Public financing of tertiary education: Does the brain drain exacerbate the reverse distribution of income?*

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Abstract

In this paper I study how the brain drain affects a society's willingness to finance tertiary education and its distribution of income. I consider an economy where agents are heterogeneous in ability and public policies are chosen by majority voting. The model shows that if the brain drain increases average productivity in the source economy, then the income gap between rich and poor households decreases while, income dispersion among skilled households increases. Besides, the model highlights the possibility that the brain drain be Pareto improving in relatively poor economies.

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Keywords: Education; Brain drain; Income distribution; Majority voting equilibrium.

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1 Motivation

In most countries individuals not acquiring tertiary education help finance the cost of this type of education through income tax. Empirical evidence shows that students from high income families are more likely to attend university (Hansen (1970), Radner and Miller (1970), Blanden and Machin (2004)). This implies redistribution of resources from the poor to the rich. A natural question then arises: why should a population be required to help finance the cost of tertiary education when only the wealthiest segment of the society benefits from it? Beviá and Iturbe-Ormaetxe (2001) suggest that individuals with high qualification that benefit from public tertiary education will earn more income and, hence, will pay more taxes. Poor households anticipate that their children will benefit from it in the future and, hence, agree to subsidize education for the wealthiest segment of the population.[1]

The possibility that tertiary educated agents work abroad clearly affects the argument outlined above. Following the terminology of Beine et al. (2001), the possibility of migrating entails a brain effect and a drain effect. Regarding the former effect, migration prospects increase the return to human capital, what may increase the size of the skilled population in the source country, so that fiscal revenue and transfers may rise at some time in the future. On the other hand, the drain effect refers to the loss of fiscal revenue caused by skilled migration. Poor households cannot benefit from the higher taxes that educated migrants would have paid, had they worked in the source economy. Thus, the drain effect exacerbates reverse distribution of resources from the poor to the rich. Therefore, it is not clear how migration prospects affect society's incentives to finance tertiary education.

In this paper I study to what extent a society agrees to subsidise tertiary education when skilled workers are allowed to migrate. I follow the argument of Beviá and Iturbe-Ormaetxe (2001) that there is a positive relationship between the perceived degree of redistribution of taxes among the society and the level of the subsidy that is allocated to tertiary education. The main difference with their model is that in this paper skilled migration is allowed. Households decide on the *composition* of the public budget by majority voting. They choose the level of the subsidy to tertiary education and the amount

[1] Johnson (1984), Fernandez and Rogerson (1995) and, Blankenau et al (2006) provide other type of explanations to this phenomenon.

of households' transfers. When households vote on the composition of public budget, they know that tertiary educated agents can migrate. I assume that migration is not certain, since the host country applies immigration controls by giving a limited number of working visas.

The model shows that even if the decisive voter benefits from the subsidy to tertiary education, migration prospects reduce the level of public financing of tertiary education. However, the reasons why the society reduces this subsidy depend on the magnitude of skilled migration.

The effects of international migration and remittances on the distribution of income in the source economy have been widely recognized in the literature. Most of the empirical and theoretical studies focus on the effect of unskilled migration and remittances on the development of rural areas (Taylor (1992), Docquier and Rapoport (2005), among others). Mountford (1997) is an exception. In an environment where education is privately financed, he shows that in the long run the brain drain may reduce the inequality in income distribution. In this paper I focus on the *interaction between the brain drain and the distribution of income across households* when tertiary education is subsidized. In particular, I address the following questions: which are the effects of a rise in the magnitude of the brain drain on income inequality? Are the effects of the brain drain on income distribution the same for any source economy, or the poorer is the economy, as measured by the international wage differential, the more vulnerable to the negative effects of the brain drain? Does the brain drain benefit skilled workers at the expense of unskilled workers, or is it possible that this kind of migration leads to a Pareto-superior outcome?

As I mentioned above, the brain drain entails two opposite effects, the brain effect and the drain effect. The model shows that the poorer the economy, the more likely is that the brain effect dominates the drain effect. When the brain effect dominates the drain effect, average productivity increases in the source economy, leading to a rise in households' transfers, thereby reducing the income gap between the poor and the rich households. Interestingly, the model highlights the possibility that while that income gap decreases, the dispersion of income *among skilled households increases*. These results imply that the effects the brain drain has on households' welfare vary within the population.

An important result of the model is that the brain drain may lead to a *Pareto-superior* outcome. This situation may arise when an increase in the magnitude of the brain drain reduces the subsidy to tertiary education and increases households' transfers, leading to a rise in poor households' lifetime income and, hence, improving their welfare. On the other hand, the fall in the subsidy reduces skilled household's welfare. However, this effect is offset by the rise in households' transfers and by the fact that more skilled households have access to higher incomes paid abroad, what makes skilled households better off as well.

The rest of the paper is organized as follows: In Section 2 I set out the model and present some preliminary results. In Section 3 I study the effects of migration prospects on the subsidy to tertiary education. Section 4 studies the relationship between the brain drain and the inequality of income distribution. In Section 5 I study the effects of the brain drain on the welfare of the source economy. In section 6 I conclude. Proofs are gathered in the Appendix.

2 Model

Consider a two-period economy with a continuum of households of mass 1. Each household is composed of one parent and one child. Both the parent and her child live two periods and I normalize the length of each period to one.

Parents are homogeneous in their productivity, or in their human capital endowments. They work in both periods and earn a wage equal to w. For simplicity I assume that agents take market wage rate as given, and that production function is linear in effective labor.

Children differ in their ability to learn. Each child has an ability a, where a is uniformly distributed on $[0, A]$. In the first period a child decides whether to get tertiary education or to work. Without tertiary education the child remains unskilled with wage w. If the child gets tertiary education, in the first period she studies and does not work. Acquiring tertiary education has a cost c. The government subsidizes tertiary education. The subsidy is e, with $e \in [0, 1]$, and it is decided by majority voting before education decisions take place. Therefore, a household whose child gets tertiary education pays $(1 - e)\, c$. In the second period, the child becomes skilled and works in a skilled job. I assume that firms match skilled workers' wage with their productivity. Thus, a skilled worker with productivity a earns a wage equal to wa.

Since I am interested in analyzing the effects of the brain drain on the distribution of income, I only allow skilled workers to migrate.[2] If a skilled worker with ability a migrates she earns a wage, net of tax and migration costs, equal to $w^F a$. I require that $w^F > w$, implying that all skilled agents want to migrate. Besides, I assume that the host country applies immigration controls. Hence, not all skilled workers can migrate. Under immigration controls there is a probability m of migrating, with $m \in [0, 1]$, which is independent of the number of workers who are eligible to migrate.

In both periods the government levies a tax on households' income. In the first period the government uses the tax revenue to finance transfers and to subsidize tertiary education. Each household receives a lump-sum transfer equal to b_1. In the second period the government uses the tax revenue to finance transfers. Households get a lump-sum transfer equal to b_2. I denote the tax rate by t. Let S denote the proportion of agents enrolled in tertiary education and $\widehat{a}$ the cutoff value above which individuals decide to get tertiary education. In the first period the government budget constraint is:

$$b_1 + ecS = t\left(w + (1 - S)\, w\right), \tag{1}$$

and in the second period it is:

$$b_2 = t\left(w + (1 - S)\, w + w\,(1 - m)\, E\left[a | a > \widehat{a}\right]\right), \tag{2}$$

where $E\left[a|a > \widehat{a}\right]$ is the average productivity of the skilled population and it is equal to:

$$E\left[a|a > \widehat{a}\right] = \int_{\widehat{a}}^{A} \frac{a}{A} da = \frac{A^2 - \widehat{a}^2}{2A}. \tag{3}$$

Consider a household whose child has ability a and does not acquire tertiary education. Let y_{1u} and y_{2u} denote the household's first and second-period disposable incomes, respectively. These incomes are equal to:

$$y_{ju} = 2\,(1 - t)\, w + b_j, \text{ with } j = \{1, 2\}. \tag{4}$$

[2] This assumption is in accordance with empirical evidence. Docquier et al (2005) show that in 2000 in poor and developing countries skilled migration rate was 7% while unskilled migration was 0.3%.

Both incomes are determined by parent and child's after-tax incomes and by household's transfers. Now, consider that the child acquires tertiary education. Let y_{1s} denote the first-period income. It is equal to:

$$y_{1s} = (1-t)\,w + b_1 - c\,(1-e)\,. \tag{5}$$

In this case, the child does not work in the first period, hence, y_{1s} is determined by the parent's income, the household's transfer and the educational cost net of the subsidy. In the second period the child works. Since I am concerned about the effect of the brain drain on the distribution of households' income, and since migration is not certain, then in the second period the expected income of a skilled household is:

$$y_{2s} = (1-t)\,w + w^e a + b_2, \tag{6}$$

where w^e is the expected wage, i.e. $(1-m)\,(1-t)\,w + mw^F$.

Households derive utility from their lifetime income. If the child does not get tertiary education, the utility of the household is:

$$u\,(y_{1u}, y_{2u}) = y_{1u} + \beta y_{2u}, \tag{7}$$

where the parameter β represents a discount factor. Finally, if the child gets tertiary education the expected utility of the household is:

$$u\,(y_{1s}, y_{2s}) = y_{1s} + \beta y_{2s}. \tag{8}$$

Summarizing, the timing of the model is the following: in the first period households decide the policy vector (e, b_1, b_2) by majority voting. Then, children decide whether to acquire tertiary education. In the second period migration takes place, agents work, pay taxes and households receive transfers. I solve the model backwards.

2.1 Education Decisions

Given a subsidy e, a child decides to acquire tertiary education if and only if the expected utility of a skilled household is higher than unskilled household's utility. That is, if and only if:

$$u\,(y_{1s}, y_{2s}) > u\,(y_{1u}, y_{2u}) \Leftrightarrow \tag{9}$$

$$a > \widehat{a}(e,m), \tag{10}$$

where:

$$\widehat{a}(e,m) = \frac{1+\beta}{\beta}\frac{(1-t)\,w}{w^e} + \frac{(1-e)\,c}{\beta w^e}. \tag{11}$$

This cutoff value divides the population into two groups: unskilled and skilled households. Note that $\widehat{a}(e,m)$ is a decreasing function of the subsidy. In particular, individuals with ability below $\widehat{a}(1,m)$ never acquire tertiary education. On the contrary, individuals with ability above $\widehat{a}(0,m)$ acquire tertiary education even when the subsidy is zero. Finally, the education decision of those children with abilities within the interval $[\widehat{a}(1,m), \widehat{a}(0,m)]$ depends on the value of the subsidy e. The higher is the subsidy, the more likely they become skilled.

It is also important to point out that $\widehat{a}(e,m)$ is negatively related with m. As m rises, $\widehat{a}(e,m)$ gets lower. That is, for a given subsidy, a rise in the probability of migrating m increases the expected return to tertiary education, what encourages more agents to become skilled, leading to a rise in the number of skilled agents. This is the brain effect.

I assume that $A > \widehat{a}(0,0)$. That is, even when the subsidy is zero and migration is not possible, at least the most able agent finds profitable to get tertiary education. Consider a subsidy e and a probability of migrating m, then the proportion of agents enrolled in tertiary education is equal to:

$$S = 1 - \frac{\widehat{a}(e,m)}{A}. \tag{12}$$

2.2 Political decisions of unskilled households

A household whose child does not get tertiary education chooses a policy vector (e, b_1, b_2) so as to maximize $u(y_{1u}, y_{2u})$ subject to the following constraints:

$$0 \leq e \leq 1. \tag{13}$$

$$b_1 = t\,(w + (1-S)\,w) - ecS \geqslant 0. \tag{14}$$

$$b_2 = t\,(w + (1-S)\,w + w\,(1-m)\,E\,[a|a > \widehat{a}(e,m)])\,. \tag{15}$$

Applying Kuhn-Tucker I obtain five possible solutions: one interior solution and four corner solutions. Each case is presented in the Appendix. Corner solutions correspond to two extreme cases: either tertiary education is completely publicly financed, i.e. $e_u = 1$, or it is completely privately financed, i.e. $e_u = 0$. Since I am interested in studying how changes in m affect the subsidy of tertiary education, I present the interior solution case, i.e. $e \in (0, 1)$ and $b_1 > 0$. In this case the optimal value of the subsidy is:

$$e_u(m) = \frac{w^e \left(\beta \widehat{a}(0, m)(t(1-m)w + w^e) - (1+\beta)tw - \beta w^e A\right)}{c(t(1-m)w + w^e) + w^e}. \tag{16}$$

In the Appendix I show that for a sufficiently small probability of migrating m, the condition below ensures that the optimal value of the subsidy is positive.

$$c > (1-t)^2 (\beta(A-1) - 1) w. \tag{17}$$

Condition (17) shows that when the cost of tertiary education is sufficiently high, unskilled households find convenient to help finance it. By subsidizing tertiary education the average productivity of the population increases, which in turn increases second-period transfers, leading to a rise in the second-period income of unskilled households. On the other hand, note that the numerator of Expression (16) is decreasing in m. In particular, whatever be the value of c, when m is equal to 1 the optimal value of e_u is zero. Unskilled households do not find profitable to finance tertiary education when the probability of migrating is extremely high.

The optimal value of e_u does not depend on the child's ability. Thereby, all households whose children do not acquire tertiary education choose the same subsidy. This subsidy induces the following indirect utility function:

$$VU(X) = \max_{\{e, b_1, b_2\}} \{2(1-t)w + b_1 + \beta(2(1-t)w + b_2)\}, \tag{18}$$

where X is a vector of parameters, i.e. $X = \left(w, w^F, m, c, t, \beta, A\right)$.

2.3 Political decisions of skilled households

Consider a household whose child has ability a. If the parent wants her child to acquire tertiary education, the parent maximizes the utility $u(y_{1s}, y_{2s})$, subject to restrictions (13), (14), (15) and the following restriction:

$$a > \widehat{a}(e, m). \tag{19}$$

This restriction ensures that the child gets tertiary education. The solution of the Kuhn-Tucker problem is in the Appendix. The optimal subsidy is:

$$e_s(m) = \frac{w^e \left(\beta \widehat{a}(0, m)\left(t(1-m)w + w^e\right) - (1+\beta) tw\right)}{c\left(t(1-m)w + w^e\right) + w^e}. \tag{20}$$

Once again, the optimal subsidy does not depend on the child's ability and, hence, all skilled households choose the same e_s. This subsidy induces the following indirect utility function:

$$VS(a, X) = \max_{\{e, b_1, b_2\}} \left\{(1-t)w + b_1 - c(1-e_s) + \beta\left((1-t)w(1+a) + b_2\right)\right\}. \tag{21}$$

In Section 2.1 above I mentioned that agents with abilities below the cutoff value $\widehat{a}(1, m)$ remain unskilled. Hence, their parents always choose the policy vector $(e_u(m), b_1(m)$ $, b_2(m))$ that maximizes $u(y_{1u}, y_{2u})$. On the contrary, parents of agents with abilities above $\widehat{a}(0, m)$ would prefer the policy vector $(e_s(m), b_1(m), b_2(m))$ that maximizes $u(y_{1s}, y_{2s})$ rather than any other feasible policy vector. The education decisions of agents with intermediate ability levels, i.e. with abilities in the interval $[\widehat{a}(1, m), \widehat{a}(0, m)]$, depend on the level of the subsidy. Therefore, their parents choose the policy vector that yields a higher level of utility. Then, the induced utility function of a household whose child has ability a, with $a \in [\widehat{a}(1, m), \widehat{a}(0, m)]$, is:

$$V(a, X) = \max\left\{VU(X), VS(a, X)\right\}. \tag{22}$$

2.4 Majority Voting Equilibrium

Let a^M denote the median of the distribution of a. The policy vector $\left(\widetilde{e}, \widetilde{b}_1, \widetilde{b}_2\right)$ is said to be an equilibrium if it cannot be defeated in any pair-wise comparison.

Proposition 1 *The household whose child has ability a^M is decisive. In particular, $(e_u(m), b_1(m), b_2(m))$ is a political equilibrium outcome whenever $V(a^M, X) = VU(X)$. However, $(e_s(m), b_1(m), b_2(m))$ is the political equilibrium outcome, if $V(a^M, X) = VS(a^M, X)$.*

Proof. See the Appendix. ■

Voters' preferences are concave and satisfy the single-crossing property. This makes the median-income household to be the decisive voter. When the median-income household prefers the policy vector $(e_u(m), b_1(m), b_2(m))$, all unskilled households agree on this policy and it cannot be defeated by any other feasible policy.

3 Effects of the brain drain on the optimal subsidy

The parameter m not only represents the probability of migrating, but also the skilled migration rate. This stems from the fact that only skilled agents are allowed to migrate. When m rises there are two opposite effects at work. On the one hand, there is a brain effect because a rise in m induces more agents to get tertiary education. Since not all of them migrate, second period revenue increases, leading to a rise in second-period transfers. On the other hand, there is a drain effect. A rise in the skilled migration rate exacerbates the reverse distribution of public resources from poor households to rich households. In this section I consider that the median-income household chooses the policy vector $(e_u(m), b_1(m), b_2(m))$, with $e_u \in (0, 1)$.

Lemma 1 *If the condition below holds, there is a threshold value $\overline{m}$ such that for m lower (higher) than $\overline{m}$, the transfer in the second period is increasing (decreasing) with m. On the contrary, if this condition does not hold, then b_2 is decreasing in m for all $m \in [0, 1]$.*

$$\frac{w^F - (1-t)\,w}{(1-t)\,w} \geqslant \Psi(A, \beta), \tag{23}$$

where

$$\Psi(A, \beta) \equiv \frac{1}{2}\frac{\beta}{1+\beta}\frac{(\beta A)^2 - (1+\beta)^2}{(1+2\beta)}.$$

Proof. See the Appendix. ■

Lemma (1) shows that second-period transfer displays an inverse U-shaped form whenever the wage premium is higher than the threshold level $\Psi(A, \beta)$. In other words, when the wage premium is high enough, there exists a range of values of m, i.e. $[0, \overline{m}]$, such that when m increases, the brain effect dominates the drain effect, the second-period revenue increases, leading to a rise in $b_2(m)$. This result is in line with previous results in the brain drain literature (Vidal (1998), Chau and Stark (1999) and, Beine et al. (2001))

Note that the left hand side of Expression (23) is decreasing in w. This implies that the poorer the economy, as measured by the wage differential, the more likely Condition (23) holds and, hence, the more likely $b_2(m)$ be increasing in m, for m small enough. Besides, the poorer the economy, the smaller the size of tertiary educated population. This is in accordance with empirical literature that shows that an increase in the magnitude of the brain drain would increase the average productivity of countries that exhibit low current skilled migration rates and low levels of human capital (see Beine et al. (2003)).

Proposition 2 *If conditions below hold, a rise in the probability of migrating leads to a fall in the subsidy* e_u.[3] *The conditions are:*

$$w^F - w > \frac{2}{w^F + w}, \tag{24}$$

and,

$$\frac{w^F - (1-t)w}{(1-t)w} > 2. \tag{25}$$

Proof. See Appendix ■

Expression (24) establishes a minimum wage gap between the two economies. This expression is not a stringent condition. As w^F is higher than w by assumption, Condition (24) is easily satisfied for all of those pairs of values (w^F, w) whose sum is high enough. On the other hand, Expression (25) establishes a minimum wage premium. Note that the left hand side of this expression is the same as that of Expression (23). It is possible to show that if parameter A is higher than a threshold level, that only depends on β, then Condition (25) implies Condition (23). If that is the case, then Proposition (2) would imply that b_2 has an inverse U-shaped form, i.e. the result of Lemma (1).

[3] In the Appendix it is shown that the subsidy e_s is negatively related with m.

It is important to point out that this proposition does not imply that the drain effect always offsets the brain effect. In fact, the reason why society agrees to reduce the subsidy varies depending on the magnitude of skilled migration. Keep in mind that the decisive voter is an unskilled household. First, assume that the rise in m is such that skilled migration is small enough, i.e. $m \leq \overline{m}$. Migration prospects encourage agents to get tertiary education. By Lemma 1, $b_2(m)$ increases, leading to a rise in the second-period income of all households. Since unskilled households derive utility from their first-period income, and since they anticipate that their second-period income will increase, they decide to reduce the subsidy. The reduction in the subsidy is such that it does not offset the effect of m on the size of the educated population. That is, S increases once the rise in m and the reduction in e have been taken into account. The reduction in e allows to cut down the total education cost, leading to a rise in $b_1(m)$. Thereby, unskilled households see that their after tax incomes increase in both periods. Second, assume that the skilled migration rate is sufficiently large, i.e. $m > \overline{m}$. In this case the brain drain reduces average productivity in the source economy. Society anticipates this and agrees to reduce the level of the subsidy in order to ameliorate the negative effects that follows skilled migration.

Before leaving this Section I study the shape of the equilibrium values of the subsidy and the transfers. Subsection 2.4 showed that the median-income household is decisive. Her preferences determine the political equilibrium outcome, i.e. the policy vector (e, b_1, b_2). These preferences may change as m varies. Consider that for some low values of m the decisive voter chooses $(e_u(m), b_1(m), b_2(m))$. It is possible that from some sufficiently large value of m on, i.e. $m > \overline{\overline{m}}$, she changes her decision. That is, she would prefer the policy vector $(e_s(m), b_1(m), b_2(m))$ rather than $(e_u(m), b_1(m), b_2(m))$. If this happens, the optimal subsidy is discontinuous at $m = \overline{\overline{m}}$.[4] Taking into account that both b_1 and b_2 are functions of e, both transfers are also discontinuous at $m = \overline{\overline{m}}$. Figure 1 illustrates this point. The left panel corresponds to first period transfers, while the right panel corresponds to the second period transfers. In the horizontal axis I draw m and in the vertical axis I draw transfers. For $m \leq \overline{\overline{m}}$, the optimal subsidy is e_u. As m

[4] If for $m = 0$ the median voter chooses the policy vector $(e_s, b_1(e_s), b_2(e_s))$, then she takes the same decision for any m. As a result, the optimal value of e is continuous in m, for all $m \in [0, 1]$. The same is true for b_1 and b_2. The fact that the median voter does not change her decision stems from the fact that when m is zero, her offspring finds profitable to get tertiary education. Since, a rise in m increases the return to education, her offspring takes the same decision and hence the median-income household keeps choosing the same kind of policy.

becomes higher than $\overline{\overline{m}}$, the median-income household starts to choose the policy vector $(e_s(m), b_1(m), b_2(m))$. Note that for extremely high values of m the first-period transfer is zero. This corresponds to two possible corner solutions of the optimization problem (see the Appendix).

4 Effects of skilled migration on income distribution

In this section I study how a rise in m affects the distribution of the second-period income. I use two alternative measures of inequality. First, I use the ratio between the income going to the richest skilled household and the income accruing to unskilled households. This ratio can be seen as an approximation of the ratio between the income accruing to households in the top 20 percent of income and the income accruing to the lowest 20 percent of income. Second, I use the Gini coefficient.

Consider two households: a household whose child has ability a_1, with $a_1 < \widehat{a}(1,1)$, and a household whose child has the highest ability A in the population. The child with ability a_1 remains unskilled, while the other becomes skilled. I assume that the child with ability A does not migrate. Recall expressions (4) and (6). The former corresponds to second-period income of the unskilled household and the latter to second-period income of the skilled household. Both functions are evaluated at the equilibrium policy $(e_u(m), b_1(m), b_2(m))$. The inequality ratio, $r(m)$, is:[5]

$$r(m) = \frac{(1-t)\, w\,(1+A) + b_2(m)}{2(1-t)\, w + b_2(m)}. \tag{26}$$

The higher is $r(m)$, the higher is the income gap between the richest skilled household and unskilled households.[6]

Proposition 3 *If Condition (23) holds, then $r(m)$ has a U-shaped form. If, however, (23) does not hold, then $r(m)$ is increasing in m for all $m \in [0,1]$.*

Proof. See the Appendix. ■

[5] If I assume that the child with ability A migrates, the shape of the inequality ratio does not change. But, for every value of m the resulting inequality ratio is higher than that of Expression (26).

[6] In Section 3 I showed that $e(m)$ may be discontinuous at $\overline{\overline{m}}$. Therefore, since $r(m)$ is a function of $e(m)$, $r(m)$ may also be discontinuous at $\overline{\overline{m}}$.

Consider the case where $r(m)$ has a U-shaped form, as in Figure 2. Let $\overline{m}$ denote the value of the skilled migration rate associated with the minimum value of the inequality ratio. Note that this cutoff value is the same as that for which the derivative of b_2 with respect to m is zero. When m is smaller than $\overline{m}$, a rise in m increases $b_2(m)$, leading to a rise in all households' income. This increment is relatively higher for unskilled households compared to skilled households. Then, the rise in $b_2(m)$ reduces $r(m)$. On the contrary, when m is higher than $\overline{m}$, a rise in the skilled migration rate reduces $b_2(m)$, leading to a rise in $r(m)$. If Condition (23) does not hold, the brain drain always reduces the second-period transfer leading to a rise in the inequality ratio.

In the previous section I showed that the smaller the wage differential, the more difficult to satisfy Condition (23). This means that in relatively rich economies it is more likely that the brain drain increases $r(m)$. This stems from the fact that in those economies, economies where the size of the educated population is relatively high, it is less likely that the brain effect dominates the drain effect. As a result, poor households are more vulnerable to the brain drain in relatively rich economies.

Now, I consider the Gini coefficient as a measure of inequality in the distribution of income in the second period. Let G denote the Gini coefficient. I am concerned with the distribution of income across households. A suitable measure of income in the source economy is the gross national income (GNI, from now on). The GNI and the Gini coefficient are given by:

$$GNI = \frac{\widehat{a}}{A} y_{2u} + \left(1 - \frac{\widehat{a}}{A}\right)\left((1-t)\,w + b_2\right) + \frac{w^e}{A} E\left[a | a > \widehat{a}\right], \tag{27}$$

and,

$$G(m) = 2\left(\frac{1}{2} - \Phi(m)\right), \tag{28}$$

where,

$$\Phi(m) = \frac{\widehat{a}^2}{2}\frac{y_{2u}}{GNI} + \frac{(1-t)\,w + b_2}{GNI}\left(1 - \frac{\widehat{a}}{A}\right) + \frac{w^e A}{GNI}\left(1 - \left(\frac{\widehat{a}}{A}\right)^2\right). \tag{29}$$

Figure 3 has a graphical representation of the Gini coefficient. In this model the Lorenz curve is composed of two parts. For the poorest p fraction of the population, with

$p \leqslant \frac{\widehat{a}(e,m)}{A}$, the Lorenz curve is a straight line. This fraction corresponds to unskilled households with a constant income equal to y_{2u}. The income of skilled households, i.e. y_{2s}, depends on children' abilities. Therefore, y_{2s} differs across skilled households. This is captured by the convex part of the Lorenz curve. The break point of the Lorenz curve measures the fraction of GNI that goes to unskilled households.

The sign of the derivative of $G(m)$ with respect to m is ambiguous. However, if a rise in m increases the slopes of both parts of the Lorenz curve, then $G(m)$ decreases. The rise in the slope of the linear part means that the fraction of income accruing to unskilled households increases. On the other hand, the rise in the slope of the curved part is a consequence of the reduction in the dispersion of income among skilled households. On the contrary, if both slopes decrease when m rises, then $G(m)$ increases.

The ambiguity of the sign of the derivative of $G(m)$ with respect to m allows for the possibility that a rise in m increases $G(m)$ while it decreases the inequality ratio $r(m)$. That is, a rise in m may increase income dispersion among skilled households, while reducing the income gap between unskilled households and the richest households in the economy. To illustrate this, I provide a numerical example.

The parameters of the model are $w^F = \$10,759.68$ and $w = \$1,520.64$. The value of the minimum wage rate in a foreign country corresponds to the real annual minimum wage in the US in 2003. The domestic wage rate, w, corresponds to the real annual minimum wage in Mexico at purchasing power parity (PPP) for the same year.[7] The tax rate, the discount rate and A are equal to 0.3, 0.55 and 10, respectively.[8] The education cost is equal to $\$4,107$. This value corresponds to per pupil expenditure on tertiary education in Mexico at PPP in 2003.[9]

Figure 4A draws the inequality ratio r as a function of m, while Figure 4B draws the Gini coefficient as a function of m. As explained above, $r(m)$ displays a U-shaped form. Nevertheless, the Gini coefficient displays an inverse U-shaped form. Keep in mind that all skilled households receive the transfer b_2. However, not all skilled workers

[7] These values are obtained from data published in http://stats.oecd.org/wbos/default.aspx?DatasetCode =RFIN1. Note that the pair $\left(w^F, w\right) = (\$10,759.68,\ \$1,520.64)$ satisfies Conditions (24) and (25). These conditions ensure that s_u and m have a negative relationship.

[8] The value of A is such that $A = 10$ is higher than $\widehat{a}(0,0)$.

[9] This value is obtained from data available at UNESCO Statistics. http://stats.uis.unesco.org.

migrate. Therefore, for m small enough, few skilled workers migrate and then, few skilled households have access to the wage paid abroad, what increases income dispersion among skilled households, leading to a rise in $G(m)$. On the contrary, for m sufficiently large, the number of skilled migrants is such that the brain drain reduces income dispersion among skilled households to such an extent that $G(m)$ decreases. Figure 4 shows that for m smaller than 0.1, $r(m)$ is decreasing in m, while the Gini coefficient is increasing in the skilled migration rate.

To sum up, it is possible that the brain drain reduces the income gap between the richest and the poorest households in the source economy, while at the same time it increases the Gini coefficient by augmenting income dispersion among skilled households.

5 Welfare effects of skilled migration

Skilled migration has a profound impact on economic outcomes in the source economy. This type of migration affects the average productivity in the source economy as well as income distribution. However, households are not only concerned about income distribution, but also about the effects of the brain drain on their welfare. Therefore, in this section I analyze how migration of skilled workers affects welfare in the source economy.

In Section 3 I showed that it is possible that unskilled households would want to reduce the subsidy $e_u(m)$ because the brain drain hurts the source economy. That is, the brain drain reduces both $b_1(m)$ and $b_2(m)$, leading to a fall in unskilled households' lifetime income. Nevertheless, as m rises, migration becomes more feasible and, hence, skilled households' expected lifetime income may increase. Thereby, it is not clear whether the brain drain benefits skilled households at the expense of unskilled households or the brain drain affects all households in the same way. The following proposition characterizes under what circumstances the brain drain leads to a Pareto-superior outcome.

Proposition 4 *If a rise in m increases the welfare of unskilled households, then the rise in the skilled migration rate is Pareto improving.*

Proof. By applying the envelope theorem and differentiating Expressions (18) and (21) with respect to m I have:

$$\frac{\partial VU}{\partial m} = \frac{\partial b_1}{\partial m} + \beta \frac{\partial b_2}{\partial m}, \tag{30}$$

$$\frac{\partial VS}{\partial m} = \frac{\partial b_1}{\partial m} + \beta \left(\frac{\partial b_2}{\partial m} + \left(w^F - w \right) a \right). \tag{31}$$

Therefore, if $\frac{\partial VU}{\partial m} > 0$, then $\frac{\partial VS}{\partial m}$ is also positive. So that a rise in m benefits all households in the source economy. ■

In Section 4 I showed that it is in poor economies where it is more likely that the brain effect overweights the drain effect, i.e. $\frac{\partial b_2}{\partial m} > 0$. So that, it is in these economies where it is more likely that the brain drain increases unskilled households' lifetime income and, where the brain drain can be Pareto improving.

6 Concluding Remarks

This paper studies the effect of the brain drain on society's willingness to finance tertiary education and shows that the brain drain leads to a fall in the level of public financing of tertiary education. However, the reasons that induce this result depend on the magnitude of skilled migration. Migration prospects entail two effects, a brain effect and a drain effect. The former refers to a rise in the size of the educated population because of the possibility of working abroad. The latter refers to the loss of fiscal revenue because of migration of skilled workers. When the probability of migrating is low, society anticipates that the brain effect may dominate the drain effect, leading to a rise in the second period after-tax incomes of all households. Since households also derive utility from first-period income, they prefer to reduce the value of the subsidy to obtain a rise in both periods income. It is in this scenario where the brain drain may be Pareto improving. On the contrary, when skilled migration is sufficiently large such that the drain effect overweights the brain effect, society reduces public financing of tertiary education. By doing this, society ameliorates negative effects that follow skilled migration. These results are important because they highlight the possibility that the brain drain not only increases average productivity in the source economy, as previous literature shows, but also improves the welfare of all households in the source economy.

The model shows that the relationship between the brain drain and the inequality ratio may display a U-shaped form. When the skilled migration rate, m, is sufficiently small, the brain effect dominates the drain effect leading to a rise in second-period transfers. Since transfers represent a higher fraction in the income of an unskilled household, compared to that of a skilled household, the inequality ratio, $r(m)$, decreases. Nevertheless, as m becomes sufficiently large, further increments in m decrease second-period transfers, leading to a rise in the inequality ratio.

Furthermore, the model highlights the possibility that a rise in the skilled migration rate reduces the inequality ratio, while at the same time it increases the Gini coefficient. As explained above, for m small enough the brain drain reduces the income gap between rich and poor households, i.e. $r(m)$ falls. On the other hand, a low value of the skilled migration rate implies that few skilled households have access to the wage paid abroad, what increases income dispersion among skilled households to such an extent that the Gini coefficient rises.

I have considered a partial equilibrium model where unskilled and skilled wages are exogenously given. In such a case, the model cannot detect the wage adjustments that follow skilled migration, nor the effects that these adjustments may have on the distribution of income. On the other hand, the reason why some agents remain unskilled is because the return to human capital is not high enough. Nevertheless, some agents may not get tertiary education because of liquidity constraints. Migration and remittances, however, may reduce liquidity constrains and increase the size of educated population in the future, what in turn affects income distribution. These effects are not detected under the present framework. Therefore, it would be interesting to test the robustness of the results of this model by endogenizing the wage rates together with incorporating dynamics to the model. These issues are left for future research.

7 Appendix

Maximization problem of unskilled households. An unskilled household maximizes Equation (7) subject to Conditions (11), (13), (14), and (15). Plugging Condition (15) into the utility function, I get the following Lagrangian function:

$$L = u(y_{1u}, y_{2u}) + \mu_1 (1-e) - \mu_2 e - \mu_3 b_1 + \lambda \left[tw \left(1 + \frac{\widehat{a}}{A}\right) - b_1 - ec \left(1 - \frac{\widehat{a}}{A}\right)\right]. \quad (32)$$

The first order conditions (FOCs from now on) and the regularity conditions are:[10]

$$\frac{\partial L}{\partial b_1} = 1 - \mu_3 - \lambda = 0, \tag{33}$$

$$\frac{\partial L}{\partial e} = \beta tw\left(1 + \frac{\widehat{a}(e,m)}{A} + K_0\right) - \mu_1 - \mu_2 + \lambda\left(\frac{tw}{A}\frac{\partial \widehat{a}}{\partial m} + K_1\right) = 0, \tag{34}$$

$$\frac{\partial L}{\partial \lambda} = tw\left(1 + \frac{\widehat{a}(e,m)}{A}\right) - b_1 - ec\left(1 - \frac{\widehat{a}(e,m)}{A}\right) = 0. \tag{35}$$

where K_0 and K_1 are, respectively:

$$K_0 = (1-m)\frac{\widehat{a}(e,m)}{A}\frac{c}{\beta w^e}, \tag{36}$$

$$K_1 = -c\left(1 - \frac{\widehat{a}(e,m)}{A}\right) + ec\frac{\frac{\partial \widehat{a}}{\partial m}}{A}. \tag{37}$$

And the regularity conditions are:

$$\mu_1(1-e) = 0, \tag{38}$$

$$\mu_2 e = 0, \tag{39}$$

$$\mu_3 b_1 = 0. \tag{40}$$

There are 5 possible solutions. Case (i). Interior solution, with $e_u \in (0,1)$ and $b_1 > 0$. Case (ii), where $e_u = 0$ and $b_1 > 0$. Case (iii), where $e_u = 1$ and $b_1 > 0$. Case (iv), where $e_u \in [0,1]$ and $b_1 = 0$. And, case (v), with $e_u = 1$ and $b_1 = 0$.

I start with case (i). By solving the FOCs I get Equation (16). The denominator of (16) is positive. So that, $e_u > 0$ if and only if the numerator is positive, that is if and only if:.

$$\beta\widehat{a}(0,m)(t(1-m)w + w^e) - (1+\beta)tw - \beta w^e A > 0. \tag{41}$$

Let $m = 0$. Condition (41) is positive, if and only if

$$c > (1-t)^2(\beta(A-1) - 1)w. \tag{42}$$

On the other hand, I see that when $m = 1$, whatever be the value of c, Expression (41) never holds. All this implies that for a cost of education sufficiently high there exists a range of values of m for which the interior solution case arises.

[10] For brevity's sake I do not present the second order conditions. However, they are available upon request.

I turn now to the second case, i.e. $e_u = 0$ and $b_1 > 0$. Solving the FOCs and the regularity conditions I have that: $\mu_2 \leqq 0$ if and only if Condition (41) does not hold. That is, whenever the second case is a possible solution, the first case cannot arise as a solution of the problem. The fact that (41) does not hold implies that Equation (16) is negative.

Consider case (iii), i.e. $e_u = 1$ and $b_1 > 0$. Using Condition (35), I have that:

$$b_1 = tw\left(1 + \frac{\widehat{a}\left(1, m\right)}{A}\right) - c\left(1 - \frac{\widehat{a}\left(1, m\right)}{A}\right). \tag{43}$$

$b_1 > 0$ if and only if:

$$tw\Psi\left(m\right) - c > 0, \tag{44}$$

where:

$$\Psi\left(m\right) = \frac{\beta w^e A + \left(1+\beta\right)\left(1-t\right)w}{\beta w^e A - \left(1+\beta\right)\left(1-t\right)w}. \tag{45}$$

The Lagrange multiplier μ_1, associated with the restriction $1 - e \geqslant 0$, must be non-negative. This is satisfied if and only if the following condition holds,

$$\beta\widehat{a}\left(1, m\right)\left(t\left(1-m\right)w + w^e\right) - \left(1+\beta\right)tw - \beta w^e A - c > 0. \tag{46}$$

Whenever Condition (44) and/or Condition (46) do not hold, this case cannot be a solution of the problem. On the other hand, note that the fact that (41) does not hold implies that this case cannot be a solution of the problem.

I turn to Case (iv), i.e. $e_u \in [0, 1]$ and $b_1 = 0$. Using (14) I have that the subsidy must satisfy:

$$x_2 e^2 + x_1 e + x_0 = 0, \tag{47}$$

where:

$$x_0 = tw\left(1 + \frac{\widehat{a}\left(0, m\right)}{A}\right), \tag{48}$$

$$x_1 = c\left(\frac{\widehat{a}\left(0, m\right)}{A} - \left(1 + \frac{tw}{\beta w^e A}\right)\right), \tag{49}$$

$$x_2 = -\frac{c^2}{\beta w^e A} < 0. \tag{50}$$

Since x_0 is positive, the polynomy has two real roots, one negative and one positive. The positive root is a solution of the problem whenever it be smaller or equal to 1.

Finally, I have Case (v), $e_u = 1$ and $b_1 = 0$. Using $L_\lambda = 0$, I have that this condition is satisfied if and only if:

$$tw\Psi(m) = c. \tag{51}$$

Assuming that A is higher than $\frac{1+\beta}{\beta}$, Expression (45) is a decreasing function of m. In addition, if I assume that the education cost is high enough, in particular $c > tw\Psi(0)$, then cases (iii) and (v) cannot arise as solutions of the problem. The latter assumption, i.e. $c > tw\Psi(0)$, implies that $tw\Psi(m)$ is smaller than c for all $m \in [0, 1]$.

Note that in each case the optimal subsidy and the optimal value of b_1 do not depend on the ability of the child, thereby, all unskilled households choose the same policy vector (e_u, b_1, b_2). ■

Maximization problem of skilled households. Superscripts "SH" denote skilled household. A skilled household whose child has ability a maximizes Equation (8) subject to conditions (11), (13), (14), (15) and, $a > \widehat{a}(e, m)$. The Lagrangian function is equal to:

$$L^{SH} = L - (1-e)c - (1-t)w - \beta(1-t)w + \beta w^e a. \tag{52}$$

By applying Kuhn Tucker I have that $\frac{\partial L^{SH}}{\partial b_1} = \frac{\partial L}{\partial b_1}$ and $\frac{\partial L^{SH}}{\partial \lambda} = \frac{\partial L}{\partial \lambda}$, the only FOC that differs from that of unskilled household's problem is the derivative of L^{SH} with respect to e, which is:

$$\frac{\partial L^{SH}}{\partial e} = \frac{\partial L}{\partial e} + c = 0, \tag{53}$$

Note that if $e = e_u$, $\frac{\partial L^{SH}}{\partial e} = c > 0$, therefore, the optimal value e_s is higher than e_u. The regularity conditions are the same as those of the unskilled household's problem. I have the same five possible solutions. For brevity's sake I present conditions that must hold in each case when they differ from the unskilled household's problem.

In Case (i) the condition associated with $e_s > 0$ is:

$$\beta\widehat{a}(0, m)(t(1-m)w + w^e) - (1+\beta)tw > 0. \tag{54}$$

In Case (ii) the condition associated with $\mu_2 \leqq 0$ is the opposite of Condition (54). In particular, when the tax rate is smaller than $\frac{1}{2}$, (54) always holds.

In Case (iii) the condition associated with $\mu_1 \geqq 0$ is:

$$\beta\widehat{a}(1, m)(t(1-m)w + w^e) - (1+\beta)tw - c \geqq 0. \tag{55}$$

And the Condition corresponding to $\frac{\partial L^{SH}}{\partial \lambda}=0$ is the same than expression (44).

Cases (iv) and (v) are the same as those of unskilled household's problem.

Note that in each case the optimal subsidy and the optimal value of b_1 do not depend on the ability of the child, thereby, all skilled households choose the same policy vector (e_s, b_1, b_2). ■

Proof of Proposition 1. Remember that all unskilled households choose the same subsidy $e_u(m)$, and all skilled households choose the same subsidy $e_s(m)$. Assume that the median-income household maximizes utility at $e = e_u(m)$, that is, $V\left(a^M, X\right) = VU(X)$. Since $V\left(a^M, X\right)$ is continuous in a, there will be some richer households in the vicinity of a^M which also prefer $e_u(m)$. As a result, the policy vector $(e_u(m), b_1(m), b_2(m))$ defeats any other feasible vector in pair-wise comparison. Note that if $a^M < \widehat{a}(1,m)$, for a given m the median-income household's child never acquires tertiary education. Hence, the median-income households always choose $e_u(m)$. Applying the same reasoning I have that $(e_s(m), b_1(m), b_2(m))$ is a political equilibrium outcome whenever $V\left(a^M, X\right) = VS\left(a^M, X\right)$. In the case where $a^M > \widehat{a}(0,m)$ the median-income household's child always acquire tertiary education, hence, the median-income household always chooses $e_s(m)$. ■

Proof of Lemma 1. By applying the envelope theorem and differentiating Expressions (11) and (15) with respect to m I get:

$$\frac{\partial \widehat{a}}{\partial m} = -\frac{\left(w^F-(1-t)\,w\right)}{w^e}\left(\frac{1+\beta}{\beta}\frac{(1-t)\,w}{w^e}+\frac{(1-e_u)\,c}{\beta w^e}\right), \tag{56}$$

$$\frac{\partial b_2}{\partial m} = -tw\left(\frac{\widehat{a}_m}{A}\left((1-m)\,\widehat{a}(e_u,m)-1\right)+E\left[a|a>\widehat{a}(e_u,m)\right]\right). \tag{57}$$

Note that if $m=1$, $\frac{\partial b_2}{\partial m}$ is negative for all $e\in[0,1]$. For $m<1$, $\frac{\partial b_2}{\partial m}$ is positive if and only if the following condition holds:

$$\begin{aligned}\frac{A^2-\widehat{a}(e_u,m)^2}{2A} &\leqslant -\frac{\frac{\partial \widehat{a}}{\partial m}}{A}\left((1-m)\,\widehat{a}(e_u,m)^2-1\right), \text{ or}\\ E\left[a|a>\widehat{a}(e_u,m)\right] &\leqslant -\frac{\frac{\partial \widehat{a}}{\partial m}}{A}\left((1-m)\,\widehat{a}(e_u,m)^2-1\right).\end{aligned} \tag{58}$$

Given $m=0$, the left hand side of (58) is increasing in e, while the right hand side is decreasing in e. Then, if this Condition is satisfied for $e=1$, it holds for all $e\in[0,1)$. By making $m = 0$ and substituting e_u by 1 in (58) I get the following expression:

$$E[a|a > \widehat{a}(1,0)] \leqslant \frac{1+\beta}{\beta}\frac{w^F - (1-t)w}{(1-t)w}\frac{\widehat{a}(1,0)^2 - 1}{A}, \tag{59}$$

after rearranging terms, Condition (59) can be written as Expression (23). By applying the median value theorem I have that there is an $\overline{m}$ such that (58) is satisfied with equality. Then, for all m smaller (higher) than $\overline{m}$, $\frac{\partial b_2}{\partial m}$ is positive (negative). ■

Proof of Proposition 2. By applying the envelope theorem and by differentiating e_u with respect to m I get:

$$\frac{\partial e_u}{\partial m} = -\frac{N(m)}{\left((1-m)(1+c-t)w + (1+c)mw^F\right)^2}, \tag{60}$$

where $N(m) = k_2 m^2 + k_1 m + k_0$. Let w_d and c_0 stand for $(1-t)w$ and $(1+c-t)$, respectively. Expressions corresponding to k_0, k_1 and, k_2 are given by:

$$k_2 = \beta A\left(w^F - w\right)\left[(1+c)\left(w^F\right)^2 - c_0 w_d w - 2(1-t) - (2-t)c\right]. \tag{61}$$

$$k_1 = \beta w_d A\left[\frac{ww^F}{w_d}\left(c_0\left(w^F - 3w_d\right) + tw^F c\right) + (1+c)\left(w^F\right)^2 - c_0\left(w^F - 2w_d\right)w\right]. \tag{62}$$

$$k_0 = w\left[tw^F\left((1+\beta)w_d + c(1+(1+\beta)tw)\right) + \beta w_d w A\left(c_0\left(w^F - w_d\right) + tcw^F\right)\right]. \tag{63}$$

The sign of Expression (60) depends on the sign of $N(m)$. Coefficient k_0 is always positive. On the other hand, Condition (24) implies that:

$$\left(w^F\right)^2 > (1-t)w^2 + 2 - t, \tag{64}$$

what in turns implies that the sign of k_2 is positive. Consider Expression (62). Condition (25) makes that both the first and third terms in square brackets be positive. Since the algebraic sum between the second and the third term of that expression is positive, coefficient k_1 is higher than zero.

$N(m)$ attains its minimum at:

$$m^* = -\frac{k_1}{k_2}. \tag{65}$$

The value m^* is negative. In addition, $N(0)$ and $N(1)$ are positive. Hence, $N(m)$ is a positive increasing function of m, for $m \in [0,1]$. Consequently, I have that e_u is always negatively related with m.

Recall Expression (20). The derivative of the subsidy e_s with respect to m is:

$$\frac{\partial e_s}{\partial m} = -\frac{t\left(1+\beta\right)ww^F\left[c^2 + w_d + c\left(\frac{1}{(1+\beta)} + \left(1-\beta-t\left(1-2\beta\right)\right)w\right)\right]}{\left[\left(1-m\right)\left(c_0 - t\left(1-\beta\right)c\right)w + \left(1+c\right)mw^F\right]^2} < 0. \tag{66}$$

■

Proof of Proposition 3. Recall Expression (57). Condition (23) implies $\frac{\partial b_2}{\partial m} > 0$ whenever m is smaller or equal to $\overline{m}$. By differentiating $r\left(m\right)$ with respect to m I get:

$$\frac{\partial r}{\partial m} = \frac{\frac{\partial b_2}{\partial m}\left(y_{2u} - y_{2s}\right)}{\left(y_{2u}\right)^2}. \tag{67}$$

Then, for all $m \leqslant \overline{m}$, $\frac{\partial b_2}{\partial m} \geqslant 0$, hence, $\frac{\partial r}{\partial m} \leqslant 0$. And $\frac{\partial r}{\partial m} > 0$ for all $\overline{m} < m \leqslant 1$. Finally, when Condition (23) does not hold, b_2 is a decreasing function of m. Hence, $\frac{\partial r}{\partial m}$ is positive for all $m \in [0, 1]$. ■

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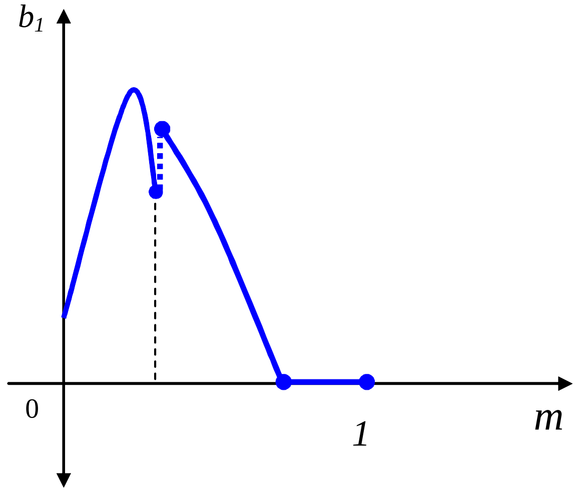

Figure 1A Relationship between first-period transfer and skilled migration rate.

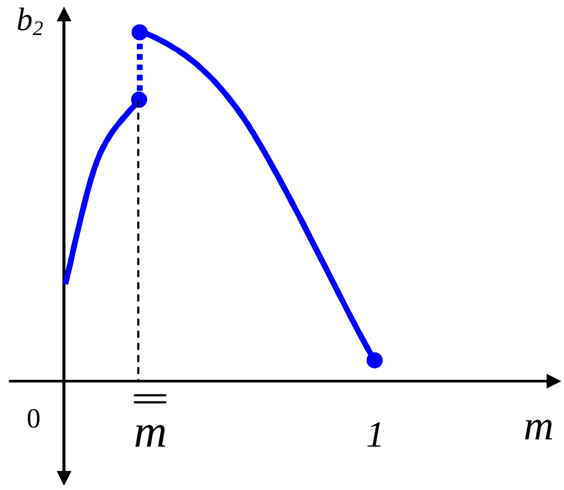

Figure 1B Relationship between second-period transfer and skilled migration rate.

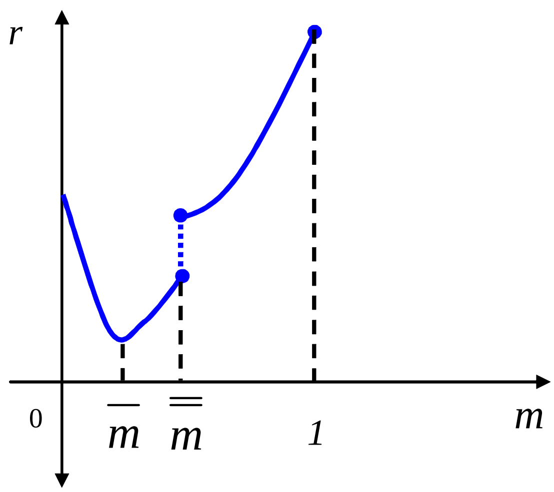

Figure 2 Relationship between inequality ratio and skilled migration rate.

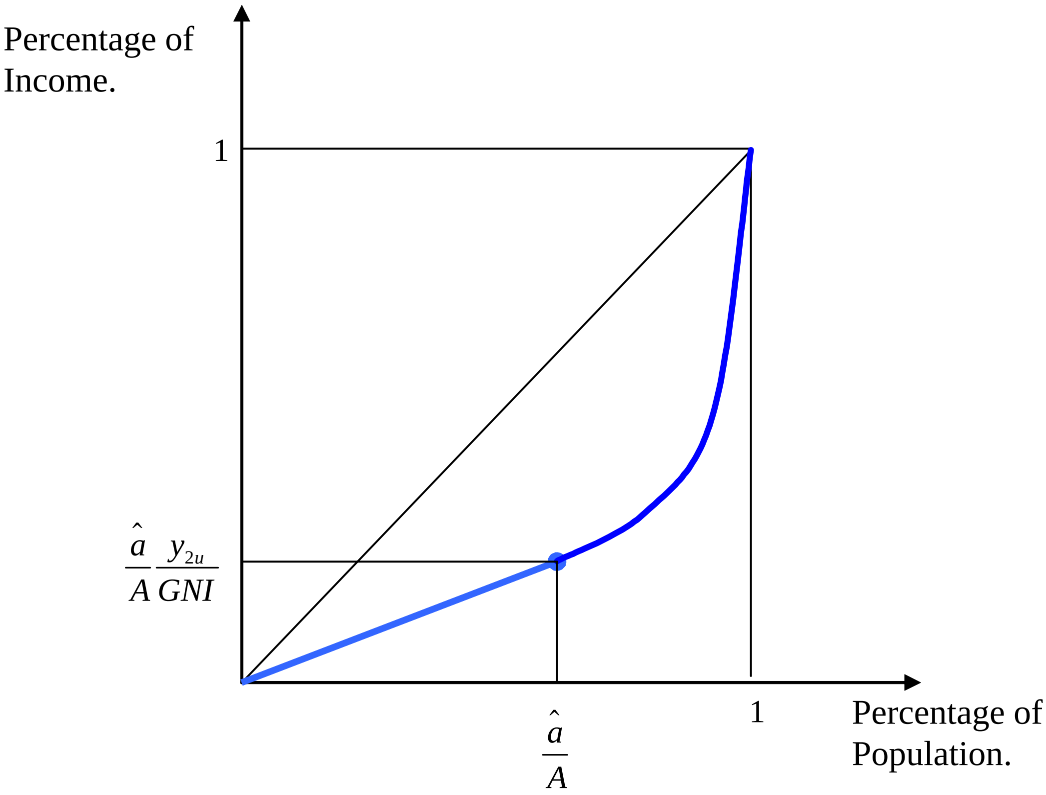
Percentage of Income.
1
$\frac{\hat{a}}{A}\frac{y_{2u}}{GNI}$
$\frac{\hat{a}}{A}$
1
Percentage of Population.

Figure 3.

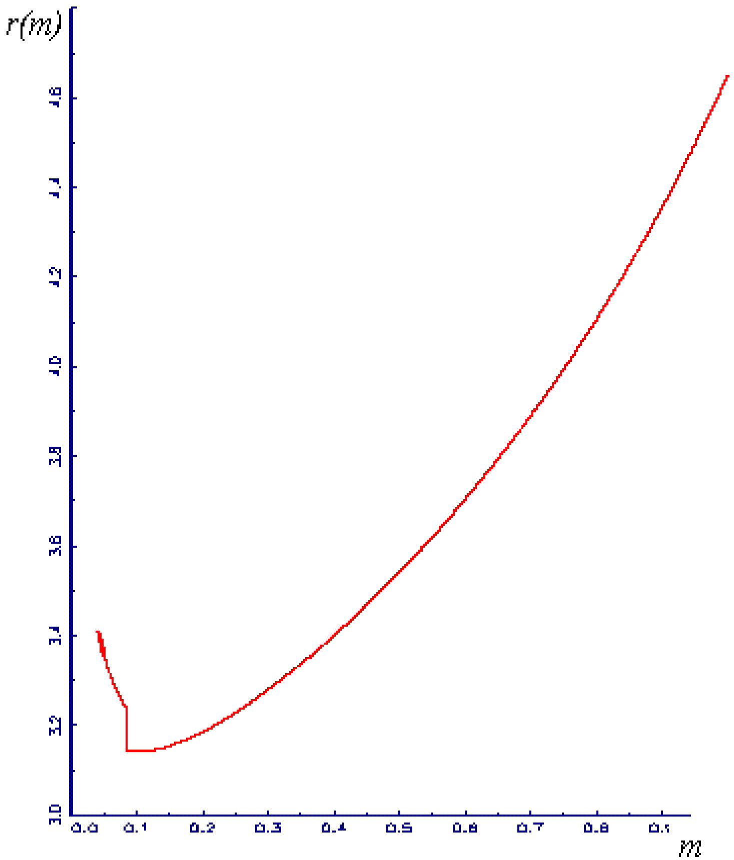

Figure 4A Relationship between inequality ratio and skilled migration rate

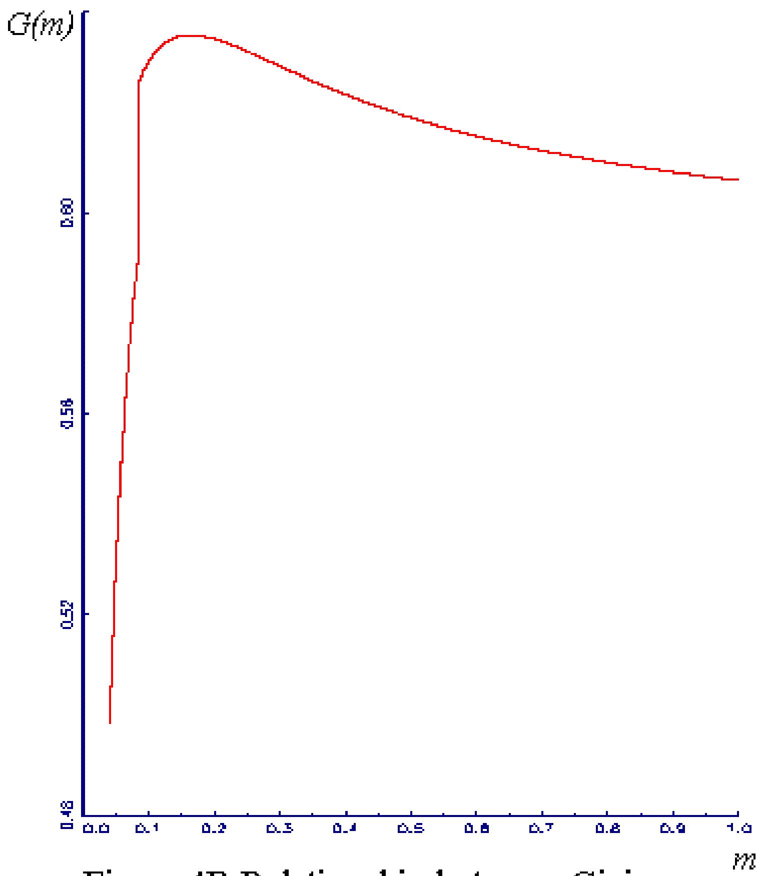

Figure 4B Relationship between Gini coefficient and skilled migration rate