Explaining Export Varieties:
The Unexplored Role of Comparative Advantage

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Abstract
In this paper we examine how factor proportions determine the extensive margin of trade. To explain the determinants of the number of export varieties, we develop a multi-sector trade model with heterogeneous firms. A semi-Heckscher-Ohlin prediction for export varieties emerges from the model: countries export more varieties in the industries that more intensively use their abundant resources as input factors. Empirical tests confirm that more varieties are exported in industries in which the exporter has the comparative advantage. The paper provides both a theoretical foundation and empirical evidence for the importance of factor proportions in explaining the pattern of exports of product varieties.

JEL classification: F11, F12, F14, L11

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1. Introduction

The recent trade literature on export/import variety has grown rapidly. The seminal work by Krugman (1979) first brought product variety into focus through his monopolistic competition model of international trade. Although the increases in product variety have long been known as an important source of gains from trade, empirical studies on the significance of the growth of product varieties, or “extensive margin,” in international trade are relatively new. For example, Kehoe and Ruhl (2003) show that the trade of new goods (extensive margin) explains a larger proportion of the growth of trade following trade liberalization than the increase in the volume of previously-traded goods (intensive margin) does. A series of empirical studies by Funke and Ruhwedel (2001a, 2001b, 2005) indicates that the growth of product variety in exports has a significant effect on the economic growth in various countries and regions. Feenstra and Kee (2004) also provide evidence supporting the positive impact of export variety on productivity growth for a large sample of developed and developing countries. Broda and Weinstein (2004) empirically show how much the increase in imported variety mattered for the welfare of United States. Their results suggest that the U.S. welfare has increased by 3% due to the increase in the extensive margin of its import.¹

Although this previous research has examined the cross-country patterns of product varieties in international trade, few studies have explored the trade patterns of product varieties

¹ Another important branch of this recent literature focuses on the quality differentiation of exported goods. Hallak (2006) attempts to identify the effect of product quality on the direction of international trade. The paper empirically investigates whether importers at a higher income level tend to buy more varieties of products from exporters with higher income as well because they tend to produce higher quality products. In a related paper Hallak applies his framework of product quality and uses sectoral level data to provide evidence for the Linder hypothesis according to which international trade is more intensive between countries with similar income levels than those that differ (Hallak, 2005). Choi, Hummels and Xiang (2006) explore the effect of income distribution on varieties in trade, whose key insight is that consumers with higher income will buy goods with higher quality rather than buy greater quantities of goods that vary in the quality dimension.
across industries. In this paper we examine whether the traditional theory of comparative advantage explains the cross-industry patterns of product varieties in the exports of countries. Our approach also considers the modern framework of firm-level heterogeneity. We first construct a theoretical model in which countries vary in factor endowment, industries differ in factor intensity, and firms belonging to the same industry are heterogeneous in productivity. This model is used to derive a prediction that relates product varieties in a country’s exports to the degree of relative factor intensity of industries. To empirically test the prediction we employ the data on the U.S. imports in 1990 from Feenstra, Romalis, and Schott (2002), which finely classifies imported commodities according to the 10-digit Harmonization System (HS). We also use the data on input factor use in various industries from the 1992 U.S. Census of Manufactures, as well as the data on factor abundance of a number of countries from Hall and Jones (1999). The empirical tests support our semi-Heckscher-Ohlin prediction for product varieties in trade; that is, countries export more varieties in the industries that more intensively use their abundant resources as input factors.

This paper contributes to the literature by extending the theoretical model of Bernard, Redding and Schott (2007), which integrates a heterogeneous firm model by Melitz (2003) into the 2-country, 2-factor and 2-sector framework, to a multi-industry setting as Dornbusch, Fischer and Samuelson (1980) and Romalis (2004). The paper also goes empirically further than others by explicitly linking the factor endowment and industry-wise factor use to the number of varieties in their exports.

The paper proceeds as follows. Section 2 develops the theoretical model in order to provide an implication for the relationship between factor proportions and export variety. Section 3 proposes an empirical approach to test the theoretical prediction, and Section 4 describes the
data. The results of the empirical tests are presented in Section 4. Section 5 concludes.

2. The Model

This paper adopts a monopolistic competition model in which consumers have an identical “love of variety” preference and firms that are heterogeneous in productivity need to incur fixed costs for market entry and export. The model also features a framework of comparative advantage in which countries differ in endowment and thus their exposure to trade leads to inter-firm and inter-industry reallocations of resources toward more productive firms and industries using a favorable factor more intensively.

We consider a world with two countries, Home (H) and Foreign (F); two factors, skilled labor (S) and unskilled labor (U); multiple \( N > 2 \) industries. Within each industry there is a continuum of firms that are heterogeneous in productivity. Countries share the same production technology for each industry, but differ in factor endowments. Home is relatively abundant in skilled labor, and Foreign is relatively abundant in unskilled labor; that is, \( \frac{S^H}{U^H} > \frac{S^F}{U^F} \).

Consumption:

The representative consumer derives her utility from the consumption of the output from all \( N > 2 \) industries. Each industry consists of a large number of differentiated products or “varieties”, each of which is uniquely produced by a single firm. In what follows we use \( i \) to index industries and \( \omega \) for firms. The upper-tier utility function from the consumption of a bundle of product varieties of all of \( N \) industries takes the following Cobb-Douglas form:

\[
U = C_1^{\alpha_1} C_2^{\alpha_2} \ldots C_N^{\alpha_N}, \quad \sum_{i=1}^{N} \alpha_i = 1
\]
where $C_i$ represents the consumption index for Industry $i=1,\ldots,N$. The representative consumer consumes all the available product varieties in each industry, and the industry-wise consumption index $C_i$ takes the following CES (or Dixit-Stiglitz) forms:

$$C_i = \left[ \int_{\omega \in \Omega_i} q_{i,\omega}^\rho d\omega \right]^{1/\rho} \quad (2.2)$$

where $\Omega_i$ denotes a set of available varieties in Industry $i$, and $q_{i,\omega}$ represents the quantity of each variety produced. Accordingly, the price index $P_i$ over individual varieties of products in Industry $i$ is defined as

$$P_i = \left[ \int_{\omega \in \Omega_i} p_{i,\omega}^{1-\sigma} d\omega \right]^{1/(1-\sigma)} \quad (2.3)$$

where $\sigma = \frac{1}{1-\rho} > 1$ is the constant elasticity of substitution across varieties.

Production in Autarky:

In each industry there is a continuum of firms, each of which produces a unique variety of products. Following Krugman (1979) and Romalis (2004), we model the total production cost of each variety as a combination of two portions: fixed costs and variable costs. The fixed costs are the same for all firms in the same industry within a country, but the variable costs vary across firms according to the difference in their productivities $\phi \in (0, \infty)$. Hence, the cost function for Firm $\omega$ in Industry $i$ in Country $\lambda$ is:

$$\Gamma_{i,\omega}^{\lambda} = \left[ f_i + \frac{q_{i,\omega}}{\phi_{i,\omega}} \right] \cdot (s^\lambda)^{\beta_i} (w^\lambda)^{1-\beta_i}, \quad 0 < \beta_1 < \beta_2 < \ldots < \beta_{N-1} < \beta_N < 1 \quad (2.4)$$

---

2 As shown in Equation (2.4), since the fixed costs also depend on the prices of two production factors,
where $s$ is the wage for skilled labor, $w$ is the wage for unskilled labor, the superscript $\lambda = H$ or $F$ denotes the country (Home or Foreign). The industries are ranked according to the skilled-labor intensity in production $(\beta_i)$, such that the industry indexed with a large number for $i$ is more skilled-labor intensive. Within the same industry, the intensity of factor use does not differ across countries or across firms.

To maximize its profit, each firm sets the price of its own product variety for domestic sale equal to the constant markup over the marginal cost of production.

$$p_{i,\omega}(\phi_{i,\omega}) = \frac{(s^\lambda)^{\beta_i} (w^\lambda)^{1-\beta_i}}{\rho \phi_{i,\omega}}$$  \hspace{1cm} (2.5)

With this optimal pricing, the domestic revenue of each firm takes the following form:

$$r_{i,\omega}(\phi_{i,\omega}) = \alpha_i Y^\lambda \left( \frac{(s^\lambda)^{\beta_i} (w^\lambda)^{1-\beta_i}}{\rho \phi_{i,\omega} P_i^\lambda} \right)^{1-\sigma}$$  \hspace{1cm} (2.6)

where $Y^\lambda$ is the total income of Country $\lambda \in \{H, F\}$. The revenue of each firm increases with productivity $\phi_{i,\omega}$, the aggregate income of the country $Y^\lambda$, and the industry price index $P_i$. The profit of each firm, which equals the revenue minus fixed and variable costs of production, is expressed as follows:

$$\pi_{i,\omega}(\phi_{i,\omega}) = \frac{r_{i,\omega}(\phi_{i,\omega})}{\sigma} - f_i (s^\lambda)^{\beta_i} (w^\lambda)^{1-\beta_i}$$  \hspace{1cm} (2.7)

*Entry in Autarky:*

To enter the domestic market, each firm needs to bear a sunk entry cost. Firms discover their own productivity after the entry. The productivity parameter $\phi$ is randomly drawn from a

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the fixed cost can be different between the two countries due to the difference in factor prices.
distribution \( G(\phi) \). The entry cost also depends on the prices of the two input factors, and takes the following form:

\[
f_{ei}(s^\lambda)^{\beta_i} (w^\lambda)^{1-\beta_i}, \quad f_{ei} > 0
\]  
(2.8)

In other words, the industry factor intensity commonly affects the fixed and variable production costs, as well as the sunk entry cost.

After paying the sunk entry cost (and realizing a productivity level), a firm must earn at least zero profit to remain and produce in the market. In other words, if the firm observes that its productivity is too low to keep zero profit, the firm will exit from the market. The minimum productivity requirement, or the “productivity cutoff,” for domestic production is thus determined by the following zero-profit condition:

\[
r_{i}^\lambda (\phi_i^* \lambda) = \sigma f_{i} (s^\lambda)^{\beta_i} (w^\lambda)^{1-\beta_i}
\]  
(2.9)

In Country \( \lambda \) and Industry \( i \), all the firms whose productivity is higher than or equal to \( \phi_i^* \lambda \) will continue producing in the domestic market, while the firms with productivity lower than this cutoff level will exit.

The value of each firm is determined as the present discount value of the future profit flows. With \( \delta < 1 \) of some positive probability of “death” in each period,\(^3\) the value of the firm is expressed as follows:

\[
v_{i,\omega}(\phi_{i,\omega}) = \max\{0, \sum_{t=0}^{\infty} (1-\delta)^t \pi_{i,\omega}(\phi_{i,\omega})\} = \max\{0, \frac{\pi_{i,\omega}(\phi_{i,\omega})}{\delta}\}
\]  
(2.10)

In the long run equilibrium, the expected value of entry, \( V_{i,\omega} \), will equal the sunk entry cost for each firm in each industry. Since the expected value of entry is the expected value of the firm

\(^3\) This can be interpreted as a risk that the firm may be hit by a negative and idiosyncratic shock and forced to be closed in business.
(future profit stream) conditional on the \textit{ex ante} probability of successful entry, we obtain the following free-entry condition:

\begin{equation}
V^\lambda_{i,\text{cs}} = [1 - G(\phi_i^{\lambda \phi})] \bar{\pi}_i^\lambda = f_{\phi} (s^\lambda)^\beta (w^\lambda)^{1-\beta}
\end{equation}

where \(\bar{\pi}_i^\lambda\) represents the per-period expected future profit for the firm successfully entering into the market in Industry \(i\). That is, \(\bar{\pi}_i^\lambda \equiv \pi_i (\bar{\phi}_i^\lambda)\) where \(\bar{\phi}_i^\lambda\) is the average productivity of the successful entrées in the industry.\(^4\)

In the case of closed economy, by combining the zero profit condition (2.9) and the free entry condition (2.11), we can derive the following equation to determine the cutoff-level productivity \(\phi_i^{\lambda \phi}\):

\begin{equation}
\frac{f_{\phi}}{\delta} \left[ \int_{\phi_i^{\lambda \phi}}^{\infty} [-(\phi_i^{\lambda \phi})^{\sigma - 1} - 1] g(\phi) d\phi \right] = f_{\phi_i}
\end{equation}

where \(g(\cdot)\) is the density function of productivity \(\phi\).\(^5\) The left-hand side of Equation (2.12) monotonically decreases as the value of \(\phi_i^{\lambda \phi}\) increases, and thus a unique value of \(\phi_i^{\lambda \phi}\) is identified as the right-hand side of the equation is constant.

\textit{Export:}

So far we have examined the decision of firms on entry and production in an autarkic state. We now analyze the decisions of the firms when a country is open to trade with the other

\(^4\) The average productivity of the successfully entering firms is determined by the ex-post distribution of the productivities defined with the zero-profit cutoff productivity level: i.e.;

\[\bar{\phi}_i^\lambda = \bar{\phi} (\phi_i^{\lambda \phi}) = \left[ \frac{1}{1 - G(\phi_i^{\lambda \phi})} \int_{\phi_i^{\lambda \phi}}^{\infty} \phi^{\sigma - 1} g(\phi) d\phi \right]^{\frac{1}{\sigma - 1}}\]

where \(g(\cdot) = G'(\cdot)\) is a density function of productivity \(\phi\).
country.

The firms in each country can export their products to another country by paying additional costs. In order for each firm to sell its product variety in the overseas market, the firm must incur fixed costs for export, which depends upon the domestic factor prices and industry factor intensity\(^6\) as the domestic production fixed costs and sunk entry cost do. In addition, international trade requires variable cost for shipping in the conventional “iceberg” form; that is, only \(1/\tau_i\) (\(\tau_i > 1\)) of the shipped quantity of products reaches the other country. This variable cost is assumed to be symmetric between the two countries.

The optimal price of the product of Firm \(\omega\) in Industry \(i\) in Country \(\lambda\) to be sold in the overseas market, \(p_{ix,\omega}^{\lambda}\), is equal to the constant markup over the marginal production cost, but the marginal cost for foreign sales must take into account the variable trade cost. That is,

\[
p_{ix,\omega}^{\lambda}(\phi) = \tau_i \cdot p_{ix,\omega}(\phi) = \frac{\tau_i (s^i)^{\beta_i} (w^i)^{1-\beta_i}}{\rho \phi_{ix,\omega}}
\]

(2.13)

Firms that successfully enter the domestic market will either produce to serve only the domestic market, or become exporters that serve both domestic and foreign markets, depending on their productivity. Therefore, the total revenue of each firm is now as follows:

\[
r_{i,\omega, total}^{\lambda}(\phi) = r_{i,\phi}^{\lambda}(\phi)
\]

if the firm serves only the domestic market;

\[
r_{i,\omega, total}^{\lambda}(\phi) = r_{i,\phi}^{\lambda}(\phi) + r_{ix,\omega}^{\lambda}(\phi)
\]

if the firm also exports.

As in the closed economy case, the zero-profit condition and the free-entry condition jointly identified the productivity cutoff that that divides the firms into domestic producers and exporters. The profit of each firm now consists of two parts:

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5 See Appendix for the derivation of Equation (2.12).

6 Specifically, the fixed costs for exporting takes the form of \(\int_{ix} (s^i)^{\beta_i} (w^i)^{1-\beta_i}, f_{ix} > 0\).
\[ \pi^\phi_{i, total}(\phi) = \pi^\phi_{i, \text{dom}}(\phi) + \max\{0, \pi^\phi_{i, \text{exp}}(\phi)\} \] (2.14)

where \[ \pi^\phi_{i, \text{dom}}(\phi) = \frac{r^\phi_{i, \text{dom}}(\phi)}{\sigma} - f^i_i(s^\phi_i)^{\beta_i}(w^\phi_i)^{1-\beta_i}; \]

\[ \pi^\phi_{i, \text{exp}}(\phi) = \frac{r^\phi_{i, \text{exp}}(\phi)}{\sigma} - f^i_x(s^\phi_x)^{\beta_i}(w^\phi_x)^{1-\beta_i}. \]

Accordingly, the zero-profit condition is two-fold, which consists of the following two equations:

Zero-profit condition for domestic production, which involves the domestic producer productivity cutoff \( \phi^\phi_i \):

\[ r^\phi_i(\phi^\phi_i) = \sigma f^i_i(s^\phi_i)^{\beta_i}(w^\phi_i)^{1-\beta_i}. \] (2.15)

Zero-profit condition for export, which involves the exporter productivity cutoff \( \phi^\phi_x \):

\[ r^\phi_x(\phi^\phi_x) = \sigma f^i_x(s^\phi_x)^{\beta_i}(w^\phi_x)^{1-\beta_i}. \] (2.16)

Equations (2.6), (2.15) and (2.16) jointly determine the relationship between the two cutoffs \( \phi^\phi_i \) and \( \phi^\phi_x \) for each country \( \lambda \in \{H, F\} \), such as follows:

\[ \phi^\phi_{ix} = \Lambda^H_i \cdot \phi^\phi_{iH} \] (2.17)

\[ \phi^\phi_{ix} = \Lambda^F_i \cdot \phi^\phi_{iF} \] (2.18)

where \[ \Lambda^H_i = \tau_i(\frac{P^H_i}{P^F_i})(\frac{Y^H_i}{Y^F_i} \cdot \frac{f^i_x}{f^i_i})^{\frac{1}{\sigma-1}} \] and \[ \Lambda^F_i = \tau_i(\frac{P^F_i}{P^H_i})(\frac{Y^F_i}{Y^H_i} \cdot \frac{f^i_x}{f^i_i})^{\frac{1}{\sigma-1}}, \] and \( P^\phi_i \) is the industry price index in each country, which is in general different across countries due to the trade costs.8

Empirical studies have shown that not all domestically active firms are engaged in export, and also that exporting firms tend to be larger (or more productive) than non-exporters. This is thus

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7 See Appendix for the derivation of Equations (2.17) and (2.18).
8 The form of price index under the costly trade is shown later in this section.
relevant to focus our analysis to the case where the productivity cutoff for export is higher than that for domestic production: i.e., $\phi^{*H} > \phi^{*F}$, or $\Lambda^{iH} > 1$. This would be the case when the fixed costs for export is sufficiently higher than the fixed costs for domestic production ($f_{ix} > f_{i}$), and/or the variable trade cost ($\tau_{i}$) is sufficiently large. In this case, only a portion of firms that successfully enter the domestic market can export. Of all the firms in a country that draw a random productivity for the sunk entry cost, a fraction of $G(\phi^{*H})$ will exit because their revenues can not cover the fixed costs for domestic production. A fraction $G(\phi^{*H}) - G(\phi^{*F})$ of the firms will serve only the domestic market in Country $\lambda$ because they will not be able to cover the higher fixed costs for export. Only the remaining firms (the fraction of $1 - G(\phi^{*H})$), which are the most productive, will be exporters.

The free-entry condition is also modified because now the value of the firm is the sum of two parts: the expected future profit stream from domestic production; and the expected future profit from the export market multiplied by the probability of being an exporter conditional on that the firm successfully enters the domestic market. That is;

$$
\nu^{H}_{i,ix}(\phi_{i,ix}) = \max\{0, \frac{\pi^{H}_{i,ix}(\phi_{i,ix})}{\delta} \} + \chi^{H}_{i} \cdot \max\{0, \frac{\pi^{H}_{ixw}(\phi_{i,ix})}{\delta} \}
$$

(2.19)

where $\chi^{H}_{i} = \frac{1 - G(\phi^{*H})}{1 - G(\phi^{*F})}$ is the probability of exporting conditional on that the firm successfully enters and produces in the domestic market in Country $\lambda = H$ or $F$.

Hence, the free-entry condition with costly international trade is that the ex ante expected value of entry, which is the value of the firm multiplied by the ex ante probability of successful entry, equals the sunk entry cost:
where $\bar{\pi}_i^\lambda \equiv \pi_i^\lambda (\bar{\phi}_i^\lambda)$ and $\bar{\pi}_{ix}^\lambda \equiv \pi_{ix}^\lambda (\bar{\phi}_{ix}^\lambda)$ are the average profit of the firms that domestic produce and the average profit of the exporters in Country $\lambda = H$ or $F$, respectively, which are determined by the average productivity levels of those groups of firms ($\bar{\phi}_i^\lambda$ and $\bar{\phi}_{ix}^\lambda$).\(^9\)

Combining this free-entry condition with the zero-profit condition (2.15) and (2.16) yields the following equation\(^10\):

$$
f_i \int_{\phi_i^\lambda}^{\infty} \left[ \left( \phi \phi_i^\lambda \right)^\sigma - 1 \right] g(\phi) d\phi + f_{ix} \int_{\phi_{ix}^\lambda}^{\infty} \left[ \left( \phi \phi_{ix}^\lambda \right)^\sigma - 1 \right] g(\phi) d\phi = f_{ei} \tag{2.21}$$

The first term of the left-hand side of this equation is monotonically decreasing in $\phi_i^\lambda$, and the second term is monotonically decreasing in $\phi_{ix}^\lambda$. Since $\phi_{ix}^\lambda$ increases as $\phi_i^\lambda$ increases (from Equations (2.17) and (2.18), $\phi_{ix}^\lambda = \Lambda_i^\lambda \cdot \phi_i^\lambda$, $\Lambda_i^\lambda > 1$), the whole of the left-hand side of the equation monotonically decreases as the value of $\phi_i^\lambda$ increases. With the right-hand side being constant, this Equation (2.21) solves for the unique value of the domestic production cutoff $\phi_i^\lambda$ and accordingly the export cutoff $\phi_{ei}^\lambda$.

**Factor Prices:**

\(^9\) The average productivity level of domestically-producing firms is defined with the cutoff productivity for domestic producers in each country, such as follows:

$$
\bar{\phi}_i^\lambda (\phi_i^\lambda) = \left[ \frac{1}{1 - G(\phi_i^\lambda)} \int_{\phi_i^\lambda}^{\infty} \phi^\sigma g(\phi) d\phi \right]^{-\frac{1}{\sigma-1}}
$$

Similarly, the average productivity level of exporters is defined with the cutoff productivity for export:

$$
\bar{\phi}_{ix}^\lambda (\phi_{ix}^\lambda) = \left[ \frac{1}{1 - G(\phi_{ix}^\lambda)} \int_{\phi_{ix}^\lambda}^{\infty} \phi^\sigma g(\phi) d\phi \right]^{-\frac{1}{\sigma-1}}
$$

\(^{10}\) The derivation of Equation (2.21) is similar to the closed-economy version, Equation (2.12), which is
In our model, unlike the case of free and frictionless trade, the factor prices will not be equalized between the two countries, due to the fixed and variable costs of trade. Instead, under costly trade the equilibrium relative prices of the two production factors will fall between the autarky level and the level under free trade. In autarky, the wage for skilled labor relative to that for the unskilled is lower in the skill-abundant Home. Opening the country to costly trade will result in an increase in the reward for the abundant factor in each country (i.e., $s$ will rise in the Home and $w$ will rise in the Foreign), which will decrease the difference in the relative factor price between the two countries, while the factor prices will not become equal. That is;

$$\begin{pmatrix} \frac{s^H}{w^H} \\ \frac{s^F}{w^F} \end{pmatrix}^A < \begin{pmatrix} \frac{s^H}{w^H} \\ \frac{s^F}{w^F} \end{pmatrix}^{CT} < \begin{pmatrix} \frac{s^H}{w^H} \\ \frac{s^F}{w^F} \end{pmatrix}^{FT}$$

where $A$, $CT$, and $FT$ indicate autarky, costly trade, and free trade, respectively. The right-hand side (the third term) of the inequality above will be equal to one under free trade with factor price equalization (FPE).

This difference in equilibrium relative factor reward implies that in this framework of two countries, two factors, multiple industries and heterogeneous firms, opening from an autarkic state to costly trade will have different impacts on each of the two countries that are asymmetric in factor endowment, as well as on each of the industries that are different in factor intensity. The profit derived from exporting will also vary across countries, across industries, and across heterogeneous firms.

**Mass of Firms:**

shown in Appendix.
Now we examine how many firms in each country will export to the overseas market in each industry. In our model the number of firms is measured by the size of the “mass” of the continuum of firms. $M_i^\lambda$ denotes the mass of the firms serving only domestic market, and $M_{ix}^\lambda$ denotes the mass of the exporting firms, for each country $\lambda \in \{H, F\}$. Only a portion of the domestically-producing firms will be exporters, and that fraction is determined by the two cutoff productivity levels: the one for domestic production and that for export, which is shown as follows:

$$M_{ix}^\lambda = \chi_i^\lambda \cdot M_i^\lambda$$ (2.22)

where $\chi_i^\lambda \equiv \frac{1 - G(\phi_i^x^\lambda)}{1 - G(\phi_i^x^\lambda)} < 1$ is as defined previously. Note that $M_i^\lambda = \frac{R_i^\lambda}{\bar{F}_i^\lambda}$, where $R_i^\lambda$ is the total revenue from domestic sales in Industry $i$ in Country $\lambda$; and $\bar{F}_i^\lambda \equiv r_i(\bar{\phi}_i^x^\lambda)$ is the average domestic revenue of the active firms (domestic producers and exporters) in the industry in the country.

Our concern is with the relative size of the exporter mass between the two countries in each industry, $\frac{M_{ix}^H}{M_{ix}^F}$, and how it will differ across industries in relation to the factor intensities of the industries. To examine it, consider the price indexes of Industry $i$ in the two countries in the costly-trade equilibrium, which are composed of the number and average price of domestically-produced products, as well as those of imported products from the other country:

$$P_i^H = [M_i^H (p_i^H (\bar{\phi}_i^H))^{1-\sigma} + \chi_i^F \cdot M_i^F (\tau_i \cdot p_i^F (\bar{\phi}_i^F))^{1-\sigma}]^{\frac{1}{1-\sigma}}$$ (2.23)

$$P_i^F = [M_i^F (p_i^F (\bar{\phi}_i^F))^{1-\sigma} + \chi_i^H \cdot M_i^H (\tau_i \cdot p_i^H (\bar{\phi}_i^H))^{1-\sigma}]^{\frac{1}{1-\sigma}}$$ (2.24)

\[11\] See Appendix for more rigorous demonstration for the equilibrium factor prices.
Dividing Equation (2.23) by (2.24) in both sides yields the following equation:

\[ \left( \frac{P_i^H}{P_i^F} \right)^{1-\sigma} = \frac{M_i^H \left( p_i^H \left( \bar{\phi}_i^H \right) \right)^{1-\sigma} + \chi_i^F \cdot M_i^F \cdot \tau_i^{1-\sigma} \left( p_i^F \left( \bar{\phi}_i^F \right) \right)^{1-\sigma}}{M_i^F \left( p_i^F \left( \bar{\phi}_i^F \right) \right)^{1-\sigma} + \chi_i^H \cdot M_i^H \cdot \tau_i^{1-\sigma} \left( p_i^H \left( \bar{\phi}_i^H \right) \right)^{1-\sigma}} \]  

(2.25)

By rearranging this equation, we can derive the following expression for the ratio of the masses of active firms in the two countries:

\[ \frac{M_i^H}{M_i^F} = \frac{\left( \frac{P_i^H}{P_i^F} \right)^{1-\sigma} \left( p_i^F \left( \bar{\phi}_i^F \right) \right)^{1-\sigma} - \chi_i^F \cdot \tau_i^{1-\sigma} \left( p_i^F \left( \bar{\phi}_i^F \right) \right)^{1-\sigma} \left( p_i^H \left( \bar{\phi}_i^H \right) \right)^{1-\sigma}}{\left( p_i^F \left( \bar{\phi}_i^F \right) \right)^{1-\sigma} - \left( \frac{P_i^H}{P_i^F} \right)^{1-\sigma} \cdot \chi_i^H \cdot \tau_i^{1-\sigma} \left( p_i^H \left( \bar{\phi}_i^H \right) \right)^{1-\sigma}} \]  

(2.26)

Combining Equations (2.22) and (2.26) and rearranging further yields the following expression for the ratio of the exporter masses in the two countries:

\[ \frac{M_{ix}^H}{M_{ix}^F} = \frac{\chi_i^H\left[ \frac{Y_i^H}{Y_i^F} \left( \frac{f_i}{f_{ix}} \right) \left( \frac{\bar{\phi}_i^F}{\phi_i^F} \right) \sigma^{-1} - \chi_i^F \left( \frac{\bar{\phi}_i^F}{\phi_i^F} \right) \sigma^{-1} \right]}{\tau_i^{-1} \left[ 1 - \chi_i^H\left( \frac{Y_i^H}{Y_i^F} \left( \frac{f_i}{f_{ix}} \right) \left( \frac{\bar{\phi}_i^F}{\phi_i^F} \right) \sigma^{-1} \left( \frac{\bar{\phi}_i^H}{\phi_i^H} \right) \sigma^{-1} \right) \right]} \left( \frac{p_i^H \left( \bar{\phi}_i^H \right)}{p_i^F \left( \bar{\phi}_i^F \right)} \right)^{\sigma^{-1}} \]  

(2.27)

That is, the relative size of the exporter mass in each industry depends upon the ratio of (or the “gap” between) the two productivity cutoffs (\( \frac{\phi_{ix}^{i^2}}{\phi_i^{i^2}} \)) and the ratio of the average productivity of exporters to that of domestic producers (\( \frac{\bar{\phi}_i^{i^2}}{\bar{\phi}_i^{i^2}} \)), as well as the ratio of the average price of domestically-supplied products between the two countries (\( \frac{p_i^H \left( \bar{\phi}_i^H \right)}{p_i^F \left( \bar{\phi}_i^F \right)} \)).

For the purpose of the cross-industry comparison of this relative exporter mass, we introduce the following assumption:

**Assumption 1:** \( f_i = f_j, f_{ix} = f_{jx}, \) and \( \tau_i = \tau_j \) for \( i \neq j \)

This assumption implies that both fixed costs for production and fixed costs for export, adjusted for factor price difference, are identical across industries, and also that the “iceberg” shipping
cost (variable cost) for export is the same for all industries.

By examining Equation (2.27) across industries under Assumption 1, we derive the following proposition regarding the relative size of the masses of exporters between the two countries.

**Proposition 1:** The mass of exporters in one country relative to that in another will be larger in an industry that uses a factor with which the country is relatively better endowed more intensively (i.e., comparative advantage industry). That is, for the relatively skilled-labor abundant Home, \( \frac{M^H_{ix}}{M^F_{ix}} > \frac{M^H_{js}}{M^F_{js}} \) for more skill-intensive Industry i than j (i.e., \( \beta_i > \beta_j \)).

**Proof:** See Appendix.

This proposition may be weaker than how it states since the cross-country comparison of the relative size of exporter masses in the two countries might leave ambiguity, as mentioned in Appendix.\(^{13}\) The intuition of this possible ambiguity is as follows. First, note that in the framework of our model, international trade has two effects. (i) Selection effect: international trade will expose firms to potential access to overseas market, which is an additional source of their revenues. The potential of the additional revenue is larger in industries in which the country has the comparative advantage, and thus in the comparative advantage industries the demand for production factors will increase. This will raise the price of the factor that is used more intensively in those industries; i.e., the factor that is more abundant in that country. The rise in the relative price of the more favorable factor will increase the production cost in the

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\(^{12}\) See Appendix for the derivation of Equation (2.27).

\(^{13}\) In order to completely remove this ambiguity, we need to specify the values of all the parameters in the model and the shape of the distribution of productivities, as well as the exogenous amounts of factor endowments in the two countries.
comparative advantage industries, and as a result firms with relatively low productivity will need to exit. This will reduce the size of the active firm mass (domestic producers plus exporters) in the comparative advantage industries relative to that in comparative disadvantage industries. (ii) 

Export comparative advantage effect: Once a firm successfully enters the domestic market with sufficiently high productivity, however, the chance to become an exporter will be larger in the comparative advantage industries since in those industries firms are more competitive against foreign producers due to the advantage in production cost. Therefore, the fraction of the exporter mass out of the mass of active firms (domestic producers) will be larger in the comparative advantage industries than in the comparative disadvantage industries. These two effects will influence the size of the mass of exporters in opposition to each other, and the ambiguity in the effect of trade on the size of the mass might occur, especially when the first effect is very significant. However, we can unambiguously predict that the share of exporters in firms that are active (producing) in the domestic market (i.e., $\chi_i^\lambda = M_{xi}^\lambda / M_i^\lambda$) will be larger in comparative advantage industries than in comparative disadvantage industries.

Can we predict the relative size of the mass of exporters under free trade with FPE? It is well-known that with FPE the cross-industry patterns of production and trade are indeterminate when the number of industries (sectors) is greater than the number of input factors (e.g., Melvin (1968)). This indeterminacy will also apply to our model, and under free trade with FPE there exist multiple equilibrium allocations of the two factors across industries. As an overall tendency, however, the production resources will on average be allocated more to industries in which the country has its comparative advantage (for both factors in the country to be fully employed), so

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14 We can see this indeterminacy in the relative size of the mass of exporters in Equation (2.26). Under free trade with FPE, $r_i = 1$, $\chi_i^\lambda = 1$ (since all active firms will be exporters), the price of a product variety will be the same in the two market, and the industry price index will be equal in the two countries. Hence, both numerator and denominator of the right-hand side of the equation is zero, which implies the
that the mass of firms will on average be larger in the comparative advantage industries.\textsuperscript{15}

Patterns in Export Varieties:

In our model, each firm produces a unique variety of differentiated product, and thus the mass of exporting firms in a country, which is examined above, represents the number of product varieties exported from the country in that industry. Therefore, Proposition 1 has the following implication for product varieties in export, which is empirically tested in the following sections of this paper:

*Proposition 2: For a certain pair of countries, international trade will exhibit the following cross-industry pattern: the relatively more skilled-labor abundant country will export more varieties of products in skill-intensive industries (i.e., industries with greater $\beta$); on the other hand, the relatively more unskilled-labor abundant country will export more varieties in unskilled labor-intensive industries (i.e., industries with smaller $\beta$).*

3. Data

An empirical test of the implication (Proposition 2) of our model requires data for three variables: the number of product varieties exported from each country in each industry, production factor endowment in each exporter, and input factor intensity in each industry.

For the product varieties in exports, we use the data on the U.S. imports in 1990 from Feenstra, Romalis and Schott (2002). The data contain information on the U.S. imports of each commodity classified according to the very disaggregated 10-digit Harmonized System (HS) indeterminacy of $M_t^i/M_t^f$. 
from each exporter country. The data also include product classification codes according to the 4-digit U.S. Standard Industrial Classification (SIC, 1987 version) corresponding to each 10-digit HS. These two classification levels enable us to count the number of product varieties in each industry for each country by defining products according to the 10-digit HS and industries according to the 4-digit SIC (see the following section for the details). Due to the availability of the data on industry factor intensity, our empirical analysis focuses on trade in manufacturing industries (the 4-digit SIC 2011 through 3999). Table 1 provides the number of exporters, number of product varieties, and total import value in the whole U.S. imports in 1990, as well as the figures in the U.S. manufacturing imports. Manufacturing industries represent 94% of the total U.S. 1990 imports in terms of the number of product varieties, and 83% in terms of value.

The data for the factor endowment of each country are from Hall and Jones (1999). Since our theoretical model is embedded in a two-factor framework with skilled labor ($S$) and unskilled labor ($U$), we use the data on the ratio of human capital to labor as the measure of the abundance of skilled labor relative to unskilled labor ($S/U$). The data on human capital to labor ratio as of 1988 are available for 127 countries.

Our theoretical model assumes a common production technology in each industry across countries. For the world common input factor intensities, we employ the data from the 1992 U.S. Census of Manufactures, which covers 458 manufacturing industries classified according to the 4-digit SIC (1987 version; the codes 2011 through 3999). We measure the skilled-labor intensity of each industry using the number of non-production workers as the share of the total number of employees in each 4-digit SIC, and the unskilled-labor intensity using the number of production workers per total employment.

The sample for our empirical analysis includes 115 countries from which the U.S.

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15 The proof of the indeterminacy under free trade with FPE is upon request.
imported in any one or more manufacturing industry in 1990; the sample also includes 394 manufacturing industries (4-digit SIC) in which the U.S. imported from one or more exporters in 1990. Table 2 lists the 115 countries in the sample. Table 3 provides the summary statistics of the relative factor endowment (the skilled-labor to unskilled-labor ratio: $S/U$) of the sample countries, as well as the ten most and least skilled labor-abundant countries. Table 4 presents the summary statistics of the intensities of the two factors ($S$ and $U$) of the 394 sample industries, and also lists the ten most and least skilled labor-intensive industries. Figure 1 displays the number of countries from which the U.S. imported in each 4-digit industry in 1990. The industries are sorted (from left to right) in order of skilled-labor intensity. Figures 2 and 3 plot the number of exporters and the total number of product varieties in the U.S. imports in each industry, respectively, against industry skilled-labor intensity. These figures indicate that the U.S., the world’s second most skilled labor-abundant country, tends to import more varieties of products from more exporters in unskilled labor-intensive industries than in skilled labor-intensive industries.

4. Empirical Tests

As stated as Proposition 2 in Section 2, our model provides one key implication: A country will export more varieties of products in industries in which the country has a comparative advantage in the Heckscher-Ohlin sense than it will in other industries. In this section we empirically test this implication using the data described in Section 3.

Measuring Exported Varieties:

Our model explains the number of product varieties in each industry exported from each
country to a common importer—in this case, the U.S.—in terms of two elements: the exporter's relative resource abundance and the industry's relative factor use or intensity. As described in the previous section, we define varieties according to the 10-digit HS commodities and industries according to the 4-digit SIC; we thus measure the number of product varieties in Industry $i$ exported from Country $c$, or $n_{ic}$, as follows:

$$n_{ic} \equiv \text{No. of 10-digit HS commodities in a 4-digit SIC } i \text{ exported from country } c .$$

Some 4-digit SIC industries may contain by nature more 10-digit HS commodities in their catalogue than other industries, and thus in the U.S. imports we may observe more product varieties in those industries than in other industries, regardless of the force of the comparative advantage. Therefore, for a proper cross-industry comparison we use an adjusted measure of the number of varieties, which is constructed as follows:$^{16}$

$$n_{-shareic} = \frac{n_{ic}}{N_i}$$

where $N_i$ is the total number of varieties that the U.S. imports from the world in industry $i$:

$$N_i = \sum_c n_{ic} .$$

Note that since the theoretical model assumes that each firm produces a unique variety of products, the imports of the same 10-digit commodities from different countries are considered as different product varieties.

(1) Regressions for Aggregate North and South:

We first test our two-country, two-factor and multi-industry model with the data for

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$^{16}$ This variable is consistent with the idea of the “relative size of firm mass” described in Proposition 1 in Section 2. Here, due to the limitation of the employed dataset, the number of exported varieties from one country in one industry is expressed as the relative value to the number of varieties exported from the rest of the world in that industry, instead of the ratio to the number of varieties exported from the trading partner (i.e., the U.S.).
country aggregates. We divide our 115 sample countries into two groups to construct two
country aggregates, one of which consists of countries that are relatively more skilled-labor
abundant than unskilled (or with relatively high $S/U$). We refer to this group as the “North.”
The other consists of countries that are relatively more unskilled-labor abundant (or with low
$S/U$), which we call the “South.” The North includes 51 countries whose $S/U$ is above the
sample mean; the South includes other 64 sample countries.17 Table 5 lists the countries
constituting the aggregates North and South. Table 6 compares the within-group averages of
relative factor abundance, $S/U$.

The following equation is estimated using the OLS for the aggregate North and South:18

$$\log(n\_share_{i,A}) = \gamma + \theta \cdot skill_{i} + \varepsilon_{i}$$

(4.1)

where $n\_share_{i,A} = \sum_{c \in A} n\_share_{i,c}$ for $A =$ North, South; and $skill_{i} =$ skill intensity of Industry
$i$.19

Our model suggests that the relatively skilled labor-abundant North will export more
product varieties in skilled-intensive industries than in unskilled-intensive industries, and the
unskilled-abundant South will export more varieties in unskilled-intensive industries. The
expected sign of the coefficient $\theta$ is therefore positive for the North and negative for the South.
The results of the estimation are in fact consistent with this prediction, as shown in Table 7.

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17 We also attempted two other “cutoffs” for $S/U$ to divide the sample countries into the North and South: above or below the 75 percentile (29 countries for North, 86 for South), and above or below 0.7 of the value of $S/U$ relative to the U.S. (25 countries for North, 90 for South). These alternative groupings are also indicated in Table 5. The qualitative results of the estimation (the sign and significance of the coefficient estimate) are the same, as shown in Table 7, regardless of the cutoffs.

18 $n\_share_{i,c}$ is skewed in distribution, and therefore log-scaled in the regressions to adjust for possible heteroskedasticity. We do not log-scale the factor intensity measure ($skill_{i}$), but the results are virtually the same even though the log-scaled intensity measure is used.

19 As described in Section 3, $skill_{i}$ is measured using the share of non-production workers in the total number of employees. Unskilled-labor intensity, which is measured using the share of production workers in the total employment, is the same as 1-$skill_{i}$.
(2) Pooled Regression for Dependent Parameter Specification:

We next use the pooled data for all the individual exporters to estimate cross-industry patterns of exports in terms of product varieties. We consider the following regression model:

\[
\log(n_{-\text{share}_{ic}}) = \gamma + \Pi_c \cdot \text{skill}_i + \epsilon_{ic}
\]  

(4.2)

The slope coefficient for skilled-labor intensity, \( \Pi_c \), would differ across exporter countries. The theory predicts that the value of the slope coefficient is higher for countries with greater relative skilled-labor endowment, and lower for exporters with smaller relative skilled-labor endowment (or greater relative unskilled-labor endowment). This pattern is indeed observed in the result of the regression (4.2) for each individual exporter. Figure 4 plots the slope coefficient \( \hat{\Pi}_c \) estimated for each country against the relative skilled-labor abundance of the country (in logarithmic scale). The figure exhibits the tendency that the coefficient \( \Pi_c \) is greater for more skill-abundant.\(^{20}\) To capture this pattern in the pooled regression, we impose the following structure on the slope coefficient \( \Pi_c \):

\[
\Pi_c = \Pi((S/U)_c) = \theta_1 + \theta_2 \cdot \log(S/U)_c
\]  

(4.3)

where \((S/U)_c\) is the skilled- to unskilled-labor ratio of exporter country \( c \).\(^{21}\) The theoretical prediction is that \( \theta_1 \) will be negative (since \( \Pi_c \) will be negative for countries with low skilled-labor abundance) and \( \theta_2 \) will be positive (since \( \Pi_c \) will increase to be positive for

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\(^{20}\) To draw the fitted line in Figure 4, the observations are weighted by the number of observations in each individual country regression (4.2) (i.e., by the number of industries for each country in the sample). Some sub-Saharan African countries such as Angola, Benin, Central African Republic, Rwanda, and Somalia have a large \( \hat{\Pi}_c \) despite their low skilled-labor abundance. However, these countries have exports to the U.S. in very few industries out of 394 4-digit SIC and they are all very unskilled-labor intensive. Hence, the slope coefficients estimated for these “outlier” countries may be vulnerable.

\(^{21}\) We use the log-scaled measure of relative factor abundance to have the size of coefficient estimate for
countries with high skilled-labor abundance). By substituting (4.3) for (4.2), we derive the following specification for our pooled regression:

\[ \log(n_{\text{share}_{c}i}) = \theta_1 \cdot \text{skill}_i + \theta_2 \cdot \text{skill}_i \cdot \log(S/U)_c + \mu_c + \varepsilon_{ic} \]  

(4.4)

We include exporter-specific dummies, \( \mu_c \), to capture the effects of all factors other than the relative skilled-unskilled abundance that differ across countries, such as fixed and variable trade costs and the size of the exporter.\(^{22}\)

The result of the estimation of Equation (4.4) using the fixed-effect OLS is shown in Table 8. The estimates of all the coefficients show the signs as expected from the theory, and they are all highly significant.\(^{23}\) In addition, using these estimates we compute the “threshold” factor abundant \((S/U)^*\) where the slope coefficient for skilled intensity \(\Pi_c\) turns from negative to positive (i.e., \(\Pi_c((S/U)^*) = 0\)). The value of the “threshold” \(S/U\) is 2.11,\(^{24}\) which is close to the relative factor abundance of Italy \((S/U = 2.15\), the 38th most skilled-abundant countries out of 115\) and China \((S/U = 2.09\), the 39th most skilled-abundant\). This factor abundance value could be interpreted as a cutoff to divide countries into the North and South.\(^{25}\)

These results of the empirical tests suggest that the semi-Heckscher-Ohlin prediction of our economic model on the exported varieties is supported by the U.S. import data.

**Alternative Measure of Export Varieties:**

\(\theta_2\) invariant to which of \(S\) or \(U\) is the denominator.\(^{22}\)

Recall that we develop the theoretical model in the two-country framework. The values of parameters in the model are likely to be different across country pairs.\(^{23}\)

This result does not change when the natural-scaled measure of \(S/U\) is used in the regression instead of \(\log(S/U)\); i.e., \(\hat{\theta}_1\) is negative and \(\hat{\theta}_2\) is positive, both significant at the 1\% level.\(^{24}\)

\((S/U)^* = \exp(-\frac{\hat{\theta}_1}{\hat{\theta}_2}) = \exp(-\frac{-1.81}{2.42}) \approx 2.11\)

The mean of \((S/U)_c\), which is used as the cutoff of North-South division in the previous subsection, is...
For checking the robustness of the results of our empirical tests, we also employ an alternative measure of product varieties in countries’ exports that are used in the recent literature. Following Feenstra and Kee (2004) and Hummels and Klenow (2005), as an alternative to the $n\_share_{ic}$, our original measure of export varieties applied in the previous subsection, we now use the following measure of “relative product variety” (Hummels & Klenow use the term of “extensive margin”) in a country’s export:

$$RV_{ic} = \frac{\sum_{\omega \in \Omega_{i}^*} p_{\omega}^* x_{\omega}^*}{\sum_{\omega \in \Omega_{i}^c} p_{\omega}^* x_{\omega}^*}$$

The script * denotes the “benchmark country” for comparison, which is the aggregate of all the 115 sample countries; $\omega$ is a 10-digit HS commodity, $\Omega_{i}^c$ is a subset of 10-digit HS commodities belonging to a 4-digit SIC industry $i$ that are exported from country $c$ to the U.S.; $\Omega_{i}^*$ is a set of all the 10-digit HS commodities in the industry $i$ that are exported to the U.S. from all other countries (defined as the 115 sample countries). $p_{\omega}^*$ and $x_{\omega}^*$ are the price and quantity of the commodity $\omega$ exported by the “benchmark country” (i.e., $p_{\omega}^* x_{\omega}^*$ is the value of the export of the commodity $\omega$ from the world country aggregate to the U.S.).

We replace the left-hand-side variable in Equation (4.4) for the pooled regression (Regression (2)) with this alternative measure of “relative variety” $RV_{ic}$ and re-estimate the following equation using the fixed-effect OLS with exporting country dummies ($\mu_c$):

$$RV_{ic} = \theta_1 \cdot skill_i + \theta_2 \cdot skill_i \cdot \log(S/U)_{c} + \mu_c + \epsilon_{ic} \quad (4.4')$$

The result is shown in Table 9. The estimate of coefficient $\theta_1$ is negative and the estimate of $\theta_2$ is 1.88, which is a little lower than this value.

26 Although this $RV_{ic}$ is a value-based measure and thus different from the number-counting measure $n\_share_{ic}$ used in the previous section, the two measures are similar in the sense that both define 4-digit SIC sectors as industries and 10-digit HS commodities as product varieties.
positive, both of which are significant at the 1% level, which is the same as the result of the estimation in the previous subsection using our original measure of export varieties (\(n_{shareic}\)). This result is also as our theoretical model suggests; and therefore the prediction of the model is re-confirmed by this empirical test with the alternative measure of product varieties in exports.

5. Conclusion

In this paper, we have investigated the relationship between export variety and the exporter’s comparative advantage in terms of relative resource abundance. We have generalized the model by Bernard, Redding & Schott (2007) to the case with continuum industries and derived a prediction that relates product varieties in a country’s exports in various industries to the “degrees” of relative factor intensity of those industries. To test the prediction we have employed the disaggregated data on the U.S. imports, as well as the data on countries’ human capital and labor endowments and the data on the industry-wise uses of skilled- and unskilled-labor in the U.S. manufacturing. The empirical tests support our semi-Heckscher-Ohlin prediction, which indicates that exporters that are more unskilled-labor abundant tend to export more varieties of products in relatively unskilled labor-intensive industries, and more skilled-abundant exporters tend to export more varieties in relatively skill-intensive industries.
References


Appendix

1. Derivation of Equation (2.12):

Note, from Equation (2.6), that the ratio of the revenues of two firms with different productivities is expressed with the ratio of those firms’ productivities, such as follows:

$$\frac{r_i'(\phi')}{r_i(\phi)} = \left(\frac{\phi'}{\phi}\right)^{\sigma^{-1}} \iff r_i'(\phi') = \left(\frac{\phi'}{\phi}\right)^{\sigma^{-1}} r_i(\phi) \quad (A.1)$$

Using this relationship, as well as Equation (2.7) for an individual firm’s profit and Equation (2.9) for the revenue of the firm with the cutoff-level productivity, the free-entry condition (2.11) becomes as follows:

$$[1 - G(\phi^{*\lambda}_i)] \frac{\bar{p}_i}{\delta} = f_{ei}(s^{\lambda})^\beta (w^{\lambda})^{1-\beta_i}$$

$$\iff [1 - G(\phi^{*\lambda}_i)] \frac{1}{\delta} \left\{ \frac{\bar{p}_i}{1} - f_i(s^{\lambda})^\beta (w^{\lambda})^{1-\beta_i} \right\} = f_{ei}(s^{\lambda})^\beta (w^{\lambda})^{1-\beta_i}$$

$$\iff [1 - G(\phi^{*\lambda}_i)] \frac{1}{\delta} \left\{ \frac{\bar{p}_i}{\phi^{*\lambda}_i} \right\}^{\sigma^{-1}} r_i^{\lambda}(\phi^{*\lambda}_i) - f_i(s^{\lambda})^\beta (w^{\lambda})^{1-\beta_i} = f_{ei}(s^{\lambda})^\beta (w^{\lambda})^{1-\beta_i}$$

$$\iff [1 - G(\phi^{*\lambda}_i)] \frac{1}{\delta} \{ (\frac{\phi}{\phi^{*\lambda}_i})^{\sigma^{-1}} - 1 \} f_i(s^{\lambda})^\beta (w^{\lambda})^{1-\beta_i} = f_{ei}(s^{\lambda})^\beta (w^{\lambda})^{1-\beta_i}$$

$$\iff [1 - G(\phi^{*\lambda}_i)] \frac{f_i}{\delta} \{ \frac{1}{1 - G(\phi^{*\lambda}_i)} \int_{\phi^{*\lambda}_i}^{\infty} \left(\frac{\phi}{\phi^{*\lambda}_i}\right)^{\sigma^{-1}} g(\phi) d\phi - 1 \} = f_{ei}$$

and thus Equation (2.12) follows.

2. Derivation of Equations (2.17) & (2.18):

WLOG, here we derive Equation (2.17) for Home. Equation (2.18) for Foreign can be derived analogously.

From Equation (2.13) for the optimal pricing of exported product, the revenue of an individual firm earned from the overseas market (export) is as follows:
\[ r_{ix}^H (\phi) = \alpha Y^F \left( \frac{\rho P^F_i \phi}{\tau_i (s^H)^{\beta_i} (w^H)^{1-\beta_i}} \right) \]  

(A.2)

From this and Equation (2.6), the ratio of the revenue earned by an exporter and that earned by a domestic producer in Home country is expressed as follows:

\[ \frac{r_{ix}^H (\phi)}{r_i^H (\phi)} = \tau_i^{1-\sigma_x} \left( \frac{p_i^F}{p_i^H} \right)^{\sigma_x-1} \left( \frac{y_i^F}{y_i^H} \right) \]  

(A.3)

Equation (A.1) can be modified to the following equation, which implies that the ratio of two firms’ productivities is a function of the ratio of the revenues that two firms earn in the same (domestic) market:

\[ \frac{\phi'}{\phi} = \left( \frac{r_i (\phi')}{r_i (\phi)} \right)^{\frac{1}{\sigma_x-1}} \]  

(A.4)

Using Equations (A.3) and (A.4), we can express the ratio of the productivity cutoff for exporting to the cutoff for domestic production in Home as follows:

\[
\begin{align*}
\frac{\phi_{ix}^{*H}}{\phi_i^{*H}} &= \left( \frac{r_{ix}^H (\phi_{ix}^{*H})}{r_i^H (\phi_i^{*H})} \right)^{\frac{1}{\sigma_x-1}} \\
&= \left( \frac{\tau_i (\phi_{ix}^{*H})^{\sigma_x-1} (p_i^H)^{\sigma_x-1} (y_i^H)^{\frac{1}{\sigma_x}}}{r_i^H (\phi_i^{*H})^{\sigma_x-1} (p_i^F)^{\sigma_x-1} (y_i^H)^{\frac{1}{\sigma_x}}} \right)^{\frac{1}{\sigma_x-1}} \\
&= \tau_i \left( \frac{r_{ix}^H (\phi_{ix}^{*H})}{r_i^H (\phi_i^{*H})} \right)^{\frac{1}{\sigma_x-1}} \left( \frac{p_i^H}{p_i^F} \right)^{\frac{1}{\sigma_x}} \left( \frac{y_i^H}{y_i^F} \right)^{\frac{1}{\sigma_x-1}} \\
&= \tau_i \left( \frac{f_{ix}}{f_i} \right)^{\frac{1}{\sigma_x-1}} \left( \frac{p_i^H}{p_i^F} \right)^{\frac{1}{\sigma_x}} \left( \frac{y_i^H}{y_i^F} \right)^{\frac{1}{\sigma_x-1}} 
\end{align*}
\]

The last equality is from the zero-profit condition in the domestic market (2.6) and the zero-profit condition in the export market (2.15). Equation (2.17) thus follows by defining the right-hand side of the last line of the equation above as \( \Lambda_i^H \).
3. Derivation of Equation (2.21):

Note that, from Equation (2.7);

\[
\pi_i^\lambda = \frac{r_i^\lambda}{\sigma} - f_i (s_i^\lambda)^{\beta_i} (w_i^\lambda)^{1-\beta_i}
\]

\[
= \frac{1}{\sigma} \left( \frac{\phi_i^\lambda}{\phi_{i^*}^\lambda} \right)^{\sigma-1} r_i^{i^*\lambda} - f_i (s_i^\lambda)^{\beta_i} (w_i^\lambda)^{1-\beta_i}
\]

\[
= \left[ \left( \frac{\phi_i^\lambda}{\phi_{i^*}^\lambda} \right)^{\sigma-1} - 1 \right] f_i (s_i^\lambda)^{\beta_i} (w_i^\lambda)^{1-\beta_i}
\]

The second equality is derived using (A.1), and the third equality is from Equation (2.15). Analogously;

\[
\pi_i^x = \left[ \left( \frac{\phi_i^x}{\phi_{ix}^x} \right)^{\sigma-1} - 1 \right] \cdot f_i (s_i^x)^{\beta_i} (w_i^x)^{1-\beta_i}.
\]

Substituting these equations for the average profit levels, as well as the average productivity levels defined in Footnote 9 in the text, yields:

\[
\frac{f_i}{\delta} \int_{\phi_i^\lambda}^{\infty} \left\{ \left( \frac{\phi}{\phi_{i^*}^\lambda} \right)^{\sigma-1} - 1 \right\} g(\phi) d\phi \cdot (s_i^\lambda)^{\beta_i} (w_i^\lambda)^{1-\beta_i} + \frac{f_i + f_{ix}}{\delta} \int_{\phi_{ix}^x}^{\infty} \left\{ \left( \frac{\phi}{\phi_{ix}^x} \right)^{\sigma-1} - 1 \right\} g(\phi) d\phi \cdot (s_i^x)^{\beta_i} (w_i^x)^{1-\beta_i}
\]

\[
= f_i (s_i^\lambda)^{\beta_i} (w_i^\lambda)^{1-\beta_i}
\]

, which Equation (2.21) follows by canceling out the term \( (s_i^\lambda)^{\beta_i} (w_i^\lambda)^{1-\beta_i} \) on the both sides.

4. Relative Factor Prices under Costly Trade:

Here we demonstrate that in equilibrium the relative prices of the two production factors (S and U) is not equalized in our framework of costly trade. The wage for skilled labor relative to the that for unskilled labor will be lower in Home, where skilled labor is relatively more abundant,
than in Foreign; i.e., \( \frac{s^H}{w^H} < \frac{s^F}{w^F} \).

First, note that autarky and free trade are the two extreme cases, or limits, of the costly trade. That is, the former is the limit with infinitely large trade costs \( (f_{ix} \to \infty, \tau_i \to \infty) \), and the latter is the limit with no additional costs for trade \( (f_{ix} \to f_i, \tau_i \to 1) \). The equilibrium relative factor price under costly trade will fall in the range between those in these two limit cases (i.e., \( \frac{s^H}{w^H} < \frac{s^F}{w^F} \)). We will thus show how the relative factor prices in the two countries will be in these two limit cases.

(1) Autarky

Since the production function (2.4) has a Cobb-Douglas form with the common factor intensities, the optimal allocation of the two factors in each industry is such that the total payment to each factor is proportional to the total revenue, which equals the total expenditure, in the industry. That is, in Country \( \lambda \in \{H, F\} \):

\[
S^\lambda_i = \left(\frac{\beta_i}{s^\lambda}\right)R^\lambda_i = \left(\frac{\beta_i}{s^\lambda}\right)\alpha_i Y^\lambda
\]

\[
L^\lambda_i = \left(\frac{1 - \beta_i}{w^\lambda}\right)R^\lambda_i = \left(\frac{1 - \beta_i}{w^\lambda}\right)\alpha_i Y^\lambda
\]  

(A.5)  

(A.6)

where \( R^\lambda_i \) is the total revenue in Industry \( i \) in each country, which is equal to the total industry expenditure in equilibrium. The industry expenditure is proportional to the national income due to the Cobb-Douglas utility function (2.1) (i.e., \( R^\lambda_i = \alpha_i Y^\lambda \)).

Inelastic supply of the each factor equals the sum of that factor allocated to each industry, that is;

\[
\bar{S}^\lambda = \sum_i S^\lambda_i = \frac{Y^\lambda}{s^\lambda} \sum_i \alpha_i \beta_i \Leftrightarrow \bar{s}^\lambda \bar{S}^\lambda = Y^\lambda \sum_i \alpha_i \beta_i
\]  

(A.7)
\[
\overline{U}^\lambda = \sum_i U_i^\lambda = \frac{Y^\lambda}{w^\lambda} \sum_i \alpha_i (1 - \beta_i) \iff w^\lambda \overline{U}^\lambda = Y^\lambda \sum_i \alpha_i (1 - \beta_i) \tag{A.8}
\]

Dividing (A.7) by (A.8) in both sides yields the following equation:

\[
\frac{s^\lambda \overline{S}^\lambda}{w^\lambda \overline{U}^\lambda} = \frac{\sum_i \alpha_i \beta_i}{\sum_i \alpha_i (1 - \beta_i)}
\]

\[
\iff \frac{s^\lambda}{w^\lambda} = \left( \frac{\sum_i \alpha_i \beta_i}{\sum_i \alpha_i (1 - \beta_i)} \right) \cdot \left( \frac{\overline{U}^\lambda}{\overline{S}^\lambda} \right) \tag{A.9}
\]

Since consumers share the identical preference and the production technology is common across countries in each industry (i.e., the parameters \( \alpha_i \) and \( \beta_i \) are common across countries), the first term of the product in the right-hand side of Equation (A.9) is the same for both countries. Hence, the relative factor price \( \frac{s^\lambda}{w^\lambda} \) in each country is determined by the ratio of the two factors that the country is endowed with, \( \frac{\overline{S}^\lambda}{\overline{U}^\lambda} \). Since \( \frac{\overline{S}^H}{\overline{U}^H} > \frac{\overline{S}^F}{\overline{U}^F} \) by assumption, (A.9) implies that \( \frac{s^H}{w^H} < \frac{s^F}{w^F} \) in the autarky equilibrium.

(2) Free Trade

Here we focus on the case with FPE. We can identify the equilibrium relative factor price with FPE by solving for the problem of the integrated world economy, which is characterized by Equations (A.5) through (A.9) in the autarky case described above, but ignoring the country script \( \lambda \). The common relative factor price \( \frac{\overline{S}}{\overline{U}} \) is determined by the world relative factor supply \( \frac{\overline{S}}{\overline{U}} \). Hence, in the free-trade equilibrium with FPE, \( \frac{s^H}{w^H} = \frac{s^F}{w^F} \).

\[27\] We can show that there exist the optimal allocations of the two factors to each industry in each country.
From Equations (2.17) and (2.18) and the definition of $\Lambda_i^\lambda$ for $\lambda \in \{H,F\}$, the ratio of the industry price index in the two countries can be expressed as follows:

$$\frac{P_i^H}{P_i^F} = \tau_i^{-1} \left( \frac{\phi_i^{*H}}{\phi_i^{*F}} \right) \left( \frac{Y_i^F}{Y_i^H} \right)^{1/\sigma} \left( \frac{f_i}{f_{ix}} \right)^{1/\sigma-1} = \tau_i \left( \frac{\phi_i^{*H}}{\phi_i^{*F}} \right) \left( \frac{Y_i^F}{Y_i^H} \right)^{1/\sigma} \left( \frac{f_i}{f_{ix}} \right)^{1/\sigma-1} \quad (A.10)$$

Substituting this Equation (A.10) to Equation (2.26) (with the second equality for the numerator and the first for the denominator of the right-hand side of (2.26)) and re-arranging yields the following:

$$\frac{M_i^H}{M_i^F} = \tau_i^{1-\sigma} \left[ \left( \frac{Y_i^H}{Y_i^F} \right) \left( \frac{f_i}{f_{ix}} \right) \left( \frac{\phi_i^{*H}}{\phi_i^{*F}} \right)^{1-\sigma} \left( p_i^F (\bar{\phi}_i^F) \right)^{1-\sigma} - \chi_i^F \left( p_i^F (\bar{\phi}_i^F) \right)^{1-\sigma} \right] \quad (A.11)$$

The optimal pricing Equation (2.5) implies that the ratio of the prices charged by two firms with different productivity in the same market can be expressed as the ratio of the two productivities, i.e.;

$$p_i^\lambda (\phi^\prime) = \left( \frac{\phi}{\phi^\prime} \right) \cdot p_i^\lambda (\phi) \quad (A.12)$$

Using this, the price charged by a firm with the average exporter productivity in the domestic market is expressed, using the average price of domestic producers, as follows:

$$p_i^H (\bar{\phi}_{ix}^H) = \left( \frac{\phi_i^H}{\bar{\phi}_{ix}^H} \right) \cdot p_i^H (\bar{\phi}_{i}^H) \quad (A.13)$$

$$p_i^F (\bar{\phi}_{ix}^F) = \left( \frac{\phi_i^F}{\bar{\phi}_{ix}^F} \right) \cdot p_i^F (\bar{\phi}_{i}^F) \quad (A.14)$$

with FPE, although the allocations are not unique (Melvin’s indeterminancy). The authors can provide the
Substituting these equations into Equation (A.11) (applying (A.14) to the numerator and (A.13) to the denominator of the right-hand side) and re-arranging the terms yields the following expression for the relative size of the masses of domestically-producing firms:

\[
\frac{M_i^H}{M_i^F} = \frac{\left(\frac{Y^H}{Y^F}\right)^{\frac{\phi_{ix}^*}{\phi_{ii}^*}} - \chi_i^F \left(\frac{\phi_{ix}^*}{\phi_{ii}^*}\right)^{\sigma^{-1}}}{{\tau_i^*}^{\sigma^{-1}} \left[1 - \chi_i^H \left(\frac{Y^H}{Y^F}\right)^{\frac{\phi_{ix}^*}{\phi_{ii}^*}} \left(\frac{\phi_{ix}^*}{\phi_{ii}^*}\right)^{\sigma^{-1}}\right]} \left(\frac{P_i^H (\phi_i^H)}{P_i^F (\phi_i^F)}\right)^{\sigma^{-1}}
\]  

(A.15)

Equation (2.27) is derived from this (A.15) and Equation (2.22).

6. Proof of Proposition 1:

Equation (2.27) indicates that the relative size of the mass of exporters in the two countries depends upon the following factors:

- The ratio of the productivity cutoff for export to the cutoff for domestic production in each country: \( \frac{\phi_{ix}^*}{\phi_{ii}^*}, \frac{\phi_{ix}^*}{\phi_{ii}^*} \)

- The ratio of the \textit{ex post} average productivity of exporters to that of domestic producers in each country: \( \frac{\overline{\phi}_{ix}^H}{\phi_i^H}, \frac{\overline{\phi}_{ix}^F}{\phi_i^F} \)

(This ratio is indeed determined by the ratio of the productivity cutoffs.)

- The levels of the average productivities of domestic producers in the two countries: \( \overline{\phi}_i^H, \overline{\phi}_i^F \)

- Equilibrium relative factor rewards in the two countries: \( \frac{S^H}{W^H}, \frac{S^F}{W^F} \)

The proof strategy is as follows:

proof upon request.
(i) We first show that the relative industry price index (Home to Foreign) is smaller for an industry in which the skill-abundant Home has the comparative advantage (i.e., \( \frac{P_i^H}{P_i^F} < \frac{P_j^H}{P_j^F} \) for \( i \neq j \) such that \( \beta_i > \beta_j \));

(ii) We next demonstrate that (i) implies that the “distance” of the two productivity cutoffs is closer in an industry in which the country has the comparative advantage (i.e., \( \frac{\phi_i^*}{\phi_i^H} < \frac{\phi_j^*}{\phi_j^H} \) and \( \frac{\phi_i^*}{\phi_i^F} > \frac{\phi_j^*}{\phi_j^F} \) for \( i \neq j \) such that \( \beta_i > \beta_j \)). This also implies that the “distance” of the average productivities of exporters and that of domestic producers is in the same relationship (i.e., \( \frac{\tilde{\phi}_i^H}{\tilde{\phi}_i^H} < \frac{\tilde{\phi}_j^H}{\tilde{\phi}_j^H} \) and \( \frac{\tilde{\phi}_i^F}{\tilde{\phi}_i^F} > \frac{\tilde{\phi}_j^F}{\tilde{\phi}_j^F} \) for \( i \neq j \) such that \( \beta_i > \beta_j \));

(iii) We then use the results in (ii) and the relationship between the relative factor prices in the two countries in equilibrium, which has been derived in 4. above in this Appendix, to compare across industries the relative sizes of exporter masses in the two countries,

\[
\frac{M_{ix}^H}{M_{ix}^F} \quad \text{and} \quad \frac{M_{ix}^H}{M_{ix}^F}.
\]

In what follows, we impose Assumption 1.

(i) Relative industry price index in two countries:

To demonstrate that \( \frac{P_i^H}{P_i^F} < \frac{P_j^H}{P_j^F} \) for \( i \neq j \) such that \( \beta_i > \beta_j \), here we apply a similar logic to the one that we have used in 4. above to show the relative factor prices in the costly-trade equilibrium \( \left( \frac{S_i^H}{w_i^H} < \frac{S_i^F}{w_i^F} \right) \). Recall Equation (2.25) for the relative industry price index in the
costly-trade equilibrium, with a slight modification:

\[
P_i^\text{H} = \left[ M_i^\text{H} (p_i^\text{H} (\bar{\phi}_i^\text{H}))^{1-\sigma} + \chi_i^F \cdot M_i^F \cdot \tau_i (-p_i^F (\bar{\phi}_i^F))^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \]

(A.16)

Since the autarky and the free-trade FPE equilibria is the two extreme or limit cases, the relative price index in the costly trade equilibrium falls between the one in the autarky equilibrium and the one in the free-trade FPE equilibrium.

In autarky, which is characterized by \( \tau_i = \infty \) and \( f_{ix} = \infty \), no firms will be exporters (\( q_i^x = 0 \) in each country \( \lambda \)). Therefore, Equation (A.16) is now as follows:

\[
P_i^\text{H} = \left( M_i^\text{H} \right)^{\frac{1}{1-\sigma}} \cdot p_i^\text{H} (\bar{\phi}_i^\text{H}) = \left( M_i^\text{H} \right)^{\frac{1}{1-\sigma}} \cdot p_i^F (\bar{\phi}_i^F) \]

(A.17)

Since \( M_i^\lambda = R_i^\lambda / r_i^\lambda (\bar{\phi}_i^\lambda) \) and \( R_i^\lambda = \alpha_i Y^\lambda \) for each country \( \lambda \in \{H, F\} \) in the autarky equilibrium, Equation (A.17) yields the following equation;

\[
P_i^\text{H} = \left( \frac{Y^H}{Y^F} \right) \left( \frac{r_i^F (\bar{\phi}_i^F)}{r_i^H (\bar{\phi}_i^H)} \right)^{\frac{1}{1-\sigma}} \cdot p_i^H (\bar{\phi}_i^H) \]

(A.18)

Using Equations (A.1) and (A.12), as well as the optima pricing (2.5) and the zero-profit condition (2.9), Equation (A.18) can be expressed as follows:

\[
P_i^\text{H} = \left( \frac{Y^H}{Y^F} \right)^{\frac{1}{1-\sigma}} \left( \frac{\bar{\phi}_i^H}{\bar{\phi}_i^F} \right)^{\sigma-1} \left( \frac{\bar{\phi}_i^\lambda}{\bar{\phi}_i^\lambda} \right)^{-\sigma-1} \left( \frac{s_i^H}{s_i^F} \right)^{\beta_i} \left( \frac{w_i^H}{w_i^F} \right)^{1-\beta_i} \]

(A.19)

Note that the productivity cutoff for each country, \( \phi_i^\lambda \), is determined by the free-entry condition (2.12), which is common for the two countries. Therefore, \( \phi_i^{*H} = \phi_i^{*F} \), and accordingly,

\( \bar{\phi}_i^H = \bar{\phi}_i^F \) since the productivity distribution is common across countries. These imply that
\( \frac{\phi_i^H}{\phi_i^H} = \frac{\phi_i^F}{\phi_i^F} \). Hence, from Equation (A.19) we obtain the following:

\[
\frac{P_i^H}{P_i^F} = \left( \frac{Y^H}{Y^F} \right)^{\frac{1}{1-\sigma}} \cdot \left\{ \left( \frac{F^H}{s^H} \right)^{\beta_i} \left( \frac{w^H}{w^F} \right)^{1-\beta_i} \right\}^{\frac{1}{1-\sigma}}
\]

\[
\Leftarrow \frac{P_i^H}{P_i^F} = \left( \frac{Y^H}{Y^F} \right)^{\frac{1}{1-\sigma}} \cdot \left\{ \left( \frac{s^H / w^H}{s^F / w^F} \right)^{\beta_i} \left( \frac{w^H}{w^F} \right)^{\frac{1}{\sigma-1}} \right\}
\]

(A.20)

Analogously,

\[
\frac{P_j^H}{P_j^F} = \left( \frac{Y^H}{Y^F} \right)^{\frac{1}{1-\sigma}} \cdot \left\{ \left( \frac{s^H / w^H}{s^F / w^F} \right)^{\beta_j} \left( \frac{w^H}{w^F} \right)^{\frac{1}{\sigma-1}} \right\}
\]

(A.21)

It has been shown in 4.(1) above that \( \frac{S^H}{w^H} < \frac{S^F}{w^F} \) in autarky. Therefore, since \( \beta_i > \beta_j \), it follows that \( \frac{P_i^H}{P_i^F} < \frac{P_j^H}{P_j^F} \) in the autarky equilibrium.

Next, consider the free-trade equilibrium, which is characterized by \( \tau_i = 1 \) and \( f_i = f_j \). Since all domestically active firms will export, \( \lambda^i \lambda^j = 1 \) in each country \( \lambda \). Furthermore, with FPE, firms in the two countries will charge the same price for both domestic sales and export if their productivities are the same, \( p_i^H (\phi_i^H) = p_i^F (\phi_i^F) = p_j^F (\phi_j^F) \) (the average productivity is the same across countries since it is determined by the common free-entry condition (2.12)).

Hence, Equation (A.16) yields:

\[
\frac{P_i^H}{P_i^F} = \left( \frac{M_i^H + M_i^F}{M_i^H + M_i^F} \right)^{\frac{1}{1-\sigma}} = 1
\]

Therefore, under costly trade, which is the intermediate case of the two extremes shown above,
\[
\frac{P^H_i}{P^F_i} < \frac{P^H_j}{P^F_j} \quad \text{for } i \neq j \text{ such that } \beta_i > \beta_j \text{ in equilibrium.}
\]

(ii) “Distance” between export productivity cutoff and domestic production cutoff:

From Equations (2.17) and (2.18):

\[
\begin{align*}
\frac{\phi_{ix}^{*H}}{\phi_i^{*H}} &= \Lambda_i^H = \tau_i \left( \frac{P^H_i}{P^F_i} \right) \left( \frac{Y^H_i}{Y^F_i} \right) \frac{1}{f_i} \\
\frac{\phi_{ix}^{*H}}{\phi_j^{*H}} &= \Lambda_j^H = \tau_j \left( \frac{P^H_j}{P^F_j} \right) \left( \frac{Y^H_j}{Y^F_j} \right) \frac{1}{f_j} \\
\frac{\phi_{ix}^{*F}}{\phi_i^{*F}} &= \Lambda_i^F = \tau_i \left( \frac{P^F_i}{P^H_i} \right) \left( \frac{Y^F_i}{Y^H_i} \right) \frac{1}{f_i} \\
\frac{\phi_{ix}^{*F}}{\phi_j^{*F}} &= \Lambda_j^F = \tau_j \left( \frac{P^F_j}{P^H_j} \right) \left( \frac{Y^F_j}{Y^H_j} \right) \frac{1}{f_j}
\end{align*}
\]

With Assumption 1 (i.e., \( \tau_i = \tau_j, f_i = f_j, \) and \( fi = f_j^x \)), and also from the result in (i) above, the first two equations imply:

\[
(1 <) \Lambda_i^H < \Lambda_j^H \iff (1 <) \frac{\phi_{ix}^{*H}}{\phi_i^{*H}} < \frac{\phi_{ix}^{*H}}{\phi_j^{*H}} \iff (1 <) \frac{\phi_{ix}^{*H}}{\phi_i^{*H}} < \frac{\phi_{ix}^{*H}}{\phi_j^{*H}} \quad \text{(A.22)}
\]

and the last two equations imply:

\[
\Lambda_i^F > \Lambda_j^F (> 1) \iff \frac{\phi_{ix}^{*F}}{\phi_i^{*F}} > \frac{\phi_{ix}^{*F}}{\phi_j^{*F}} (> 1) \iff \frac{\phi_{ix}^{*F}}{\phi_i^{*F}} > \frac{\phi_{ix}^{*F}}{\phi_j^{*F}} (> 1) \quad \text{(A.23)}
\]

Now recall the free-entry condition (2.21) for costly trade (with Assumption 1):

\[
\frac{f}{\phi_{ix}^*} \int_{\phi_{ix}^*}^{\infty} \left( (\frac{\phi}{\phi_{ix}^*})^{\sigma-1} - 1 \right) g(\phi) d\phi + \frac{f_x}{\phi_{ix}^*} \int_{\phi_{ix}^*}^{\infty} \left[ (\frac{\phi}{\phi_{ix}^*})^{\sigma-1} - 1 \right] g(\phi) d\phi = f_e
\]

The first term of the left-hand side of the free-entry condition is monotonically decreasing in
\( \phi^x \), and the second term is monotonically decreasing in \( \phi^x \). Since \( \phi^x = \Lambda^x \phi^y \) for \( \Lambda^x > 1 \), the whole left-hand side is monotonically decreasing, which identifies the unique solutions for \( \phi^x \) and \( \phi^x \). Note that the left-hand side of the free-entry condition decreases more rapidly as the two cutoffs \( \phi^y \) and \( \phi^y \) are more distant from each other (i.e., \( \Lambda^x = \phi^y / \phi^y \) is smaller), so that the equilibrium value of \( \phi^y \) is smaller. Therefore, (A.22) indicates that \( \phi^y \) > \( \phi^y \), and (A.23) implies that \( \phi^y < \phi^y \). These results imply the “selection effect” of international trade that is intuitively described in Section 2: i.e., through the costly international trade the cutoff-level productivity for successful entry, and the average productivity of active firms accordingly, will be higher in industries in which each country has its comparative advantage, due to a keener competition.

Although we can rank the productivity cutoff (and accordingly the average productivity of active firms) according to the factor intensities of industries for each country, we cannot specify in which country the cutoff productivity (and accordingly the average productivity) in the same industry will be greater (i.e., \( \phi^y \) > \( \phi^y \) or \( \phi^y < \phi^y \)). It is because the level of productivities in the two countries also depend upon the total incomes of the two countries, which are somewhat (but not completely) exogenously determined by the factor endowments of the countries.

(iii) Relative size of exporter masses in two countries:

Now we demonstrate the cross-industry difference of the size of the masses of exporters in the two countries, Home and Foreign. WLOG, Industry \( i \) is more skill intensive than Industry \( j \) (\( \beta_i > \beta_j \)). First, the following are derived from (A.22) and (A.23) above:
\[ \chi_i^H > \chi_j^H \]  \hspace{1cm} (A.24)

\[ \chi_i^F < \chi_j^F \]  \hspace{1cm} (A.25)

\[ \iff \frac{\chi_i^H}{\chi_i^F} > \frac{\chi_j^H}{\chi_j^F} \]  \hspace{1cm} (A.26)

Now recall Equation (2.27) for the relative exporter mass:

\[
\frac{M_{ix}^H}{M_{ix}^F} = \frac{\chi_i^H}{\chi_i^F} \cdot \frac{A_i}{\tau_i^{\sigma^{-1}} \cdot B_i} \cdot \left( \frac{p_i^H (\phi_i^H)}{p_i^F (\phi_i^F)} \right)^{\sigma^{-1}} \]

Let us rewrite this as follows:

\[
\frac{M_{ix}^H}{M_{ix}^F} = \frac{\chi_i^H}{\chi_i^F} \cdot \frac{A_i}{\tau_i^{\sigma^{-1}}} \cdot B_i \cdot \left( \frac{p_i^H (\phi_i^H)}{p_i^F (\phi_i^F)} \right)^{\sigma^{-1}} \]

where \[ A_i \equiv \left( \frac{Y_i^H}{Y_i^F} \right) \left( \frac{f_i}{f_{ix}} \right) \left( \frac{\phi_i^{HF}}{\phi_i^{HF}} \right)^{\sigma^{-1}} - \chi_i^H \frac{\phi_i^F}{\phi_i^F} \] and \[ B_i \equiv 1 - \frac{\chi_i^H}{\chi_i^F} \left( \frac{Y_i^H}{Y_i^F} \right) \left( \frac{f_i}{f_{ix}} \right) \left( \frac{\phi_i^{HF}}{\phi_i^{HF}} \right)^{\sigma^{-1}} \frac{\phi_i^F}{\phi_i^F}. \]

The relative exporter mass thus depends upon the ratio of the fractions of exporters among active firms in the two countries \( \frac{\chi_i^H}{\chi_i^F} \), the terms \( A_i \) and \( B_i \), and the relative average price of domestic products in the two countries \( \frac{p_i^H (\phi_i^H)}{p_i^F (\phi_i^F)} \). Let us examine these four factors in order.

- \( \frac{\chi_i^H}{\chi_i^F} \) vs \( \frac{\chi_j^H}{\chi_j^F} \): As already shown in (A.26), \( \frac{\chi_i^H}{\chi_i^F} > \frac{\chi_j^H}{\chi_j^F} \).

- \( A_i \) vs \( A_j \): With other things being equal, the first term is larger in \( A_i \) from (A.23), but the second term for subtraction is mixed due to (A.23) (smaller in \( A_i \)) and (A.25) (greater in \( A_i \)). The comparison is thus not completely clear without specifying all the parameter values and the function of productivity distribution, but it is more likely that \( A_i > A_j \).
• \(B_i\) vs \(B_j\): With other things being equal, the first variable in the second term for subtraction is greater in \(B_i\) from (A.24) but the last two variables are mixed due to (A.22). The comparison is thus not completely clear without specifying all the parameter values and the function of productivity distribution, but it is more likely that \(B_i < B_j\).

• \(\frac{p_i^H}{p_i^F}\) vs \(\frac{p_j^H}{p_j^F}\): From the optimal pricing Equation (2.5), the relative average price depend on two factors: the ratio of the average productivity of active firms in the two countries, and the relative factor prices. The relative average price takes the following form:

\[
\frac{p_i^H}{p_i^F} = \left(\frac{\phi_i^F}{\phi_i^H}\right) \left(\frac{s_i^H}{w_i^H}\right) \left(\frac{s_i^F}{w_i^F}\right)
\]

(A.27)

Although the second term of the right-hand side of (A.27) is smaller for Industry \(i\) since \(\frac{s_i^H}{w_i^H} < \frac{s_j^F}{w_j^F}\) and \(\beta_i > \beta_j\), we cannot be assured of the first term without specifying all the parameter values and the function of productivity distribution. However, let us focus our attention on the case in which the relative price follows the comparative advantages of the countries; i.e., \(\frac{p_i^H}{p_i^F} < \frac{p_j^H}{p_j^F}\).

Considering from these examinations of the four elements, ambiguity remains depending on the parameter values, the shape of the productivity distribution, and the exogeneous size of total income of each country. It is, however, likely to be more generally the case that \(\frac{M_i^H}{M_i^F} > \frac{M_j^H}{M_j^F}\), which means that each country will have a larger mass of exporters in its comparative advantage.
industries relative to the other country.
Table 1: U.S. Import and Varieties in 1990

<table>
<thead>
<tr>
<th></th>
<th>Total Import</th>
<th>Manufacturing Import</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Exporting Countries</td>
<td>153</td>
<td>153</td>
</tr>
<tr>
<td>Number of Varieties</td>
<td>182,230</td>
<td>171,322</td>
</tr>
<tr>
<td>Total Import Value (in million $)</td>
<td>495,260</td>
<td>409,953</td>
</tr>
</tbody>
</table>

Notes:
1. The data are from Feenstra, Romalis, and Schott (2002).
2. Manufacturing import is the import in the industries classified as the 4-digit U.S. SIC (1987 version) 2011 through 3999.
3. Exporters in this table include overseas territories of countries.
4. The number of varieties is defined as the number of commodities classified by the 10-digit Harmonization System (HS) that the U.S. imports from each exporter. (I.e., the same 10-digit HS commodities imported from different exporters are counted as different varieties.)
5. Import value is the customs value of general imports. General Imports measure the total physical arrivals of merchandise from foreign countries, whether such merchandise enters consumption channels immediately or is entered into bonded warehouses or Foreign Trade Zones under Customs custody.
<table>
<thead>
<tr>
<th>Country</th>
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<tbody>
<tr>
<td>Algeria</td>
<td>Guinea-Bissau</td>
<td>Poland</td>
</tr>
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<td>Angola</td>
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<td>Guinea</td>
<td>Philippines</td>
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</table>
Table 3: Factor Abundance of Countries: Skilled Labor ($S$) to Unskilled Labor ($U$) Ratio

Summary Statistics:

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S/U$ ratio</td>
<td>1.879</td>
<td>0.553</td>
<td>1.075</td>
<td>3.369</td>
</tr>
<tr>
<td>$\log(S/U)$</td>
<td>0.589</td>
<td>0.290</td>
<td>0.072</td>
<td>1.215</td>
</tr>
</tbody>
</table>

Number of countries: 115

10 most skilled labor-abundant countries:

<table>
<thead>
<tr>
<th>Country</th>
<th>$S/U$ ratio</th>
<th>$\log(S/U)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand</td>
<td>3.369</td>
<td>1.215</td>
</tr>
<tr>
<td>Hungary</td>
<td>3.086</td>
<td>1.127</td>
</tr>
<tr>
<td>Norway</td>
<td>3.010</td>
<td>1.102</td>
</tr>
<tr>
<td>Canada</td>
<td>3.008</td>
<td>1.101</td>
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<tr>
<td>Denmark</td>
<td>2.999</td>
<td>1.098</td>
</tr>
<tr>
<td>Australia</td>
<td>2.981</td>
<td>1.092</td>
</tr>
<tr>
<td>Finland</td>
<td>2.833</td>
<td>1.041</td>
</tr>
<tr>
<td>Sweden</td>
<td>2.825</td>
<td>1.039</td>
</tr>
<tr>
<td>Israel</td>
<td>2.818</td>
<td>1.036</td>
</tr>
<tr>
<td>Belgium</td>
<td>2.768</td>
<td>1.018</td>
</tr>
</tbody>
</table>

10 most unskilled labor-abundant countries:

<table>
<thead>
<tr>
<th>Country Name</th>
<th>$S/U$ ratio</th>
<th>$\log(S/U)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niger</td>
<td>1.075</td>
<td>0.072</td>
</tr>
<tr>
<td>Guinea-Bissau</td>
<td>1.078</td>
<td>0.075</td>
</tr>
<tr>
<td>Benin</td>
<td>1.098</td>
<td>0.094</td>
</tr>
<tr>
<td>Mali</td>
<td>1.116</td>
<td>0.110</td>
</tr>
<tr>
<td>Rwanda</td>
<td>1.119</td>
<td>0.113</td>
</tr>
<tr>
<td>Gambia</td>
<td>1.119</td>
<td>0.113</td>
</tr>
<tr>
<td>Sudan</td>
<td>1.130</td>
<td>0.122</td>
</tr>
<tr>
<td>Mozambique</td>
<td>1.156</td>
<td>0.145</td>
</tr>
<tr>
<td>Central African Republic</td>
<td>1.184</td>
<td>0.169</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1.217</td>
<td>0.196</td>
</tr>
</tbody>
</table>

Note: The relative skilled-labor abundance to unskilled labor ($S/U$) is measured by the human capital-to-labor ratio provided by Hall and Jones (1999).
Table 4: Input Factor Intensity of Industries:  
Skilled-labor \((S)\) to Unskilled-labor \((U)\) Ratio

Summary Statistics:

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-intensity</td>
<td>0.296</td>
<td>0.124</td>
<td>0.078</td>
<td>0.827</td>
</tr>
<tr>
<td>U-intensity</td>
<td>0.704</td>
<td>0.124</td>
<td>0.173</td>
<td>0.922</td>
</tr>
</tbody>
</table>

Number of industries: 394

10 Most Skilled-labor intensive industries

<table>
<thead>
<tr>
<th>SIC</th>
<th>Industry Description</th>
<th>S-intensity</th>
<th>U-intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2721</td>
<td>Periodicals</td>
<td>0.827</td>
<td>0.173</td>
</tr>
<tr>
<td>2731</td>
<td>Book Publishing</td>
<td>0.766</td>
<td>0.234</td>
</tr>
<tr>
<td>3571</td>
<td>Electronic Computers</td>
<td>0.718</td>
<td>0.282</td>
</tr>
<tr>
<td>3761</td>
<td>Guided Missiles &amp; Space Vehicles</td>
<td>0.685</td>
<td>0.315</td>
</tr>
<tr>
<td>2711</td>
<td>Newspapers</td>
<td>0.676</td>
<td>0.324</td>
</tr>
<tr>
<td>2741</td>
<td>Miscellaneous Publishing</td>
<td>0.638</td>
<td>0.362</td>
</tr>
<tr>
<td>2835</td>
<td>Diagnostic Substances</td>
<td>0.633</td>
<td>0.367</td>
</tr>
<tr>
<td>3572</td>
<td>Computer Storage Devices</td>
<td>0.627</td>
<td>0.373</td>
</tr>
<tr>
<td>3826</td>
<td>Analytical Instruments</td>
<td>0.617</td>
<td>0.383</td>
</tr>
<tr>
<td>2086</td>
<td>Bottled and Canned Soft Drinks</td>
<td>0.604</td>
<td>0.396</td>
</tr>
</tbody>
</table>

10 Most Unskilled-labor intensive industries

<table>
<thead>
<tr>
<th>SIC</th>
<th>Industry Description</th>
<th>S-intensity</th>
<th>U-intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2322</td>
<td>Men's &amp; Boys' Underwear &amp; Nightwear</td>
<td>0.078</td>
<td>0.922</td>
</tr>
<tr>
<td>2281</td>
<td>Yarn Spinning Mills</td>
<td>0.089</td>
<td>0.911</td>
</tr>
<tr>
<td>2284</td>
<td>Thread Mills</td>
<td>0.097</td>
<td>0.903</td>
</tr>
<tr>
<td>2211</td>
<td>Weaving Mills, Cotton</td>
<td>0.102</td>
<td>0.898</td>
</tr>
<tr>
<td>2436</td>
<td>Softwood Veneer and Plywood</td>
<td>0.105</td>
<td>0.895</td>
</tr>
<tr>
<td>2015</td>
<td>Poultry and Egg Processing</td>
<td>0.108</td>
<td>0.892</td>
</tr>
<tr>
<td>3263</td>
<td>Fine Earthenware Food Utensils</td>
<td>0.111</td>
<td>0.889</td>
</tr>
<tr>
<td>2325</td>
<td>Men's &amp; Boys' Trousers &amp; Slacks</td>
<td>0.116</td>
<td>0.884</td>
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<tr>
<td>2321</td>
<td>Shirts, Men's and Boys'</td>
<td>0.120</td>
<td>0.880</td>
</tr>
<tr>
<td>3144</td>
<td>Women's Footwear, Except Athletic</td>
<td>0.120</td>
<td>0.880</td>
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</tbody>
</table>

Notes:
1. The source of the data for factor intensity is 1992 U.S. Census of Manufactures.
2. Industries are classified according to the 4-digit U.S. Standard Industrial Classification (SIC; 1987 version).
3. Skilled-labor \((S)\) intensity is defined as the share of non-production workers in the total number of employees; and unskilled-worker \((U)\) intensity is defined as the share of production workers. The sum of S-intensity and U-intensity is thus one for each industry.
<table>
<thead>
<tr>
<th>North (51 countries)</th>
<th>South (64 Countries)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Sri Lanka#, ##</td>
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<tr>
<td>Australia</td>
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<td>Austria#, ##</td>
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<tr>
<td>Barbados</td>
<td>Taiwan##</td>
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<tr>
<td>Belgium</td>
<td>Thailand##</td>
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<tr>
<td>Canada</td>
<td>Trinidad and Tobago##</td>
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<tr>
<td>Chile##, ##</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>China##, ##</td>
<td>Uruguay##, ##</td>
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<tr>
<td>Costa Rica##, ##</td>
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<td>Nigeria</td>
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</tbody>
</table>

Notes:
Countries in North are those with the skilled-to-unskilled labor ratio \((S/U)\) above the sample mean. 
# indicates the countries grouped into South if the cutoff of 75 percentile value of \((S/U)\) is applied (22 countries); and ## indicates those grouped into South if the cutoff of 0.7 of \((S/U)\) relative to the U.S. is applied (26 countries).
Table 6: Skilled-to-Unskilled Labor Ratios ($S/U$) of North and South

<table>
<thead>
<tr>
<th></th>
<th>$S/U$ (group average)</th>
<th>log($S/U$) (group average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>2.40</td>
<td>0.862</td>
</tr>
<tr>
<td>South</td>
<td>1.47</td>
<td>0.371</td>
</tr>
</tbody>
</table>

Note: The relative factor abundance ($S/U$) is measured by the human capital to labor ratio in Hall & Jones (1999).
Table 7: Regressions for Aggregate North and South

*Dependent Variable:* Log of aggregate no. of varieties as the share in the total no. of varieties imported by the U.S. (*n_sharei,A*)

<table>
<thead>
<tr>
<th></th>
<th>North</th>
<th>South</th>
</tr>
</thead>
<tbody>
<tr>
<td>skilli</td>
<td>0.256***</td>
<td>-1.21***</td>
</tr>
<tr>
<td></td>
<td>(0.041)</td>
<td>(0.208)</td>
</tr>
<tr>
<td>constant</td>
<td>-0.256***</td>
<td>-1.54***</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.063)</td>
</tr>
<tr>
<td>Observations</td>
<td>394</td>
<td>385</td>
</tr>
<tr>
<td>R²</td>
<td>0.10</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Notes:
1. Regression equation is (4.1).
2. skill is skilled-labor intensity of each industry.
3. Robust standard errors are in parentheses.
4. *, **, and *** indicate that the coefficient estimate is significant at the 1%-level, 5%-level, and 10%-level, respectively.

Table 8: Pooled Regression for Individual Exporters

*Dependent Variable:* Log of no. of exported varieties in each industry as the share in the total no. of varieties imported by the U.S. (*n_shareic*)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>skilli</td>
<td>-1.81***</td>
</tr>
<tr>
<td></td>
<td>(0.433)</td>
</tr>
<tr>
<td>skilli * log((S/U)c</td>
<td>2.42***</td>
</tr>
<tr>
<td></td>
<td>(0.521)</td>
</tr>
<tr>
<td>Observations</td>
<td>17,050</td>
</tr>
<tr>
<td>R²</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Notes:
1. Regression equation is (4.4). Country-specific dummies are included.
2. skill is skilled-labor intensity of each industry; and (S/U)c is skilled-to-unskilled labor endowment ratio in each exporter.
3. Standard errors in parentheses are clustered by country.
4. *, **, and *** indicate that the coefficient estimate is significant at the 1%-level, 5%-level, and 10%-level, respectively.
### Table 9: Pooled Regression using Alternative Measure of Export Varieties

*Dependent Variable:* Measure of “Relative Product Variety” in Export \( (RV_{ic}) \)

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>skill_i</td>
<td>-0.030***</td>
<td>(0.007)</td>
</tr>
<tr>
<td>skill_i * log((S/U)_{ic})</td>
<td>0.044***</td>
<td>(0.011)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Observations</th>
<th>R^2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17,050</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Notes:
1. The measure of relative product variety is defined as follows:
   \[
   RV_{ic} \equiv \frac{\sum_{o \in \Omega_i} \hat{p}_{oic} \hat{x}_{oic}}{\sum_{o \in \Omega_i} \hat{p}_{oic} \hat{x}_{oic}}
   \]
2. Regression equation is (4.4'). Country-specific dummies are included.
3. \( skill_i \) is skilled-labor intensity of each industry; and \( (S/U)_{ic} \) is skilled-to-unskilled labor endowment ratio in each exporter.
4. Standard errors in parentheses are clustered by country.
5. *, **, and *** indicate that the coefficient estimate is significant at the 1%-level, 5%-level, and 10%-level, respectively.
Figure 1: Number of Exporters to the U.S. in each manufacturing industry; in 1990

Notes:
1. Industries are listed in order of skilled-labor intensity. The left is the most skilled-labor intensive, and the right is the least.
2. Skilled-labor intensity is defined as the share of non-production workers in the total number of employees.
Figure 2: Scatterplot of Number of Exporters v.s. Industry Skilled-labor Intensity (U.S. Manufacturing Imports in 1990)

Note: Skilled-labor intensity is defined as the share of non-production workers in the total number of employees in each industry.
Figure 3: Scatterplot of Number of Varieties v.s. Industry Skilled-labor Intensity (U.S. Manufacturing Imports in 1990)

Notes:
1. The number of varieties in each industry is defined as the number of 10-digit HS commodities that the U.S. imports from each exporter in each 4-digit SIC industry (i.e., the same HS commodity imported from different countries are counted as different varieties). The mapping between the 10-digit HTS and the 4-digit SIC is according to Feenstra, Romalis, and Schott (2002).
2. Skilled-labor intensity is defined as the share of non-production workers in the total number of employees in each industry.
Figure 4: Individual Exporter Regression:
Scatterplot of Slope Coefficient v.s. Skill Abundance of the Country

Notes:
1. The individual regression specification is \( \log(n_{-share_{i,c}}) = \gamma_c + \Pi_{i} \cdot \text{skill}_i + \epsilon_{i,c} \) where \( i \) indexes 4-digit SIC industries and \( c \) indexes exporter countries. The regression is performed for each country to obtain the country-specific slope coefficient \( \hat{\Pi}_c \).

2. The figure plots \( \hat{\Pi}_c \) for each country (marked by the ISO country code) against the skilled-labor to unskilled-labor ratio of the country \( (S/U)_c \) in logarithm.

3. The fitted line is based on the weighted regression of \( \hat{\Pi}_c \) on \( \log(S/U)_c \), with the observations weighted by the number of 4-digit industries for each country in the sample. (That is, the weight is the number of observation used for each individual country regression.)
Figure 5-1: Exporter’s Relative Factor Abundance, Industry Factor Intensity, and Number of Varieties in U.S. Manufacturing Imports in 1990 (1): Selected Skilled Labor-abundant Countries (relative to unskilled: S/U)

<table>
<thead>
<tr>
<th>Rank in S/U ratio</th>
<th>Exporter</th>
<th>Average variety number share in 20 most skill-intensive industries</th>
<th>Average variety number share in 20 most unskill-intensive industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>New Zealand</td>
<td>0.0113</td>
<td>0.0084</td>
</tr>
<tr>
<td>2</td>
<td>Hungary</td>
<td>0.0065</td>
<td>0.0076</td>
</tr>
<tr>
<td>3</td>
<td>Norway</td>
<td>0.0161</td>
<td>0.0046</td>
</tr>
<tr>
<td>4</td>
<td>Canada</td>
<td>0.0758</td>
<td>0.0780</td>
</tr>
<tr>
<td>5</td>
<td>Denmark</td>
<td>0.0226</td>
<td>0.0099</td>
</tr>
<tr>
<td>6</td>
<td>Australia</td>
<td>0.0259</td>
<td>0.0139</td>
</tr>
<tr>
<td>7</td>
<td>Finland</td>
<td>0.0160</td>
<td>0.0057</td>
</tr>
<tr>
<td>8</td>
<td>Sweden</td>
<td>0.0308</td>
<td>0.0176</td>
</tr>
<tr>
<td>9</td>
<td>Israel</td>
<td>0.0273</td>
<td>0.0205</td>
</tr>
<tr>
<td>10</td>
<td>Belgium</td>
<td>0.0249</td>
<td>0.0200</td>
</tr>
<tr>
<td>11</td>
<td>Switzerland</td>
<td>0.0275</td>
<td>0.0245</td>
</tr>
<tr>
<td>12</td>
<td>United Kingdom</td>
<td>0.1250</td>
<td>0.0461</td>
</tr>
<tr>
<td>13</td>
<td>Netherlands</td>
<td>0.0294</td>
<td>0.0146</td>
</tr>
<tr>
<td>14</td>
<td>Germany</td>
<td>0.0469</td>
<td>0.0457</td>
</tr>
<tr>
<td>15</td>
<td>Japan</td>
<td>0.0376</td>
<td>0.0389</td>
</tr>
</tbody>
</table>

Notes: The numbers of varieties are as the shares in the total number of varieties that the U.S. imports in each industry.
Figure 5-2: Exporter’s Relative Factor Abundance, Industry Factor Intensity, and Number of Varieties in U.S. Manufacturing Imports in 1990 (2): Selected Unskilled Labor-abundant Countries (relative to skilled: U/S)

<table>
<thead>
<tr>
<th>Rank in S/U ratio</th>
<th>Exporter</th>
<th>Average variety number share in 20 most skill-intensive industries</th>
<th>Average variety number share in 20 most unskill-intensive industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>106</td>
<td>Nigeria</td>
<td>0.0006</td>
<td>0.0011</td>
</tr>
<tr>
<td>105</td>
<td>Haiti</td>
<td>0.0014</td>
<td>0.0042</td>
</tr>
<tr>
<td>101</td>
<td>Pakistan</td>
<td>0.0033</td>
<td>0.0090</td>
</tr>
<tr>
<td>84</td>
<td>Guatemala</td>
<td>0.0028</td>
<td>0.0101</td>
</tr>
<tr>
<td>81</td>
<td>Cote d’Ivoire</td>
<td>0.0010</td>
<td>0.0014</td>
</tr>
<tr>
<td>80</td>
<td>India</td>
<td>0.0085</td>
<td>0.0155</td>
</tr>
<tr>
<td>79</td>
<td>Kenya</td>
<td>0.0017</td>
<td>0.0015</td>
</tr>
<tr>
<td>74</td>
<td>Turkey</td>
<td>0.0035</td>
<td>0.0078</td>
</tr>
<tr>
<td>73</td>
<td>Brazil</td>
<td>0.0147</td>
<td>0.0244</td>
</tr>
<tr>
<td>72</td>
<td>Honduras</td>
<td>0.0012</td>
<td>0.0057</td>
</tr>
<tr>
<td>71</td>
<td>El Salvador</td>
<td>0.0022</td>
<td>0.0051</td>
</tr>
<tr>
<td>70</td>
<td>Indonesia</td>
<td>0.0023</td>
<td>0.0186</td>
</tr>
<tr>
<td>67</td>
<td>Portugal</td>
<td>0.0083</td>
<td>0.0195</td>
</tr>
<tr>
<td>63</td>
<td>Jamaica</td>
<td>0.0029</td>
<td>0.0055</td>
</tr>
<tr>
<td>62</td>
<td>Dominican Republic</td>
<td>0.0037</td>
<td>0.0090</td>
</tr>
</tbody>
</table>

Notes: The numbers of varieties are as the shares in the total number of varieties that the U.S. imports in each industry.