrease of \( \tau \) induces the entry of productive foreign suppliers, which increases the expected profit of final-good producers. The increase in the average profit of each final-good producer leads the least efficient final-good producers to exit the market. As a result, \( \phi^* \) increases.

In contrast, the impact of a decrease in fixed exporting costs, \( f_x \), differs from that of a decrease in \( \tau \). When \( f_x \) is high, a decrease in \( f_x \) increases the expected profit of final-good producers, \( \bar{\pi}_{FN} \), which increases the competition in the market, inducing the least productive final-good producers to exit the market. Therefore, a decrease of \( f_x \) first raises \( \phi^* \). However, when \( f_x \) is low, a decrease in \( f_x \) reduces the expected profit of final-good producers, \( \bar{\pi}_{FN} \), which enables less productive final-good producers to operate in the market. Then it lowers the cutoff-productivity, \( \phi^* \). These results are summarized in following proposition, which is a corollary of Propositions 1 and 2.

**Proposition 3 (The impact of trade on equilibrium cutoff-productivity)**

A reduction in variable trade costs in the intermediate-good sector

(i) raises the equilibrium cutoff-productivity of final-good producers, \( \phi^* \);

(ii) raises the equilibrium cutoff-productivity of suppliers for domestic operations, \( \lambda^*_d \);

(iii) lowers the equilibrium cutoff-productivity of suppliers for exporting, \( \lambda^*_x \).

Moreover, a reduction in fixed exporting costs in the intermediate-good sector

(iv) raises the equilibrium cutoff-productivity of final-good producers, \( \phi^* \), when trade costs, \( \tau \) and \( f_x \), are high and lowers the cutoff-productivity when trade costs are low;

(v) raises the equilibrium cutoff-productivity of suppliers for domestic operations, \( \lambda^*_d \);

(vi) lowers the equilibrium cutoff-productivity of suppliers for exporting, \( \lambda^*_x \).

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23) Even if \( f_x \) equals \( f_x \), exporting suppliers are more productive than domestic suppliers, since exporting suppliers must be productive enough to overcome variable trade costs, \( \tau \) (the extensive margin effect). However, at the same time, the existence of variable trade costs reduces the joint profit of a pair of firms (the intensive margin effect). The intensive margin effect and the extensive margin effect are in balance in this model. Therefore, when \( f_x \) equals \( f_x \) the expected profit from matching with a domestic supplier is equal to the expected profit from matching with a foreign supplier.
4.4 The impact of trade on the average productivity and welfare

This subsection analyzes the impact of trade liberalization on the average industry productivity and welfare per worker to derive policy implications. The average productivity in the final-good sector is calculated as 
\[ \tilde{\phi} = \int_{\phi^*}^{\infty} \phi \frac{dF(\lambda)}{1-F(\phi^*)} = \frac{k}{k-1} \phi^* \] and the average productivity in the intermediate-good sector is given as 
\[ \tilde{\lambda} = \int_{\lambda^*}^{\infty} \lambda \frac{dG(\lambda)}{1-G(\lambda^*)} = \frac{k}{k-1} \lambda^*. \] The welfare per worker is represented as 
\[ W = P^{-1} = \rho L \phi^* \left( \frac{pL}{\sigma f} \right)^{\lambda^*} \] , where the second equality follows from equation (28).

The impact of a decrease in variable trade costs, \( \tau \), is straightforward. A decrease in the value of \( \tau \) unambiguously increases the average productivity in both sectors and welfare. A decrease in the value of \( \tau \) induces the most productive suppliers to engage in exporting, which expands the profit of suppliers. Moreover, tougher competition induced by trade leads the least productive suppliers to exit the market. As a result, the average productivity of suppliers, \( \bar{\phi} \), increases. This result is simulated in Panel A in Figure 3. Furthermore, a decrease in the value of \( \tau \) increases the expected profit of final-good producers thanks to the matching effect. They benefit from a decrease in \( \tau \) because it increases the probability of matching with foreign productive suppliers. This leads the least productive suppliers to exit the market, thus increasing the average productivity of the intermediate-good sector, \( \bar{\lambda} \). This result is simulated in Panel B in Figure 3.

The proof of Proposition 3 follows from equation (38) and Propositions 1 and 2. As is evident from (54), the increase in \( \bar{\phi} \) and \( \bar{\lambda} \) due to a decrease in \( \tau \) unambiguously increases welfare, \( W \). Workers/consumers in the economy benefit from a decrease in \( \tau \) because this

![Figure 3](image_url)  

**Figure 3** The impact of a decrease in variable trade costs

Note: It is assumed that \( \delta = 0.1, L = 10, f_c = 1.0 \) and \( f_i = 2.0 \). For other parameter values, see the note in Figure 1.
reduces the prices of products, which increases real wages.\textsuperscript{24} A decrease in $\tau$ may reduce the variety of products available to consumers, which would lower welfare. However, the gains from improvements in productivity are greater than the losses sustained from a reduction in variety.\textsuperscript{25} This result is simulated in Panel C in Figure 3.

Next, the impact of a reduction in fixed exporting costs, $f_x$, are considered. A decrease in $f_x$ always increases the average productivity of suppliers, $\hat{\lambda}$. The impact of a decrease in $f_x$ on $\hat{\lambda}$ is essentially the same as the impact of a reduction in variable trade costs, $\tau$. This result is described in Panel A in Figure 4. However, the impact of a reduction in $f_x$ on the average productivity of final-good sector, $\hat{\phi}$, differs from the impact of a reduction in $\tau$ on $\hat{\phi}$. It is already shown that a reduction in $f_x$ raises $\phi^*$ when trade costs, $\tau$ and $f_{x^n}$ are high, and lowers $\phi^*$ when trade costs are low. Therefore, it follows that a reduction in $f_x$ increases the average productivity in the final-good sector, $\hat{\phi}$, when trade costs are high, but lowers $\hat{\phi}$ when trade costs are low. The result is simulated in Panel B in Figure 4.

The preceding considerations imply that, when trade costs $\tau$ and $f_x$ are high, a reduction in $f_x$ unambiguously increases welfare because it raises $\phi^*$ and $\hat{\lambda}_d^*$. However, when trade costs are low, the impact of a reduction in $f_x$ is apparently ambiguous, because it raises $\hat{\lambda}_d^*$ while lowering $\phi^*$. However, it is shown that a reduction in $f_x$ increases welfare when trade costs, $\tau$ and $f_x$, are high and reduces welfare when trade costs are low.\textsuperscript{26} These results are summarized in the following proposition.\textsuperscript{27}

\textbf{Figure 4} The impact of a decrease in fixed exporting costs

\textbf{Panel A} The average productivity of suppliers

\textbf{Panel B} The average productivity of final-good producers

\textbf{Panel C} Welfare

Note: For parameter values, see the note in Figures 1 and 3.

\textsuperscript{24} This result is true because the nominal wage is fixed and normalized to unity.

\textsuperscript{25} Similar theoretical results are found in, for example, Arkolakis, Demidova, Klenow, and Rodriguez-Clare (2008) and Baldwin and Forslid (2010).

\textsuperscript{26} When trade costs are low, the impact through the final-good sector dominates the impact through the intermediate-good sector, and vice versa.

\textsuperscript{27} The proof of Proposition 4 is found in Sasahara (2012)
Proposition 4 (The impact of trade on average productivity and welfare)

A reduction in variable trade costs in the intermediate-good sector
(i) raises the average productivity in the final and intermediate-good sectors and welfare.
However, a decrease in fixed exporting costs in the intermediate-good sector
(ii) increases the average productivity in the final-good sector when trade costs, $\tau, f_x$, are high and reduces it when trade costs are low;
(iii) raises the average productivity in the intermediate-good sector;
(iv) first increases welfare when trade costs are high, and reduces welfare when trade costs are low.\(^{28}\)

In the final analysis in this paper, we relate our theoretical prediction of the model to previous empirical findings. The model predicts that, when fixed exporting costs, $f_x$, are high, the final-good sector gains more from trade than does the intermediate-good sector. Panel A in Figure 5 simulates the average productivity of two sectors when $f_x$ is high ($f_x=7.0$). This shows that the productivity growth due to a reduction in variable trade costs is greater in the final-good sector than the intermediate-good sector. Intuitively, because higher fixed exporting costs lead to only productive suppliers entering the export market, a decrease in $\tau$ significantly increases the average productivity of final-good producers. Therefore, the expected profit of final-good producers increases, leading to productivity growth in the final-good sector.\(^{29}\) For suppliers, higher values of $f_x$ lead to fewer suppliers engaging in exporting, which implies that they expect a smaller increase in their expected profit, leading to

Figure 5

The differential impact of trade on the final- and intermediate-good sectors

Panel A: $f_x=7.0$

Panel B: $f_x=1.5$

Note: Fixed exporting costs, $f_x$, are assumed as indicated in the figure. For other parameter values, see the note in Figures 1 and 3.

\(^{28}\) The critical values of $\tau$ and $f_x$ that change the impact of a reduction in $f_x$ on welfare is complicated. Therefore, the critical values are left in Appendix C in Sasahara (2012).

\(^{29}\) In other words, for final-good producers, the negative extensive margin effect is small, and the positive matching effect is large. Therefore, this leads to productivity growth in the final-good sector.
lower productivity growth in the intermediate-good sector.

However, when \( f_x \) is low, the intermediate-good sector gains more from trade than does the final-good sector. Panel B in Figure 5 shows the case in which \( f_x \) is low (\( f_x = 1.5 \)), indicating that productivity growth is greater in the intermediate-good sector than the final-good sector. Smaller fixed exporting costs, \( f_x \), induces less productive suppliers to enter the export market. Therefore the positive impact of a reduction in \( \tau \) on the average productivity of final-good producers is small.

These theoretical predictions may explain the underlying mechanism behind the empirical results in Amiti and Konings (2007) and Khandelwal and Topalova (2011). These studies found that, using Indonesian and Indian data, respectively, productivity gains after reducing tariffs on intermediate-goods are greater than productivity gains after reducing tariffs on final-goods. While our model shows that, when \( f_x \) is high, productivity gains from cutting variable trade costs of importing intermediate-goods is higher than productivity gains from cutting variable trade costs of exporting intermediate-goods. Therefore, it might be the case that fixed exporting costs are high between these countries and the rest of the world.

5. Conclusions

This paper examined the impact of trade liberalization in the intermediate-good sector on the final- and intermediate-good sectors. It has been shown that a reduction in variable trade costs in the intermediate-good sector has a positive impact on the final-good sector as well as the intermediate-good sector. The intermediate-good sector gains from a reduction in variable trade costs via intra-industry resource reallocation towards the most productive firms from the least productive firms, as shown by Melitz (2003). The final-good sector gains as a result of the increase in the probability of matching with productive foreign suppliers.

However, it has been shown that the impact of a reduction in fixed exporting costs in the intermediate-good sector has asymmetric impacts on the two sectors. The intermediate-good sector unambiguously gains from a reduction in fixed exporting costs, but may reduce the average productivity of the final-good sector. Specifically, when trade costs are high, a reduction in fixed exporting costs increases the average productivity of the final-good sector, since new exporters in the intermediate-good sector are more productive in this case. However, when trade costs are low, new exporters are less productive, thus reducing the profit of final-good producers. In this case, the productivity of the final-good sector decreases.

The results obtained in this study rely on some restrictive assumptions. First, a firm matches with at most one partner in the market. Second, final-good producers do not expect the entry of foreign suppliers when they enter the market. However, relaxing these assumptions would not affect the main results.

Our model could be extended in various ways. For example, allowing final-good producers to transact with multiple intermediate-good producers, we can introduce multi-product firms into the model, which may help understand the impact of trade in intermediate goods on multi-product firms. In addition, the impact of liberalization of trade in intermediate-goods on the final-good sector through the labor market is of interest. We can incorporate both multiple sectors and the labor market into our framework (see Segerstrom
and Sugita, 2012, for example) to analyze such an issue. These analyses are left for future research.

The random matching model developed in this paper gives us new insight into the impact of trade liberalization in one sector on another sector. The model gives us a new mechanism of gains from trade through the intensive margin effect, the extensive margin effect, and the matching effect. Furthermore, the model makes it possible to consider how and when the importing sector gains from trade.

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