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JULIANO ASSUNCAO
LEANDRO CARVALHO

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LABOR AND POPULATION

Financial Constraints, Endogenous Educational Choices and Self-Selection of Migrants

Juliano Assunção
Pontifical Catholic University of Rio de Janeiro
juliano@econ.puc-rio.br

Leandro Carvalho
Rand
carvalho@rand.org

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Abstract

The Roy model predicts that migrants will be disproportionately drawn from the lower half of the educational distribution of the sending country if the sending country has a higher return to schooling. However, Mexican immigrants in the U.S. tend to be disproportionately drawn from the middle of the distribution. We argue that financial constraints may explain why. We study migrants' selectivity when agents that face credit constraints make joint decisions about how much to invest in education and whether to migrate. Our results show that financial constraints can explain the intermediate selection of migrants observed in the data.

JEL: O15, O16, R23

Keywords: migration, financial constraints, self-selection, human capital

1 Introduction

There is great concern in developed countries whether immigration hurts the labor market prospects of natives. In developing countries, the concern is whether emigration of the most skilled workers hinders economic growth. The welfare impacts of migration on the sending and receiving countries depend on which workers migrate. The literature on migrants' selectivity studies which workers choose to migrate. How do they compare to the workers who remained in the sending economy? How do they compare to the workers in the receiving economy?

In a seminal article, Borjas (1987) uses the Roy model framework to investigate which workers have incentives to migrate between two economies. He argues that if the sending country (e.g., Mexico) has a higher return to schooling than the destination country (e.g., the U.S.), then Mexican immigrants will be disproportionately drawn from the lower part of the Mexican educational distribution. However, there is consistent evidence showing that Mexican immigrants are disproportionately drawn from the middle of the distribution of observable skills in Mexico (Cuecuecha 2003; Orrenius and Zavodny 2005; Chiquiar and Hanson 2005; Mckenzie and Rapoport 2007; Moraga 2008) – Ibarraran and Lubotsky (2005) find mixed results.

In this paper, we argue that endogenous educational choices and financial constraints may explain why the empirical literature has failed to provide evidence that supports the Roy model. The literature on selection takes the educational distribution in the sending country as given and analyzes how workers sort into the two labor markets based on their incentives to migrate. However, the literature on brain drain (Mountford 1997; Stark et al 1997, 1998; Vidal 1998; Beine, Docquier and Rapoport 2001, 2008) argues that workers in the home country make their educational choices taking into account the return to education in the receiving country and their migration prospects.

We study the selectivity of migrants when agents make joint decisions about how much to invest in education and whether to migrate. We compare our case with endogenous educational choices to the case with exogenous educational choices traditionally analyzed in the literature, where by exogenous educational choices we mean that investments in education are exogenous to the wage structure in the receiving economy. We show that, if the education premium is higher in the sending country than in the receiving country, migrants invest less in education than if they had stayed. The analysis highlights the importance of the transferability of immigrants' human capital as a determinant of migrants' selectivity. The lower is the transferability of immigrants' human capital, the lower are the incentives for immigrants to invest in education. For example, Jasso, Rosenzweig and Smith (2002) calculate that only 34% of immigrants' skills are initially transferred to the U.S. labor market.

Our framework also considers the selectivity of migrants when there are credit constraints.[1] We show that financial constraints explains why workers from the left tail of the distribution of education are underrepresented among migrants. Individuals with little wealth get little education and stay in the home country because they cannot afford migration costs. The analysis suggests that in this case the predictions of the Roy model may not hold. Finally, we discuss that – as have been argued by other authors (Chiquiar and Hanson 2005; Orrenius and Zavodny 2005; Mckenzie and Rapoport 2007) – financial constraints can explain the intermediate selection of migrants observed in the data. If the education premium in the sending country is higher than in the receiving country, the most educated workers choose to stay in the origin country.

One of our contributions is to provide a general framework which is useful for analyzing issues related to the selection of migrants. We use our framework to look at some of these issues. We first investigate the effect of immigration policies on migrants' selectivity. The Roy model assumes perfect credit markets. Under this assumption, a skill-biased increase in migration costs raises the average education of immigrants, but a skill-neutral change in migration costs does not have an effect on the selection bias. Our analysis shows that under credit constraints a skill-neutral change in migration costs affects migrants' selectivity. An increase

[1] Orrenius and Zavodny (2005) change the Roy model to incorporate credit constraints. However, in their model credit constraints only restrict migration choices – and not educational choices – and they assume that savings is an increasing function of education.

in migration costs raises the average education among stayers and reduces the resources migrants have to invest in education.

We also use our framework to study the selectivity of illegal immigrants. The literature on selection does not distinguish between illegal and legal immigrants – Hanson (2006) being the exception. Our results suggest that more attention should be paid to this distinction. We investigate the case in which the education premium for legal immigrants is higher than for illegal immigrants and legal migration costs are decreasing in education. We show that legal migrants are, on average, more educated than illegal migrants because they have more incentives to invest in education. Under some conditions, the model predicts negatively selected illegal migrants and positively selected legal migrants.

We consider a very simple general equilibrium model with two countries in which individuals in the sending country make educational and migration choices. Agents choose how much to invest in education in order to maximize income and choose whether to migrate by comparing their consumption prospects in the two countries. Individuals are endowed with some initial wealth, which differs across workers. If there are perfect credit markets, workers can borrow against future wages to finance educational and migration costs. If there are financial constraints, they have to pay their educational and migration costs out of their initial wealth. The wage schedules in the two countries are different and are endogenously determined by the behavior of a representative price-taker firm.

The analysis is presented as follows. In section 2, we lay out the firm's maximization problem. The consumer's maximization problem is presented in sections 3 and 4. In section 3, we study the case in which the educational distribution in the sending country is taken as given – i.e., educational choices are independent of migration choices. In section 4, the case in which education is endogenously determined is investigated. We proceed in two steps. In section 4.1, we assume perfect credit markets and show how the educational choices of migrants, when education is endogenously determined, compare to migrants' educational choices in a model in which educational choices are exogenously determined. In section 4.2, we examine the case in which agents cannot borrow to finance their decisions. To isolate the impact of the financial constraints on the selection of migrants, we equalize the education premium in the two countries and study the educational choices of migrants and non-migrants. In section 5, the implications of our analysis for empirical work on the selectivity of migrants are presented. Section 6 uses our framework to discusses some policy implications. We make our final remarks in Section 7.

2 The Firm Problem

We start by describing the optimal decision of a firm without any reference to the country in which it operates.

We consider homogeneous firms which are price-takers in both the product and labor markets and produce a single good whose price is normalized to 1. The production function of the firms is homogeneous of degree 1 with respect to physical capital K and human capital H:

$$Y = F(K, H),$$

where $F_K > 0$, $F_L > 0$, $F_{KK} < 0$ and $F_{HH} < 0$.

The human capital H of the firm is given by:

$$H = L \int_0^\infty \phi(e)\, g(e)\, de,$$

where L is the number of workers hired by the firm and g is the density function of workers with different education levels.

Firms choose physical capital K and the composition of workers in terms of education – which is given by $g(.)$ – in order to maximize profits.[2] The firm's problem is given by:

$$\max_{K, g(\cdot)} \; F\left(K, L \int_0^\infty \phi(e)\, g(e)\, de\right) - rK - L \int_0^\infty w(e)\, g(e)\, de,$$

where $k \equiv \frac{K}{H}$ and $f(k) \equiv F(k, 1)$. The necessary conditions for the firm's optimal behavior are:

$$f_k(k^*) = r \tag{1a}$$

$$\frac{w(e)}{\phi(e)} = f(k^*) - rk^*, \text{ for all } e \in [0, \infty). \tag{1b}$$

The interest rate r is determined exogenously in international capital markets and determines k^*:

$$k^* = f_k^{-1}(r).$$

In this economy, when there is an inflow of migrants which increases the marginal productivity of capital per effective worker, the stock of capital increases until the capital per effective worker returns to its equilibrium

[2] The assumption of homogeneity of degree 1 of $F(.)$ in K and H make the size of the firm in terms of number of workers L irrelevant for the firm's maximization problem.

level k^*.

The profit maximization of the firm implies the following wage schedule:

$$w(e) = \gamma\phi(e), \text{ for all } e \in [0, \infty), \tag{2}$$

where $\gamma \equiv f\left(f_k^{-1}(r)\right) - rf_k^{-1}(r)$. Relative wages between workers with different educational levels are determined by their relative productivities:

$$\frac{w(e)}{w(e')} = \frac{\phi(e)}{\phi(e')} \text{ for all } e, e'.$$

We are now ready to discuss the wage schedules in the two countries, $w^0(\cdot)$ and $w^1(\cdot)$, where the superscript 0 denotes the source country and the superscript 1 denotes the destination country. We assume that the countries have the same production functions. The assumption that the interest rate is determined exogenously in international capital markets implies that γ is the same for both countries. Thus, the wage schedule in country j is completely described by the function $\phi^j(\cdot)$.

Using the Fundamental Theorem of Calculus, we get:

$$w^j(e) = \gamma\phi^j(e) = \gamma\left[\phi^j(0) + \int_0^e \phi_e^j(x)\,dx\right], \tag{3}$$

for all $e \in [0, \infty)$ and $j = 0, 1$.

The productivity (and wages) of a worker in country j depends on the technology parameters of country j. The wage schedule in country j, as expressed in equation (3), depends on the baseline productivity $\phi^j(0)$ and the marginal productivity of education $\phi_e^j(\cdot)$. We define the **education premium** in country j as $\phi_e^j(e)$ and the **migration premium** as $\gamma\phi^1(0) - \gamma\phi^0(0) - M$, where M is the migration cost.

3 Exogenous Educational Choices

The model focuses on individuals "born" in the source country who have to decide how much to invest in education and whether to migrate to work in the destination country. The model is static, but the sequence of events is as follows: individuals study, join the labor market – i.e., they stay in the source country or migrate – work, receive wages and consume.

Agents are heterogenous in their initial wealth endowment a and skill $\theta \in \left[\underline{\theta}, \overline{\theta}\right]$. As discussed in the previous section, a worker with education e is paid $w^j(e)$ in country j. Individuals complete their education

in the home country before migrating.[3] An individual with skill θ who obtains e units of education pays $m(e|\theta)$ in education costs. Individuals with higher θ are more skilled, having lower costs and marginal costs of education – i.e., $m_\theta < 0$ and $m_{e\theta} < 0$. Migrants pay $M(e)$ in migration costs.

To simplify the presentation of our main argument, we assume perfect foresight about labor markets in both countries. There is no uncertainty and the wage schedules are perfectly anticipated by agents. Finally, we make the following assumptions about the wage schedule and the cost of education function: $\phi_e^j(e) > 0$ for all $e \geq 0$ and $j \in \{0,1\}$, $m_e(e|\theta) > 0$ for all $e \geq 0$ and $m_{ee}(e|\theta) > \max\left\{0, \phi_{ee}^0(e), \phi_{ee}^1(e)\right\}$ for any $e > 0$ – which guarantees that the second order conditions are satisfied.[4]

3.1 Consumer Problem

The literature on selection takes the education distribution in the source country as given. We initially follow the literature and consider the case in which individuals make the decisions of how much to invest in education and whether to migrate separately. First, individuals choose how much to invest in education by equalizing the marginal cost of education to the education premium in the source country. Workers' educational choices give rise to the education distribution in the source country. Given their education, workers sort into the two labor markets – i.e., they migrate or stay in the sending country – by choosing to work in the country in which they will have the highest level of consumption.

Following the literature, we assume that there are perfect credit markets. Individuals can borrow against (future) wages to cover the costs of education. Therefore, the choices of an agent with initial wealth a and skill θ are restricted only by the lifetime budget constraint, which is given by:

$$c + m(e|\theta) \leq a + w^0(e).$$

The agent chooses how much to invest in education by maximizing income:

$$\max_{e \geq 0} \; a + w^0(e) - m(e|\theta),$$

[3] We could enrich the model by allowing countries to have different educational production functions, in which case agents could choose where to study. For convenience, we assume that migrants complete their schooling before migrating. In reality, the majority of Mexican immigrants to the U.S. complete their schooling before migrating.

[4] Notice that the assumptions imply that:

$$\frac{\partial}{\partial e}\left(\frac{\gamma\phi_e^j(e)}{m_e(e|\theta)}\right) = \frac{\gamma\phi_{ee}^j(e)\, m_e(e|\theta) - \gamma\phi_e^j(e)\, m_{ee}(e|\theta)}{[m_e(e|\theta)]^2} < 0$$

for all $j \epsilon \{0,1\}$ given that $\gamma\phi_e^j(e) \geq m_e(e|\theta) > 0$.

and the solution is given by:[5]

$$w_e^0\left(\widetilde{e}\right) = m_e\left(\widetilde{e}|\theta\right), \tag{4}$$

where $\widetilde{e}$ denotes the optimal level of education when education is determined exogenously and there are perfect credit markets.

Given his education, the individual decides to migrate if the net benefit of migration $\widetilde{B}$ is positive:

$$\widetilde{j} = 1 \Leftrightarrow \widetilde{B} \equiv w^1\left(\widetilde{e}\right) - w^0\left(\widetilde{e}\right) - M\left(\widetilde{e}\right) \geq 0. \tag{5}$$

3.2 Selection

We define **selection on unobservables** in terms of the skill parameter θ and **selection on observables** in terms of education e. We first discuss how the selection on both observables and unobservables is determined by the mechanisms that have been most commonly suggested in the literature: sorting and migration costs.

3.2.1 Sorting

In an important article, Borjas (1987) uses the Roy model framework to investigate which workers have incentives to migrate between two economies. He argues that migrants from the source country will be less educated (skilled) than residents of the source country if the returns to education (skill) are higher in the source country than in the destination country. The model takes the educational distribution in the source country as given and workers with different education sort into the two labor markets based on the difference in returns to education.[6] We reproduce this result in the context of our model. We assume a linear utility function and for this reason the selectivity of migrants depend on the education premium in the 2 countries rather than in the returns to education. We discuss this in more detail in section 6.

We begin by examining how the benefit of migration is related to education in a context where the education premium is lower in the destination country. From (3) and (5), we can show that:

$$\phi_e^1 < \phi_e^0 \text{ for all } e \geq 0 \Rightarrow \frac{\partial \widetilde{B}}{\partial \widetilde{e}} = \left[w_e^1\left(\widetilde{e}\right) - w_e^0\left(\widetilde{e}\right)\right] < 0$$

Educated workers have a lower benefit of migration in this situation - their schooling is better rewarded in the origin country. As a consequence, migrants are on average less educated than non-migrants. A similar argument applies to the selection on unobservables. The derivative of the benefit of emigration with respect

[5] Throughout the analysis, we assume that the conditions of the economy are such that the interior solution characterizes the optimal levels of education.

[6] Grogger and Hanson (2008) consider a setting with multiple countries and make a distinction between sorting and selection. We consider a setting with only two countries and use sorting and selection to denote the same effect.

to θ is negative if $\phi_e^1 < \phi_e^0$:[7]

$$\phi_e^1 < \phi_e^0 \text{ for all } e \geq 0 \Rightarrow \frac{\partial \widetilde{B}}{\partial \theta} = \left[w_e^1\left(\widetilde{e}\right) - w_e^0\left(\widetilde{e}\right)\right] \frac{\partial \widetilde{e}}{\partial \theta} < 0. \tag{6}$$

Migrants are on average less skilled than non-migrants and therefore negatively selected on unobservables. Skilled workers invest more in education than unskilled workers. Thus, they choose to stay in the source country because of the higher education premium.

3.2.2 Migration costs

Borjas (1987) assumes that migration costs are constant across individuals. Other authors (Chiswick 1999; Chiquiar and Hanson 2005) have suggested that Borjas' result might not hold if the migration costs are decreasing in education. To simplify the exposition, we present the case in which the education premium is the same in the two countries – i.e., $\phi_e^0\left(e\right) = \phi_e^1\left(e\right)$ for all $e \geq 0$. The Roy model suggests there should be no selection bias in this case.

The derivative of (5) with respect to education is:

$$\frac{\partial \widetilde{B}}{\partial \widetilde{e}} = -M_e\left(\widetilde{e}\right),$$

which is greater than zero if $M_e < 0$.

Educated workers have a higher benefit of migration if the costs of migration are decreasing in education. Educated workers are more likely to migrate because they pay lower migration costs than workers with less education. As a consequence, migrants are on average more educated than non-migrants. A similar argument applies to the selection on unobservables.

The derivative of the benefit of emigration with respect to θ is positive if $M_e < 0$:

$$\frac{\partial \widetilde{B}}{\partial \theta} = -M_e\left(\widetilde{e}\right) \frac{\partial \widetilde{e}}{\partial \theta}.$$

Migrants are on average more skilled than non-migrants and therefore positively selected on unobservables. Skilled workers are more educated than unskilled workers and they are more likely to migrate because they pay smaller migration costs.

[7] Notice that the first order condition implies:

$$\frac{\partial \widetilde{e}}{\partial \theta} = -\frac{-m_{e\theta}\left(\widetilde{e}|\theta\right)}{w_{ee}\left(\widetilde{e}\right) - m_{ee}\left(\widetilde{e}|\theta\right)} > 0.$$

4 Endogenous Educational Choices

In this section, we investigate the selection of migrants when education is endogenously determined. We proceed in two steps. First, we analyze the case in which the education premium is higher in the source country and there are perfect credit markets to finance migration costs and investments in education. Second, we analyze how financial constraints affect the selection of migrants. In order to isolate the effects of financial constraints, we assume that the education premium is the same in the two countries. We show that migrants are positively selected on observables if the wealth distribution among migrants (shifted to the left by M) first-order stochastically dominates the wealth distribution among non-migrants.

We solve the consumer problem in two stages. First, we solve for the optimal education if the worker stays in the sending country, e_0, and the optimal education if the worker migrates, e_1. We then analyze the worker's migration decision. If the worker migrates, he pays $m(e_1|\theta)$ in education costs, $M(e_1)$ in migration costs and receives $w^1(e_1)$ in wages; his consumption c_1 is equal to initial wealth plus wages minus migration costs and education costs. If the worker stays, he pays $m(e_0|\theta)$ in education costs and receives $w^0(e_0)$ in wages; his consumption c_0 is equal to initial wealth plus wages minus education costs. A worker decides to migrate if c_1 is greater than c_0 and he can afford migration costs (if there are financial constraints).

Finally, it is worth discussing how we model the constraints agents face. When there are perfect credit markets, we assume that individuals can borrow against (future) wages to cover the costs of education and migration. Therefore, choices are only restricted by the lifetime budget constraint. When there are no credit markets available, agents' choices are wealth-constrained; they have to pay education and migration costs out of their wealth. We denote the educational choices by e^* when there are perfect credit markets and by e^{**} when there are financial constraints.

4.1 Perfect Credit Markets

We first consider the case in which education is determined endogenously and there are perfect credit markets to finance migration and education decisions.

4.1.1 Consumer Problem

With perfect credit markets, agents' choices are restricted only by the lifetime budget constraint:

$$c + m(e|\theta) + j\ M \leq a + w^j(e).$$

The consumer problem is given by:

$$\max_{j,e_j \geq 0} \; a + w^j\left(e_j\right) - m\left(e_j|\theta\right) - j\; M. \tag{7}$$

The (interior) solution of (7) is characterized by:

$$w_e^j\left(e_j^*\right) = m_e\left(e_j^*|\theta\right), \tag{8}$$

$$c_j^* = a + w^j\left(e_j^*\right) - m\left(e_j^*|\theta\right) - j\; M. \tag{9}$$

$$j^* = 1 \Leftrightarrow B^* \equiv c_1^* - c_0^* \geq 0, \tag{10}$$

where e_j^* determines the optimal level of education (if the worker decides to work) in country j when education is determined endogenously and there are perfect credit markets.

For each pair (a, θ), the system (8)-(10) determines all relevant variables in the model. In particular, equation (10) determines whether an individual migrates or not.

4.1.2 Selection

The literature on the selection of migrants takes the education distribution in the sending country as exogenous and analyzes how workers sort into the source and destination economies based on the returns to their characteristics. The literature overlooks that educational choices of migrants depend on the education premium in the destination country. If the education premium is higher in the source country, then workers who decide to migrate invest less in education than if they had stayed.

The following lemma states that migrant workers invests less in education than if they had stayed.

Lemma 1 *Assume $\phi_e^0(e) > \phi_e^1(e)$ for all $e \geq 0$. Then, $e_0^* > e_1^*$ for all migrants.*

Proof. *Given (2), the assumption that $\phi_e^0(e) > \phi_e^1(e)$ for all $e \geq 0$ implies $w_e^0(e) > w_e^1(e)$ for all $e \geq 0$. Given $\frac{\partial}{\partial e}\left(\frac{w_e^j}{m_e}\right) < 0$, equation (8) implies $e_0^* > e_1^*$.* ■

Figure (1) is useful in analyzing the selection of migrants. When there are perfect credit markets, education does not depend on initial wealth. Therefore, we can fully characterize the educational distribution of migrants and non-migrants by graphing the educational choices as a function of the skill parameter θ. We assume that the education premium is higher in the home country. An analogous result is true for the alternative case.

$$\phi_e^0 > \phi_e^1 \text{ for all } e > 0 \Rightarrow \frac{\partial B^*}{\partial \theta} < 0.$$

The result follows from lemma 1.[8] Let θ' define the threshold such that workers with skill above θ' migrate. The education of migrants is given by the curve labeled e_1 while the education of non-migrants is given by e_0. The curve e_1 is always below e_0 suggesting that, because the education premium in the destination country is lower, migrants invest less in education than if they had stayed.

4.2 Financial Constraints

We now turn to the consumer problem when there is no credit market to finance agents' choices. Since agents have no access to credit, their choices are wealth-constrained.

4.2.1 Consumer Problem

Individuals choose how to allocate their resources among educational costs and the costs of migration:[9]

$$m\left(e_j|\theta\right) + j\ M\left(e_1\right) \leq a. \tag{11}$$

After having incurred such costs, they spend the available income (wages plus the remaining wealth) to finance consumption:

$$c_j = a - m\left(e_j|\theta\right) - j\ M\left(e_1\right) + w_j\left(e\right). \tag{12}$$

Thus, the optimum choice of an individual is represented by the following problem:

$$\max_{j, e_j \geq 0}\ a - m\left(e_j|\theta\right) - j\ M\left(e_1\right) + w^j\left(e_j\right)\ \text{ s.t. }\ m\left(e_j|\theta\right) + j\ M\left(e_1\right) \leq a.$$

The (interior) solution is given by the following system of equations:[10]

$$w_e^j\left(e_j^{**}\right) = \left(1 + \lambda_j^{**}\right)\left(m_e\left(e_j^{**}|\theta\right) + j^{**} M_e\left(e_1^{**}\right)\right), \tag{13}$$

[8] Differentiating (10) with respect to θ and using the Envelope Theorem, we get:

$$\frac{\partial B^*}{\partial \theta} = -\left[m_\theta\left(e_1^*|\theta\right) - m_\theta\left(e_0^*|\theta\right)\right].$$

The assumption that $m_{e\theta} < 0$ together with $e_0^* > e_1^*$ (from lemma 1) imply that $m_\theta\left(e_1^*|\theta\right) > m_\theta\left(e_0^*|\theta\right)$.

[9] To simplify the illustration, we assume that agents cannot borrow to cover migration costs. It is easy to extend the model to include the possibility that agents are allowed to borrow up to a fraction of future wages.

[10] For the sake of simplification, we focus on the interior solution, ignoring the constraints $e_j \geq 0$. Therefore, we need to address this issue. The condition $e_1 \geq 0$ clearly binds for those individuals with $a \leq M$. We deal with this possibility by adding a condition $a > M$ in equation (16) for those choosing to migrate, i.e., $j^{**} = 1$.

$$\lambda_j^{**}\left(a - m\left(e_j^{**}|\theta\right) - j^{**}M\left(e_1^{**}\right)\right) = 0, \lambda_j^{**} \geq 0, \tag{14}$$

$$c_j^{**} = a + w^j\left(e_j^{**}\right) - m\left(e_j^{**}|\theta\right) - j^{**}\ M\left(e_1^{**}\right), \tag{15}$$

$$j^{**} = 1 \iff B^{**} \equiv c_1^{**} - c_0^{**} \geq 0 \text{ and } a > M\left(e_1^{**}\right), \tag{16}$$

where λ_j^{**} is the multiplier associated with (11) and e_j^{**} is the optimal level of education (if the worker decides to work) in country j when education is determined endogenously and there are financial constraints.

B^{**} is the net benefit of migration and workers migrate if $B^{**} \geq 0$ and they can afford migration costs. The derivative of B^{**} with respect to wealth for those with $a > M\left(e_1^{**}\right)$ is given by:[11]

$$\left.\frac{\partial B^{**}}{\partial a}\right|_{\theta, a>M} = \frac{\gamma\phi_e^1\left(e_1^{**}\right)}{m_e\left(e_1^{**}|\theta\right) + M_e\left(e_1^{**}\right)} - \frac{\gamma\phi_e^0\left(e_0^{**}\right)}{m_e\left(e_0^{**}|\theta\right)}. \tag{18}$$

4.2.2 Selection

We now analyze the effect of financial constraints on the selection of migrants. To focus on the impacts of financial constraints, we assume that (1) the education premium is the same in the two countries – i.e., $\phi_e^1(e) = \phi_e^0(e) = \phi_e(e)$ for all $e \geq 0$; (2) migrant costs are the same for all workers, $M_e = 0$ for all $e \geq 0$ and (3) the migration premium is positive, $w^1(0) - w^0(0) - M > 0$.

Under these assumptions, all workers would choose migrate if they could. However, individuals with wealth smaller than M cannot afford migration costs and remain in the home country. Individuals with wealth greater than M migrate. We analyze next the educational choices of stayers and migrants.

Figure (2) illustrates the education choice as a function of initial wealth (for a given level of skill). The level of wealth $\bar{a}$ corresponds to the threshold above which individuals migrate. The figure shows that migrants are wealthier than non-migrants, suggesting that migrants might be positively selected on

[11] From (14) we get:

$$\frac{\partial e_j^{**}}{\partial a} = \begin{cases} \frac{1}{m_e\left(e_j^{**}|\theta\right)}, & \text{if } \lambda_j^{**} > 0; \\ 0, & \text{if } \lambda_j^{**} = 0. \end{cases} \tag{17}$$

Differentiating (16) with respect to a and using (13) and (17), we have:

$$\begin{aligned}
\left.\frac{\partial B^{**}}{\partial a}\right|_{\theta, a>M} &= \left[\gamma\phi_e^1(e_1^{**}) - m_e(e_1^{**}|\theta)\right]\frac{\partial e_1^{**}}{\partial a} - \left[\gamma\phi_e^0(e_0^{**}) - m_e(e_0^{**}|\theta)\right]\frac{\partial e_0^{**}}{\partial a} \\
&= \lambda_1^{**} m_e(e_1^{**}|\theta)\frac{\partial e_1^{**}}{\partial a} - \lambda_0^{**} m_e(e_0^{**}|\theta)\frac{\partial e_0^{**}}{\partial a} \\
&= \lambda_1^{**} - \lambda_0^{**} = \frac{\gamma\phi_e^1\left(e_1^{**}\right)}{m_e\left(e_1^{**}|\theta\right)} - \frac{\gamma\phi_e^0\left(e_0^{**}\right)}{m_e\left(e_0^{**}|\theta\right)}.
\end{aligned}$$

observables – i.e., migrants might be on average more educated than non-migrants.

Although migrants are wealthier than non-migrants, migrants have to pay migration costs and are left with $a - M$ to invest in education. Figure (2) shows that the first migrant has less education than the last stayer. This effect suggests migrants are negatively selected on observables; they invest less in education because of migration costs. The two effects have opposite signs and it is unclear which effect dominates. We can show, however, that the first effect dominates and migrants are positively selected if workers with initial wealth M are willing to migrate.

Assume that workers with wealth M are willing to migrate. We have shown that the benefit of migration is increasing in wealth and therefore any worker with wealth greater than M is willing to migrate – i.e., $\overline{a} = M$. Individuals with wealth smaller than M cannot afford migration costs and therefore do not migrate. The wealth distribution among non-migrants is the wealth distribution truncated from above at M. The wealth distribution among migrants is the wealth distribution truncated from below at M. Migrants have to pay migration costs M. Thus, the net wealth of a migrant is $a - M$. This is the amount available for investing in education. Define the net wealth distribution among migrants as the wealth distribution among migrants net of migration costs – i.e., the original wealth distributed shifted to the left by M.

Given our assumption that the education premium is the same in the two countries, a migrant with wealth $a+M$ invests the same amount in education as a non-migrant with wealth a. Thus, migrants are more educated than non-migrants if migrants are, net of migration costs, wealthier than non-migrants. In other words, migrants are positively selected if the net wealth distribution (net of migration costs) among migrants first-order stochastically dominates the wealth distribution among non-migrants. Notice that there is no selection on unobservables if the distribution of skill and the distribution of initial wealth are independent. Finally, we can show that the selection on observables is decreasing in the size of migration costs M if the mass of probability around M is small. Migrants have to pay higher migration costs and invest less in education because they have fewer resources.

There results are summarized in the following proposition.

Proposition 2 *Suppose that all individuals with wealth M are willing to migrate and that the education premium is the same in the source and destination countries, i.e., $\gamma\phi^1(0) - M > \gamma\phi^0\left(e_0^{**}\left(M,\overline{\theta}\right)\right) - m\left(e_0^{**}\left(M,\overline{\theta}\right)|\overline{\theta}\right)$ and $\phi_e^1(e) = \phi_e^0(e) = \phi_e(e)$ for all $e \geq 0$. Then, migrants are positively selected on observables if the distribution of wealth among migrants (shifted to the left by M) first-order stochastically dominates the distribution of wealth among non-migrants. There is no selection on unobservables if the distribution of skill and the distribution of initial wealth are independent. The selection on observables is decreasing in M if the mass of probability around M is small.*

Proof. *see appendix.* ■

5 Empirical Implications

5.1 Financial Constraints and Positive Selection

In this section, we discuss one reason why the predictions of the Roy model might be rejected in the data: credit constraints.[12] The usual approach to testing the model's predictions is to compare the wage or educational distribution of immigrants to the distribution of residents (Chiquiar and Hanson 2005; Moraga 2008).[13] A simpler test involves comparing the averages of the two distributions (Gabriel and Schmitz 1995). To simplify the illustration, we consider this test.

We can use the model laid out in the paper to compare the average education of stayers and migrants under perfect credit markets and when there are financial constraints. Given equations (8) and (13), we can write:

$$e_i = e_0^* (\theta_i) (1 - I_i) + e_1^* (\theta_i) I_i + f (a_i, \theta_i, I_i), \tag{19}$$

where $e_j^* (.)$ gives the optimal unconstrained education – i.e., if there are no financial constraints – when the individual decides to work in country j, $I_i = 1$ if the individual migrates and $f (.)$ captures the deviations of education from $e_j^* (.)$ if there are financial constraints. Notice that $f (a_i, \theta_i, I_i) = 0$ if there are perfect credit markets.

First, we analyze the case of perfect credit markets. The Roy model predicts that migrants are negatively self-selected on observables if the return to schooling is higher in the source country than in the destination country. The difference in the average education of migrants and stayers can be calculated from (19):

$$E [e|I = 1] - E [e|I = 0] = E [e_1^*|I = 1] - E [e_0^*|I = 0]$$

since $f (a, \theta, I) = 0$. We showed in Section 4.1.2 that – under perfect credit markets – $E [e_1^*|I = 1] < E [e_0^*|I = 0]$ if the education premium is higher in the source country. Thus, the difference in the average education of migrants and stayers provides a simple test of the Roy model if there are perfect credit markets.[14]

[12] This hypothesis had already been suggested by other authors (Chiquiar and Hanson 2005; Orrenius and Zavodny 2005; Mckenzie and Rapoport 2007).

[13] The articles differ in the procedure used to calculate the wage distribution of immigrants. Chiquiar and Hanson (2005) compute the counterfactual wage densities that Mexican immigrants would have obtained were they paid according to skill prices in Mexico. Moraga (2008) calculates the wage density of immigrants using their wages in Mexico before they emigrated. See Moraga (2008) for a discussion.

[14] Notice that the predictions about the selectivity of migrants are the same if education is endogenously or exogenously determined.

If, however, there are financial constraints, then the predictions of the Roy model may not hold. Individuals with few resources cannot afford migration costs and invest little in education, which might lead to positive selection. Formally, the difference in the average education of migrants and stayers would be given by:

$$E[e|I=1] - E[e|I=0] = E[e_1^*|I=1] - E[e_0^*|I=0] + \\ + E[f(a,\theta,I)|I=1] - E[f(a,\theta,I)|I=0],$$

where the Roy model makes predictions about the first term, $E[e_1^*|I=1] - E[e_0^*|I=0]$. The financial constraints imply that $E[f(a,\theta,I)|I=1] > E[f(a,\theta,I)|I=0]$, in which case we may observe positive selection when the Roy model would predict negative selection.

5.2 Intermediate Selection

The returns to schooling in Mexico are much higher than the returns to schooling in the U.S. (Chiquiar and Hanson 2005). The Roy model predicts that Mexican immigrants in the U.S. would be negatively selected. However, there is a good deal of evidence showing that Mexican immigrants are disproportionately drawn from the middle of the wage distribution (Orrenius and Zavodny 2005; Chiquiar and Hanson 2005; Mckenzie and Rapoport 2007; Moraga 2008).

In this section, we argue that the combination of financial constraints with a higher education premium in the source country can generate intermediate selection on observables. It is useful to think first about the case in which there are perfect credit markets. All workers who migrate receive the migration premium. However, the benefit of migration is decreasing in education as the education premium is higher in the sending country. Indeed, we showed in section 4.1.2 that in this setting migrants are negatively selected on observables and on unobservables. Individuals' choices are, however, constrained when they cannot borrow to finance their investment decisions. In particular, individuals with wealth below M cannot migrate and individuals with intermediate levels of wealth have to trade-off migration costs and investments in education. In section 4.2.2, we showed that under some conditions credit constraints generate positively selected migrants because wealthier individuals – who can afford larger investments in education – are more likely to migrate.

Figure (3) is useful in illustrating how the combination of financial constraints with a higher education premium in the source country can generate intermediate selection on observables. It shows the educational and migration choices of workers with different levels of initial wealth, holding the skill level θ constant. Workers from the bottom of the wealth distribution – with initial wealth below M – cannot afford migration

costs and remain in the sending country. Because they have small initial wealth, they make small investments in education. Workers from the top of the wealth distribution – with wealth above $\max\{m(e_1^*)+M, m(e_0^*)\}$ – are not wealth constrained. They choose to remain in the country of origin as long as $w^1(e_1^*) - m(e_1^*|\theta) - M < w^1(e_0^*) - m(e_0^*|\theta)$. They make large investments in education. Workers with intermediate levels of wealth between a_0 and a_1 migrate. The small initial wealth prevents them from making large investments in education and they prefer to migrate and receive the migration premium than to stay and investment more in education.

Figure (3) presents a simple case in which all workers with wealth between a_0 and a_1 migrate. Although we do know that workers with wealth below M and workers who are unconstrained stay in the source country, it is harder to determine which workers, among the individuals with intermediate levels of wealth, choose to migrate. This can be seen from the derivative of the benefit of migration with respect to wealth:[15]

$$\left.\frac{\partial B^{**}}{\partial a}\right|_{\theta, a>M} = \left[\frac{\gamma\phi_e^1(e_1^{**})}{m_e(e_1^{**}|\theta)} - \frac{\gamma\phi_e^1(e_0^{**})}{m_e(e_0^{**}|\theta)}\right] + \left[\frac{\gamma\phi_e^1(e_0^{**})}{m_e(e_0^{**}|\theta)} - \frac{\gamma\phi_e^0(e_0^{**})}{m_e(e_0^{**}|\theta)}\right].$$

We have discussed in the previous section the intuition for why the first term is positive. Workers who migrate pay migration costs and therefore invest less in education than if they had stayed. Because of decreasing marginal returns, the (net) return to one dollar invested in education is higher if the worker migrates than if he stays. The second term is, however, negative. Wealthier workers can afford larger investments in education and the education premium is higher in the sending country. Therefore, the two terms have opposite signs and one cannot determine the sign of the derivative without further assumptions.

6 Policy Implications

6.1 Immigration Policy and the Selection of Migrants

Governments have preferences over the number of immigrants who enter their countries and the skill-composition of the immigrant population. Policy makers have two policy instruments available to reach their goals. They can affect the costs of entering the country as an illegal immigrant and the costs of entering the country as a legal immigrant. Increasing border control, for example, is used to curb illegal immigration. Indeed, Cornelius (2001) reports that the budget more than tripled (to US$ 5.5 billion) while the Border Patrol more than doubled in size in the period of ten years starting in 1993. Alternatively, governments control who enters the countries as legal immigrants through screening procedures as employment-based preference categories. The selection framework can be used to evaluate which policies are more effective in

[15] We assume $M_e = 0$.

reaching the policy makers' goals.

The traditional literature on selection predicts that skill-biased changes in migration costs affect the selectivity of migrants but that an uniform change in migration costs – i.e., a skill-neutral change in migration costs – has no effect on the selectivity of migrants. Indeed, we showed in section 3.2.2 that – under perfect credit markets – migration costs affect selectivity only through $M_e(e)$. However, this prediction does not hold if agents cannot borrow to finance their investment decisions.

Skill-neutral changes in migration costs affect migrants' selectivity if there are credit constraints. Let us consider the case in which migration costs are independent of the level of education, $M_e(e) = 0$. The total effect of a raise in migration costs is a priori ambiguous. On one hand, some workers who used to migrate can no longer afford the migration costs and there is an increase in the (gross) average wealth among migrants (this also increases the average education among stayers). On the other hand, migrants have to pay higher migration costs and therefore have fewer resources to invest in education. However, one can show that under some conditions the second effect dominates and the selectivity bias in decreasing in the migration costs. As stated in Proposition 2, an increase in migration costs reduces migrants' selectivity bias if the mass of probability around M is small.

6.2 Illegal Immigration

As concerns about the impacts of immigration have increased, governments in developed countries have adopted screening policies in an attempt to gain control over which individuals enter the country to work. Nevertheless, there is a large fraction of immigrants who enter these countries illegally.

In this section, we use our framework to compare the educational distribution among stayers, legal and illegal immigrants. Our analysis suggests that it may be important to separately analyze legal and illegal immigrants. According to Hanson (2006), legal and illegal immigrants face different migration costs as well as different returns to skill:

> "While legal migrants face entry costs associated with queues in obtaining visas, illegal migrants face costs associated with evading immigration authorities. Once in the receiving country, the risk of detection may make some employers unwilling to hire illegal migrants, limiting their occupational prospects and reducing the returns to skill they perceive. Variation in migration costs and in receiving-country wage profiles between legal and illegal migration suggest the characteristics of illegal migrants may differ from those of legal migrants." (Hanson 2006, p. 872)

We consider a setting where illegal and legal migration are treated as two different technologies. An illegal immigrant with education e pays migration costs $M^I(e)$ and receives wages $w^{1,I}(e)$. A legal migrant

with the same level of education pays migration costs $M^L(e)$ and receives wages $w^{1,L}(e)$. We assume that illegal migration costs are the same for all levels of education – i.e., $M^I(e) = \mu^I$ – corresponding to the costs of evading immigration authorities. Legal migration costs, on the other hand, are assumed to be decreasing in education, $M^L(e) = \mu^L - \delta e$ with $\delta > 0$, representing the bias in employment-based visas toward educated workers. We analyze the case in which $\mu^L > \mu^I$ and $w_e^{1,I}(e) < w_e^{1,L}(e)$ for all $e \geq 0$.

In what follows, we analyze the educational choices of illegal and legal migrants for the three cases: exogenous education, endogenous education with perfect credit markets and endogenous education with credit constraints.

6.2.1 Illegal migration with exogenous education: the selection effect

We first analyze the case in which education is exogenous with respect to the migration decision. To simplify the exposition, we assume that $w^1(e) = w^{1,I}(e) = w^{1,L}(e)$ for all $e \geq 0$. It is easy to see that, with exogenous educational choices, the assumption that $w_e^{1,I}(e) < w_e^{1,L}(e)$ for all $e \geq 0$ is equivalent to assuming that legal migration costs are decreasing in education.

The distribution of education in the source economy follows from the distribution of ability according to (4). The migration decision is given by (5), where

$$M(e) = \min\left\{M^I(e), M^L(e)\right\}.$$

Figure (4) presents the shape of the migration cost $M(e)$.

In this case, the less educated migrants enter the receiving country as illegal immigrants. Let $\overline{e} = \frac{\mu^L - \mu^I}{\delta}$ be the education level at which workers are indifferent between being illegal or legal migrants. Workers with education level above $\overline{e}$ minimize their migration costs if they migrate legally while workers with education level lower than $\overline{e}$ minimize their migration costs if they migrate legally. The workers who decide to migrate self-select into two different groups. The less educated migrants enter the receiving country as illegal immigrants while the most educated enter as legal immigrants.

6.2.2 Illegal migration with endogenous education: the incentive effect

We now consider the case in which that the educational choices are endogenous and there are perfect credit markets. Agents have to choose between entering the receiving country as illegal immigrants, entering as legal immigrants or staying in the sending country and decide how much to invest in education. We assume that $w_e^{1,I}(e) < w_e^{1,L}(e)$.

Based on (9), we can define the optimal levels of consumption of an individual with wealth a and ability

θ as:

$$\begin{aligned} c_0^* &= \max_{e_0 \geq 0} a + w^0(e_0) - m(e_0|\theta), \\ c_{1,k}^* &= \max_{e_{1,k} \geq 0} a + w^{1,k}(e_{1,k}) - m(e_{1,k}|\theta) - M^k(e_{1,k}), \end{aligned}$$

where $k \in \{L, I\}$ is the migration channel (legal L or illegal I). Substituting $M^k(e)$ in the equations above, we have that the optimal education choices are given by

$$w_e^0(e_0^*) = m_e(e_0^*|\theta), \tag{20}$$

$$w_e^{1,L}\left(e_{1,L}^*\right) = m_e\left(e_{1,L}^*|\theta\right) - \delta, \tag{21}$$

$$w_e^{1,I}\left(e_{1,I}^*\right) = m_e\left(e_{1,I}^*|\theta\right). \tag{22}$$

A worker enters the receiving country as a legal immigrant if $c_{1,L}^* \geq \max\left\{c_0^*, c_{1,I}^*\right\}$ and as an illegal immigrant if $c_{1,I}^* \geq \max\left\{c_0^*, c_{1,L}^*\right\}$.

The equations (21) and (22) imply that legal migrants are more educated than illegal migrants – i.e., $e_{1,L}^* > e_{1,I}^*$. Legal migrants invest more in education than illegal migrants because 1) legal migration costs are decreasing in education and 2) the education premium is higher for legal migrants – i.e., $w_e^{1,L}(e) > w_e^{1,I}(e)$ for all $e \geq 0$.

The analysis stresses the importance of separately analyzing legal and illegal immigrants. Equations (20) and (21) suggest that legal immigrants are more educated than stayers if $w_e^{1,L}(e) \geq w_e^0(e)$ for all $e \geq 0$. On the other hand, illegal immigrants are less educated than stayers if $w_e^0(e) > w_e^{1,I}(e)$ for all $e \geq 0$. Under these conditions, legal migrants are positively selected while illegal migrants are negatively selected.

6.2.3 Illegal migration with endogenous education with financial constraint

In this section, we assume that there are credit constraints such that agents cannot borrow. In the previous sections, we showed how the selection and incentive effects result in legal immigrants being more educated than illegal immigrants. These results assumed perfect credit markets and consequently educational choices did not depend on wealth. Here we adopt a different approach. We hold the skill level θ constant and analyze the educational and migration choices of agents with different initial wealth.

We show that wealthier agents are more likely to enter the receiving country as legal immigrants. Individuals with higher initial wealth can also afford larger investments in education. As a consequence, legal migrants are more educated than illegal migrants (even if we hold the skill level constant).

Define $\overline{e}$ as the level of education which makes individuals indifferent between entering the receiving

country as illegal or legal migrants – i.e., $w^{1,L}(\overline{e}) - M^{L}(\overline{e}) = w^{1,I}(\overline{e}) - M^{I}(\overline{e})$. Let $\overline{a}^{L}$ be the wealth level which allows a legal migrant to obtain $\overline{e}$ – i.e., $\overline{a}^{L} = m(\overline{e}|\theta) + M^{L}(\overline{e})$. Agents with wealth above $\overline{a}^{L}$ can afford education $\overline{e}$ and therefore minimizes migration costs by entering the receiving country as a legal immigrant – moreover, the returns to skill are higher if one enters as a legal immigrant. Agents with wealth below $\overline{a}^{L}$ are better off by migrating as illegal immigrants. Figure (5) shows the educational choices of illegal and legal migrants.

In summary, our analysis suggests that more attention should be paid to the distinction between legal and illegal immigrants. We show that legal migrants tend to be more educated than illegal immigrants and it may be possible that legal migrants are positively selected while illegal migrants are negatively selected.

7 Conclusion

This paper studies the effect of financial constraints and endogenous educational choices on migrants' selectivity. We argue that the combination of these two ingredients changes substantially the predictions of the Roy model, offering a way of reconciling the empirical literature with the theory. In particular, we show that financial constraints explain why workers from the lower half of the distribution of education are underrepresented among migrants and state conditions under which the model predicts intermediate selection of migrants.

The framework is also used to study the consequences of financial constraints for migration policies. The model implies that under credit constraints skill-neutral migration policies affect the selectivity of migrants. Finally, we show that legal migrants tend to be more educated than illegal immigrants and that under some conditions legal migrants are positively selected while illegal migrants are negatively selected.

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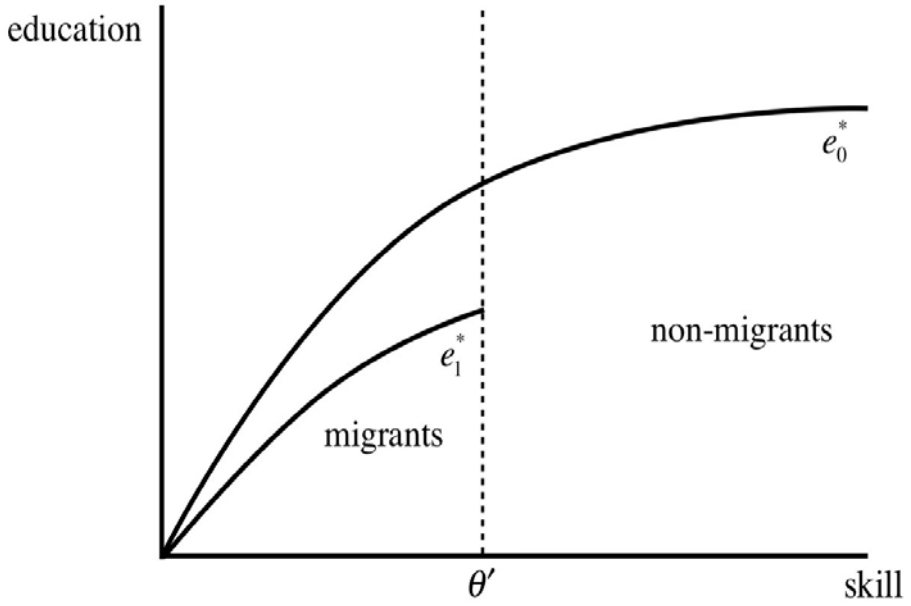

Figure 1: Selection of migrants and educational choices

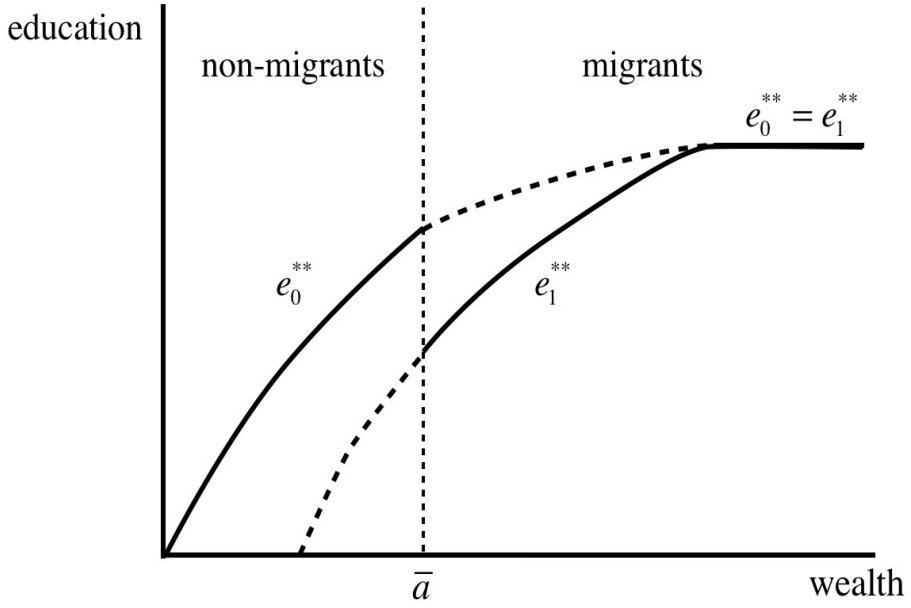

Figure 2: Optimal Education, Migration Choices and Wealth

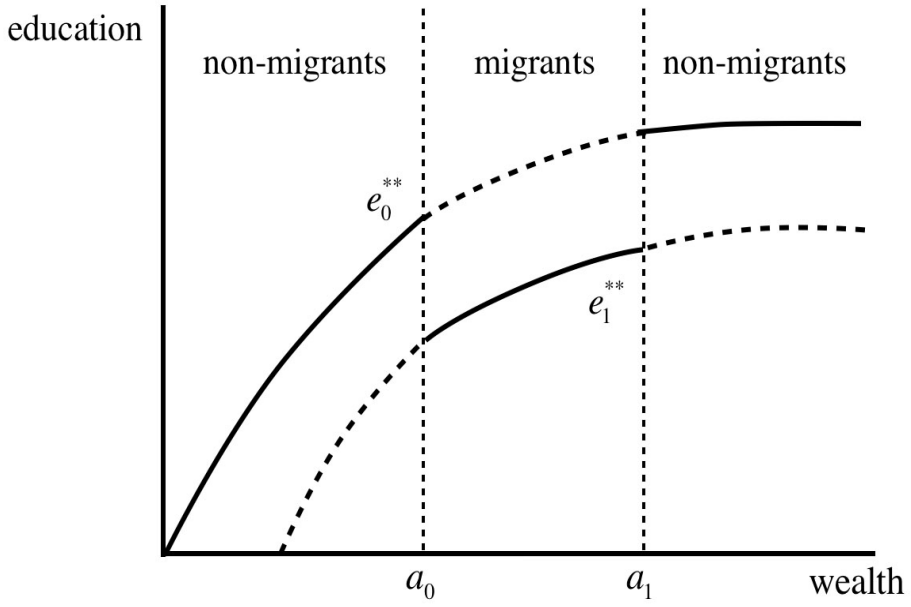

Figure 3: Intermediate Selection

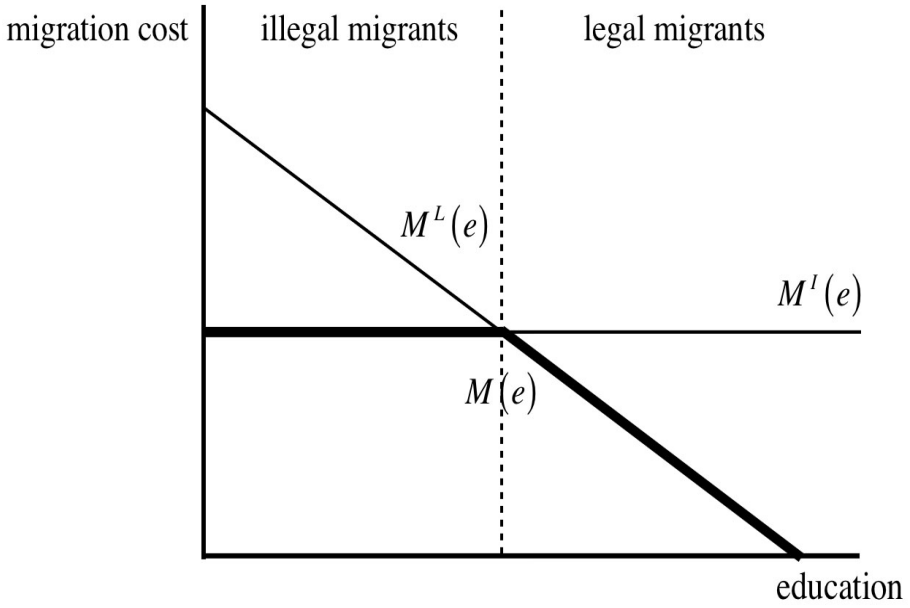

Figure 4: Migration Costs and Education

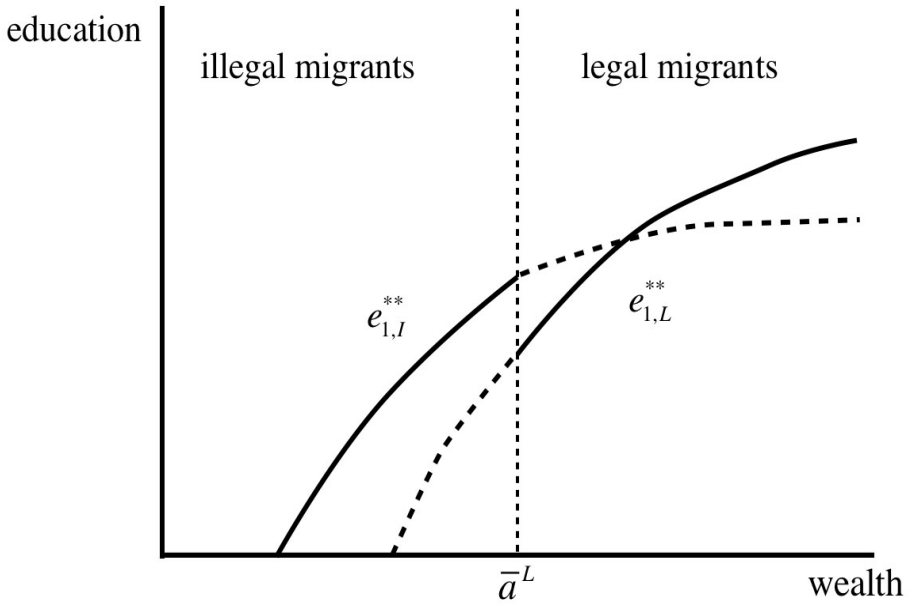

Figure 5: Illegal and Legal Migration, Education and Wealth

Appendix

Proof. [Proof (Proposition 2)] Assume that $\phi_e^1(e) = \phi_e^0(e) = \phi_e(e)$ for all $e \geq 0$ and $\gamma\phi^1(0) - M > \gamma\phi^0\left(e_0^{**}\left(M,\overline{\theta}\right)\right) - m\left(e_0^{**}\left(M,\overline{\theta}\right)|\overline{\theta}\right)$. Let $e_j(a,\theta)$ denote the optimal education of a worker with initial wealth a and skill θ who works in country j. The first assumption implies that

$$e_1(a+M,\theta) = e_0(a,\theta).$$

The second assumption implies that $B^{**} > 0$ for any individual with wealth above M. Thus, $\overline{a} = M$.

The average education among non-migrants is given by:

$$\begin{aligned} E[e_0|I=0] &= \int_{\underline{\theta}}^{\overline{\theta}}\int_0^M e_0(a,\theta)\frac{f(a)}{F(M)}f(\theta)\,da d\theta = \\ &= \int_{\underline{\theta}}^{\overline{\theta}}\int_0^\infty e_0(a,\theta)\frac{f(a)\,I\{a<M\}}{F(M)}f(\theta)\,da d\theta \end{aligned}$$

and the average education among migrants is:

$$\begin{aligned} E[e_1|I=1] &= \int_{\underline{\theta}}^{\overline{\theta}}\int_M^\infty e_1(a,\theta)\frac{f(a)}{1-F(M)}f(\theta)\,da d\theta = \\ &= \int_{\underline{\theta}}^{\overline{\theta}}\int_0^\infty e_0(a,\theta)\frac{f(a+M)}{1-F(M)}f(\theta)\,da d\theta. \end{aligned}$$

Thus, we can write:

$$E[e_1|I=1] - E[e_0|I=0] = \int_{\underline{\theta}}^{\overline{\theta}}\int_0^\infty e_0(a,\theta)\left[\frac{f(a+M)}{1-F(M)} - \frac{f(a)\,I\{a<M\}}{F(M)}\right]f(\theta)\,da d\theta.$$

Define

$$\begin{aligned} G_1(\widetilde{a}) &= \int_0^{\widetilde{a}}\frac{f(a+M)}{1-F(M)}da, \\ G_2(\widetilde{a}) &= \int_0^{\widetilde{a}}\frac{f(a)\,I\{a<M\}}{F(M)}da. \end{aligned}$$

We have that $e(a,\theta)$ is nondecreasing in a. For any θ, the term between brackets is nonnegative – and consequently $E[e_1|I=1] \geq E[e_0|I=0]$ – if $G_1(.)$ first-order stochastically dominates $G_2(.)$.

Finally, we show that the selection bias is decreasing in M if $f(M) \approx 0$. Differentiating with respect to

M, we have:

$$\begin{aligned}
\frac{\partial E\left[e_0|I=0\right]}{\partial M} &= \int_{\underline{\theta}}^{\overline{\theta}}\left[\left(e_0\left(M,\theta\right)-E\left[e_0|I=0,\theta\right]\right)\frac{f\left(M\right)}{F\left(M\right)}\right]f\left(\theta\right)d\theta, \\
\frac{\partial E\left[e_1|I=1\right]}{\partial M} &= \int_{\underline{\theta}}^{\overline{\theta}}\left[E\left[e_1|I=1,\theta\right]\frac{f\left(M\right)}{1-F\left(M\right)}\right. \\
&\qquad \left.-\int_M^{\infty}\frac{\partial e_0}{\partial a}\left(a-M,\theta\right)\frac{f\left(a\right)}{1-F\left(M\right)}da\right]f\left(\theta\right)d\theta,
\end{aligned}$$

where we have used the fact that $e_0\left(0,\theta\right)=0$. Assuming $f\left(M\right)\approx 0$, we get:

$$\begin{aligned}
\frac{\partial E\left[e_0|I=0\right]}{\partial M} &\approx 0, \\
\frac{\partial E\left[e_1|I=1\right]}{\partial M} &\approx -\int_{\underline{\theta}}^{\overline{\theta}}\left[\int_M^{\infty}\frac{\partial e_0}{\partial a}\left(a-M,\theta\right)\frac{f\left(a\right)}{1-F\left(M\right)}da\right]f\left(\theta\right)d\theta<0.
\end{aligned}$$

■