Trade, Firm Structure, and Migration of Talent

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Abstract

Throughout economic history there have been episodes in which the liberalization of trade has been accompanied by a positive flow of migrants. Such phenomena are notable because they contradict the basic Heckscher-Ohlin conclusion that trade and labor mobility are substitutes. Also notable is the fact that migrants to the U.S. have been largely skilled rather than unskilled. This paper links these two phenomena by pointing out the simple fact that increased trade can involve different types of firm structures and different types of goods being traded, which in turn have different effects on skilled and unskilled labor. The interaction between different frictions that impact labor movements, specifically the interaction between capital adjustment costs and trade costs, has a significant effect on the gap between the returns to labor in the South and North. Although the decrease in trade costs and increase in trade dampens labor movements, the existence of asymmetric capital adjustment costs in the North and South increases it.

To show these results formally, this paper calibrates and solves a two-country, two-sector model of trade and migration, in which countries differ in skill endowments and capital adjustment costs and sectors differ in structures and capital intensities. Empirical analysis is then provided, with results supporting the main qualitative implications of the model.


Keywords: International migration, multinational firms, capital adjustment cost.
1 Introduction

Throughout economic history there have been episodes in which the liberalization of trade has been accompanied by a positive flow of migrants (Faini, De Melo, and Zimmermann 1999). Such phenomena are notable because they contradict the basic Heckscher-Ohlin conclusion that trade and labor mobility are substitutes. Also notable is the fact that migrants to the U.S. have been largely skilled rather than unskilled (Hanson 2007). This paper links these two phenomena by pointing out the simple fact that increased trade can involve different types of firm structures and different types of goods being traded, which in turn have different effects on skilled and unskilled labor. To establish the link formally, the paper develops, calibrates, and solves a two-country model of trade and migration.

The primary force driving the model’s results is the interaction between different frictions that impact labor movements. Specifically, the interaction between capital adjustment costs and trade costs has a significant effect on the gap between the returns to labor in the skilled-labor-abundant (North) and unskilled-labor-abundant (South) countries. Though the decrease in trade costs and increase in trade dampen labor movements, the existence of asymmetric capital adjustment costs in the North and South increases it, thereby producing the empirical phenomena mentioned above.

Although the actual link between capital flows, migration and trade has been explored before (Baldwin and Venables 1994), this paper expands the analysis further by looking at the exact structure of trading firms and the type of goods they trade. In the real world, firms in need of intermediate goods from abroad must choose whether to outsource and therefore import the good, or to vertically integrate by establishing a subsidiary in another country. Following (Antràs 2003), the model here assumes that firms whose final good is capital-intensive vertically integrate the production of requisite intermediate goods from
abroad, while firms whose final product is labor-intensive outsource that type of production.

The model also incorporates trade (iceberg) costs and capital adjustment costs, since the former has been empirically established as a significant determinant of trade (Anderson and van Wincoop 2003), and the latter has been shown theoretically to impact the skilled-unskilled wage gap in the North (Chakrabarti and Mitra 2009). In doing so, the model shows that the interaction between those two frictions can alter migration patterns.

Without any capital adjustment costs, an increase in trade volume of labor-intensive goods results from decreasing trade costs, thus leading to an increase in the migration of skilled labor and a decrease in the migration of the unskilled. This is because of the North substituting towards imported unskilled-labor-intensive goods, raising the return to labor in that sector for the South as trade costs decrease. At the same time, capital flows out of the labor-intensive sector in the North and also out of the capital-intensive sector in the South. Although investment increases in the South, it increases more in the North. This closes the North-South unskilled wage gap but widens the Skilled-wage gap. The increase in the volume of trade of capital-intensive intermediates, on the other hand, shrinks the North-South wage gap and decreases skilled migration. This type of trade also leads to higher investment (in steady state) in the South, mitigating some of the negative effect on unskilled labor that comes with the expansion of the skill-intensive sector.

When an asymmetric adjustment cost of capital is introduced in the North and South, the resulting migration patterns are different from the previous description. Mainly, as trade costs decrease in the capital intensive sector, the North-South skilled wage gap widens. The main reason is that the North, who benefits from trade, is always able to increase its investment and capital accumulation more than the South. With the assumption that capital and skilled labor are complements as in Krusell et al. (2000), skill follows capital to where it used more efficiently and is abundant in supply.
Since the presence or absence of adjustment costs changes the conclusion of the model, it is prudent to conduct a final step of analysis. In Section 5 an empirical model tests which pattern of migration prevails in the data. Using a panel of 61 countries over 10 years, a fixed-effects estimation favors the capital adjustment model, since regression results shows a positive relation between skill migration and imports of both types.

2 Trends and Related Literature

During the 1990s the foreign-born share of the US population steadily increased, ultimately reaching 11% in 2000 (Hanson 2007). An important aspect to that trend is that the emigration rates for those who count as skilled are reported to be much higher than average (Docquier, Lohest, and Marfouk 2007). 36% of migrants in OECD countries have a tertiary education, and another 35% have at least a primary education. Furthermore, of all those classified as skilled immigrants, 61.6% are from developing countries.

The phenomenon of skilled emigration from low income countries to high income ones has long been coined as brain drain in the literature. Beine, Docquier, and Schiff (2008) show that brain drain remains a major problem for small countries and investigate its determinants empirically. They ignore, however, what this paper stresses: that along with the negative of brain drain comes trade ties with developed countries and, more importantly, an influx of capital.

Another trend in globalization over the last 20 years is the rise of trade at a rate faster than production (Faini, De Melo, and Zimmermann 1999). And at the same time, the type of goods that are traded and the structure of the firms that engage in trade has changed. As Burstein, Kurz, and Tesar (2008) explain, because technological advances in communication and transportation have decreased trade costs, firms are now better able
to locate production stages in different parts of the world. As the stages are broken down, intermediate goods must then be imported or exported to be combined with other goods into the final product (Yi 2003; Bergin, Feenstra, and Hanson 2007).

It follows then, that a large portion of trade involves the movement of intermediate goods. Some firms import their intermediate goods from subsidiaries in foreign countries while others do so from independent foreign producers. In the first case the firm is said to be producing a vertically integrated integrated good. In the second case, the firm is said to be producing a horizontally differentiated good. Importantly for the current study, Antrás (2003) shows that if a firm produces a capital intensive good, it is more likely to import intermediates from a subsidiary and therefore be vertically integrated. If the good is labor intensive, the firm is more likely to purchase it from a supplier not affiliated with the company.

Migration and trade have long been linked together by the basic Heckscher-Ohlin model, in which the two are considered substitutes. The two-input, two-good, two-country model describes a scenario in which each country has a different endowment of the factors of production. If goods and labor movement are restricted, the scarce factor has a higher price. Opening up trade or allowing for free migration, however, results in eventual price equalization. The basic intuition is that the country with a higher labor endowment would either export labor intensive goods or labor.

Markusen (1983) stresses that the conclusion of the Heckscher-Ohlin model is based on several key assumptions, and that if some of these are relaxed, migration and trade could in fact become complements. Schiff (2006), for example, shows that if tariffs are initially high, migration and trade move in the same direction, but if tariffs are low enough, migration

\footnote{While the use of vertical and horizontal production differ in the literature, here the definition utilized by Burstein, Kurz, and Tesar (2008) is adopted.}
and trade are complements. To empirically test the relationship between labor and goods movements, Aroca, Bosch, and Maloney (2005) look at labor movement in Mexico after the implementation of North American Free Trade Agreement (NAFTA). They find that trade deters migration, however, they make no distinction between skilled and unskilled labor emigration. An alternative perspective on migration and trade is that increased migration may help foster trade relations between the host and migrant-supplying countries. This consideration has been explored by Mundra (2005) and Docquier and Lodigiani (2007), who verify that migration does indeed increase trade relations.

3 The Model

3.1 The Industries

The model environment consists of two countries, one North and one South. The North is skill-abundant while the South is abundant with unskilled labor. Formally, \( s > s^* \), where \( s \) is the fraction of the population that is considered skilled in the North and \( s^* \) is the same fraction for the South. In turn, \( (1 - s) \) and \( (1 - s^*) \) are the fractions of unskilled labor in the North and South respectively.

In the North, there are two types of final goods industries, \( X \) and \( Y \). For each industry production takes two stages, intermediate and final. In industry \( Y \) the first stage of production requires two intermediate goods which are capital- and skill-intensive, one imported (or outsourced) denoted by \( y_{21} \) and one locally produced, \( y_{11} \). In industry \( X \), the intermediate goods required are unskilled-labor-intensive. One of the intermediate goods is imported, denoted by \( x_{21} \), and the other, \( x_{11} \), is locally produced.

An additional distinction between the two industries is that the elasticity of substitution between the intermediate inputs in \( Y \) is smaller than that in \( X \). This is justified by the fact
that the $Y$ industry is engaged in production sharing as defined in Burstein, Kurz, and Tesar (2008), meaning that it trades in intermediate goods that constitute parts of a vertically-integrated production process that spans internationally. This type of trade structure has received much attention in the literature and is analyzed in Yi (2003). As explained in the previous section, $Y$ is chosen to be the vertically-integrated industry because it is capital-intensive (Antràs 2003).

As listed in Antràs and Helpman (2003), a real-world example of industry $Y$ would be Intel Corporation, which undertakes the assembly of microchips at its subsidiaries in China, Costa Rica, Malaysia, and the Philippines. An example of industry $X$ is Nike, which outsources many of its intermediate goods internationally to independent producers in Thailand, Indonesia, Cambodia, and Vietnam.

Similar industries exist in the South. Final goods industries there are denoted by $Y^*$ and $X^*$. Again, the former requires capital- and skill-labor-intensive intermediate goods, one necessarily imported ($y_{12}$) and the other locally produced ($y_{22}$). The latter requires intermediate goods which are unskilled-labor-intensive, one of which is produced at home ($x_{22}$) and the other which is imported ($x_{11}$). For emphasis, recall that the key difference between the two industries is that the intermediate goods needed for $X$ are more substitutable than are those needed for $Y$.

### 3.2 Technologies

In the North, intermediate goods $Z$ and $V$ are produced using capital and labor available in the North, some of which is then exported or used for production. The capital- and skilled-labor-intensive good is $V$, while $Z$ is the unskilled-labor-intensive intermediate good. Similarly, in the South, intermediate goods $Z^*$ and $V^*$ are produced and later exported and used in domestic production of the goods.
The total production of intermediate goods which are capital- and skill-intensive in
the North and the South is therefore denoted by $V$ and $V^*$ respectively and given by the
following technologies:\footnote{This type of production function is a special case of the more general production
function used in Krusell et al. (2000) with $\sigma = 0$}

$$V = b g(K_y, H_y, N_y) = b N_y^\beta \left[ \mu K_y \xi + (1 - \mu) H_y \xi \right]^{1-\beta \over \xi}, \quad (1)$$

$$V^* = b^* g^*(K_y^*, H_y^*, N_y^*) = b N_y^* \beta \left[ \mu K_y^* \xi + (1 - \mu) H_y \xi \right]^{1-\beta \over \xi}. \quad (2)$$

The total production of intermediate goods which are unskilled-labor-intensive in the
North and the South is denoted by $Z$ and $Z^*$ respectively and given by the following
technologies:

$$Z = a f(K_x, H_x, N_x) = a N_x^\alpha \left[ \mu K_x \xi + (1 - \mu) H_x \xi \right]^{1-\alpha \over \xi}, \quad (3)$$

$$Z^* = a^* f^*(K_x^*, H_x^*, N_x^*) = a^* N_x^* \alpha \left[ \mu K_x^* \xi + (1 - \mu) H_x^* \xi \right]^{1-\alpha \over \xi}. \quad (4)$$

Here, $H_x^*$ and $H_y^*$, $N_x^*$ and $N_y^*$ are the skilled and unskilled labor in the South employed
in the $Z$ and $V$ industries respectively. Similarly, $H_x$ and $H_y$, $N_x$ and $N_y$ are the skilled
and unskilled labor employed in the North. $K_x$ and $K_y$ are the capital goods employed by
the North in the two sectors while and $K_y^*$ and $K_x^*$ are employed in the the South. The
elasticity of substitution between skill and capital is give by $1 \over \xi$. Finally, $\beta > \alpha$ since
the intermediates used to produce $Z$ are more unskilled labor intensive than those used to
produce $V$. 

\begin{align}
\left[ \beta n^* + (1 - \beta) \left( \mu K^* + (1 - \mu) h^* \xi \right) \right]^{(1 \over \xi)}. \nonumber
\end{align}
As explained, one portion of the intermediate goods is exported while the other is used in the domestic production of the final goods. The portion of the intermediate production of $Z$ that remains at home is denoted $x_{11}$, while the portion exported is denoted by $x_{12}$. Similarly, the portion of $Z^*$ exported is denoted $x_{21}$ the portion used in domestic production is $x_{22}$. The same notation is used to denote the portions of $V$ and $V^*$ exported and used domestically so that the following resource constraints on the production of intermediate goods hold

$$Z = x_{11} + x_{12}, \quad Z^* = x_{22} + x_{21}, \quad (5)$$

$$V = y_{11} + y_{12}, \quad V^* = y_{22} + y_{21}. \quad (6)$$

The final stage of production in the North assembles the intermediates, with no additional cost, into the final composite nontradable goods via the following Armington aggregators:

$$X = F(x_{11}, x_{21}) = \left[ \theta x_{11}^\rho + (1 - \theta)x_{21}^\rho \right]^\frac{1}{\rho}, \quad (7)$$

$$Y = G(y_{11}, y_{21}) = \left[ \omega y_{11}^\zeta + (1 - \omega)y_{21}^\zeta \right]^\frac{1}{\zeta}. \quad (8)$$

Similarly in the South, the intermediate goods are combined via the following Armington aggregators:

$$X^* = F^*(x_{22}, x_{12}) = \left[ \theta^* x_{22}^\rho + (1 - \theta^*)x_{12}^\rho \right]^\frac{1}{\rho}, \quad (9)$$

$$Y^* = G^*(y_{22}, y_{12}) = \left[ \omega^* y_{22}^\zeta + (1 - \omega^*)y_{12}^\zeta \right]^\frac{1}{\zeta}. \quad (10)$$

The elasticity of substitution between the imported and domestic intermediates in the
capital- and skill-intensive sector is lower than that of the unskilled-intensive sector such that \( \frac{1}{1-\rho} > \frac{1}{1-\zeta} \). Low elasticity of substitution between imports and domestic intermediates for vertically-integrated firms reflects the distinction of every stage of production, as compared to horizontally differentiated goods with a higher degree of substitutability (mentioned above). Lastly, the two nontradable final goods are then combined for consumption according to

\[
\Upsilon = X^\gamma Y^{1-\gamma}, \quad \Upsilon^* = X^{*\gamma} Y^{*1-\gamma}.
\] (11)

### 3.3 Preferences

Each economy has a continuum of infinitely-lived households who supply their labor inelastically. On each continuum there are two types of households, skilled and unskilled, as in Mandelman and Zlate (2008).

To simplify, labor in the North is not mobile while labor in the South can move across boarders. For the North, the planner maximizes the weighted sum of utilities for the two representative households as follows

\[
\max_{c_{t,s}, c_{t,n}, K_{t+1}} \sum_{t=0}^{\infty} \Delta^t \left\{ \phi s \ln(c_{t,s}) + (1 - \phi)(1 - s) \ln(c_{t,n}) \right\}
\] (12)

subject to the budget constraint

\[
w_{t,s} H + w_{t,n} N + \Pi = C_{t,n} + C_{t,s},
\] (13)

where \( s \) and \( \phi \) are the fraction of skilled natives and the weight placed on their utility, and \((1-s)\) and \((1-\phi)\) are the fraction of unskilled natives and the weight places on their utility.
The wages paid for skilled and unskilled labor in the North are $w_{t,s}$ and $w_{t,n}$ respectively. Aggregate consumption for the skilled in the North is given by $C_{t,s} = sc_{t,s}$, and aggregate consumption for the unskilled is $C_{t,n} = (1 - s)c_{t,n}$. Since labor is supplied inelastically by the two households, it follows that $H = s$ and $N = (1 - s)$. Finally, the households are the owners of the firms, and therefore receive the profits $\Pi$.

For the South, the problem is similar to that stated above for the North but with the addition of the migration decision. The planner maximizes the weighted sum of utilities for the two representative households as follows

$$\max_{c_{t,s}^*, c_{t,n}^*, K_{t+1}}, \sum_{t=0}^{\infty} \Delta^t \{ \phi^* s^* \ln(c_{t,s}^*) + (1 - \phi^*)(1 - s^*) \ln(c_{t,n}^*) \}$$

(14)

subject to the budget constraint

$$w_{t,s}(i_h)H^* + w_{t,n}(i_n)N^* = (i_n)C_{t,n}^* + (i_h)C_{t,s}^*,$$

$$w_{t,s}^*(1 - i_h)H^* + w_{t,n}^*(1 - i_n)N^* + \Pi^* = (1 - i_n)C_{t,n}^* + (i - i_h)C_{t,s}^*,$$

(15)

where $i_h$ and $i_n$ are the fractions of skilled and unskilled workers that migrate. The wages paid for skilled and unskilled labor in the South are $w_{t,s}^*$ and $w_{t,n}^*$ respectively. Labor is supplied inelastically so that $N^* = (1 - s^*)$ and $H^* = s^*$. Aggregate consumption for the skilled who do no migrate in the South is given by $(1 - i_h)s^*c_{t,s}^*$, and aggregate consumption for the unskilled is $(1 - i_n)(1 - s^*)c_{t,n}^*$. 

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3.4 Investment

The final output in each country is allocated towards consumption and investment goods. Therefore, the resource constraint for the final good in each country is given by

\[ \Upsilon_t = C_{t,h} + (i_n)C^*_{t,h} + C_{t,n} + (i_n)C^*_{t,n} + I_t, \]  

(16)

\[ \Upsilon^*_t = (1 - i_h)C^*_{t,h} + (1 - i_n)C^*_{t,n} + I^*_t, \]  

(17)

where \( I_t \) and \( I^*_t \) are investment in the North and South respectively. Investment goods are a composite of foreign and domestic goods and there is no restriction on the movement of capital goods between sectors. Two cases for capital accumulation are considered. In the first case, capital accumulates with no cost of adjustment. In the second, firms face both a fixed cost and a quadratic adjustment cost of capital. Assume that investment expenditures of magnitude \( I_t \) and \( I^*_t \) result in net increases to each country’s current capital stock \( K_t \) and \( K^*_t \) as specified by the following in the first case

\[ K_{t+1} = I_t + (1 - \delta)K_t, \]  

(Case 1)

\[ K^*_{t+1} = I^*_t + (1 - \delta)K^*_t, \]

and for the second case,

\[ K_{t+1} = \frac{\psi}{2} \left( \frac{I_t}{K_t} \right)^2 K_t + (1 - \delta)K_t - FK_t, \]  

(Case 2)

\[ K^*_{t+1} = \frac{\psi^*}{2} \left( \frac{I^*_t}{K^*_t} \right)^2 K^*_t + (1 - \delta)K^*_t - F^*K^*_t, \]
where the fixed cost of increasing capital ($F$ and $F^*$) is incurred only when investment is positive and depends on the scale of the adjustment ($K_t$ and $K_t^*$). Again, the difference in the two cases is that in the first, capital can adjust with no cost, while in the second case, capital adjustment faces two costs, a quadratic and a fixed cost that differ in the North and in the South.

The reason for adding the adjustment cost is twofold. First, Chakrabarti and Mitra (2009) show theoretically that adjustment costs of capital between sectors have an impact on the wage gap between skilled and unskilled labor when firms engage in offshoring, but they do not consider the effect of this adjustment in the South (unskilled-labor-abundant) countries. Second, the nature and magnitude of capital adjustment costs have been chronicled empirically and estimated for developing countries. Gelos and Isgut (2001) find evidence for fixed costs in data for Colombian and Mexican firms while Bond, Söderbom, and Wu (2009) estimate a rich model of capital adjustment costs for African and Asian firms. They note that unlike data on firms in developed countries such as the U.K. and the U.S., firms in China and India experience much more zero-investment periods. This is consistent with the importance of fixed investment costs where firms prefer to simply not invest rather than undertaking costly changes in capital. Also, these estimates of adjustment costs for developing countries are significantly higher than those found by Cooper and Haltiwanger (2006) for developed countries.

### 3.5 Market Clearing and Equilibrium

Using the resource constraints on the final and intermediate goods and defining gross national product in each country in terms of the intermediate goods, the following national
accounts identities holds for each country

\[ p_z Z + p_v V = p_T \left[ C_{t,h} + (i_h)C_{t,h}^* + C_{t,n} + (i_n)C_{t,h}^* + I_t \right] + NX, \]  
\[ NX = p_z x_{12} + p_v y_{12} - \left( \frac{p_z^*}{\tau_1} \right) x_{21} - \left( \frac{p_v^*}{\tau_2} \right) y_{21}, \]  
\[ p_z^* Z^* + p_v^* V^* = p_T^* \left[ (1 - i_h)C_{t,h}^* + (1 - i_n)C_{t,h}^* + I_t^* \right] + NX^*, \]  
\[ NX^* = p_z^* x_{21} + p_v^* y_{21} - \left( \frac{p_z}{\tau_1} \right) x_{12} - \left( \frac{p_v}{\tau_2} \right) y_{12}, \]

where \( p_z, p_v, p_z^* \) and \( p_v^* \) are domestic prices of intermediate goods produced in the North and the South respectively. Specifically, they are the prices of \( x_{11}, y_{11}, x_{22} \) and \( y_{22} \). Trade costs are introduced in the form of iceberg costs such that for any amount exported, a fraction of the good melts along the way. Such iceberg costs of trade create a gap between the domestic and foreign prices of identical goods. For example, the North exports a fraction of the intermediate good \( Z \) to the South that has a value of \( p_z x_{12} \) in the North, however, a fraction of \( (1 - \tau_1) \) is incurred as a cost of shipping and only \( \tau_1 x_{12} \) arrives. Effectively, the price paid by the South for their imports of \( Z \) denoted by \( x_{21} \), is given by \( \frac{p_z}{\tau_1} \).

The same logic works for the prices of \( y_{12}, x_{21} \) and \( y_{21} \). Exports of \( y_{12} \) incurs a cost of \( (1 - \tau_2) \) of the good while exports from the South denoted by \( x_{21} \) and \( y_{21} \) incur iceberg costs of \( (1 - \tau_1^*) \) and \( (1 - \tau_2^*) \). A value of \( \tau_1 \) and \( \tau_2 \) equal to 1 implies costless trade. The interpretations of trade costs are as in Anderson and van Wincoop (2003) where they represent transportation costs, any regulatory or legal expenses, geographical barriers or information costs.

Note here that financial autarky is reached in equilibrium, and therefore each country is constrained by its output which is allocated to consumption and investment.
Full employment conditions in the labor market imply

\[ H + i_h H^* = H_x + H_y, \quad N + i_n N^* = N_x + N_y, \]

\[ (1 - i_h)H^* = H^*_x + H^*_y, \quad (1 - i_n)N^* = N^*_x + N^*_y, \]

where \( H = S, \ N = (1 - s), \ H^* = s^* \) and \( N^* = (1 - s^*) \).

### 3.6 Calibration

Taking the period length as a year, the standard parameters used are the discount rate and the depreciation rate for capital, calibrated such that \( \triangle \) is 0.98 and both \( \delta \) and \( \delta^* \) equal .06. The elasticity of substitution between capital and skilled labor \( (\frac{1}{1 - \xi}) \) is .67 as in Krusell et al. (2000). The weight on the skilled in the planner problem \( (\phi) \) is set equal to .6888 as in Mandelman and Zlate (2008). This is done so that the consumption ratio for representative skilled and unskilled households can match the wage ratio of each household.

As in Backus, Kehoe, and Kydland (1994), the share parameters \( (\omega, \omega^*, \theta, \theta^*) \) are set equal to the means of import shares. The share of North’s intermediate input \( y_{21} \) in the vertically-integrated composite, \( (1 - \omega) \) is set equal to 0.13 which is the average import share in production for manufacturing industries whose capital income share \( (1 - \beta) \) is .8 over the period of 1997-2005. Similarly, the share of the North’s intermediate input \( x_{21} \) in the horizontally-integrated composite is set equal to 0.28, which is the import share for industries whose capital income share \( (1 - \alpha) \) is 0.65. The industries included in each group are listed in Table 4. The sources of the data are discussed below in Section 5.1. For the south, \( \omega^* \) is initially set at .5 and then varied to check the results for sensitivity. The value used for \( \theta^* \) is similar to \( \theta \). The choice for \( \omega^* \) comes from the fact that the equipment import share relative to absorption in developing countries ranges from 24.3\% in India, to 72.2\%
for Zimbabwe, and all the way up to 94% in Sri Lanka (Eaton and Kortum 2001). Import share of equipment is chosen since it represents capital intensive imports.

The parameter $\rho$ is set such that the elasticity of substitution between the imported intermediates and the domestically produced one in the $X$ sector is equal to 2. While $\zeta$ is set such that the elasticity of substitution between the imported and domestic intermediate is equal to .91 and varied as a robustness check. The fraction of skilled labor in the North and South ($s$ and $s^*$) are set equal to .9 and .3. Finally, the capital adjustment costs parameters $\psi$ and $F$ are taken from Cooper and Haltiwanger (2006), and $\psi^*$ and $F^*$ are based on Bond, Söderbom, and Wu (2009). The basic variables used are listed in Table 1.

<table>
<thead>
<tr>
<th>Table 1: Calibration Values</th>
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<tbody>
<tr>
<td>$\Delta$ = 0.985</td>
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<tr>
<td>$\theta$ = 0.720</td>
</tr>
<tr>
<td>$1 - \beta$ = 0.8</td>
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<tr>
<td>$\delta$ = 0.060</td>
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<tr>
<td>$\rho$ = 0.500</td>
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<td>$\psi$ = 0.125</td>
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4 Model Results

The goal of the model is to investigate labor movements, both skilled and unskilled, given different volumes of trade in both industries, $X$ and $Y$. To generate different trade volumes iceberg costs associated with the exports of both industries are varied to create a cross section of trade volumes and migration levels of skilled and unskilled labor. In this way, the change in migration rates resulting from different trade volumes in each sector can be
isolated. Trade costs are symmetric in each sector such that $\tau_1^* = \tau_1$ and $\tau_2^* = \tau_2$. The impact from in trade costs on the skilled and unskilled migration comes from the following first order condition for the use of intermediates in the North

\[
\frac{x_{11}}{x_{21}} = \left(1 - \frac{\theta}{z} \frac{p_z}{p_{z^*}/\tau_1^*}\right)^{\frac{1}{\rho-1}}, \quad (20)
\]

\[
\frac{y_{11}}{y_{21}} = \left(1 - \frac{\omega}{v} \frac{p_v}{p_{v^*}/\tau_2^*}\right)^{\frac{1}{\zeta-1}}. \quad (21)
\]

Along with Equations (20) and (21), the changes in the final composites $X$ and $Y$ determine the demand for imports by the North. To look at these changes, the model is numerically solved for its steady state where the first order conditions represent a system of nonlinear equations given the calibration parameters listed above.

**Case 1**

If capital accumulates according to the equation listed under Case 1, then there are no adjustment costs in either country. In that situation, the migration of skilled labor reacts differently to changes in trade volumes in industry $X$ and changes in trade volumes in industry $Y$. The patterns of migration as exports by the South increase are shown in Figure 1.

As exports of $x_{21}$, which is unskilled-labor-intensive, increase, the return to skill changes in the North and the South. The decrease in trade costs, $\tau_1^*$, decreases the price of $x_{21}$, and therefore the final good producer substitutes away from $x_{11}$ towards the imported intermediate according to Equation (20). At the same time, capital in the North flows to the $V$ industry out of $Z$, raising the return to capital in the North. Since capital and skill are complements, this also raises the return to skill. Essentially, the returns to skilled labor
increase in the North while the returns to unskilled labor decrease. The reverse happens in the South. Capital flows out of the capital intensive sector $V^*$ and into $Z^*$, and this in turn increases the migration of skilled labor and decreases that of the unskilled. The total effect is shown in the top panels of Figures 1 and 2.

On the other hand, when $y_{21}$ increases with the decrease in its export cost, producers in the North substitute away from $y_{11}$ and towards the now relatively cheaper import according to Equation (21). At the same time, industry $V^*$ expands as capital flows into it out of $Z^*$. Both effects raise the return to skill and capital in the South. Consequently, the migration rate of skilled labor decreases and capital accumulated in steady state increases
as trade costs, $\tau^*_2$, go down. Higher capital dampens the decrease of return to unskilled labor in the South and slightly offsets capital flight out of $Z^*$. The total effect can be seen in the bottom panels of Figures 1 and 2.

For the case of unskilled labor migration, as trade costs of the skill-intensive intermediate decrease, the elasticity of substitution between imports and domestic intermediates in the skill intensive sector ($\frac{1}{1+\xi}$) plays an important role. If this elasticity is low (as was assumed), then as $\tau^*_2$ decreases, the reallocation from $y_{11}$ to $y_{21}$ is relatively low, and therefore the change in the return on investment in the South and the subsequent steady-state capital levels is relatively low. And since the increase in capital as $\tau^*_2$ dampens the decrease in the
return to low-skilled labor, with lower \( \frac{1}{1-\psi} \), the unskilled migration rate is higher.

In both cases, the decrease in trade costs gives way to more investment as can be seen in the constraints and the national identities given in Equations (6), (5), (18) and (19). The steady-state capital levels in each sector, under changes in trade costs for each good, are shown in Figure 3. The dashed line represents the steady-state capital under increases in \( \tau_1^* \), while the solid line represents the capital levels under decreases in \( \tau_2^* \). In this figure, the x-axis is an index that rates trade costs in a descending order, from large to small.
Case 2

In this section, the model is solved with the assumption that capital accumulates as in Case 2 where capital is mobile across sectors and countries, but the difference is that adjusting capital through investment comes at a cost. These costs are both quadratic and fixed, and importantly are higher for the South.

The main implication of such a cost is that the South is less able to increase investment (compared to the North) as trade costs decrease. Therefore, as $\tau^*_2$ decreases, migration rates increase both for skilled and unskilled labor. To see the intuition behind this, assume that the fixed costs for increasing investment are high enough to bind, as they do in this calibration. As a result, the South is constrained with a unchanging level of capital. As $\tau^*_1$ decreases, and the North substitutes towards the unskilled-intensive intermediate, and unskilled labor’s wages increase. However, the North is able to accumulate more capital than the North, and therefore regardless of the cost of trade the North-South wage gap is sustained.

Therefore, the interaction between the adjustment cost of capital and trade costs is what determines the migration patterns for both skilled and unskilled labor. The decrease in the export cost of the good increases the wages of the the factor used most intensively in the production. However, if capital adjustment is sufficiently high in the South compared the North, the returns to labor in the North will be higher. This is because, in steady state, the North will accumulate significantly more capital, and the increase in exports from the South leads to even higher investment in the North as compared to the South. Especially since the investment good is a composite of both imports and domestic goods.

The patterns of migration can be seen in Figures 4 and 5. Worth noting is that if the adjustment costs were decreased then the skilled migration would eventually fall with the decrease in $\tau^*_2$. The intuition is that, with sufficiently small adjustment costs, the return
on investment is high enough to overcome the costs and increase capital in the South. This implies that the interaction between trade costs and adjustment costs is what eventually determines the migration patterns of skilled labor.

The results of migration patterns in the South and North are different under Case 1 and Case 2. Therefore, the next step is to consult data to explore which case prevails in reality.

## 5 Estimation

This section estimates the relationship between skill migration and different types of imports. The estimation strategy and specification used here are similar to those in Rotte
and Vogler (2000), who explore the relationship between migration and income for German migrants. Here, the relationship between skilled immigrants to the U.S. and the imports of their country of birth is estimated.

5.1 Data

The data on skilled-labor migration is from the Department of Homeland Security Year Book statistics on H-1B visas granted. There are several reasons for the use of this variable. The first is that this type of visa is only granted to those who have college or advanced degrees, so it clearly distinguishes the entry of these migrants from those who could be
considered as unskilled. Second, the variable specifically describes the inflow of skilled migrants and not the stock of migrants, which makes it a better fit for the model. This particular data on migration is available yearly by country of birth, which makes it easy to match the migration of skilled labor with the trade volumes of their country of birth. Finally, an H-1B visa is granted specifically for skills and a need to work in a specific sector, not for asylum or political instability needs in the home country. However, it is worth mentioning that this is also a reason why this variable is not a perfect measure of skilled migration, since it misses many more skilled migrants who have decided to migrate but chose other visas or migration applications.

Trade data is taken from the Office of Trade and Industry Information, Manufacturing and Services, U.S. Department of Commerce and the source of the data is Foreign Trade Division, U.S. Census Bureau. Imports by the U.S. from developed countries are collected and broken down by industry according to the North American Industry Classification System (NAICS). Then the industries’ capital to labor intensity is measured from the NBER Manufacturing Industry Productivity Database. The measure of capital intensity is the ratio of the total real capital stock to total production employment. Imports are then broken into two groups, low capital intensity and high capital intensity. The industries are listed in Table 4.

The country variables are taken from the World Development Indicators. The list of independent variables include GPD per capita and the square of the GDP per capita of the migrants’ country of birth. The squared term captures the inverted U-shape relation between migration and income documented by Rotte and Vogler (2000). Another dependent variable used is the difference between the migrant’s country of birth GDP and that of the U.S. to capture productivity differences between the two countries. The population of the migrant’s country of birth is also used since bigger countries usually experience higher
emigration rates. Finally, the stock of migrants already in the United States is used to capture the effects of migrant networks on the decision to migrate.

5.2 Specification

The final list of variables comprise an unbalanced panel of 10 years and 61 countries. Since the data spans 1998-2007, a dummy variable is included to account for any effect the events of September 11th terrorist attacks might have had on migration flows. Also, in some specifications, a time trend is added to capture any changes over time in communication links between the U.S. and its trading partners. The Hausman test is run to test whether unobserved country-specific effects should be treated as random versus fixed parameters. The test favors fixed effects. The fixed effects estimation results are presented in Table 2.

The migration process is sometimes modeled as dynamic by adding a lagged dependent variable as a regressor\(^3\). However, introducing such a variable could be problematic since it may be correlated with the error term. To estimate this specification, the difference GMM estimator is used. The method was first introduced by Holtz-Eakin, Newey, and Rosen (1988) and later developed by Arellano and Bond (1991). The procedure entails differencing the variables to get rid of fixed effects and instrumenting the transformed variables that are not strictly exogenous with their lagged levels. This is possible since the lagged levels of a variable (lagged dependent or other endogenous regressors) are mathematically related to the differenced values of the variable but not to the error term. One can conceivably use all valid lags as instruments. Using the entire set of these instruments has significant efficiency gains, but a large number of instruments weakens the Hansen test of the validity of instruments. A suggested rule of thumb is to keep the instrument count below the number of groups (Roodman 2006).

\(^3\)Brücker and Siliverstovs (2006) review and evaluate empirical models of migration.
To deal with possible endogeneity of the trade variables, the transformed import variables are also instrumented for using their lagged levels. The differenced lagged dependent variable is instrumented with the first lag its level values while the differenced import variables are instrumented with the second lag and higher of their level values. The results are shown in Table 3. Also in the table are the p-values for the Hansen test with the null hypothesis that the instruments are exogenous and the Arellano-Bond test for second-order correlation in differences in order to check for autocorrelation (aside from fixed effects).

5.3 Results

In both estimation strategies, the signs on the coefficients of high capital intensity imports and low capital intensity imports are both positive and significant. This implies the applicability of the capital adjustment cost model presented above. In this case, manufacturing imports and skilled labor appear to be complements.

The coefficient on GPD is positive and GDP$^2$ is negative, which implies that migration increases at low levels of GPD and decreases at high levels, as documented by Rotte and Vogler (2000). The income differential has a positive impact on migration; the higher the income gap between the US and and the migrants’ country of birth, the higher the migration rate. The coefficient on existing migrant stock is insignificant and positive in most specifications. This could indicate the effect of the quotas enacted by the United States on different countries’ migrants. FDI has a negative but insignificant coefficients in all specifications. The Economic Freedom Index has a positive coefficient, however, which could imply that in countries with more freedom in general, the mobility of labor is not restricted.
6 Conclusion

To study the link between the migration of skilled labor and the type of good traded and structure of firms engaged in trade, this paper sets up a two-country, two-sector model where intermediate goods that are capital-intensive, both imported and domestically produced, are combined to create a vertically-integrated good, and labor-intensive intermediates are combined to create a capital-intensive good. Two frictions to trade and investment are tested, iceberg costs and capital adjustment costs. In the absence of any capital adjustment costs, an increase in trade volumes of labor-intensive goods resulting from decreased trade costs leads to an increase in skilled migration and a decrease in the migration of the unskilled. The reason is that as trade costs decrease, the skill-abundant North substitutes towards imported unskilled-labor-intensive goods, thereby raising the return to labor in that sector in the unskilled-abundant South. At the same time, capital leaves the the labor-intensive sector in the North and leaves the capital-intensive sector in the South. Although investment increases in the South, it increases more in the North. This shrinks the North-South unskilled wage gap but widens that for the skilled. The increase in the trade volume of capital-intensive intermediates, on the other hand, shrinks the North-South wage gap and decreases skill migration. This type of trade also increases investment in the South mitigating some of the negative effect on the unskilled labor that comes with the expansion of the Skill intensive sector.

When an asymmetric adjustment cost of capital is introduced in the North and South, however, the patterns change. Notably, as trade costs decrease in the capital-intensive sector, the North-South skill wage gap widens. The main reason for this is that the North will increase its investment more than the South since it always benefits from increased trade. And since capital and skill are complements, skill follows capital to where it is used
more efficiently and is abundant in supply.

Since the presence or absence of adjustment costs changes the conclusion of the model, an empirical model tests which pattern of migration holds. The results favor the capital adjustment model since a fixed-effects panel regression shows a positive relation between skill migration and imports of both types.
References


Table 2: Fixed Effects Estimates

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<th>ln Inflow (rate)*</th>
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<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
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<td>ln low capital imports (%)</td>
<td>0.219**</td>
<td>0.231**</td>
<td>0.240**</td>
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<td>0.281**</td>
<td>0.073</td>
<td>0.115</td>
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<td>(2.280)</td>
<td>(2.430)</td>
<td>(2.490)</td>
<td>(2.160)</td>
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<td>(2.890)</td>
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<td>0.326**</td>
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<td>(ln GDP per capita)**</td>
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<td>-0.123*</td>
<td>-0.355**</td>
<td>-0.201**</td>
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<td>1.997</td>
<td>4.828**</td>
<td>2.228**</td>
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<td>ln fdi</td>
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<td>(0.550)</td>
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<td>(-3.180)</td>
<td>(-4.540)</td>
<td>(-3.370)</td>
<td>(-1.350)</td>
<td>(-4.920)</td>
<td>(-4.420)</td>
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<td>ln migrant stock</td>
<td>-0.243**</td>
<td>-0.258**</td>
<td>-0.193**</td>
<td>-0.221**</td>
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| ln Inflow (rate)
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<td>(1)</td>
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<td>Lagged inflow</td>
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<td>ln low capital imports (%)</td>
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<tr>
<td>(3.680)</td>
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<tr>
<td>ln high capital imports (%)</td>
</tr>
<tr>
<td>(2.180)</td>
</tr>
<tr>
<td>ln Gdp per capita</td>
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<tr>
<td>ln Gdp per capita²</td>
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<td>(-0.880)</td>
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<tr>
<td>ln fdi</td>
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<tr>
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<tr>
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<tr>
<td>ln pop</td>
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<td>(-6.410)</td>
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<td>Number of Instruments</td>
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<tr>
<td>Arellano-Bond test for AR(2)</td>
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<tr>
<td>Hansen Test</td>
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*Difference one-step GMM estimates with robust t-statistics in parentheses. * and ** indicate significance at the 5% and 10% levels, respectively. The lagged dependent variable is instrumented for using its first lags. Imports variables are instrumented for using their second to fourth lags.
Table 4: Manufacturing Industries by Capital Intensity

<table>
<thead>
<tr>
<th>NAICS -High capital labor ratio industries</th>
<th>NAICS -Low capital labor ratio industries</th>
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<tbody>
<tr>
<td>311 - Food Manufacturing</td>
<td>314 - Textile Product Mills</td>
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<tr>
<td>326 - Plastics and Rubber Products Mfg</td>
<td>315 - Apparel Manufacturing</td>
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<td>333 - Machinery Manufacturing</td>
<td>316 - Leather and Allied Product Manufacturing</td>
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<td>335 - Elec. Equip., App., &amp; Component Mfg</td>
<td>337 - Furniture and Related Product Mfg</td>
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<td>339 - Miscellaneous Manufacturing</td>
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<td>322 - Paper Manufacturing</td>
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<td>327 - Nonmetallic Mineral Product Mfg</td>
<td>323 - Printing and Related Support Activities</td>
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<td>331 - Primary Metal Manufacturing</td>
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<td>336 - Transportation Equipment Manufacturing</td>
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<td>312 - Beverage and Tobacco Product Mfg</td>
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<tr>
<td>325 - Chemical Manufacturing</td>
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<td>334 - Computer and Electronic Product Mfg</td>
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