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# Is Migration a Good Substitute for Education Subsidies?

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## Abstract

Assuming a given educational policy, the recent brain drain literature reveals that skilled migration can boost the average level of schooling in developing countries. This paper introduces educational subsidies determined by governments concerned by the number of skilled workers remaining in the country. The theoretical analysis shows that developing countries can benefit from skilled emigration when educational subsidies entail high fiscal distortions. However when taxes are not too

distortionary, it is desirable to impede emigration and subsidize education. The authors investigate the empirical relationship between educational subsidies and migration prospects, obtaining a negative relationship for 105 countries. Based on this result, the analysis revisits the country specific effects of skilled migration upon human capital. The findings show that the endogeneity of public subsidies reduces the number of winners and increases the magnitude of the losses.

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This paper—a product of the Trade Team, Development Research Group—is part of a larger effort in the department to analyze the impact of migration on poverty and economic development.. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The author may be contacted at [frederic.docquier@uclouvain.be](mailto:frederic.docquier@uclouvain.be).

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# Is Migration a Good Substitute for Education Subsidies?

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# 1 Introduction

The recent literature on the the brain drain asserts that the migration of the highly skilled may entail beneficial feedback effects for source countries. Remittances, return migration and diaspora externalities are potentially important feedback channels. In addition, several authors such as Vidal (1998), Mountford (1999), Beine *et al.* (2001) and Stark and Wang (2002) have recently argued that migration prospects increase the expected returns to education and may foster educational investments in developing countries, therefore making it possible for a brain drain to be beneficial to the source country (i.e., the country may end up with a higher level of human capital after emigration is netted out). Obviously, causality is hard to establish in cross-sectional regressions and the "brain gain" concept deserves further empirical investigations based on richer data. However, Beine *et al.* (2001, 2007a) found evidence in support of such an incentive mechanism.<sup>1</sup>

In this paper, we analyze the policy implications of the brain gain hypothesis, especially the interactions between skilled migration and education policies. These interactions were studied by Stark and Wang (2002) who demonstrated that, by allowing a controlled proportion of skilled individuals to emigrate to a richer country, the government can stimulate the expected returns to schooling so as to obtain the socially desirable level of human capital without subsidies. Although it can be refuted that sending countries (except perhaps totalitarian regimes) have no perfect control over emigration rates, Stark and Wang's analysis suggests that the emigration policy acts as a perfect substitute for public subsidies (i.e. that the higher the skilled emigration rate, the lower is the rate of subsidy required to decentralize the social optimum). The purpose of our paper is to theoretically and empirically revisit the

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<sup>1</sup>See also Kangasniemi *et al.* (2004), Commander *et al.* (2004), Lucas (2004) or Batista *et al.* (2007).

migration-subsidy policy mix in a more realistic framework where distortions and efficiency costs are factored in.

Theoretically, we use a normative approach and derive the optimal emigration and education policies when social costs and distortions are linked to both instruments. The financing of public subsidies usually induces many costs such as tax evasion, distortive effects on labor supply, exit to the informal sector, administrative costs and corruption. Emigration also entails some costs to the government. It can reasonably be argued that emigration causes social welfare losses for the domestic country when the government is concerned by the aggregate stock of residents' human capital or has ethical opposition against skilled emigration.<sup>2</sup> In such cases, our model shows that the first best emigration rate is zero. With non-distortive taxes or at low efficiency costs, an appropriate education policy always dominates a controlled emigration policy. When tax distortions are sufficiently large, a controlled and rationed emigration rate can be second best. Skilled migration becomes a substitute to public subsidies, i.e. a negative correlation exists between the second best subsidy and the controlled emigration rate. Interestingly, such a negative relationship is also obtained in a "third-best" framework when the emigration rate is exogenously determined (i.e. when the planner has no control on emigration).

Such "crowding out" effects of skilled migration upon subsidies have been disregarded in the empirical literature, thereby overestimating the magnitude of incentive mechanisms. Empirically, we use a large sample of middle and low-income countries, and confirm the existence of a negative relationship between education subsidies and skilled migration rates. The elasticity of public subsidies to migration equals -0.20.

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<sup>2</sup>These can be related to population size acting as a cultural public good creating social capital, or to externalities associated with the total stock of human capital. Authors such as Kremer (1993), Lagerloef (2001) and Becker *et al.* (1999) have stressed the role of population growth and population density in the economic/demographic transition. Galor and Weil (1999) argued that a larger stock of human capital generates greater numbers of innovations.

We then revisit the country specific effects of skilled migration on human capital by considering public subsidies as endogenous. Our counterfactual experiment consists of equating the skilled emigration rate to the unskilled emigration rate (considered as the minimal rate of emigration given colonial ties, distance, etc.) and computing the hypothetical human capital change between 1990 and 2000. Unsurprisingly, the endogeneity of public subsidies decreases the relative number of winners, reduces the size of the gains and increases the size of the losses in other countries. It is noteworthy that although a brain gain is observed in the largest developing countries, skilled emigration reduces the number of post-secondary educated in the developing world by about 2.7 percent.

The remainder of the paper is organized as follows. Section 2 describes the theoretical model and compares the first best and second best solutions. Section 3 provides the empirical analysis and its implications. The final section concludes.

## 2 Migration as a second best policy option

To analyze the optimal migration-subsidy mix, we consider a small open economy populated by two overlapping generations. As in Stark and Wang (2002), agents are homogenous within generations and there are no credit market imperfections. The number of young individuals living at time  $t$  is denoted by  $N_t$  and the number of adults is denoted by  $A_t$ . Each adult gives birth to  $n > 1$  children. At each period, a composite good ( $Y_t$ ) is produced using capital ( $K_t$ ) and labor measured in efficiency units ( $H_t$ ) according to a neoclassical technology,  $F(K_t, H_t)$ . This good can be consumed, saved or used as an input for the formation of human capital. Young agents inherit a fraction  $a \in [0, 1]$  of adults' human capital,  $h_t$ . Labor in efficiency units is given by

$$H_t = N_t a h_t + A_t h_t = A_t (1 + na) h_t$$

The production function exhibits constant returns to scale and is time invariant. Assuming physical capital is perfectly mobile across countries, the time-invariant world interest rate  $R$  determines the wage rate per efficiency unit of labor  $w$ . Our economy is assumed to be poor. Due to a technological gap, the wage rate per efficiency unit of labor is lower than it is in the rich world:  $w < w^*$ . We assume no migration costs. Hence, each worker has an incentive to emigrate to rich countries.

Individuals are only concerned about their level of consumption in the second period of life,  $C_{t+1}$ . They are risk neutral and maximize their expected consumption level. Every young individual has the possibility to invest an amount  $e_t$  in education, to increase their second period stock of human capital. Individuals face a common training technology:

$$h_{t+1} = e_t^\alpha h_t^\delta \quad (1)$$

with  $\alpha + \delta < 1$  (decreasing returns to scale). The latter condition will ensure the convergence of the human capital stock to a steady state.

A fraction  $\sigma_t$  of education expenditures is subsidized by the government ( $\sigma_t$  is a Pigouvian policy instrument). The public budget constraint is balanced by levying lump-sum taxes on the young ( $\tau_t^y$ ) and adults ( $\tau_t^a$ ). This implies:  $n\sigma_t e_t = n\tau_t^y + \tau_t^a$ .

Individuals' saving is given by  $S_t = w a h_t - e_t(1 - \sigma_t) - \tau_t^y$ . Young agents make their education decision by anticipating a probability  $m_{t+1}$  of emigrating to a rich country when reaching adulthood. Their second period consumption equals  $C_{t+1}^* = R S_t + w^* h_{t+1}$  with probability  $m_{t+1}$ , and  $C_{t+1} = R S_t + w h_{t+1} - \tau_{t+1}^a$  with probability  $(1 - m_{t+1})$ . Young individuals maximize their expected (linear) utility

$$E(C_{t+1}) = R [w a h_t - e_t(1 - \sigma_t) - \tau_t^y] + m_{t+1} w^* h_{t+1} + (1 - m_{t+1}) [w h_{t+1} - \tau_{t+1}^a]$$

Given our assumptions concerning the training technology, there exists a unique

and interior solution to the individuals' maximization problem:

$$e_t = \left[ \frac{\alpha h_t^\delta [w + m_{t+1}(w^* - w)]}{R(1 - \sigma_t)} \right]^{\frac{1}{1-\alpha}} \quad (2)$$

and the dynamics of human capital is governed by the equation:

$$h_{t+1} = \left[ \frac{\alpha [w + m_{t+1}(w^* - w)]}{R(1 - \sigma_t)} \right]^{\frac{\alpha}{1-\alpha}} h_t^{\frac{\delta}{1-\alpha}} \quad (3)$$

Given decreasing returns to scale in the human capital technology, this function is concave and there is a unique interior steady state level of human capital:

$$h_{ss} = \left[ \frac{\alpha [w + m(w^* - w)]}{R(1 - \sigma)} \right]^{\frac{\alpha}{1-\alpha-\delta}} \quad (4)$$

Hence, our model is compatible with the analysis of Vidal (1998) and Stark and Wang (2002). When individuals are equally capable of responding to emigration incentives, migration prospects have an unambiguously positive impact on human capital. In the absence of distortions, public subsidies and a properly controlled emigration policy can be used to reach any level of human capital. Would this result resist a normative analysis?

## 2.1 The first best utilitarian solution

Except in totalitarian regimes, it is fairly obvious that sending countries have little control over emigration. Nevertheless, in line with the new literature on the brain drain, it is worth analyzing whether developing countries can benefit from a positive skilled emigration rates: i.e. what would be their optimal choice if they could perfectly control their skilled emigration rate? To address this question, we suppose that the government is concerned by the total welfare of residents. The social welfare function is of the Benthamite utilitarian form: it sums utilities of all remaining adults. This specification implies that the government is concerned by the resident population



size. Through this channel, we summarize all the social costs of emigration for the sending country. Given  $(R, w, A_0, S_0, h_0)$ , the planner's problem involves maximizing the social welfare function subject to the production technology of human capital. At time 0, the Lagrangian can be written as

$$\mathcal{L}^{FB} = \frac{A_0 c_0}{\beta} + \sum_{t=0}^{\infty} \beta^t \{ A_{t+1} [Rw a h_t - R e_t + w h_{t+1}] + \lambda_t A_{t+1} [e_t^\alpha h_t^\delta - h_{t+1}] \} \quad (5)$$

where  $\beta$  is the factor of social time preference such that  $\beta n < 1$ .

In the first-best problem, the planner has a perfect control on all individual decisions. Using the first order conditions with respect to  $h_{t+1}$ ,  $e_t$  and  $m_{t+1}$  (see Appendix 6.1), we have:

**Proposition 1** *Decentralizing the first best solution requires setting the emigration rate to zero and using both education subsidies and lump-sum taxes.*

The intuition is straightforward. There are two sources of intergenerational externalities in the model: individual education decisions impact upon the next generation income ( $\beta n R w a$ ) and affect the future productivity of education investments ( $\beta n \delta$ ). The long-run level of human capital at the first best is given by:

$$h_{ss}^{FB} = \left[ \frac{\alpha w [1 + \beta n R w a]}{R [1 - \beta n \delta]} \right]^{\frac{\alpha}{1 - \alpha - \delta}} \quad (6)$$

From (4), two instruments (emigration and subsidies) can be used to increase human capital. Resorting to emigration induces a social loss: the number of skilled residents decreases. Consequently, with no tax distortion, educational subsidy is to be preferred over emigration as it keeps all skilled individuals at home.

Comparing (6) to (4), the first best solution can be obtained as a market outcome if the government chooses a subsidy rate that corrects for both externalities:

$$\sigma_{ss}^{FB} = \frac{\beta n R w a + \beta n \delta}{1 + \beta n R w a} \quad (7)$$

It can be easily shown that the unique tax-mix that balances the budget constraint and verifies the optimality conditions requires  $\tau_{ss}^{y,FB} = \sigma_{ss}e_{ss}$  and  $\tau_{ss}^{a,FB} = 0$ . When the capital stock is exogenous and saving does not matter, there is no need for intergenerational transfers. For simplicity, in the remainder of this paper, we will only consider taxes on the young.

## 2.2 The second-best utilitarian solution

Let us now assume that levying taxes induces some distortions. Efficiency costs are denoted by  $c(\tau_t^y)$ : levying  $\tau_t^y$  dollars induces a fiscal revenue of  $\tau_t^y - c(\tau_t^y)$ . The idea that revenue collection entails a loss in efficiency is traditionally associated with labor/leisure choices, but they can also be linked to administrative costs of running programs, which in turn can be linked to the quality of governance and rent-seeking activities in developing countries. The planner now faces a second-best problem in that he has perfect control of policy instruments, which indirectly affect individual decisions. Hence, the government takes into account that individuals will maximize their own utility taking taxes and subsidies as given. The second-best problem now consists of maximizing the utilitarian social welfare function subject to the production technology of human capital (with multiplier  $\lambda_t$ ), the government budget constraint including efficiency costs (with multiplier  $\rho_t$ ), and the individual first order condition (eq. (2) with multiplier  $\mu_t$ ). At time 0, the Lagrangian can be written as:

$$\begin{aligned} \mathcal{L}^{SB} = & \frac{A_0 c_0}{\beta} + \sum_{t=0}^{\infty} \beta^t A_{t+1} \{ [Rw a h_t - R(1 - \sigma_t)e_t - R\tau_t^y + w h_{t+1} - \tau_{t+1}^a] \quad (8) \\ & + \lambda_t [e_t^\alpha h_t^\delta - h_{t+1}] + \rho_t [\tau_t^y - c(\tau_t^y) - \sigma_t e_t] \\ & + \mu_t [\alpha h_t^\delta [w + m_{t+1}(w^* - w)] - R(1 - \sigma_t)e_t^{1-\alpha}] \} \end{aligned}$$

and must be maximized with respect to  $h_{t+1}$ ,  $e_t$ ,  $\sigma_t$ ,  $\tau_t^y$  and  $m_{t+1}$ .

In Appendix 6.2, we provide the first order conditions expressed at the steady

state. In the absence of any perception cost ( $c'(\tau^y) = 0$ ), the optimal emigration rate is zero and the optimal level of human capital is naturally identical to  $h_{ss}^{FB}$ . This is the first best solution.

When perception costs are positive ( $c'(\tau^y) > 0$ ), the optimal migration rate can be positive. For the sake of simplicity, we consider the case of linear efficiency costs:  $c'(\tau^y) = \gamma$ .<sup>3</sup> The optimal level of human capital becomes:

$$h_{ss}^{SB} = \left[ \frac{\alpha w \phi(\gamma, m)}{R} \right]^{\frac{\alpha}{1-\alpha-\delta}} \quad (9)$$

where  $\phi(\gamma, m)$ , as detailed in appendix 6.2, is a decreasing function of  $\gamma$  and  $m$ .

We have:

**Proposition 2** *In the case of exogenous emigration rates and linear perception costs, the optimal level of human capital and the subsidy rate are decreasing in  $m$ .*

From (6) and (9), decentralizing the second best solution requires a subsidy rate equal to

$$\sigma_{ss}^{SB} = \frac{\phi(\gamma, m) - 1 - m \frac{(w^* - w)}{w}}{\phi(\gamma, m)}, \quad (10)$$

which is, for reasonable values of the parameters, a decreasing function of  $\gamma$  and  $m$ .

The interpretation is intuitive. On the one hand, the probability of migration reduces the social return to education (fewer remaining adults induces fewer externalities), and the optimal level of education decreases. On the other hand, migration stimulates the laissez-faire investment in education. Consequently, the gap between private and social returns to education decreases.

The above results characterize the "third best" solution with *exogenous emigration rates*, i.e. when the domestic government has no control on the migration rate (or when the first order condition with respect to  $m_{t+1}$  is not used).

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<sup>3</sup>Although perception costs in public finance are usually convex, the assumption of linear costs was made for simplicity. The introduction of convex costs would yield similar results.

Is migration good or bad for the sending country? Using the first order condition with respect to  $m_{t+1}$ , we can determine whether or not a positive migration rate is desirable from the perspective of the sending country. The condition for a positive emigration rate is  $\frac{\partial \mathcal{L}^{SB}}{\partial m} > 0$  evaluated at  $m = 0$ . This requires

$$\frac{\gamma}{1 - \gamma} \alpha h^\delta (w^* - w) > wh(1 + aR) - e \quad (11)$$

We have:

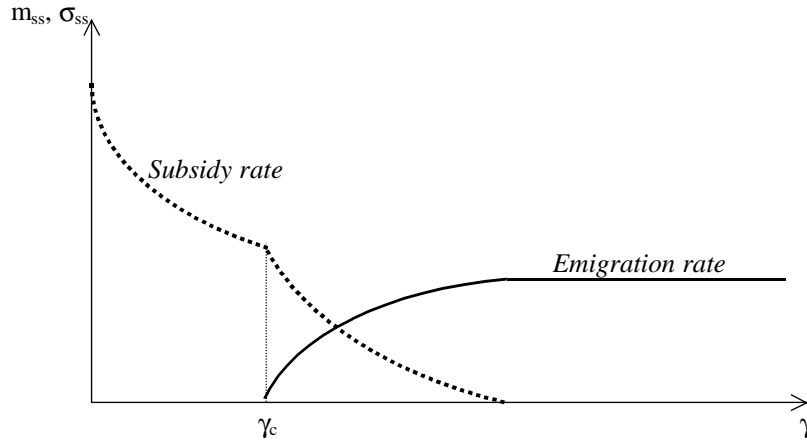
**Proposition 3** *There is a cutoff level in the distortion parameter  $\gamma_c$  above which the optimal migration rate is positive.*

Indeed, the right hand side term in (11) is decreasing in  $\gamma$ : from (9), a rise in  $\gamma$  reduces the level of human capital. The left hand side term is increasing in  $\gamma$  (it tends to infinity when  $\gamma$  tends to one and is equal to zero when  $\gamma = 0$ ).

Figure 1 below describes the impact of distortion costs on emigration and subsidy rates. As in the exogenous migration case,  $\sigma_{ss}^{SB}$  falls to zero when perception costs are sufficiently high (when  $\phi(\gamma, m) < 1 + m \frac{(w^* - w)}{w}$ ). Then perception costs vanish and there is no room for increasing the emigration rate.

Assuming exogenous educational policies and abstracting from any normative consideration, the recent literature on the brain drain reveals that skilled migration can stimulate human capital accumulation in the sending country. Endogenizing education subsidies, our analysis shows that emigration can be desirable if and only if tax distortions are sufficiently high. On the contrary, when tax distortions are low, impeding emigration and using domestic education policies is preferable. Hence, a welfare improving brain drain can only be obtained in particular circumstances (high fiscal distortions and limited emigration rates). When efficiency costs are low, the beneficial brain drain hypothesis hardly resists a normative analysis.

**Fig 1. Perception costs, optimal subsidy and emigration rates**



### 3 Empirical analysis

A central prediction of our theoretical model is that, whether an inefficient government can control emigration or not, there should exist a negative relationship between skilled emigration rates and public education subsidies. In this section, we use a recent data set on emigration to address two empirical issues. Firstly, do human capital accumulation and public subsidies effectively respond to skilled migration rates? Secondly, does the endogeneity of public subsidies modify the gains and losses of skilled migration compared to previous studies? We address these questions in a sample of 108 countries. We eliminate high-income countries (we select nations for which migration is likely to induce a clear incentive effect), countries for which data on public expenditures in education are not available and countries that experienced civil war and political turmoil during the 1990s.<sup>4</sup>

<sup>4</sup>Among countries for which data is available, we exclude Afghanistan, Armenia, Bosnia and Herzegovina, Dem. Rep. of Congo, Croatia, Eritrea, Georgia, Guinea-Bissau, Iraq, Liberia, Macedonia, the Federated States of Micronesia, Rwanda, Serbia and Montenegro, Sierra Leone and Somalia.

### 3.1 Data on skilled migration

Our empirical analysis is based on a recent data set on international migration by educational attainment detailed in Docquier and Marfouk (2006) (henceforth DM). DM use the receiving country  $r$ 's census or population register to extract information on immigrants country of birth, age, and skill level. Such statistics were collected for all OECD countries (Organization for Economic Cooperation and Development). Let  $M_{t,s}^r$  denote the stock of working-age individuals born in a given country, of skill level  $s = l, h$  ( $h$  stands for individuals with post-secondary certificates,  $l$  stands for those with less than post-secondary schooling) and living in country  $r$  at time  $t$ . The stock of emigrants from a given country for a given education level,  $M_{t,s} = \sum_r M_{t,s}^r$ , is then obtained by summing over receiving countries. Emigration rates by education levels are then obtained by comparing the number of emigrants to the population at origin with similar characteristics,  $N_{t,s}$ . Skilled and unskilled emigration rates are denoted by  $m_t = \frac{M_{t,h}}{N_{t,h} + M_{t,h}}$  and  $\underline{m}_t = \frac{M_{t,l}}{N_{t,l} + M_{t,l}}$  respectively. The data set also allows us to compute the proportion of post-secondary educated among natives ( $H_t = \frac{N_{t,h} + M_{t,h}}{\sum_s (N_{t,s} + M_{t,s})}$ ) and among residents ( $h_t = \frac{N_{t,h}}{\sum_s N_{t,s}}$ ).

The DM estimates are built according to a broad definition of "skilled migrants" in that they include all foreign-born workers with post-secondary schooling wherever they acquired education.<sup>5</sup> Beine *et al.* (2007b) use immigrants' age of entry as a proxy for where education has been acquired. They provide alternative measures of the brain drain by defining skilled immigrants as those arrived in the receiving country after age 12, 18 or 22. These corrected skilled emigration rates, which can be seen as intermediate bounds to the brain drain estimates, are by construction lower than those computed without age-of-entry restrictions by DM. Let us denote

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<sup>5</sup>For example, Mexican-born individuals who arrived in the US at age 5 or 10 and later graduated from US high-education institutions are counted as highly-skilled Mexican immigrants.

by  $m_{J,t}$  the skilled emigration rate based on migrants who left their country after age  $J$  ( $J = 12, 18, 22$ ), i.e. on restrictive measures of  $M_{t,h}$ . We denote by  $H_{J,t}$  the corresponding proportion of educated among natives. These alternative measures are only available for migrants with post-secondary level education. We use them to evaluate the robustness of our empirical model in Appendix 6.3.

### 3.2 Empirical model and econometric issues

The theoretical model predicts (i) a negative relationship between skilled emigration and subsidy rates and (ii) a positive effect of migration prospects and subsidies on human capital formation. In the theoretical model, individuals live a single adult period. Hence, the stock of human capital is equal to the lagged investment of the young. In the real world, the flow of investment in human capital can be approximated by the change in the stock. Hence, our empirical analysis distinguishes two dependent variables, the growth rate of human capital between 1990 and 2000 and the logarithm of the education subsidy rate in 1990. Human capital is measured as the proportion of post-secondary educated natives (including emigrants). The education subsidy rate is measured as the amount of public expenditure in tertiary education per student as percentage of GDP per capita (provided by the United Nations Educational, Scientific and Cultural Organization - UNESCO).<sup>6</sup> We consider these two variables as endogenous and estimate two empirical equations.

Regarding human capital accumulation, we use a " $\beta$ -convergence" equation and regress the log-ratio of human capital,  $\ln(H_{00}/H_{90})$ , on:

- the log of the skilled emigration rate in 1990,  $\ln(m_{90})$ , so as to capture the incentive effect of migration prospects. Note that in our estimates, we first use as a benchmark the skilled emigration rate of all foreign born individuals regardless of whether they

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<sup>6</sup>There is a high correlation between public expenditure in secondary and tertiary education (67 percent). This is not the case between the primary and tertiary levels.

acquire their education in their origin or host country;<sup>7</sup>

- the log of tertiary educated in 1990,  $\ln(H_{90})$ , so as to capture convergence or divergence forces;

- the log of public subsidy per student as percentage of GDP per capita in 1990,  $\ln(\sigma_{90})$ , so as to control for the local education policy;

- the age structure of the population within a country. It can be argued that the growth rate of human capital is stronger in countries where the population turnover (replacement of old cohorts by young ones) is important. Since migrants usually belong to young cohorts, it is important to control for the population structure in our regressions. We account for that possibility by using the demographic share of individuals aged 15 to 24,  $S_{15/24}$ , and the share of those 49 to 55,  $S_{49/55}$  (Source: United Nations Population Division);

- the urbanization rate,  $UR_{90}$ , which accounts for access to schooling facilities within a country (Source: World Development Indicators);

- the level of remittances in 1990,  $R_{90}$ , which potentially alleviates liquidity constraints impeding human capital investments (Source: World Development Indicators);

- a set of regional dummies  $REGD_i$  (Sub-Saharan Africa, Latin America, Middle East and North Africa, East Asia and Pacific, Eastern Europe and Central Asia) capturing regional unobserved characteristics. South Asia is used as reference.

This specification is similar to that used in Beine et al (2007a) but is more general it in several respects. We add new control variables (including regional fixed effects) and use new UNESCO estimates of public expenditures in tertiary education. We expect the inclusion of the latter variable to improve our assessment of the incentive mechanism.

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<sup>7</sup>In Appendix 6.3, we estimate our model using alternative measures of the skilled emigration rate ( $m_{J,t}$ ) and human capital stock ( $H_{J,t}$ ) which control for the age of entry of migrants.



Regarding education subsidies, we estimate the log of public expenditure per student as percent of GDP per capita in 1990,  $\ln(\sigma_{90})$ , as a function of:

- the log of the high skilled emigration rate,  $\ln(m_{90})$ , so as to capture the policy trade-off predicted by our theoretical model;
- the investment rate in 1990,  $I_{90}$ , since investments in public education are mainly profitable where there are machines to complement skills;
- the "rule of law" dimension of governance measuring the extent to which agents have confidence in and abide the rules of society,  $RLAW$ . It ranges from -2.5 (bad governance) to 2.5 (good governance). We average the annual scores provided in Kaufmann *et al.* (2003);
- dummies for middle-income ( $MINC$ ) countries based on the World Bank classification;
- the level of remittances in 1990,  $R_{90}$ , so as to capture the political demand for public transfers (as remittances are potential determinants of liquidity constraints);
- the same set of regional dummies,  $REGD_i$ , as above.

Our specifications are:

$$\ln\left(\frac{H_{00}}{H_{90}}\right) = a_0 + a_1 \cdot \ln(m_{90}) + a_2 \cdot \ln(H_{90}) + a_3 \ln(\sigma_{90}) + a_4 S15/24 \quad (12)$$

$$+ a_5 S49/55 + a_6 UR_{90} + a_7 R_{90} + \sum_{i=8}^{12} a_i REGD_i + \epsilon_H$$

$$\ln(\sigma_{90}) = b_0 + b_1 \cdot \ln(m_{90}) + b_2 \cdot I_{90} + b_3 \cdot RLAW + b_4 \cdot MINC + \quad (13)$$

$$+ b_5 \cdot R_{90} + \sum_{i=6}^{10} b_i REGD_i + \epsilon_\sigma$$

where  $\epsilon_H$  and  $\epsilon_\sigma$  are error terms.

The potential correlation between unobserved characteristics and the emigration rate can affect both the growth rate of human capital and level of public subsidies

per student. Therefore, the OLS method can generate inconsistent estimates. To address such a problem, we use the instrumental variable (IV) method and estimate the two equations with the two-stage least square procedure (2SLS). We consider  $\ln(m_{90})$  as the instrumented variable. The recent empirical growth literature (Barro and Sala-i-Martin, 1995; Hall and Jones, 1999) paid attention to the determinants of instruments when estimating a migration equation. However, it is difficult to select excluded instruments for migration due to an obvious presumption of correlation with human capital. Here, the first-stage migration equation uses geographical proximity with developed countries (minimal distance to OECD countries), and two indicators of disadvantageous location (dummies for landlocked countries and small islands). In previous versions of the paper, we ran many regressions with different sets of instruments and obtained similar results.

In our estimation strategy, several diagnostic tests are conducted to assess the reliability of the IV estimates. We first check whether our instruments are relevant and valid using the first-stage F-statistic of joint significance of the instruments (the rule of thumb in Staiger and Stock (1997) is that F-statistic should exceed 10), Anderson's canonical correlations likelihood ratio test statistic, and the Cragg-Donald statistic for weak instruments. The instruments' strength is analyzed against the null hypothesis of weak instruments, as suggested in Stock and Yogo (2002). The validity of our instruments is assessed using the Hansen J-statistic for overidentification. Finally, provided that our instruments satisfy the relevance and validity conditions, IV estimates can be consistent but inefficient. Therefore, if regressors are exogenous, consistent and more efficient estimates produced by OLS are preferred. Thus, we test for exogeneity of  $\ln(m_{90})$  using a C-test. We also correct for the presence of heteroscedasticity in the data and checked for multicollinearity.

### 3.3 Results for the human capital equation

Table 1 reports the OLS and IV estimation results for human capital accumulation using the overall skilled emigration rate regardless of the age of entry of individuals. For each method, the first column corresponds to the full specification of the equation of human capital accumulation; the second column gives a parsimonious specification in which insignificant or weakly significant variables such as  $I_{90}$  and  $R_{90}$  are excluded. Note that dropping these variables increases the size of our sample. For IV regressions, we report first and second stage diagnostic tests.

The results in Table 1 show a positive and significant association between skilled migration rates and human capital accumulation. This effect is robust across different specifications and estimation methods. However, the magnitude differs across methods. The size of the IV estimate is twice as large as the one obtained with OLS. Our estimates also indicate that an increase in public subsidies has a positive and stable impact on human capital formation. Another finding worth emphasizing is the negative and significant impact of the initial human capital stock. This suggests the existence of a conditional convergence process between 1990 and 2000. The share of the young cohort  $S_{15/24}$  has negative sign. This can be explained by the fact that human capital formation is lower in poor countries with high fertility and population growth rates. The share of the older cohort  $S_{49/55}$  has negative sign, indicating that a lower turnover of the population reduces the growth rate of human capital. Urbanization has a positive and significant impact on human capital formation. Regional dummies are not reported in the table. In all specifications, the sub-Saharan dummy is significant and negative. The dummies for East-Asia and Pacific and Eastern Europe and Central Asia are significant and positive. There is no significant effect for Latin America and Middle East and North Africa.

In every IV regression, the instruments satisfy the relevance and validity conditions. Indeed, the Hansen statistic has high p-values, suggesting that the null hypothesis is not rejected and the instrument excludability requirement is satisfied. The first-stage statistics support instrument relevance and strength: the F-statistics are above 10; the low p-values of the Anderson canonical correlation likelihood ratio test, indicate rejection of the irrelevance hypothesis. The Cragg-Donald weak identification test rejects the weakness of the instruments. However, the C-tests strongly suggest rejection of endogeneity. This indicates that the variable  $\ln(m_{90})$  can be treated as exogenous. It follows that the OLS method is the most appropriate estimation technique. Thus, based on the F-Statistic, the OLS 2 model appears to be the superior specification. The growth rate of human capital between 1990 and 2000 exhibits an elasticity between 3.2 and 4.2 percent with respect to skilled migration (Beine et al (2007a) found 4.8 percent) and an elasticity of 12 percent with respect to public subsidies. Appendix 6.3 discusses the robustness of these results.

### **3.4 Results for the subsidy equation**

Table 2 gives the OLS and IV estimates for education expenditures per student. In all regressions, we obtain a negative and significant impact of  $\ln(m_{90})$  on the subsidy rate. We note that the coefficients of  $\ln(m_{90})$  are biased downward in OLS estimations models compared to their magnitudes in IV models. The quality of governance (*RLAW*) is an important factor, significantly and positively affecting public education subsidies. Subsidies are significantly higher in middle-income countries; remittances and investments have no effect on education expenditures per student. All regional dummies proved to be significant and positive (compared to the reference region, South Asia).

**Table 1. Log Ratio of Human Capital ( $H_{00}/H_{90}$ )**

	OLS 1	OLS 2	IV 1	IV 2
$\ln(m_{90})$	0.042** (0.021)	0.032** (0.006)	0.082** (0.036)	0.077** (0.037)
$\ln(H_{90})$	-0.285*** (0.039)	-0.273*** (0.038)	-0.278*** (0.040)	-0.278*** (0.040)
$\ln(\sigma_{90})$	0.119** (0.058)	0.121** (0.049)	0.125** (0.060)	0.116** (0.053)
$S15/24$	-2.227*** (0.860)	-2.346*** (0.792)	-1.897** (0.821)	-1.907** (0.807)
$S49/55$	-10.44*** (3.215)	-10.11*** (2.972)	-10.57*** (3.112)	-10.37*** (3.086)
$UR_{90}$	0.228* (0.137)	0.263** (0.117)	0.410*** (0.148)	0.380*** (0.147)
$R_{90}$	-0.000* (0.000)		-0.000* (0.000)	
$I_{90}$	-0.000 (0.000)		-0.000 (0.000)	
$REGD$	yes	yes	yes	yes
F-statistic	32.255	41.265	36.438	40.021
N. Obs	88	105	104	105
Hansen test (i)			4.622	3.567
p-value			0.099	0.168
First-stage F stat.(ii)			15.52	16.43
Anderson test (iii)			38.398	38.793
p-value			0.000	0.000
Cragg-Donald test (iv)			13.398	13.707
C-test (v)			1.763	1.319
p-value			0.184	0.251

Between brackets, Standard errors. Reported heteroskedastic-robust.

IV excluded instruments: distance to OECD, dummies for landlocked and small island.

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

(i) Hansen J statistics - Over-identification test.

(ii) F statistics for first stage regression - Instrument relevance.

(iii) Anderson LR statistics - Instrument relevance.

(iv) Cragg-Donald statistics Instrument relevance.

(v) C-test - Exogeneity of  $\ln(m_{90})$ .

The  $p$ -values associated with the Chi-square statistics of the  $C$ -test suggests the variable  $\ln(m_{90})$  is not exogenous. The implication is that OLS estimates are not consistent and that the IV estimation technique is therefore more appropriate. Thus, the estimated coefficients of model IV2 (the best specification in the table given the  $F$  – *Statistic*) indicate a strong and highly significant relationship between these two variables: the average elasticity of public education subsidies to skilled migration rates amounts to -0.20. Such a result is consistent with the main prediction of our theoretical model. For IV regressions, F-tests on excluded instruments indicate that these are jointly significant in predicting the endogenous regressor,  $\ln(m_{90})$ . The Anderson relevance tests suggest that these instruments as a set are relevant and strong predictors of  $\ln(m_{90})$ . The Cragg-Donald statistics exceed the critical value of 9.08 (at least in model IV2), which imply a bias relative to OLS of less than 10 percent (Stock and Yogo, 2002). The overidentification tests (Hansen J statistic) do not reject the null hypothesis that the instruments are independent of the second-stage disturbance terms at the 5 percent level of significance.

**Table 2. Public education subsidy,  $\ln(\sigma_{90})$** 

	OLS 1	IV 1	OLS 2	IV 2
$\ln(m_{90})$	-0.039*	-0.232***	-0.051*	-0.201***
	(0.041)	(0.075)	(0.032)	(0.057)
$I_{90}$	0.000**	0.000**	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
$RLAW$	0.494***	0.407***	0.420***	0.363***
	(0.117)	(0.138)	(0.109)	(0.124)
$MINC$	0.503***	0.333**	0.512***	0.391***
	(0.136)	(0.148)	(0.130)	(0.125)
$R_{90}$	-0.000	-0.000		
	(0.000)	(0.000)		
$REGD$	Yes	Yes	Yes	Yes
F-statistic	80.80	52.34	101.63	72.51
N. obs	92	92	107	107
Hansen test (i)		1.827		1.410
p-value		0.176		0.235
First-stage F stat.(ii)		13.47		18.07
Anderson test (iii)		26.65		32.32
p-value		0.000		0.000
Cragg-Donald test (iv)		13.44		16.93
C-test (v)		7.86		7.856
p-value		0.005		0.005

Between brackets, Standard errors. Reported heteroskedastic-robust.

IV excluded instruments: distance to OECD, landlocked dummy

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

(i) Hansen J statistics - Over-identification test.

(ii) F statistics for first stage regression - Instrument relevance.

(iii) Anderson LR statistics - Instrument relevance.

(iv) Cragg-Donald statistics Instrument relevance.

(v) C-test - Exogeneity of  $\ln(m_{90})$ .

### 3.5 Brain drain and human capital accumulation

Let us now use our empirical findings to simulate the effect of skilled migration on human capital accumulation. We use a counterfactual experiment, which consists of setting the 1990 skilled emigration rate to the level of the unskilled rate,  $\underline{m}_{90}$ .<sup>8</sup> The unskilled migration rate may be considered as a minimal emigration rate given country characteristics such as size, geographic proximity, colonial and linguistic links with OECD members and political factors at origin. Hence, our experiment consists of minimizing the size of the brain drain. We first use (13) to simulate the impact on education subsidies,  $\hat{\sigma}_{90}$ , and then use (12) to predict the 2000 level of human capital among natives,  $\hat{H}_{00}$ . Note that a similar method is used in Beine et al (2007a) to compute the effect of skilled migration on human capital accumulation between 1990 and 2000. However, taking education subsidies as exogenous (BDR method) potentially overestimates the size of the incentive effect on human capital formation.

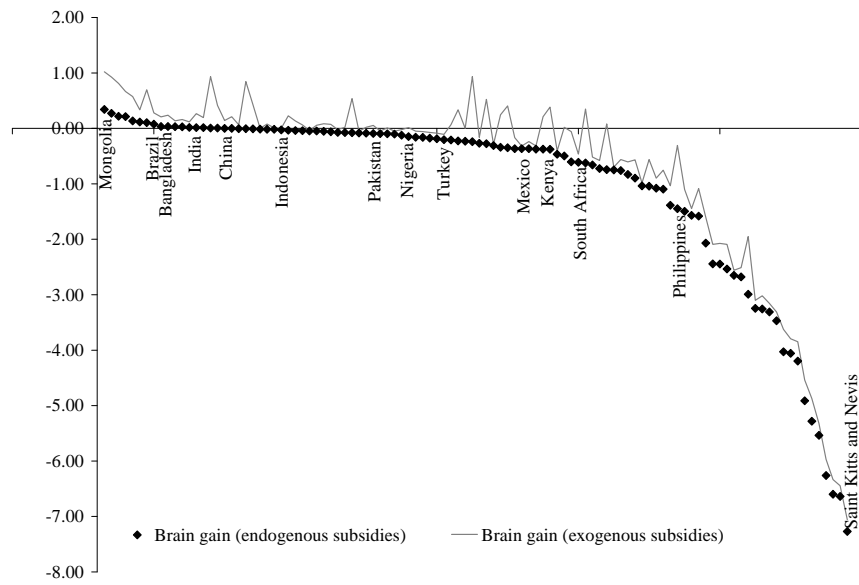
We compare the observed and hypothetical proportions/numbers of skilled residents. Figure 2 gives the simulated impact of skilled emigration on the proportion of skilled among residents (intensive measure of human capital) and Figure 3 gives the impact on the number of skilled residents (extensive measure). A positive amount means that the country benefit from skilled migration, i.e. has more human capital than in the counterfactual scenario where the brain drain is reduced. The grey lines reports simulations with exogenous subsidies (BDR method).

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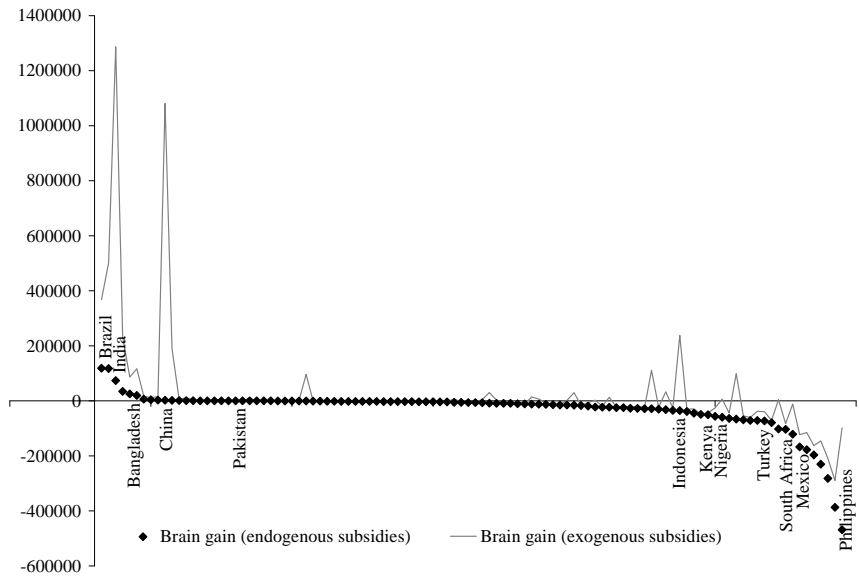
<sup>8</sup>For a couple of countries where the unskilled emigration is very close to zero, we impose a lower bound equal to one tenth of the skilled emigration rate. Since we use a log specification, this avoids unrealistic effects.



**Fig 2. Net effect of skilled migration on the proportion of skilled residents**



**Fig 3. Net effect of skilled emigration on the number of skilled residents**



Setting skilled migration rates to unskilled migration rates induces a rise in the subsidy rate in almost all countries.<sup>9</sup> On average the rate is multiplied by about 1.48. Notwithstanding the rise in education subsidies, reducing skilled migration rates would have a negative impact on the proportion of educated in 20 countries and a negative impact on the number of educated in 18 countries (out of 108 countries). Such *brain gain* or *beneficial brain drain* cases are obtained in large countries combining relatively low levels of human capital and low skilled emigration rates, confirming the BDR results.

The group of winners includes large countries (e.g., China, India, Brazil, Bangladesh) which represent a large fraction of the population residing in developing countries. Our results are more pessimistic than those of Beine et al (2007a) who treat education subsidies as exogenous (see grey line on Figures 2 and 3). The BDR method gives 51 winners, larger gains or smaller losses. In addition, BDR predict that the brain drain generates a positive net gain for developing countries as a whole (+2.2 percent of post-secondary graduates). Endogenizing education subsidies increases the number of losers and the size of the losses. On the whole, the brain drain induces a net negative effect on the total number of post-secondary educated in the developing world (-2.7 percent).

## 4 Conclusion

One of the arguments levelled at the brain drain is the loss of investment of public spending in the education of emigrants. How do developing countries adjust their education policies to skilled migration? What is the resulting effect of their policy on human capital accumulation? Our paper addresses these questions both theoretically

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<sup>9</sup>The only exception is Bulgaria where the unskilled emigration rate exceeds the skilled emigration rate.

and empirically.

Assuming exogenous education policies, the new literature on the brain drain asserts that high-skill migration entails beneficial feedback effects for the source countries. Authors such as Vidal (1998), Mountford (1999) and Stark and Wang (2002) argue that migration prospects may foster education investments in developing countries, thus making it possible for a brain drain to be beneficial to the source country. Survey data and macroeconometric studies confirm that possibility. Endogenizing education subsidies, our theoretical analysis reveals that a positive emigration can be desirable if, and only if, tax distortions are sufficiently high, i.e. if the local government is unable to decentralize the first best solution with non distortive tax-transfers. Conversely, when tax distortions are low, impeding skilled emigration would be socially better. The optimal emigration rate is zero. Hence, resorting to the brain drain must be considered as a second-best policy option that reflects the inability of the government to costlessly use domestic instruments.

Some recent studies such as Beine *et al.* (2001, 2007a) provide empirical support for the beneficial brain drain hypothesis, abstracting from various indirect effects on skill premia, fiscal policies, etc. In particular, they disregard possible "crowding-out" fiscal effects on public subsidies. Investigating the empirical relationship between education subsidies and migration prospects, we obtain a significant and negative relationship in a cross-section of 108 countries. Skilled migration and public subsidies are empirical substitutes. We then revisit the country specific effects of skilled migration on human capital by considering public subsidies as endogenous. Our counterfactual experiment consists in setting the skilled emigration rate to the unskilled rate. We then compute the hypothetical human capital change between 1990 and 2000. The endogeneity of public subsidies strongly reduces the relative number of losers, increases the size of the losses and reduces the size of the gains in other

countries. Obviously, focusing on human capital formation, our analysis abstracts from all other indirect channels through which migration affects the sending country (through return migration, remittances, network effects, etc.) or the domestic return to education (wage rate, skill premium, etc.). Although the perspective of a beneficial brain drain appears more limited than in previous studies, we still obtained "winning" countries. However, the net effect on the total number of educated workers residing in the developing world becomes negative.

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## 6 Appendix

### 6.1 Proof of Proposition 1

Using  $A_{t+1} = nA_t(1 - m_{t+1})$ , the planner maximizes  $\mathcal{L}^{FB}$  in (5) with respect to  $h_{t+1}$ ,  $e_t$  and  $m_{t+1}$ . This gives the following first order conditions:

$$\begin{aligned}\frac{\partial \mathcal{L}^{FB}}{\partial h_{t+1}} &= \beta^t A_{t+1} w + \beta^{t+1} A_{t+2} R w a - \beta^t A_{t+1} \lambda_t + \beta^{t+1} A_{t+2} \lambda_{t+1} e_{t+1}^\alpha \delta h_{t+1}^{\delta-1} = 0 \\ \frac{\partial \mathcal{L}^{FB}}{\partial e_t} &= -\beta^t A_{t+1} R + \beta^t A_{t+1} \lambda_t \alpha e_t^{\alpha-1} h_t^\delta = 0 \\ \frac{\partial \mathcal{L}^{FB}}{\partial m_{t+1}} &= -\beta^t A_t n C_{t+1} < 0\end{aligned}$$

Focusing on the steady state, the social return to human capital,  $\lambda_{ss}^{FB} = \frac{w[1+\beta n R w a]}{1-\beta n \delta}$ , exceeds the private return on human capital,  $w$ .

From the first order condition with respect to  $m_{t+1}$ , emigration deteriorates social welfare. The optimal emigration rate is therefore zero.

### 6.2 Proof of Proposition 2

At the steady state, the first order conditions of (8) are:

$$\begin{aligned}
(i) \quad 0 &= w [1 + \beta n(1 - m)Rwa] - \lambda [1 - \beta n(1 - m)\delta] \\
&\quad + \beta n(1 - m)\mu\alpha [w + m(w^* - w)] \delta h^{\delta-1} \\
(ii) \quad 0 &= -R(1 - \sigma_t) + \lambda\alpha e^{\alpha-1} h^\delta - \rho n\sigma - \mu R(1 - \sigma)(1 - \alpha)e^{-\alpha} \\
(iii) \quad 0 &= R - \rho n + \mu R e \\
(iv) \quad 0 &= -R + \rho n [1 - c'(\tau^y)] \\
(v) \quad 0 &\geq -C + \mu(1 - m)\alpha h^\delta (w^* - w)
\end{aligned}$$

Clearly, when  $c'(\tau^y) = 0$ , conditions (iii)-(iv) imply  $\rho n = R$  and  $\mu = 0$ . From condition (v), the optimal migration rate is zero. From condition (i), the social return on human capital  $\lambda$  is identical to the first best value,  $\lambda_{ss}^{FB}$ . Consequently, the first best solution emerges.

When perception costs are positive,  $c'(\tau^y) > 0$ , we have  $\rho n > R$ ,  $\mu > 0$  so that the optimal migration rate can be positive. Assuming linear efficiency costs ( $c'(\tau^y) = \gamma$ ) and combining conditions (i), (iii) and (iv), the social return on human capital is given by:

$$\lambda_{ss}^{SB} = \frac{w \left\{ 1 + \beta n(1 - m)Rwa + \beta n(1 - m) \frac{\gamma\delta\alpha}{1-\gamma} \left[ 1 + m \frac{(w^* - w)}{w} \right] \right\}}{1 - \beta n(1 - m)\delta}$$

From condition (ii), the optimal level of education amounts to:

$$e_{ss}^{SB} = \left[ \frac{\alpha h^\delta \left[ (1 - \gamma)\lambda_{ss}^{SB} + \alpha\gamma (w + m(w^* - w)) \right]}{R} \right]^{\frac{1}{1-\alpha}}$$

Combining these results and using (1) yields:

$$h_{ss}^{SB} = \left[ \frac{\alpha w \phi(\gamma, m)}{R} \right]^{\frac{\alpha}{1-\alpha-\delta}}$$

with  $\phi(\gamma, m) \equiv \frac{(1-\gamma)[1+\beta n(1-m)Rwa] + \gamma\beta n(1-m)\alpha\delta \left[ 1 + m \frac{(w^* - w)}{w} \right] + \alpha\gamma \left[ 1 + m \frac{(w^* - w)}{w} \right] [1 - \beta n(1-m)\delta]}{1 - \beta n(1-m)\delta}$ , which

is, for reasonable values of the parameters, a decreasing function of  $\gamma$  and  $m$  (at

least for  $\gamma$  ranging from 0 to 0.5 and for any  $m$ ). Note that, we have  $w\phi(0,0) = \frac{w[1+\beta nRwa]}{1-\beta n\delta} = \lambda_{ss}^{FB}$ .

Decentralizing the second best solution requires a subsidy rate equal to:

$$\sigma_{ss}^{SB} = \frac{\phi(\gamma, m) - 1 - m\frac{(w^*-w)}{w}}{\phi(\gamma, m)}$$

such that the subsidy rate is a decreasing function of both  $\gamma$  and  $m$ :

$$\begin{aligned} \frac{\partial \sigma}{\partial m} &= \frac{(1 + m\frac{(w^*-w)}{w})\phi'_m - \frac{(w^*-w)}{w}\phi}{\phi^2} < 0 \\ \frac{\partial \sigma}{\partial \gamma} &= \frac{(1 + m\frac{(w^*-w)}{w})\phi'_\gamma}{\phi^2} < 0 \end{aligned}$$

It should be noted that  $\sigma_{ss}^{SB}$  can be negative for high emigration rates (when  $\phi(\gamma, m) < 1 + m\frac{(w^*-w)}{w}$ ). The budget constraint requires  $\tau_{ss}^y = \sigma_{ss}^{SB} e_{ss}^{SB} / (1 - \gamma)$ .

### 6.3 Human capital regressions - Robustness check

The incentive effect of skilled emigration on human capital accumulation remains positive and significant whatever the measures of brain drain used. Table A reports replications of the specifications OLS2 and IV2 of Table 1 distinguishing different ages of entry. We only report estimates for the three main explanatory variables although results for other controls and diagnostic tests are almost identical to those in Table 1. Clearly, Table A supports the robustness of the incentive mechanism and the positive effect of public education subsidies.

In previous version of the paper, we investigated the robustness of this mechanism using functional forms other than the log-linear specification we have adopted here. The incentive mechanism depicted in Table 1 is robust to the alternative specifications: results with  $m_{90}$  or  $\ln(1 + m_{90})$ , rather than  $\ln(m_{90})$ , can be obtained upon request. It could also be argued that further efficiency gains would be obtained by



estimating both equations simultaneously as a system. We tested our model using a three-stage least squares (3SLS) system and obtained similar results.<sup>10</sup>

**Table A. Log Ratio of Human Capital ( $H_{J,00}/H_{J,90}$ ), controlling for age of**

	entry					
	J = 12		J = 18		J = 22	
	OLS	IV	OLS	IV	OLS	IV
$\ln(m_{J,90})$	0.032** (0.015)	0.077** (0.036)	0.033** (0.016)	0.077** (0.036)	0.033** (0.016)	0.077** (0.036)
$\ln(H_{J,90})$	-0.273*** (0.038)	-0.279*** (0.040)	-0.273*** (0.038)	-0.277*** (0.040)	-0.273*** (0.038)	-0.277*** (0.040)
$\ln(\sigma_{90})$	0.121** (0.049)	0.116** (0.053)	0.121** (0.048)	0.116** (0.051)	0.120** (0.048)	0.115** (0.051)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
F-statistic	41.45	40.11	41.29	40.28	41.37	40.24
N. Obs	104	104	104	104	104	104

Between brackets, Standard errors. Reported heteroskedastic-robust.

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

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<sup>10</sup>These results can be obtained upon request to the authors.