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Beyond Icebergs: Toward A Theory of Biased Globalization

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The Final Version

Abstract

In contrast to domestic trade, international trade inherently requires more intensive use of skilled labor with expertise in areas such as international business, language skills, and maritime insurance, and the transoceanic transportation is more capital intensive than the local transportation. In the presence of such bias in factor demands, globalization caused by an improvement in the export technologies can lead to a *world-wide* increase in the relative prices of the factors used intensively in international trade. Furthermore, a *world-wide* increase in the factors used intensively in international trade can lead to globalization. To capture these effects, we develop a flexible approach to model costly international trade, which includes the standard iceberg approach as a special case. More specifically, we extend the Ricardian model of trade with a continuum of goods (Dornbusch, Fischer and Samuelson, 1977) by introducing multiple factors of production and by making technologies of supplying goods depend on whether the destination is home or abroad. If the technologies of supplying the same good to the two destinations differ only in total factor productivity, the model becomes isomorphic to the DFS Ricardian model with the iceberg cost. By allowing the two technologies to differ in the factor intensities, our approach enables us to examine the links between factor endowments, factor prices and globalization that cannot be captured by the iceberg approach.

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1. Introduction.

This paper proposes a flexible approach to model costly international trade.[2] The key idea is to make the technologies of supplying goods depend on the destinations.[3] By using the word, "supply," we mean to include all the activities associated with delivering the goods to the customers in a particular market. It includes not only the production and the physical shipment of the goods, but also the marketing and customer services, which involve communication with the dealers, customers, and government agencies, as well as the services related to export financing and maritime insurance. Under the assumption that it is more costly to supply goods to the export market than to the domestic market, this approach naturally leads to the home market bias, deviations from the law of one price, and generates endogenously nontraded goods (i.e., the goods that are potentially "tradeable" but not traded in equilibrium.)

Our approach includes the standard approach of modeling costly trade, the iceberg approach, as a special case. According to this approach, commonly attributed to Samuelson (1954), the technologies of producing the goods are the same, regardless of whether the destination of the goods is home or abroad. The cost of trade takes the form of "shrinkage" in transit so that only a fraction of the good shipped abroad actually arrives. Our approach would become isomorphic to the iceberg approach if we add the restriction that the technologies of supplying the goods to different markets differ only in total factor productivity. Our approach is more flexible than the iceberg approach because it allows for the possibility that supplying the goods abroad may use the factors in a different proportion from supplying the goods at home. This flexibility enables us to explore the links between factor endowments, factor prices, and globalization that cannot be captured by the iceberg approach.

For example, imagine that the cost of supplying the goods abroad declines relative to the cost of supplying domestically. Such a change in the relative cost can happen for many different reasons, e.g., advances in information technology (telegraphs, telephones, facsimiles, internet, communication satellites, etc), a tariff reduction, a harmonization of the regulations across countries, a wider acceptance of English as the global business language, an emergence of the global consumer culture that reduces the need for the goods to be tailor-made for each country,

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[2] For the empirical significance of trade costs, see a survey by Anderson and van Wincoop (2004).

etc. The resulting globalization means a reallocation of the factors from the activities associated with supplying the goods to the domestic market to those associated with supplying the goods to the export market. If we were to model this process by a reduction in the iceberg cost, globalization could change relative factor demands only through the standard Stolper-Samuelson effect. That is to say, relative factor demands of a country could change only when the country's exported goods and its imported goods have different factor intensities. This also means that globalization would tend to move the factor prices in different directions in different countries. If the wage rate of white-collar workers relative to blue-collar workers goes up in one country because of the factor content of its net exports, then the relative wage of white-collar workers must go down in its trading partners. Our approach has a different implication. If exporting goods inherently require more intensive use of some factors (say, white-collar workers, particularly those with language skills, international business experiences and/or specialists in export finance and maritime insurance) than supplying the same goods domestically, globalization may lead to an increase in the relative price of these factors in all of the countries.

To give another example, the standard factor proportion theory of trade, such as the Heckscher-Ohlin model, relies on the cross-country difference in factor proportions as a basis of international trade, and hence it does not have a clear prediction as to how the volume of trade responds when the factor proportions change in the same direction across countries. Our model has a different implication, because the factor endowments affect international trade in a more direct manner. If servicing the foreign customers requires more skilled labor, if the transoceanic transportation is more capital intensive than the local transportation, etc., a world-wide increase in the relative supply of these factors will lead to globalization.

Obviously, one could apply our approach to any existing model of international trade that uses the iceberg approach. In this paper, we have chosen the Ricardian model with a continuum of goods, developed by Dornbusch, Fischer, and Samuelson (1977), hereafter DFS. For a variety of reasons, their model offers a useful background against which to demonstrate our approach. First, the Ricardian structure of the DFS model enables us to illustrate the difference between our approach and the iceberg approach without the additional complication of the well-understood

[3] Deardorff (1980) also allowed for the technologies to depend on the destination. However, he did not pursue any of the issues investigated in this paper.

Hechscher-Ohlin-Stolper-Samuelson effects. Second, to the best of our knowledge, DFS is the first study that derived the set of nontraded goods endogenously by making use of the iceberg approach. Furthermore, DFS has inspired many recent studies on competitive models of international trade with the iceberg approach.[4]

Section 2 develops our model, which extends the DFS model in two respects. First, it has multiple factors of production. Second, the technologies of supplying each good depend on whether the destination is the domestic or export market, and it is assumed that it is more costly to supply the good abroad than at home. Section 3 considers the special case, where the technologies of supplying the goods to the two markets differ only in total factor productivity. With this additional restriction, an improvement in the export technologies[5] leads to globalization, but has no effect on the relative factor prices, and the factor proportions play no role in determining the extent of globalization. Indeed, it is demonstrated that this special case is isomorphic to the DFS model with the iceberg cost. Section 4 considers the general case, where the technologies may differ also in factor intensity. It shows how an improvement in the export technologies and a change in the factor proportions lead to globalization as well as a change in the relative factor prices. Section 5 considers an application to the debate on the role of globalization in the recent rise in the skill premia. Under the assumption that exporting goods requires more intensive use of skilled labor than supplying the same goods to the domestic market, it is shown that a *world-wide* increase in the relative supply of skilled labor leads to globalization, in sharp contrast to Heckscher-Ohlin. It is also shown that globalization, when it is caused by (Hicks-neutral) technical change in the export sectors, by (Hicks-neutral) skilled-labor augmenting technical change, or by a reduction in trade barriers, leads to a rise in the skill premia in all the countries, in sharp contrast to Stolper-Samuelson. Section 6 concludes.

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[4]See, e.g., Obstfeld and Rogoff (1996, Chapter 4), Eaton and Kortum (2002), and Alvarez and Lucas (2004). Another literature that makes extensive use of the iceberg approach is monopolistic competition models of trade. Unlike these models, the DFS model has the advantage of highlighting the difference between the two approaches without the complications of the market structure, monopoly power, and expanding product variety.

[5]By "an improvement in the export technologies," we mean general technical changes that improve the efficiency of supplying the goods to the foreign markets (relative to the domestic market), which are not specific to a particular good or industry. It should not be confused with "an export-biased technical change," the well-known concept that can be found in most standard textbooks of international trade, first proposed by Hicks (1953). The latter is an industry-specific technical change that improves the efficiency of production in an exporting industry. This type of technical change does not change the cost of supplying the same good to the foreign markets relative to the domestic market.   It changes the relative cost of producing the exportable goods to the importable goods.

2. The Framework

Consider the following variation of the DFS (1977) model. The world economy consists of two countries, Home and Foreign, and there are a continuum of competitive industries, identified by the good it produces, $z \in [0,1]$. The Home consumers have the identical Cobb-Douglas preferences with b(z) being the expenditure share of good z, with $\int_0^1 b(z)dz = 1$. Thus, the Home demand for good z is given by $D(z) = b(z)E/p(z)$, where p(z) is the Home price of good z and E is the Home aggregate expenditure. Likewise, the Foreign demand for good z is $D^*(z) = b^*(z)E^*/p^*(z)$, where $b^*(z)$ is the Foreign expenditure share of good z, with $\int_0^1 b^*(z)dz = 1$, $p^*(z)$ is the Foreign price of good z, and E* is the Foreign aggregate expenditure.

This paper departs crucially from DFS in two respects. First, there are J factors of production, with $V = (V_1, V_2, \ldots, V_J)^T$ and $V^* = (V_1^*, V_2^*, \ldots, V_J^*)^T$ being the column vectors of the Home and Foreign factor endowments, where V_j and V_j^* are the Home and Foreign endowments of the j-th factor (j = 1, 2, …, J). The factors are nontradeable and the factor prices are given by the row vectors, $w = (w_1, w_2, \ldots, w_J)$ and $w^* = (w_1^*, w_2^*, \ldots, w_J^*)$. We may think of these factors not only as capital, land, and labor, but also as different types of labor, with different skill levels, expertise, and specialties. Second, the technologies may depend on the destination of goods. More specifically, we may think of each industry consisting of two sectors: a domestic sector and an export sector. The domestic sector of industry z at Home can supply one unit of good z to the Home market at a cost of $a(z)\Phi(w)$, while its export sector can supply one unit of good z to the Foreign market at a cost of $a(z)\Psi(w;\tau)$. It should be noted that the word, "supply," here includes all of the activities needed to deliver the good to the consumers in a particular market. It includes not only the production cost, but also the marketing costs, including all sorts of communication costs and shipping costs, including the insurance and other financial costs.[6] Both Φ and Ψ are assumed to be linear homogeneous, increasing, and concave

[6] Recall that we identify "industries" and "sectors" by the goods they produce and by the market they serve. Hence, all the factors that go into the same good must be considered as part of the same industry, even though they may be employed by many different firms scattered across many different industries. Likewise, all the factors that go into the same goods heading for the same destination must be considered as a part of the same sectors. For example, the

in w. Thus, they satisfy the standard properties of the unit cost functions associated with CRS technologies.[7] Likewise, the unit cost of the domestic sector of the Foreign industry z is $a^*(z)\Phi^*(w^*)$, while the unit cost of the export sector of the Foreign industry z is $a^*(z)\Psi^*(w^*; \tau^*)$. Note the presence of the shift parameters, τ and τ^*, in the cost functions of the export sectors. We will use them to examine the effect of the technical change in the export sectors.[8] Furthermore, we will make the following assumptions.

(A1) $A(z) \equiv a^*(z)/a(z)$ is continuous and decreasing in z.

(A2) $\Phi(w) < \Psi(w;\tau)$; $\Phi^*(w^*) < \Psi^*(w^*;\tau^*)$.

The first assumption, (A1), is borrowed directly from DFS. It means that the goods are indexed according to the patterns of comparative advantage; Home (Foreign) has comparative advantage in lower (higher) indexed goods. (A2) implies that supplying (i.e., producing, marketing, shipping, insuring etc.) goods to the export market is more costly than supplying (i.e., producing, marketing, shipping, insuring etc.) goods to the domestic market. This model may be viewed as a hybrid of the Ricardian model of trade and the factor proportion models of trade. Across the goods (and industries), the technologies differ only in total factor productivity, but not in factor

payment made by a manufacturer or a distributor and received by the insurer for its coverage of the domestic (international) shipping has to be included in the cost of the domestic (export) sector, just like the payment for any raw materials that go into the goods supplied to the domestic (export) market has to be included in the cost of the domestic (export) sector. In other words, to the extent that the factors employed in the maritime insurance industry are involved, either directly or indirectly, in exporting a particular good, they should be considered as a part of the same export sector, even if its manufacturer, its distributor, and its insurer may be in different categories in the standard industry classification.

[7] Some readers might think that certain activities required for exporting impose the fixed cost for an exporting firm. The presence of the fixed cost for a firm does not invalidate our assumption that each sector has CRS technologies. As Alfred Marshall and many others pointed out, the correct unit of analysis in a competitive model is the industry or the sector, not the firm. The firm level fixed cost can be the variable cost at an industry level, because the size of the industry changes as the number of firms in the industry adjusts. (Any introductory economics textbook should explain how the U-shaped average cost curve of a firm is consistent with the constant average cost curve of an industry.)

[8] By allowing the unit cost function of the Home (Foreign) export sector to depend solely on the factor prices at Home (Foreign), this specification implicitly assumes that exporting goods does not require any factors local to the export market. Of course, it would be more realistic to assume that US exports to Italy generate demand for factors in Italy and that Italian exports to the US generate demand for factors in the US (particularly in the service sectors). To allow for this possibility, Matsuyama (2005, section 6.1) extends the present model to let the unit cost function of the Home (Foreign) export sector to depend also on w* (w) and shows that such an extension does not affect the basic mechanism. (One could also allow the unit cost function of the domestic sector to depend on the foreign factor

intensity. Within each industry, on the other hand, the domestic and export sectors may differ not only in total factor productivity, but also in factor intensity. It should be noted, however, that, unlike the standard factor proportion models of trade, the factor intensity differences are based on the destination of the goods, not on the goods themselves. We deliberately rule out the factor intensity differences across goods, in order to isolate our result from the well-known Hechscher-Ohlin-Stolper-Samuelson mechanism.[9]

The consumers everywhere purchase the goods from the lowest cost suppliers. Hence, the price of good z is equal to $p(z) = \min\{a(z)\Phi(w), a^*(z)\Psi^*(w^*;\tau^*)\}$ and $p^*(z) = \min\{a(z)\Psi(w;\tau), a^*(z)\Phi^*(w^*)\}$. Assumptions (A1) and (A2) thus imply that, for any factor prices, w and w*, there are two marginal industries, $m < m^*$,

(1) $$A(m) = \Psi(w;\tau)/\Phi^*(w^*),$$

(2) $$A(m^*) = \Phi(w)/\Psi^*(w^*;\tau^*),$$

such that only the Home industries supply to the Home and Foreign markets in $z \in [0,m)$, only the Foreign industries supply to the Home and Foreign markets in $z \in (m^*,1]$, and only the Home industries supply to the Home market and only the Foreign industries supply to the Foreign market in $z \in (m,m^*)$. In other words, Home exports and Foreign imports in $z \in [0, m)$ and Home imports and Foreign exports in $z \in (m^*, 1]$. There is no trade in $z \in (m, m^*)$. These goods are endogenously nontraded goods (i.e., potentially tradeable goods that are not traded in equilibrium). The patterns of production and trade are illustrated in Figure 1.

From the standard result of the duality theory of production (see, e.g., Dixit and Norman 1980), each unit of good z produced and purchased in Home generates demand for Home factor j equal to $a(z)\Phi_j(w) = p(z)\Phi_j(w)/\Phi(w)$, where subscript j signifies the partial derivative with respect to w_j. Similarly, each unit of good z produced in Home and purchased in Foreign generates demand for Home factor j equal to $a(z)\Psi_j(w;\tau) = p^*(z)\Psi_j(w;\tau)/\Psi(w;\tau)$. Thus, the equilibrium condition for the market for Home factor j is given by

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prices to allow for the possibility of international outsourcing. Again, such an extension merely complicates the notation without affecting the basic mechanism.)

[9] It should be pointed out, however, that our approach can be applied to a Heckscher-Ohlin model, as well. See Matsuyama (2005, section 6.2).

$$V_j = [\Phi_j(w)/\Phi(w)] \int_0^{m^*} [p(z)D(z)]dz + [\Psi_j(w;\tau)/\Psi(w;\tau)] \int_0^{m} [p^*(z)D^*(z)]dz, \quad (j = 1, 2,\ldots J),$$

where the first (second) term of the RHS is the derived demand for Home factor j from supplying goods to the domestic (export) market. By using $p(z)D(z) = b(z)E$ and $p^*(z)D^*(z) = b^*(z)E^*$, this condition can be rewritten to

$$V_j = [\Phi_j(w)/\Phi(w)]B(m^*)E + [\Psi_j(w;\tau)/\Psi(w;\tau)]B^*(m)E^*, \qquad (j = 1, 2,\ldots J)$$

where $B(z) \equiv \int_0^z [b(s)]ds$ and $B^*(z) \equiv \int_0^z [b^*(s)]ds$ are the Home and Foreign expenditure shares of the goods in [0, z]. They are strictly increasing and satisfy $B(0) = B^*(0) = 0$ and $B(1) = B^*(1) = 1$. This condition can be further simplified as

(3) $$w_jV_j = \alpha_j(w)B(m^*)wV + \beta_j(w;\tau)B^*(m)w^*V^* \qquad (j = 1, 2,\ldots J)$$

by defining $\alpha_j(w) \equiv w_j\Phi_j(w)/\Phi(w)$ and $\beta_j(w;\tau) \equiv w_j\Psi_j(w;\tau)/\Psi(w;\tau)$, and making use of the budget constraints in the two countries, $E = wV$ and $E^* = w^*V^*$. Eq. (3) is easily interpreted. Since $B(m^*)$ is the fraction of the Home aggregate income spent on the Home industries and $\alpha_j(w)$ is the share of factor j in the domestic sector of the Home industries, the first term of the RHS of eq. (3) is the income earned by Home factor j derived from the domestic market. The second term is the income earned by Home factor j derived from the export market, because $B^*(m)$ is the fraction of the Foreign aggregate income spent on the Home industries, and $\beta_j(w;\tau)$ is the share of factor j in the export sector of the Home industries.

Similarly, the equilibrium condition for the market for Foreign factor j is given by

(4) $$w_j^*V_j^* = \alpha_j^*(w^*)[1-B^*(m)]w^*V^* + \beta_j^*(w^*;\tau^*)[1-B(m^*)]wV, \qquad (j = 1, 2,\ldots J),$$

where $\alpha_j^*(w^*) \equiv w_j^*\Phi_j^*(w^*)/\Phi^*(w^*)$ is the share of factor j in the domestic sector of the Foreign industries; $\beta_j^*(w^*;\tau^*) \equiv w_j^*\Psi_j^*(w^*;\tau^*)/\Psi^*(w^*;\tau^*)$ is the share of factor j in the export sector of the Foreign industries; $1-B(m^*)$ is the fraction of the Home aggregate income spent on the Foreign industries; and $1-B^*(m)$ is the fraction of the Foreign aggregate income spent on the Foreign industries.

Recall that the linear homogeneity of $\Phi(w)$ and $\Psi(w)$ implies $\sum_{j=1}^{J} \alpha_j(w) = \sum_{j=1}^{J} \beta_j(w;\tau) = 1$. Hence, adding up (3) for all j yields

$$(5) \qquad [1-B(m^*)]wV = B^*(m)w^*V^*.$$

This may be viewed as the balanced trade condition, as the LHS is the total value of the Foreign exports and the RHS is the total value of the Home exports. Likewise, adding up (4) for all j also yields eq. (5). This means that each of eq. (3) and eq. (4) offers J −1 independent equilibrium conditions in addition to eq. (5). Thus, eqs. (1)-(5) altogether contain 2J+1 independent equilibrium conditions. They jointly determine 2J+1 unknowns: the two marginal industries, m and m*, and 2J −1 relative factor prices (i.e., 2J absolute factor prices, w and w*, up to a scale.) We can use eqs. (1)-(5) to examine the effects of factor endowments, by shifting V and V*, as well as the effects of globalization caused by technological change in the export sectors, by shifting the two parameters, τ and τ^*.

3. Unbiased Globalization: Restoring DFS (1977).

Let us first consider the following special case of (A2).

$$(A3) \qquad \Psi(w;\tau) = \tau\Phi(w) \text{ with } \tau > 1; \ \Psi^*(w^*;\tau^*) = \tau^*\Phi^*(w^*) \text{ with } \tau^* > 1.$$

Thus, the cost function of the export sector can be obtained by a homogeneous shift of the cost function of the domestic sector. This assumption thus implies that both sectors have the same factor intensity: $\beta_j(w;\tau) = \alpha_j(w)$ and $\beta_j^*(w^*;\tau^*)= \alpha_j^*(w^*)$. The two sectors differ only in total factor productivity. Furthermore, the technical change in the export sectors, a shift in τ and τ^*, satisfies Hicks-neutrality.

With (A3) and using eq. (5), eqs. (1)-(4) become

(6) $A(m) = \tau\Phi(w)/\Phi^*(w^*)$,

(7) $A(m^*) = \Phi(w)/\tau^*\Phi^*(w^*)$,

(8) $w_jV_j = \alpha_j(w)wV$, $(j = 1, 2,\ldots J)$

(9) $w_j^*V_j^* = \alpha_j^*(w^*)w^*V^*$, $(j = 1, 2,\ldots J)$

To simplify the above equations further, let us define $F(x) \equiv \min_q \{qx \mid \Phi(q) \geq 1\}$. It is linear homogeneous, increasing and concave in x, and satisfies $\Phi(w) \equiv \min_x \{wx \mid F(x) \geq 1\}$. Thus, it can be interpreted as the primal functions underlying $\Phi(w)$, where the technologies of the domestic and export sectors of the Home industry z may be described by $F(V^D(z))/a(z)$ and $F(V^E(z))/\tau a(z)$, where $V^D(z)$ and $V^E(z)$ are the vector of factors used in the domestic and export sectors of industry z. Since all the J factors are used in the same proportion in all the activities in equilibrium, they must be used in the same proportion with the factor endowment in equilibrium. Hence, since F_j is homogeneous of degree zero, $w_j = p(z)F_j(V)/a(z) = p^*(z)F_j(V)/\tau a(z) = \Phi(w)F_j(V)$ for all j. Therefore, from the linear homogeneity of F,

(10) $wV = \Phi(w)F(V) = WL$,

where W and L are defined by $W \equiv \Phi(w)$ and $L \equiv F(V)$. In other words, we can aggregate all the factors into the single quantity index, "labor", $L = F(V)$, with the single price index, "the wage rate," $W = \Phi(w)$.[10] Likewise, by defining $F^*(x) \equiv \min_q \{qx \mid \Phi^*(q) \geq 1\}$,

(11) $w^*V^* = \Phi^*(w^*)F^*(V^*) = W^*L^*$,

where the quantity index, $L^* = F^*(V^*)$, is the Foreign "labor" endowment and the price index, $W^* = \Phi^*(w^*)$, is the Foreign "wage rate." Using (10)-(11), eqs. (5)-(7) become

(12) $A(m)/\tau = W/W^* = B^*(m)L^*/[1-B(m^*)]L$,

[10]Recall that $W = \Phi(w)$ and $L = F(V)$ are scalars, while w is a J-dimensional row vector and V is a J-dimensional column vector.

(13) $A(m^*)\tau^* = W/W^* = B^*(m)L^*/[1-B(m^*)]L,$

while (8) and (9) become

(14) $V_j = \Phi_j(w)L, \qquad (j = 1, 2,\ldots J),$

(15) $V_j^* = \Phi_j^*(w^*)L^*, \qquad (j = 1, 2,\ldots J).$

Note that eqs. (12)-(13) jointly determine m and m* as a function of τ and τ*, as shown in Figure 2. A decline in τ shifts the steeper curve, representing (12), to the right, and as a result, leads to a higher m, a lower m*, and a higher W/W*. Note that an improvement in the Home export technologies not only expands the Home export sectors but also the Foreign export sectors. Intuitively, as the improved export technologies enable the Home export sectors to replace the Foreign domestic sectors in (m, m'), the Home wage rate goes up relative to the Foreign wage rate, which leads to a replacement of the Home domestic sectors by the Foreign export sectors in (m*',m*). This causes a reallocation of the Home labor from the domestic sectors in (m*', m*) to the export sectors in (m, m'). At the same time, the Foreign labor is reallocated from the domestic sectors in (m, m') to the export sectors in (m*', m*). Likewise, a decline in τ* leads to a lower m*, a higher m, and a lower W/W*. Thus, an improvement in the export technologies, regardless of whether it takes place at Home or at Foreign, leads to a growth of trade and a reallocation of labor from the domestic to export sectors *in both countries*.

Under (A3), however, this reallocation of labor from the domestic to the export sectors does not have any effect on the relative factor prices within each country. Note that, eqs. (14)-(15) are independent of τ and τ*, as well as of m, m*, and W/W*. The relative factor prices within each country are determined solely by eqs. (14)-(15). Recall that technical change in the export sectors is Hicks-neutral, hence their relative factor demands are unaffected. Furthermore, the export sectors use all the factors in the same proportion with the domestic sectors. Hence, the relative factor demands cannot change through the composition effect, either. When globalization does not change the relative factor demands, it has no effect on the relative factor prices.[11]

Note also that eqs. (12)-(13) are entirely independent of V and V*. Hence, the factor proportions have no effect on the patterns of trade. This is because the change in the relative factor prices would not affect the relative cost of the two sectors.[12]

It is worth pointing out that the above model, under (A3), is essentially the same with the DFS model. For example, if we set $\tau = \tau^* = 1$, then $m = m^*$ and eqs. (12)-(13) collapse into $A(m) = W/W^* = B^*(m)L^*/[1-B(m)]L$. This is isomorphic to the equilibrium condition of the basic model of DFS (1977, Section I), except that they assumed $B(z) = B^*(z)$. This should come as no surprise. The two critical departures of the present model from DFS (i.e., the multiplicity of the factors and the distinction between the domestic and export sectors) are inconsequential in this case, because (A3) means that all the activities have the same factor intensity, which allow us to aggregate all the factors into the single composite, "labor," as in the basic DFS model, and because, with $\tau = \tau^* = 1$, both the domestic and export sectors produce the identical goods with the identical technologies, again as in the basic DFS model. DFS (1977, Section IIIB) also extended their model to allow for transport costs. Following the iceberg model of Samuelson (1954), they assumed that a fraction g of good z shipped to the export market actually arrives. Therefore, in order to supply one unit of good z to the Foreign country, Home must produce and ship 1/g units of good z, which makes the price of the Home good z in the Foreign market equal to $a(z)W/g$. Eqs. (12)-(13) are identical to the equilibrium conditions for the DFS model with the iceberg transport cost if we set $\tau = \tau^* = 1/g > 1$. This suggests a broad interpretation of the iceberg cost. Instead of thinking that each industry produces with the same technology both for the domestic and export markets, but only a fraction of the goods shipped arrives to the export market, one can think that the domestic and export sectors produce different goods, each tailor-

[11]This is because the source of comparative advantage is Ricardian in the present model. If the source of comparative advantage were Heckscher-Ohlin (i.e. if the factor intensity differs across the goods and the two countries differ in the factor proportion), technical changes in the export sectors could change the factor prices through the well-known Stolper-Samuelson effect, even when the domestic and export sectors use the factors in the same proportion in each industry. See Matsuyama (2005, section 6.2).

[12]This is because the source of comparative advantage is Ricardian in the present model. If the source of comparative advantage were Heckscher-Ohlin (i.e. the factor intensity differs across the goods and the two countries differ in the factor proportion), factor endowments could affect the patterns of trade through the well-known Heckscher-Ohlin effect, even when the domestic and export sectors use the factors in the same proportion in each industry. See Matsuyama (2005, section 6.2).

made for each market, and that the total factor productivity of the export sector is a fraction of that of the domestic sector. As long as the two sectors use all of the factors in the same proportion, these two specifications give identical results. In short, we can view a decline in the iceberg cost as a special form of technical changes that benefits the export sectors.

According to this broad interpretation, however, a reduction in τ and τ^* can occur not only through an improvement in transport technologies, but also through any changes that help to lower the cost of servicing the export markets. Such changes may include an improvement in communication and information technologies (telegraphs, telephones, facsimiles, internet, communication satellite, etc), a harmonization of the regulations across countries, a wider acceptance of English as the common business language, and an emergence of the global consumer culture that reduces the need for the goods to be tailor-made for each country.

Perhaps more importantly, this broad interpretation also suggests a natural way of going beyond the iceberg specification. Once we start thinking about the possibility that the destination of the good affects the technologies of supplying the good, we may start thinking about the possibility that it affects not only the total factor productivity but also the factor intensity. *A priori*, such a possibility would be difficult to deny. Exporting naturally requires and generates more demand for skilled labor with expertise in areas such as international business, language skills, and maritime insurance. The transoceanic transportation is more capital intensive than the local transportation. As will be seen below, this opens up the possibility that factor proportion changes *in the same direction* both at Home and Foreign lead to globalization, as well as the possibility that a change in the export technologies, and the resulting growth of trade and reallocation of the factors from the domestic to export sectors, lead to a change in the relative factor prices *in the same direction* both at Home and Foreign.

Before proceeding, it is worth pointing out that one could reinterpret eqs. (12)-(15) as the equilibrium conditions for the case where the domestic and export sectors share the same technology, but the Foreign government imposes import tariffs on the Home goods at the uniform rate of $\tau - 1$, and the Home government imposes import tariffs on the Foreign goods at the uniform rate equal to $\tau^* - 1$, under the assumption that the tariff revenues are entirely wasted so that they do not affect the aggregate expenditure of the two countries.[13] Then the above result suggests that a reduction in the import tariffs leads to globalization (an increase in m and a decline in m*), but it does not affect the relative factor prices under (A3).

4. Biased Globalization

We are now going to show how the factor proportions affect globalization and how technical changes in the export technologies can affect the relative factor prices, if we drop the restrictive assumption, (A3). Recall the equilibrium conditions are given by eqs. (1)-(5). Since the key mechanism does not rely on the asymmetry between Home and Foreign (and introducing asymmetry would merely obscure the key mechanism), let us focus on the case where the two countries are the mirror images of each other. That is,

(M) $A(z)A(1-z) = 1$.

$b(z) = b^*(z)$, $b(z) = b(1-z)$ (so that $B(z) = B^*(z)$ and $B(z) + B(1-z) = 1$ for $z \in [0,1/2]$),

$\Phi = \Phi^*$, $\Psi = \Psi^*$ (so that $\alpha_j = \alpha_j^*$, $\beta_j = \beta_j^*$), and $\tau = \tau^*$, and $V = V^*$.

Note that the symmetry does not mean that the two countries are identical. Rather, they are the mirror images of each other. More specifically, because $A(z)$ is strictly decreasing in z, $A(z)A(1-z) = 1$ implies that $A(z) > 1$ for $z \in [0,1/2)$, $A(1/2) = 1$ and $A(z) < 1$ for $z \in (1/2,1]$. Without these cross-country differences in total factor productivity, trade would not take place.

Under the mirror image assumption, the equilibrium is symmetric, $w = w^*$, $m = 1-m^* < ½$, and the equilibrium conditions are now reduced to

(16) $A(m) = \Psi(w;\tau)/\Phi(w)$,

(17) $V_j = \{\alpha_j(w) + [\beta_j(w;\tau)-\alpha_j(w)]B(m)\}wV/w_j$ $\qquad$ $(j = 1, 2,\ldots J)$.

Eq. (16) shows that, given the factor prices, an improvement in the export technologies (a change in τ that causes a downward shift of Ψ) leads to an increase in m (and a decline in $m^* = 1-m$).

[13] Imagine, for example, that Foreign (Home) government confiscate a fraction $1-1/\tau$ ($1-1/\tau^*$) of the Home (Foreign) goods and use them for the public goods, which enter in the preferences of their residents in a separable form.

The RHS of Eq. (17) is the demand for factor j. It shows that a shift in τ could affect the factor demand for two separate routes. The first is through international trade. A higher m increases the demand for the factors used more intensively in the export sectors (those with $\beta_j > \alpha_j$) and reduces demand for those used more intensively in the domestic sectors (those with $\beta_j < \alpha_j$). Thus, globalization can affect the factor demand by changing the composition between the domestic and export sectors. The second is by changing the relative factor demand within the export sectors, if $\beta_j(w;\tau)$ depends on τ. Note that there is an important special case, where a shift in τ could affect the factor demands only through the first route. This is the case where the technical change in the export sectors satisfies Hicks-neutrality:

(A4) $\Psi(w;\tau) = \tau\Psi(w)$ with $\tau > 1$ and $\Psi(w) > \Phi(w)$.

In this case, $\beta_j(w;\tau)$ is independent of τ, which allow us to simply drop τ and denote it as $\beta_j(w)$. Under (A4), the RHS of eq. (17) no longer depends on τ. Thus, a shift in τ affects the factor demands only by changing the composition of the domestic and export sectors.[14]

To analyze eqs. (16)-(17) further, let us consider the two-factor case (J = 2). Then, eqs. (16)-(17) become

(18) $A(m) = \psi(\omega;\tau)/\varphi(\omega)$

(19) $$\frac{V_1}{V_2} = \left[\frac{\alpha_1(\omega) + [\beta_1(\omega;\tau) - \alpha_1(\omega)]B(m)}{1 - \alpha_1(\omega) - [\beta_1(\omega;\tau) - \alpha_1(\omega)]B(m)}\right]\Big/\omega,$$

where $\omega \equiv w_1/w_2$ (= $\omega^* \equiv w_1^*/w_2^*$) is the relative factor price; $\varphi(\omega) \equiv \Phi(\omega,1) = \Phi(w_1,w_2)/w_2$, $\psi(\omega;\tau) \equiv \Psi(\omega,1;\tau) = \Psi(w_1,w_2;\tau)/w_2$; $\alpha_1(\omega) = 1-\alpha_2(\omega)$ and $\beta_1(\omega;\tau) = 1-\beta_2(\omega;\tau)$ are the shares of factor 1 in the domestic and export sectors. (Recall that Φ and Ψ are linear homogeneous and that the factor shares, α_j and β_j, are homogeneous of degree zero). Note that the RHS of eq. (19) is the demand curve for factor 1 relative to factor 2.

[14]On the other hand, a shift in τ cannot affect the factor demand only through the second route. This is because we must assume $\beta_j(w;\tau) = \alpha_j(w)$ in order to shut down the first route and hence β_j becomes independent of τ.

Figures 3 depict eqs. (18)-(19) over the (m, ω)-space, under the assumption that the export sector is more factor 1 intensive than the domestic sector: $\alpha_1(\omega) < \beta_1(\omega;\tau)$. This factor intensity assumption implies that eq. (18) is downward-sloping.[15] Intuitively, a lower ω makes the cost of the export sectors decline more than the cost of the domestic sectors, and therefore trade take places in a larger fraction of the industries (i.e., a higher m and a lower m* = 1−m). Under the same factor intensity assumption, an expansion of the export sectors at the expense of the domestic sector (a higher m and a lower m* = 1−m) leads to an increase in the relative demand for factor 1. This in turn leads to a higher ω in a stable factor market equilibrium. Thus, eq. (19) is upward-sloping, whenever the factor market is stable.[16] Figures 3 are drawn under the assumption that the factor market equilibrium is always stable, so that the curve depicting eq. (19) is everywhere upward-sloping.[17] The equilibrium is given by point E, at the intersection of the two curves.

Figure 3a depicts the effects of an increase in V_1/V_2. It shifts the upward-sloping curve downward, and the equilibrium moves from point E to point E'. The result is a decline in ω and an increase in m. Note that, due to the symmetry assumption, this captures the effects of a *world-wide* increase in the relative supply of the factor used more intensively in export activities. This leads to a decline in the cost of supplying the foreign markets relative to the cost of supplying the domestic markets, which leads to globalization, measured either in the share of the traded industries, m+1−m* = 2m, or in the Trade/Income ratio, B*(m)+B(1−m*) = 2B(m). The effect is thus different from the Heckscher-Ohlin mechanism, which relies on the *difference* in factor proportions across the countries.

Figure 3b depicts the effects of a decline in τ, which shifts eq. (18), the downward-sloping curve, to the right. Under (A4), i.e., when the improvement in the export technologies

[15]Algebraically, log-differentiating eq. (18) yields $d\omega/dm = \omega A'(m)/A(m)[\beta_1(\omega;\tau)-\alpha_1(\omega)] < 0$.

[16]To see this algebraically, let the RHS of eq. (19), the relative factor demand, be denoted by f(ω, m; τ). Then, $\beta_1(\omega;\tau) > \alpha_1(\omega)$ implies $f_m > 0$. The Walrasian stability of the factor market equilibrium requires that the relative demand curve is decreasing in the relative price: i.e., $f_\omega < 0$. Thus, $d\omega/dm = -f_m/f_\omega > 0$ along the stable factor market equilibrium satisfying eq. (19).

[17]This is the case, for example, if Φ and Ψ are Cobb-Douglas so that α_1 and β_1 are constant. Of course, without making some restrictions on the functional forms of Φ and Ψ, one cannot rule out the possibility that the relative factor demand, f(ω, m; τ), may be increasing in ω over some ranges, and eq. (19) may permit multiple factor price equilibriums. If so, the curve depicting eq. (19) over the (m, ω)-space could have an S-shape. In such a case, the downward-sloping part corresponds to an unstable equilibrium, and hence only the upward-sloping parts are relevant

satisfies Hicks-neutrality, eq. (19) is independent of τ, so that the upward-sloping curve remains intact. Hence, the equilibrium moves from E to E'. The result is an increase in both m and ω. An improvement in the export technologies not only leads to globalization. It also leads to an increase in the relative price of the factor used intensively in the export sectors.

The analysis would become a little bit more complex when (A4) does not hold, i.e., when the improvement in the export technologies violates Hicks-neutrality. However, unless the non-neutrality is too strong, the result would go through. If the technical improvement favors factor 1 over factor 2 within the export sectors (i.e., if it increases the export sector's demand for factor 1 relative to factor 2 at each relative factor price), then the upward-sloping curve shifts upward when the downward-sloping curve moves to the right. The relative factor price, ω, unambiguously goes up. It also leads to an increase in m, unless the non-neutrality is too strong and the upward-sloping curve shifts too much. If the improvement favors factor 2 over factor 1, then the upward-sloping curve shifts downward, while the downward-sloping curve moves to the right. It leads unambiguously to an increase in m. The relative factor price also goes up, unless the non-neutrality is too strong and the upward-sloping curve shifts too much.[18]

It is worth reminding the reader that the case of the Hicks-neutral technical change in the export sector, (A4), depicted in Figure 3b, can be reinterpreted as a reduction in import tariffs. According to this interpretation, (A4) means that the cost functions of the export sector is given by $a(z)\Psi(w)$ at Home and $a^*(z)\Psi(w)$ at Foreign, but the tariffs at the rate equal to $\tau-1$ are levied to all the imports. Then, one can interpret Figure 3b as capturing the effect of a reduction in the tariff. Thus, globalization, whether it is caused by a Hicks-neutral improvement in the export technologies or a reduction in the tariff, leads to a rise in the prices of the factors used intensively in the export sectors relative to those used intensively in the domestic sectors both at Home and at Foreign.

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for the comparative statics. For this reason, we will not discuss such "pathological" cases of downward-sloping eq. (19) in what follows. This is nothing but the famous "Correspondence Principle" of Samuelson (1947).

[18] A strong form of non-neutrality can certainly overturn the result. For example, imagine that factor-1is the foreign language skill, required only in the export sector. If the primitive technology prevents any international communication, demand for factor-1 is zero and $\omega = 0$. As the technology improves, this generates demand for factor-1, and ω goes up. However, if the technology continues to improve, demand for factor-1 and hence ω could go down. Under the Hicks-neutrality, this cannot happen, as technical change affects factor prices only through its effects of the composition between the two sectors.

Another thought-experiment that can be conducted by means of Figure 3b are the effects of a change in A(z). Specifically, let us generalize A(z) to $[A(z)]^{\theta}$, where the power, $\theta > 0$, is the shift parameter. This keeps the mirror image assumption, and a higher θ raises $[A(z)]^{\theta}$ for $z \in [0, 1/2)$, and reduces $[A(z)]^{\theta}$ for $z \in (1/2,1]$, thereby magnifying the cross-country difference in total factor productivity in each industry. This change shifts the downward-sloping curve upward, which leads to a higher m and a higher ω, as shown in Figure 3b. The intuition should be clear. As the two countries become more dissimilar, there are more reasons to trade, which shifts the demand in favor of the factors used more intensively in the export sectors.

5. An Application: Globalization, Technical Change, and Skill Premia

The model presented above can be useful for thinking about the debate on the role of globalization in the recent rise in the skill premia. Imagine that there are two types of factors, J =2, which are skilled and unskilled labor. Furthermore, suppose that the export sector is more skilled labor intensive than the domestic sector. Under this interpretation of the model, Figure 3a suggests that a world-wide increase in the relative supply of skilled labor leads to globalization. Figure 3b suggests that the skill premia in all the countries rise as a result of globalization caused by technical changes that take place in the export sectors (or by a reduction in the trade barriers).

However, we do not *need* to assume that the technical changes are specific to the export sectors to obtain the above result. Skilled-labor augmenting technical changes can also have the same effect, as long as we maintain the assumption that the export sector is more skilled-labor intensive.

To see this, let us now modify the above model as follows. There are two factors, now labeled as s for skilled labor and u for unskilled labor. The cost functions of the domestic and export sectors of industry z are given by $a(z)\Phi(\tau w_s,w_u)$ and $a(z)\Psi(\tau w_s,w_u)$ at Home and $a^*(z)\Phi^*(\tau^* w_s^*, w_u^*)$ and $a^*(z)\Psi^*(\tau^* w_s, w_u)$ at Foreign. Note that the shift parameters, τ and τ^*, enter in the cost functions of both the domestic and export sectors. Contrary to what was assumed in the previous analysis, the technical changes are no longer specific to the export sector. Now, a reduction in τ (and τ^*) means a skilled-labor augmenting technical change, and hence it reduces the costs of both the domestic and export sectors for fixed wage rates. We also need to replace (A2) by

(A5) $\Phi(\tau w_s, w_u) < \Psi(\tau w_s, w_u)$ and $\Phi^*(\tau^* w_s^*, w_u^*) < \Psi^*(\tau^* w_s^*, w_u^*)$.

Then, by following the same steps as done in Section 2, we can conduct the analysis of this modified model and derive its equilibrium conditions, analogous to eqs.(1)-(5).

Instead of repeating the whole analysis, let us focus on the case where the two countries are the mirror-images of each other. Then, the equations analogous to eqs. (18)-(19) are given by

(20) $A(m) = \psi(\tau\omega)/\varphi(\tau\omega)$,

(21) $$\frac{V_s/\tau}{V_u} = \left[\frac{\alpha_s(\tau\omega) + [\beta_s(\tau\omega) - \alpha_s(\tau\omega)]B(m)}{1 - \alpha_s(\tau\omega) - [\beta_s(\tau\omega) - \alpha_s(\tau\omega)]B(m)}\right] \Big/ (\tau\omega),$$

where $\omega \equiv w_s/w_u$ ($= \omega^* \equiv w_s^*/w_u^*$) is the price of skilled labor measured in unskilled labor. The intuition behind eqs. (20)-(21) should be clear. Because a reduction in τ is now skilled-labor augmenting, τ enters in these equations only through the "effective" price of skilled labor measured in the units of unskilled labor, $\tau\omega$, and through the "effective" supply of skilled labor, V_s/τ.

As before, we further focus on the special case, where the technical changes satisfy Hicks-neutrality. A skilled labor augmenting technical change can be Hicks-neutral if and only if the functional forms for Φ and Ψ are Cobb-Douglas.[19] That is to say, we assume that

(A6) $\Phi(\tau w_s,w_u) = (\tau w_s)^{\alpha}(w_u)^{1-\alpha}$, $\Psi(\tau w_s,w_u) = \Gamma(\tau w_s)^{\beta}(w_u)^{1-\beta}$, $\quad 0 < \alpha < \beta < 1$.

where the parameter, Γ, is sufficiently large to ensure that $\Phi(\tau w_s,w_u) < \Psi(\tau w_s,w_u)$ in equilibrium. Then, eqs. (20)-(21) become

[19]We skip the proof because this is formally equivalent to the following well-known result in the neoclassical growth literature, first shown by Uzawa (1961): technical changes are both Hicks-neutral (TFP-augmenting) and Harrod-neutral (labor-augmenting) if and only if the aggregate production function is Cobb-Douglas.

(22) $A(m) = \Gamma(\tau\omega)^{\beta-\alpha}$,

(23) $$\frac{V_s}{V_u} = \left[\frac{\alpha + (\beta - \alpha)B(m)}{(1-\alpha) - (\beta - \alpha)B(m)} \right] \Big/ \omega ,$$

respectively. These equations can be analyzed by means of Figure 3b. The assumption that the export sector is more skilled-labor intensive, $\alpha < \beta$, implies not only that eq. (22) is downward-sloping and eq. (23) upward-sloping in the (m-ω) space. It also implies that a skilled-labor augmenting technical change (a reduction in τ) shifts the downward-sloping curve to the right, because it reduces the cost of the export sector more than the cost of the domestic sector. Hence, it leads to globalization and an increase in skill premia. Needless to say, if we drop the assumption of Hicks-neutrality, the analysis would be more complex, because eq. (21) generally depends on τ. However, unless the non-neutrality is too strong, the effect would be qualitatively similar.

In summary, we have shown the two scenarios in which globalization leads to a rise in the skill premia in all the countries. In the first scenario, globalization is driven by (Hicks-neutral) technical changes that take place in the export sectors (or by a reduction in the trade barriers). In the second scenario, globalization is driven by the skilled-labor augmenting technical changes. In both scenarios, the assumption that the export sector is more skilled-labor intensive than the domestic sector plays a critical role.

This assumption is consistent with the empirical evidence that exporting manufacturing firms employ more non-production workers than production workers, to the extent that non-production workers may be viewed as a proxy for skilled labor, as is commonly done. Maurin, Thesmar, and Thoenig (2002) offers more direct evidence, because their French dataset provides detailed information on skill structure within both the production and non-production units of the manufacturing firms. They have found that export firms employ more skilled labor than non-exporters. Interestingly, they have found that the very act of exporting requires skilled labor force. That is to say, more skilled labor is needed when they sell the products outside of France, but the skill intensity does not vary much on whether they export to developed markets, such as the US or to developing countries, such as China and India, which suggests that it is not the type of products that determine the skill intensity.

It should be pointed out, however, that the existing empirical evidence based on firm/plant level employment data within manufacturing, while largely consistent with our assumption, is likely to underestimate the skill intensity of the export activities, because many manufacturing firms rely on trading companies (such as the Japanese *sogo shosha*) and maritime insurance companies for their export needs. The manufacturers outsource these services to such companies presumably because they are more skilled in these activities. In order to account for the factor content of the export goods properly, those working in the trading and insurance sectors need to be included in the export sector to the extent that they are involved, directly or indirectly, in the export activities.[20]

It is beyond the scope of this paper to survey the vast literature on the role of globalization in the recent rise of the skill premia.[21] Much of the literature draws a sharp distinction between two possible causes; skill-biased technical change and international trade. Most economists seem to discount the role of trade in favor of skill-biased technical changes for a couple of reasons. First, according to the factor proportion theory of trade, an increase in trade can explain the recent rise in the skill premium in the skilled-labor abundant United States, but not the similar rise in the skill premia among the skilled-labor scarce trading partners. Second, the factor proportion theory of trade also suggests that the rise in the skill premium in the U.S. must be accompanied by a rise in the relative price of the skilled-labor intensive goods, which has not been observed empirically. Our explanation is not subject to these criticisms because what is skilled labor intensive in our model is trade itself, not the types of goods traded.

[20] A relevant question is then: Do trading companies engaged more heavily in international trade employ more skilled workers? Consider *sogo shosha*, Japanese general trading companies. These companies play a key role in the Japanese foreign trade. They own worldwide networks of branches and stations through which they gather information relevant to the trade. They trade a wide range of goods, ranging "from instant noodle to missiles" as a well-known expression puts it. The top nine general trading companies handle 47 percent of Japan's exports, 65 percent of imports (Ito, 1992, p.190). According to Yoshino and Lifton (1986, Ch.7), the most authoritative account of *sogo shosha* available in English, "The firms recruit only from a limited number of universities, all of which are highly selective institutions…. The *sogo shosha* has occupied an extremely privileged position…, for survey research has consistently shown that, among graduating college students, the six *sogo shosha* have been considered virtually the most desirable private employers in Japan…. Whatever the reasons, the *sogo shosha* traditionally has had little trouble in attracting what is considered to be the cream of the crop of Japanese college graduates to its recruitment process." The same cannot be said about *senmon shosha*, trading companies specializing mostly in domestic trade.

Perhaps more importantly, our analysis questions the validity of the dichotomy between skill- biased technical change and international trade. In this respect it is worth mentioning Acemoglu and Zilibotti (2001, pp. 597-599), Acemoglu (2003), and Thoenig and Verdier (2003), which developed models of endogenous technical changes to show how international trade stimulates skill-biased technical changes. Their studies suggest that "globalization vs. skill-biased technical changes" is a false dichotomy, because globalization *induces* skill-biased technical change. The present study identifies the two scenarios that suggest that "globalization vs. skill-biased technical changes" is a false dichotomy. According to the first scenario, it is a false dichotomy, because globalization *is* inherently skill biased.[22] According to the second scenario, it is a false dichotomy, because globalization *is induced by* skilled-labor augmenting technical changes.

Our approach also allows us to pose the following critical question, seldom asked in the literature on trade and wages. What do we mean by "skilled labor"? After all, skilled labor is not homogeneous; business majors and engineering majors are far from perfect substitutes. To address this question, Matsuyama (2005, section 6.2) applies our approach of modeling costly trade to the Heckscher-Ohlin model with a continuum of goods, *a la* Dornbusch, Fischer, and Samuelson (1980). There are three factors: two types of skilled labor, those with business degrees and those with engineering degrees, and unskilled workers. Home and Foreign share the same technologies, but Foreign has a higher engineer/worker ratio than Home, and the industries differ in the ratio of engineers to workers. Across all the industries, the export sectors use those with business degrees more intensively than the domestic sectors. An improvement in the export technology and the resulting globalization would increase the relative wage of those with business degrees both at Home and at Foreign. In this sense, globalization contributes to the global rise in the skill premia. However, the relative wage of engineers would go down at Home,

[21]For an overview of this literature, see Feenstra (2000).

[22]Epifani and Gancia (2005a, b) also show that globalization is inherently skill biased, when the skill-intensive sectors are characterized by stronger increasing returns and different sectors produce highly substitutable goods. The Acemoglu (and Acemoglu-Zilibotti) models rely on the asymmetry of the countries, and hence has the implication that North-South trade should be skill-biased. On the other hand, our model (and the Epifani and Gancia models) does not rely on the asymmetry of the countries, and hence suggests that all trade should be skill biased. This might make our argument more appealing to those who think that North-South trade is too small to have had much of an effect. (We thank Daron Acemoglu for making this observation.)

where they are scarce, while it would go up at Foreign, where they are abundant, just as Stolper-Samuelson predicts.

6. Concluding Remarks

If international trade generates more demand for certain factors than domestic trade, globalization can directly affect the relative factor prices, and the factor proportions can directly influence the extent of globalization. Exporting inherently requires the use of skilled labor with expertise in areas such as international business, language skills, and maritime insurance. The transoceanic transportation is more capital intensive than the local transportation. This opens up the possibility that a *world-wide* increase in the factors used intensively in international trade could lead to globalization, as well as the possibility that a change in the export technologies, and the resulting globalization and reallocation of the factors from domestic trade to international trade, could lead to a *world-wide* increase in the relative prices of the factors used intensively in international trade. The standard approach to model costly international trade, the iceberg approach, is too restrictive for capturing these effects.

In this paper, we explore a flexible approach to model costly international trade, which includes the standard iceberg approach as a special case. To demonstrate our approach, we extend the Ricardian model with a continuum of goods, due to Dornbusch, Fischer, Samuelson (1977), by introducing multiple factors of production and by making technologies of supplying goods depend on whether the destination is the domestic or export market. If the technologies of supplying the good to different destinations differ only in total factor productivity, the model becomes isomorphic to the DFS model with the iceberg cost. By allowing them to differ in the factor intensities, our approach enables us to explore the links between factor endowments, factor prices, and globalization that cannot be captured by the iceberg approach. For example, a *world-wide* change in the factor proportion can lead to globalization, in sharp contrast to the Heckscher-Ohlin effect, which relies on the cross-country difference in factor proportions. It is also shown that an improvement in the export technologies changes the relative factor prices *in the same direction* across countries, in sharp contrast to the usual Stolper-Samuelson effect, which suggests that the relative factor prices move in different directions in different countries. We also applied our analysis to the debate on globalization and the recent rise in the skill premia.

Although we have used the DFS model as a background to highlight the difference between the two approaches, this modeling choice was made for simplicity. The assumption that the source of comparative advantage is Ricardian – i.e., countries trade because of the exogenous cross-country total factor productivity differences–, is not essential for the key mechanisms, which rely on the differences in the factor demand composition between the export and domestic activities. Indeed, Matsuyama (2005. section 6.2) demonstrates the same results within the framework of the Heckscher-Ohlin model with a continuum of goods, developed by Dornbusch, Fischer, and Samuelson (1980), where the source of comparative advantage is the exogenous cross-country factor proportion differences.

More broadly, the iceberg specification has been used in many different classes of models. Consider, for example, monopolistic competition models of trade, where, starting from Krugman (1980), the iceberg specification is the most common way of modeling costly international trade. The iceberg trade costs also play a prominent role in the international macroeconomics literature: see Obstfeld and Rogoff (2000). Our approach, as a more flexible alternative to the iceberg cost, should provide many new sights in these areas. Indeed, applications of our approach need not to be restricted to those models that previously used the iceberg approach. It can be useful for any situation where the international activities are inherently more costly than the domestic activities. For example, it would be natural to assume not only that FDI or international outsourcing is more costly than building plants at home or domestic outsourcing but also that such oversea operations require different types of skills from the domestic operations.[23] What has been shown in this paper is merely the tip of, well, the iceberg.

[23] Just think of those highly compensated international business consultants sent abroad to supervise the oversea operations.

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Figure 1: Patterns of Trade:

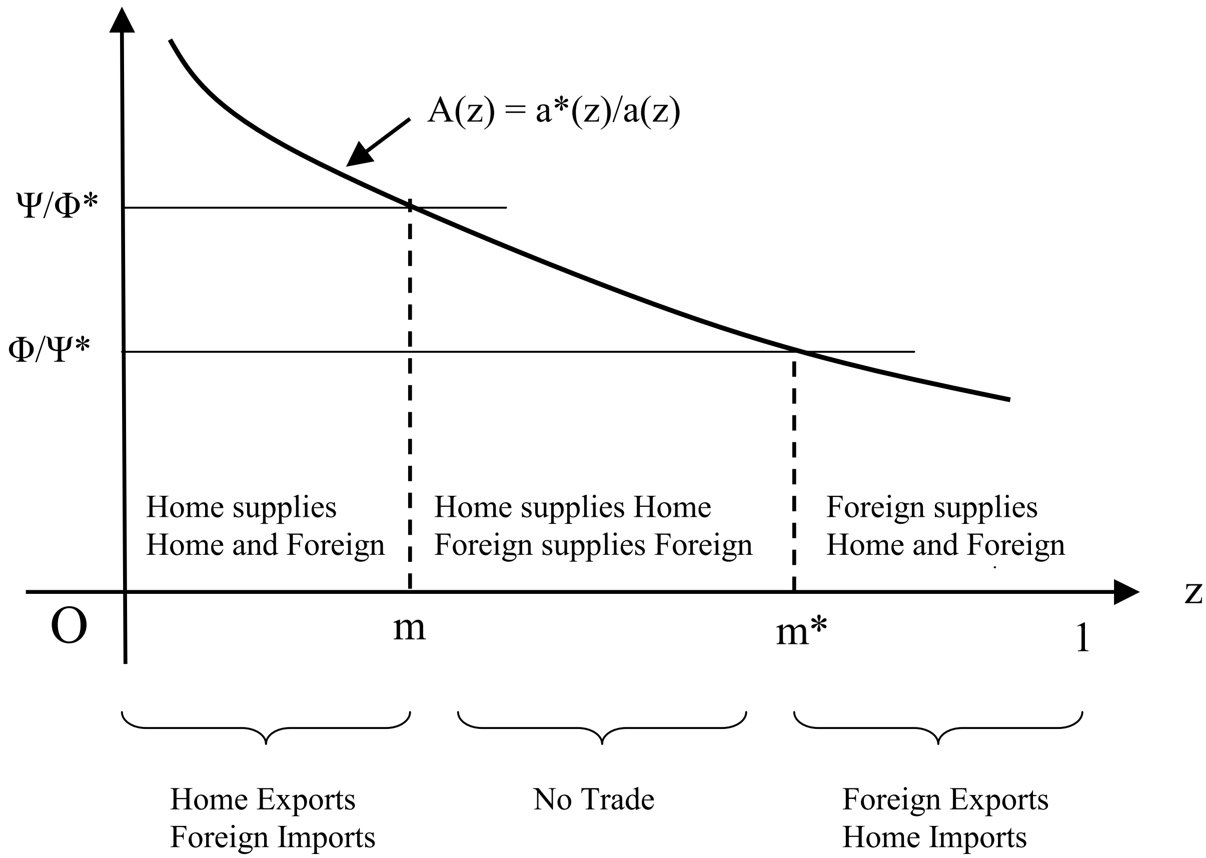
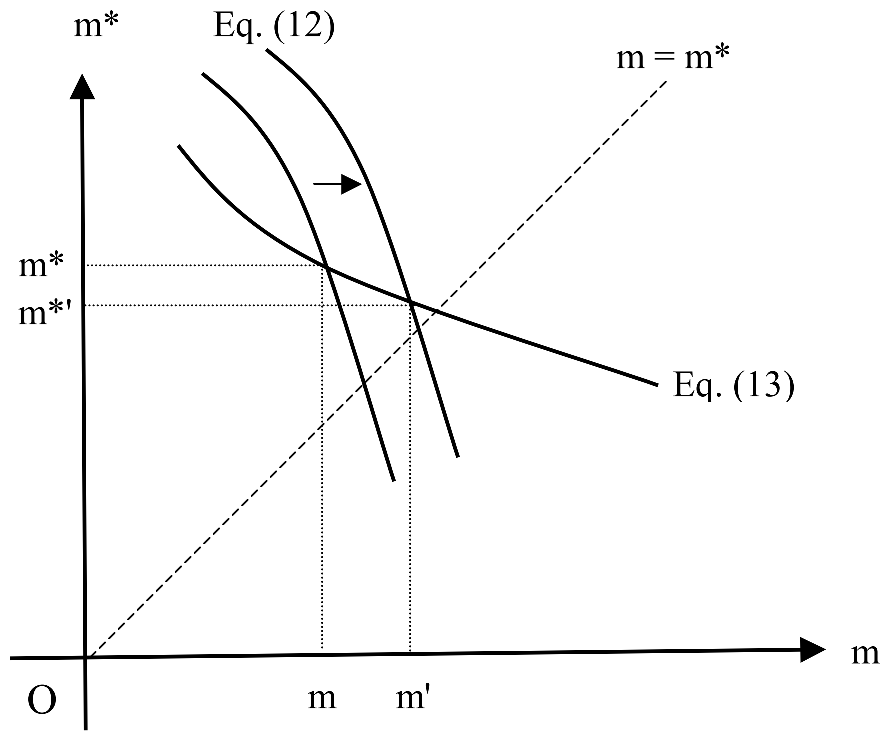


Figure 2: Unbiased Globalization



Figures 3: Biased Globalization

Figure 3a:

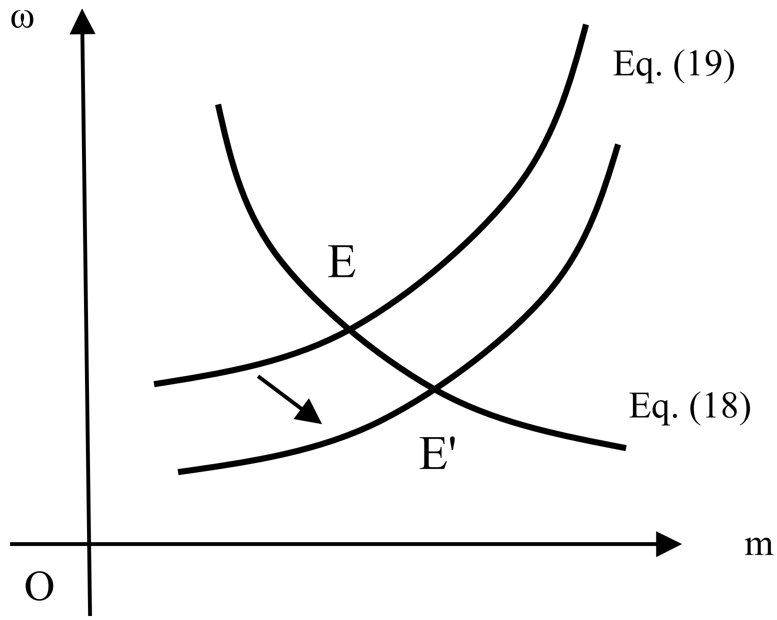


Figure 3b: