Skilled migration and human capital formation in developing countries - A survey*

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Abstract

In this paper we focus on the consequences of skilled migration for source (developing) countries. We first present new evidence on the magnitude of the "brain drain" at the international level. Using a unified stylized model of education investment in a context of migration, we then survey the theoretical and empirical literature on the impact of highly-skilled emigration on human capital formation in developing countries. Finally we use a particular specification of the model to discuss what new policy insights may be obtained against a background of international mobility of the highly-skilled.

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Contents

1 Introduction

The current wave of economic globalization has opened a window of opportunity for human capital to agglomerate where it is already abundant and yet best rewarded, i.e, in the most economically advanced countries. This trend has been strengthened by the gradual introduction of selective immigration policies in many OECD countries since the 1980s. What started as an effort to increase the quality of immigration in countries such as Australia or Canada has developed into an international competition for attracting the highly educated and skilled. Together with traditional self-selection effects on the supply-side, this explains the overall tendency for migration rates to be much higher for the highly-skilled. While the world Export/GDP ratio has been multiplied by a factor of 1.51 between 1990 and 2000 (WTO, 2004), the total number of foreign-born individuals legally residing in the OECD countries has increased in the same proportions (+51%) over that period, a figure that jumps to 70% for highly-skilled migrants against only 28% for low-skilled migrants (Docquier and Marfouk, 2004).

What are the consequences of this human capital flight for sending (developing) countries? In a world of perfect competition with complete markets, the free mobility of labor would seem to be Pareto-improving: migrants receive higher incomes, natives in the receiving countries can share the immigration surplus, and remaining residents in the sending countries can benefit from the rise in the land/labor and capital/labor ratios. However, in the case of highly-skilled migrants, such labor movements also generate a number of "externalities" that have to be factored in. First, skilled migrants are net contributors to the government budget and their departure generates a fiscal burden for those left behind (fiscal externality). Second, skilled labor and unskilled labor complement one another in the production process; in a context of scarcity of skilled labor and abundant unskilled labor, as is the case in developing countries, skilled labor migration may have a substantial negative impact on low-skilled workers' productivity and wages (intragenerational spillover) and therefore increase economic inequality in the home country. Third, human capital depletion through emigration would seem to impact negatively on a country's growth prospects, inasmuch as human capital formation is now viewed as a central engine of growth (intergenerational spillover). Fourth, as demonstrated in various new economic geography frameworks (e.g., Fujita et al., 1999), skilled labor is instrumental to attracting FDIs and fostering R&D expenditures (technological externality); therefore, the mobility of human capital may contribute to the concentration of economic activities in specific locations at the expenses of the origin regions. On the other hand, high-skill migration may also induce positive feedback effects as skilled emigrants continue to affect the economy of their origin country after they have left. Such possible feedbacks include migrants' remittances, return migration after additional skills have been acquired abroad, and the creation of networks that facilitate trade, capital flows and knowledge diffusion.

Given the many channels involved, an evaluation of the exact impact of the mi-

gration of skilled labor (the "brain drain") for source countries is a very complex task. As we shall advocate in this paper, most of this impact may ultimately be captured through the effect of emigration on the composition of the labor force, that is, on the stock of human capital per worker remaining in the home country. Until recently, empirical attempts in this direction have been hampered by the lack of harmonized international data on migration by origin country and education level. In the absence of such empirical material, the debate has remained almost exclusively theoretical. The early "brain drain" literature of the 1970s emphasized the negative consequences for those left behind. Its main conclusions were that skilled emigration contributes to increased inequality at the international level, with the rich countries getting richer at the expenses of the poorer countries. By contrast, more recent contributions ask whether the traditional negative effects of the brain drain stressed in the early literature may be offset by possible beneficial effects arising from remittances, return migration, creation of trade and business networks, and possible incentive effects of migration prospects on human capital formation at home.[1] In particular, a new theoretical literature has emerged around the idea that migration prospects may well foster domestic enrollment in education in developing countries and studies the conditions under which the net effect of the brain drain may be positive for the source country (i.e., the country ends up with a higher level of human capital after emigration is netted out).

We first summarize in Section 2 the data on the magnitude of the brain drain, and then provide new estimates on the international mobility of the highly skilled; our measures are based on immigration data collected from nearly all OECD countries for 1990 and 2000 by Docquier and Marfouk (2004). These data show that the brain drain has gained in magnitude over the period covered although substantial differences remain across countries and regions. Section 3 presents the arguments of the "new" and "old" brain drain literatures in a fully harmonized framework: it first exposes the rather pessimistic view of the early brain drain literature, and contrasts it to more recent models suggesting that some developing countries may have experienced a social gain from the brain drain. It also reviews the various channels whereby skilled migrants may impact on their home country after they have left (remittances, return migration, migrant networks), and provides evidence on these different channels when available. Section 4 is dedicated to policy implications, with emphasis on migration policy, education policy and taxation policy in a context of international migration. Section 6 concludes.

[1] Grubel and Scott (1969) already mentioned the various possible feedback effects of the brain drain for source countries (remittances, networks, innovation in the host country that may spillover to the origin country, etc), and argued that the short-term loss (due to intragenerational and fiscal externalities) could well be offset in the the long run. However, such possible feedbacks were considered too small to make a difference, and the brain drain literature of the 1970s focused on its detrimental (short-term) impact.

2 How big is the brain drain?

There is clear evidence that the brain drain has increased dramatically since the 1970s, both in absolute and relative terms. Nearly thirty years ago, the United Nations estimated the total number of highly-skilled South-North migrants for 1961-72 at only 300,000 (UNCTAD, 1975); less than a generation later, in 1990, the U.S. Census revealed that there were more than 2.5 million highly educated immigrants from developing countries residing in the U.S. alone, excluding people under age 25 (that is, without counting most foreign students). Country studies commissioned by the International Labor Organization also showed that nearly 40% of Philippines' emigrants are college educated, and, more surprisingly, that Mexico in 1990 was the world's third largest exporter of college-educated migrants (Lowell and Findlay, 2001). Since 1990, the chief causes of the brain drain have gained in strength and these increasing trends have been confirmed. Indeed, selective immigration policies first introduced in Australia and Canada in the 1980s have spread to other OECD countries, first to the U.S. with the Immigration Act of 1990 and the substantial relaxation of the quota for highly-skilled professionals (H1-B visas), and then to most EU countries (including France, Germany, Ireland and the UK) which recently introduced similar programs aiming at attracting a qualified workforce (e.g., creation of labor-shortage occupation lists) (OECD, 2002).

Until very recently, however, there were no comparative data on the magnitude of the brain drain. The first serious effort to put together harmonized international data on migration rates by education level is due to William Carrington and Enrica Detragiache from the International Monetary Fund, who used US 1990 Census data and other OECD statistics on international migration to construct estimates of emigration rates at three education levels (primary, secondary and tertiary schooling) for about 60 developing countries.[2] The Carrington-Detragiache (henceforth CD) estimates, however, suffer from four main shortcomings. First, CD assumed for each country that the skill composition of its emigration to non-US OECD countries is identical to that of its emigration to the US; for example, Nigerian immigrants in the UK are assumed to be distributed across educational categories in the same way as Nigerian immigrants in the US. Consequently, the CD estimates are not reliable for countries for which the US is not the main destination (transposition problem). Second, at the time CD conducted their study, the OECD immigration data (notably for the EU, Japan, Switzerland or New Zealand) did not allow for a full decomposition of the immigrants' origin-mix; more precisely, many OECD countries used to publish statistics indicating immigrants' origin country just for the top 5 or 10 sending countries. For small countries not captured in these statistics, the figures reported in the CD data set are therefore biased: the total number of emigrants is underestimated, and in some cases one is (mis)led to conclude that 100% their immigrant

[2]See Carrington and Detragiache (1998, 1999). Relying on the same assumptions, Adams (2003) provides estimates for 2000.

to the OECD area immigrated to the US (under-reporting problem); as acknowledged by Carrington and Detragiache, this may approximate the reality for Latin America, but is clearly erroneous, for example, in the case of Africa. Third, the CD data set excludes South-South migration, which may be significant in some cases (e.g., migration to the Gulf States from Arab and Islamic countries, or to South-Africa from neighboring countries, etc.). Finally, recall that all foreign-born individuals residing in an OECD is considered an immigrant to that country, independently of his or her age at arrival; for example, Mexican-born individuals who arrived in the US at age 5 or 10 and then graduated from US high-education institutions later on are counted as highly-skilled immigrants.

In an attempt to extend Carrington and Detragiache's work, Docquier and Marfouk (2004) collected data on the immigration structure by education levels and country of birth from most OECD countries in 1990 and 2000. They used the same methodology and definitions as Carrington and Detragiache (1998), but extended their work in a number of ways. First, Census data reporting educational levels and countries of birth were used for nearly all OECD countries: 26 countries in 2000 (representing 96 percent of the total OECD immigration stock) and 24 countries in 1990 (93 percent). For the few remaining countries, data by country of birth were splitted across educational levels on the basis of the regional structure or of the OECD average, allowing Docquier and Marfouk (2004) to provided "reliable" emigration rates by education level based for 195 origin countries in 2000 and 175 origin countries in 1990.[3] Their estimates are therefore of a much higher quality than the CD estimates in that they address two of the problems that arose from the CD database: under-reporting for small countries, and transposition of the US immigration education structure to the rest of OECD countries (and, in addition, they provide data for a second year, 2000). Aggregating over countries, Docquier and Marfouk (2004) estimated the total number of adult immigrants living in the OECD area and aged 25 or more at 60.3 million in 2000 and 42.4 million in 1990. Emigration rates by education levels are obtained by comparing the number of emigrants to the population from which they are drawn. The latter information is taken from the Barro and Lee (2000) data set on educational attainments. At the world level, it appears that 1.8% of the working-aged population is living in a foreign country. The worldwide average emigration rates amount to 1.2%, 1.8% and 5.5% for low-skill, medium-skill and high-skill workers, respectively.

However, the two other problems that characterized the CD database remain: South-South migration is not taken into account (but in the absence of immigration data from countries such as South Africa or the Gulf countries, there is not much that can be done about this), and no distinction is made between familial and economic migration. The US being one of the few countries for which data on both age at the

[3]By reliable, DM (2004) mean an estimate based on observed education attainments for at least 80% of a country's total emigration stock. At the same reliability rate, Carrington and Detragiache (1998) provided reliable estimates for about 25 countries.

date of the Census and age at arrival in the country are available, a partial, cost-effective way to cope with this last problem is to use these US data and transpose the age-of-entry structure by education level of US immigration to the rest of the OECD countries (note that the US account for nearly half of total immigration to the OECD); aggregating over receiving countries, on may then derive emigration rates by education level and country of birth that somewhat control for age at arrival. We will refer to the initial DM estimates as to the "basic rates", and to our re-calculated estimates after controlling for age of entry as to the "corrected rates". We count as immigrants all those who were 16 or older upon arrival in the host country;[4] that is, we exclude 7% of all immigrants to OECD countries in 2000, a proportion that is slightly higher for the highly-skilled (see Figure 1). A look at the distribution by country shows that for some countries, notably Central American and Carribean countries, not controlling for age of entry could lead to a substantial over-estimation (see Figure 2). In the following, therefore, we present both the "basic" estimates as computed by Docquier and Marfouk (2004) and our own corrected rates after controlling for age of entry based on the age and education structure of US immigrants.

[Insert Figure 1]

[Insert Figure 2]

Where do skilled immigrants come from? Table 1 compares total and skilled-emigration rates in 1990 and 2000 by region, income group (for the four categories distinguished by the World Bank) and country-size group (for countries with population above 25 million, from 10 to 25 million, from 2.5 to 10 million and below 2.5 million). The comparison is based on the basic rates computed by Docquier and Marfouk (2004). It shows that average migration rates are strongly decreasing with country size: small countries tend to be more opened to trade and migration. Regarding income groups, the highest rates are observed for middle-income countries, where people have both the incentives and means to emigrate. High-income countries (less incentive to emigrate) and low-income countries (where liquidity constraints are more binding) exhibit the lowest rates. It is readily seen that between 1990 and 2000, the magnitude of the brain drain has decreased in middle-income countries but increased in low-income countries. Finally, the analysis by region shows that the most affected regions are Africa and, due to small-size effects, the Pacific and the Carribean. Eastern Europe and the Middle East also exhibit relatively high emigration rates for the highly–skilled.

[Insert Table 1]

Obviously, the intensity of the brain drain differs if it is measured in absolute or relative terms. After excluding high-income countries from our sample, we present in Table 2 the data for developing countries only. In terms of absolute numbers, the Philippines, India, Mexico, China, Korea, Vietnam and Poland appear as the major

[4]Setting the threshold at 18 or 20 would not change the results. It may be seen from Figure 1 that a majority of those who arrived before age 20 actually arrived before age 10 as children accompanying their parents, and only a handfull of the immigrants arriving between age 16 and 20.

sending countries. In terms of emigration rates (that is, as a percentage of the native-born skilled labor force), the picture is obviously quite different. Table 2 shows the 30 countries for which emigration rates among the highly-skilled are the highest and the lowest (in 2000). The brain drain appears very strong in small countries, with figures as high as 80% in some Pacific or Carribean islands. Controlling for familial migration does not significantly affect the rankings, as may be seen from the Table. For a better illustration of the phenomenon, we present in the right-columns of Table 2 the basic and corrected rates only for countries with a population higher than 4 million. Skilled emigration appears particularly strong (higher than 30 percent) in countries that suffered from civil war and political instability during the last decades (e.g., Haiti, Somalia, Sierra Leone, Lebanon) and located mostly in Central America and Africa. By contrast, Eastern European or South American countries exhibit relatively low brain drain levels. Finally, it is noteworthy that China and India are among the less affected countries in relative terms despite their important contribution to the overall stock of skilled immigrants at the world level.

We now turn to the economic theories that have analyzed the determinants and consequences of international skilled-migration from the perspective of developing countries.

3 Theory and evidence

This section provides an overview of the theoretical and empirical literature on the consequences of highly-skilled emigration for source countries. This issue has given rise to a large body of research since the late 1960s, with the early literature generally supporting the view that the brain drain is detrimental to those left behind and the more recent literature providing a more balanced view. We first present the general set-up, reformulate the results of early contributions within this framework, and then introduce the various channels emphasized in later research. We also present the existing evidence on each particular channel.

3.1 The model

Consider a stylized small open economy populated by two-period lived individuals. At each period, a composite good is produced according to a Cobb-Douglas technology, $Y_t = A_t K_t^{1-\alpha} L_t^{\alpha}$. For simplicity, the stock of capital, K_t, is assumed to be composed of foreign investments only (no domestic savings), and the labor supply, L_t, sums up skilled and unskilled labor. Normalizing the number of efficiency units offered by an unskilled individual working full time to 1, a skilled individual working full-time offers $h > 1$ such units. The scale factor is time-variable and can be positively related to the economy-wide average level of human capital of the workers remaining in the country, H_t, itself a function of the proportion of skilled workers in that generation,

P_t. Therefore, we have $H_t = 1 + P_t(h-1)$, with P_t the share of skilled workers and $h > 1$ their relative productivity, and $A_t = A(H_t)$,with $A' \geq 0$.[5]

This latter mechanism allows us to introduce the spillover effects associated to human capital formation. The international mobility of capital is such that the marginal productivity of capital equals to the world interest rate (r^*) plus a risk premium (π_t) associated to internal factors such as political instability, corruption, individual freedom, etc. Hence, the domestic wage rate per efficiency unit of labor is given by:

$$w_t = \alpha \left[\frac{1-\alpha}{r^* + \pi_t} \right]^{\frac{1-\alpha}{\alpha}} [A(H_t)]^{\frac{1}{\alpha}} \equiv w(\pi_t, H_t)$$

with the derivatives $w_1' < 0$ and $w_2' > 0$.

When young, people are offered the choice between working as unskilled workers or devoting part of their time to education. There is a single education program, the cost of which is proportional to the domestic wage rate w_t. However, individuals are heterogenous in the ability to learn and may therefore be characterized by different education costs, with high-ability individuals incurring a lower cost. The cost of education for a type-c agent is denoted by cw_t, with c distributed on $[0,1]$ according to the cumulative distribution $F(c)$. When adult, skilled (educated) and unskilled agents work full-time, with education enhancing one's productivity and, thus, one's income, by an exogenous skill premium $h \in [1,2]$.[6] Utility is linear in consumption and there is no time-discount rate. There is no domestic saving so that the stock of capital is totally owned by foreign investors.

Without migration, the lifetime income for an uneducated agent is $w_t + w_{t+1}$. By contrast, the lifetime income for an educated agent is $w_t - cw_t + w_{t+1}h$. Clearly, education is worthwhile for individuals whose education cost is lower than a critical value. At the steady state ($w_{t+1} = w_t$), the condition for investing in education in an economy with no migration (henceforth denoted using the subscript n) is:

$$c < c_n \equiv h - 1.$$

In poor countries, however, liquidity constraints are likely to impact on education choices. Assume, therefore, that the first-period consumption cannot be lower than a minimal threshold, ϕw_t, which is assumed to be proportional to wages. Hence, an agent with education cost above $c_L \equiv 1 - \phi$ has no access to education, and the liquidity constraint may or may not be binding depending on whether $c_L \gtrless c_n$.

Consequently, the economy-wide average level of human capital of the current generation of adults may be written as:

$$H_n = 1 + P_n(h-1)$$

[5] We will later restrict the values of h to $]1,2[$ to obtain interior solution when we assume an uniform distribution of abilities.

[6] Given $c \in [0,1]$, the restriction $h < 2$ ensures that the proportion of educated is lower than one, even when c is uniformly distributed.

where $P_n = Min\left[F(c_n); F(c_L)\right]$ measures the proportion of educated adults.

Let us now examine the impact of skilled migration on the sending economy. In the model with private education funding, the impact of migration on reamining residents is related to the way it affects the composition of the labor force. What matters is the effect of migration on the equilibrium wage rate. If the stock of human capital per worker remaining in the home country decreases (resp. increases), the wage rate also decreases (resp. increases) and there is a loss (a gain) of welfare for those left behind. For different reasons, we are aware that the relationship between welfare and skilled migration is likely to depend on other channels which are not modeled here:

- as we shall argue in the policy discussion (see section 4.2), results can be different under public funding of education. Suppose maintaining the same average stock of human capital requires increasing subsidies and taxes, then uneducated workers (who receive no subsidies) experience a welfare loss due to the reduction in net wages (despite constant gross wages);

- as developed in section 3.5, a rise in welfare can be obtained with decreasing human capital when migration gives rise to international transfers. For the main recipients, disposable income can rise despite decreasing wage rate;

- another possible criticism is that migration is likely to affect welfare through non-income channels. Buidling on the idea that individuals obtain pleasure from interaction with whom they share social capital (including norms, language, culture and more), Schiff (2002) models the negative externality of emigration per se for those left behind. Even if empirical evidence on social capital and migration is limited, the "social capital drain" is likely to reduce welfare despite constant income.

To avoid using a welfare criterion, our analysis focuses on the impact of the brain drain on the economic potential of the sending country, summarized by the average stock of human capital among remaining members.

3.2 The traditional view

The first "modern" economic papers on the impact of highly-skilled migration on source countries date back to the late 1960s (Grubel and Scott, 1966, Johnson, 1967). Their conclusions were not too pessimistic. For example, Grubel and Scott (1966) argued that the short-term loss to the source country (due to the intragenerational and fiscal externalities outlined above) could well be offset in the the long run thanks to various possible feedback effects in the form of remittances, networks effects, or innovations that may spillover from the host to the origin country. However, such possible feedbacks were considered too small to make a difference, and the brain drain literature of the 1970s focused on its detrimental (short-term) impact.

The central conclusion of the early brain drain literature, namely, that the brain drain is detrimental to the welfare of those left behind, relies on a number of critical assumptions: (i) Migrants are self-selected among the pool of emigrants, (ii) there is free mobility and, hence, no uncertainty regarding future migration opportunities and, (iii) there is a complete disconnection between emigrants and their country of origin once they have left (no diaspora effect, no return migration, no remittances). Is such conditions, clearly, emigration can only affect negatively the proportion of educated in the remaining population, P.

Building on the stylized model above, consider that workers now have the possibility to emigrate toward a developed country where, due an exogenous technological gap, one unit of human capital is paid $w^* > w_t$. The wage ratio can be written as $\omega_t = w^*/w_t = \omega(P_t)$ with $\omega^{'} < 0$. Migration involves a cost kw^* which captures transportation, search, assimilation and psychological costs of leaving one's home country. Individuals have to choose whether to educate or not (ED or NE), and whether to migrate or not (MI or NM). The lifetime income associated to each pair of decision is determined by

$$\begin{aligned} U(NE, NM) &= w_t + w_{t+1} \\ U(NE, MI) &= w_t + w^*(1-k) \\ U(ED, NM) &= w_t - cw_t + w_{t+1}h \\ U(ED, MI) &= w_t - cw_t + w^*(h-k) \end{aligned}$$

At the steady state, the condition for a self-selection equilibrium to emerge (i.e., skilled workers only emigrate) is :

$$\omega(1-k) < 1 < \omega(1-\frac{k}{h})$$

In this case, migration prospects impact on the critical ability level required for investing in education; the condition for investing in education becomes:

$$c < c_o \equiv \omega(h-k) - 1$$

which is higher than $c_n = h - 1$ providing that the self-selection condition holds.

Their is a great deal of evidence that migration prospects indeed impact on people's decisions to invest in higher education. For example, in their survey on medical doctors working in the UK, Kangasniemi et al. (2004) evaluate that the migration premium in the medical profession lies between 2 and 4 (in PPP values); about 30% of Indian doctors surveyed acknowledge that the prospect of emigration affected their effort to put into studies; furthermore, the doctors surveyed estimate that migration prospects affect the effort of about 40% of current medical students in India. Focusing on the software industry, Commander et al. (2004) estimate that the migration premium for Indian IT workers contemplating emigration to the US lies between 3 to

5 (depending on the type of job) in PPP values.[7] According to the IOM (2003), the prospects of working abroad have increased the expected return to additional years of education and led many people to invest in more schooling, especially in occupations in high demand overseas.

Migration prospects stimulate domestic enrollment in education but actual emigration deprives the country from its educated citizens, the proportion of educated in the remaining population falls to zero, and the average level of human capital of remaining members falls to 1.

In the presence of a minimal threshold for consumption, migration can be limited by an additional liquidity constraint. Liquidity constraints are due to the monetary fraction of the migration costs only (as psychological costs of leaving and assimilation costs are incurred only once migration has occured). Let us denote by $k^{'}w^{*} < kw^{*}$ this monetary component of the migration cost. Agents with education costs above $c_M \equiv 1 - k^{'}\omega - \phi < c_L$ cannot both educate and migrate. A positive number of educated individuals thus remains in the source country when the threshold c_M is lower than c_n. In this case indeed, individuals with personal ability between c_M and c_n cannot afford paying for both migration and education costs but still have an incentive to invest in education (see case 1 on Figure 5). When c_M is higher than c_n, however, agents who cannot afford paying for migration costs have no incentive to educate and all the educated would leave the country at the end of period 1 (see case 2 on Figure 5).

[INSERT FIGURE 5]

Basically, the central prediction of the traditional view is that once migration opportunities are introduced, the average level of human capital among remaining residents decreases. The effect on natives' income depends on $A(H_t)$, through which various types of externalities can be considered. Building on the idea that the social return to education is higher than its private return, the literature of the 1970s generally concluded to a detrimental effect based on the externality argument (Hamada, 1977, Usher, 1977, Blomqvist, 1986). In a similar spirit, Bhagwati and Hamada (1974) developed a model of wage determination in which the departure of skilled workers also reduces unskilled workers' expected earnings. The mechanism whereby skilled workers' emigration negatively impacts on remaining workers' wages involve a mechanism of wage-setting that accounts for inefficiences of labor markets in developing countries. Assume that there are two types of workers (educated and uneducated), and wages for the educated are determined by workers' unions and incorporates an element of international emulation (i.e., depend positively on wages abroad). Once skilled-workers wages are set, unskilled-workers wages follow with some rule of proportionality. In this setting, skilled migration reduces skilled unemployment, meaning

[7] In current \$, the migration premium is much larger (higher than 10 for many countries). Many migrants confess that they were unable to compare earnings on a PPP basis. The expected migration premium is likely to lie between the PPP and the current \$ values.

that wage pressures become stronger. While the net effect on skilled employment depends on the elasticity of demand for skilled labor (determining whether the skilled labor wage bill increases or not), this tends to extend unemployment and reduces welfare among the uneducated.

Note that Bhagwati and Hamada (1974), as well as McCulloch and Yellen (1977), take into account the incentive effects of the brain drain on education decisions, with the increase in the expected-wage for skilled workers stimulating human capital investments; they also raise a number of questions regarding optimal public financing of education in such a context, an issue that we will deal with in Section 4.

Modern theories of endogenous growth have considerably renewed the analysis of the relations between education, migration and growth. Unsurprisingly, the first models to address the issue of the brain drain in an endogenous growth framework also emphasized its negative effects (e.g., Miyagiwa, 1991, Haque and Kim, 1995). At the same time, a series of studies have tried to promote the simple idea that one should also look at how a given stock of human capital is built up. In particular, it is likely that in the presence of huge inter-country wage differentials, as is the case between developing and developed countries, the prospect for migration deeply modifies the incentive structure faced by developing countries' residents when making their education decisions. When migration is temporary or when the education decision is made in a context of uncertainty regarding future migration opportunities, a beneficial brain drain or a brain gain may result for the source country.

3.3 Temporary migration

Let us first introduce return migration and temporary visas. As documented in international reports (e.g., OECD, 1998), most receiving countries have recently made admission conditions for candidate immigrants more restrictive. On the one hand, as detailed in the introduction, selective procedures have been put in place; on the other hand, most new specific immigration programs targeting the educated and skilled are designed for temporary immigrants, the general trend being towards an increase in the share of temporary visas relatively to permanent visas. Assume, therefore, that candidate immigrants are allowed to spend only a fraction γ of their working life in the destination economy. Substituting temporary to permanent visas reinforces self-selection among migrants: the expected return to education being lowered, fewer people will invest in education and only those at the upper-end of the ability distribution will find it beneficial to do so. Obviously, the exact impact on those who would have invested in education would visas had been permanent visas, depends on the length of the migration period. In terms of our notations, the lifetime income for

educated agents are now given by:[8]

$$\begin{aligned} U(ED, NM) &= w_t - cw_t + w_{t+1}h \\ U(ED, MI) &= w_t - cw_t + \gamma w^* h + (1-\gamma)hw_{t+1} - kw^* \end{aligned}$$

At the steady state, emigration is optimal for skilled workers when the following condition holds:

$$\gamma h(\omega - 1) > k\omega$$

If the latter condition does not hold, migration prospects have no effect on human capital formation. If it holds, the perspective of temporary migration stimulates human capital investments.

Without liquidity constraints, the condition for investing in education becomes:

$$\begin{aligned} c &< c_\gamma \equiv \gamma(\omega - 1)h + h - 1 - k\omega \quad if \;\; \gamma h(\omega - 1) > k\omega \\ &< c_n \equiv h - 1 \;\; if \; not \end{aligned}$$

In the first alternative, and assuming a uniform distribution of abilities, the proportion of educated workers in the country becomes:

$$P_\gamma = \frac{(1-\gamma)c_\gamma}{1 - \gamma c_\gamma}.$$

Graphically, the case of temporary migration is similar to the case of permanent migration, except that the incentive effect is propotional to γ. Nevertheless, the major difference is that, by contrast to the case with permanent visas, the incentive effect partly benefits to the sending country. Indeed, the probability P_γ can be lower or higher than P_n. Formally, a possibility of "beneficial brain drain" emerges if the derivative of P_γ with respect to γ is positive for low values of γ, i.e. a value such that skilled workers start opting for migration ($\gamma = \frac{k\omega}{h(\omega-1)}$). We obtain

$$\left[\frac{\partial P_\gamma}{\partial \gamma}\right]_{\gamma h(w-1)=k\omega} = \frac{(h-1)(h-2) + h(\omega - 1) - k\omega}{\left[1 - \gamma(h-1)\right]^2} \gtreqless 0$$

If this derivative is positive, there is an interval of γ for which the temporary migration of skilled workers can stimulate the share of educated workers in the source country and, in turn, the economy-wide average level of human capital.[9] Several elements are likely to mitigate this result, however. First, liquidity constraints are

[8] Note that for simplicity we assume migration costs to be identical as in the case of permanent migration. This could be justified by assuming that higher transportation costs (since people now travel both ways) strictly compensate for reduced psychological costs, or that the latter are incurred at the first years following immigration. Alternatively, we could assume that in the case of a temporary migration, people incur a migration cost of $k' + \gamma(k - k') \equiv k''$.

[9] Clearly, for $\gamma = 1$, the traditional view applies: the effect of brain drain is unambiguously detrimental.

likely to limit the size of the incentive effect. If $c_\gamma > c_L$, some agents have no access to education in spite of the fact that education is optimal, which reduced the likelihood of a beneficial brain drain. Similarly, if liquidity constraints restrict migration prospects, the incentive effect is thereby weakened. In the particular case where $c_M > c_n$, the number of individuals engaging in education is constant and temporary migration reduces the share of educated workers.

Dos Santos and Postel-Vinay (2003) argue that a beneficial brain drain could emerge even if the share of educated workers decreases. This is shown in a setting where growth is exogenous at destination and endogenous at origin, with the sole engine of growth there being knowledge accumulation embodied in migrants returning from the more advanced country. Their caveat relies on knoweldge diffusion, that is, on the idea that the more advance technology spillovers to the developing country as it is in a way carried out by returning migrants. To the extent that returnees contribute to the diffusion of the more advanced technology they experienced abroad, emigrants' return is therefore a potential source of growth for their home country. This means that return migrants come back with a productivity gain, $\Theta h > h$, which stimulates the average level of human capital. The average stock of human capital then becomes:

$$H = 1 + P_\gamma(\Theta h - 1)$$

which must be compared to the case of no migration, $H = 1 + P_n(h - 1)$.

In a companion paper, Dos Santos and Postel-Vinay (2004) show that a shift in immigration policy, with an increase in the share of temporary visas, may benefit to the sending countries of educated migrants. Two effects of the proposed shift in immigration policy are described: a decrease in the incentives to acquire education, which reduces the pre-migration stock of human capital at origin, and a higher proportion of returnees among emigrants, which increases the country's stock of knowledge, a complement of human capital. Their paper derives the theoretical conditions required for an overall positive effect to occur.

Using a different perspective, Stark *et al.* (1997) elaborate on the possibility of a brain gain associated with a brain drain in a context of imperfect information with return migration. In their setting, workers' productivity is revealed at destination only after a certain period of time during which people are paid according to the average productivity of their group. Some relatively low-skill workers will therefore find it beneficial to invest in education so as to migrate and be pooled at destination with high-skill workers; once individuals' ability are revealed, the low-skill workers return to their home country, which may therefore benefit from their educational investments.

There is limited evidence that return migration is significant among the highly-skilled, or that skilled returnees largely contribute to technology diffusion. We know that in general, return migration is characterized by negative self-selection (Borjas and Bradsberg, 1996) and is seldom among the highly skilled unless sustained growth preceded return. For example, less than a fifth of Taiwanese PhDs who graduated

from US universities in the 1970s in the fields of Science and Engineering returned to Taiwan (Kwok and Leland, 1982) or Korea, a proportion that rose to about one half to two-thirds in the course of the 1990s, after two decades of impressive growth in these countries. Is it due to the economic boom at origin or to changes in the immigration policy at destination? Recent evidence is quite mitigated.

On the one hand, the figures for Chinese and Indian PhDs graduating from US universities in the same fields during the period 1990-99 are fairly identical to what they were for Taiwan or Korea 20 years ago (stay rates of 87% and 82%, respectively) (OECD, 2002). This would seem to be confirmed by a recent survey which shows that in the Hsinchu Science Park in Taipei, a large fraction of companies have been started by returnees from the USA (Luo and Wang, 2001). In the case of India, Saxeenian (2001) shows that despite the quick rise of the Indian software industry, only a fraction of Indian engineers in Bangalore are returnees. According to these papers, return skilled migration appears relatively limited, however, and is often more a consequence than a trigger of growth.

On the other hand, a more recent and comprehensive survey of India's software industry reached more optimistic and confirmed the presence of network effects and the importance of temporary mobility (strong evidence of a brain exchange or a brain circulation), with 30-40% of the higher-level employees having relevant work experience in a developed country (Commander et al., 2004). In their survey on medical doctors working in the UK, Kangasmieni et al (2004) found that "many" intend to return after completing their training.

3.4 Uncertainty

Before 1965, the US immigration policy was based on country-specific quotas. This quota system is now abolished but various types of requirements and restrictions imposed by the US and other country's immigration authorities render the migration decision very uncertain. Implicit or explicit size-quotas are effectively in place, and receiving an immigration visa, whether temporary or permanent, requires being in a close relationship either with relatives or employers who must then demonstrate that the migrant's skills can hardly be found among native workers. Moreover, in some countries, point-systems are used to evaluate the potential contribution of immigrants to the host economy. This means that at all stages of the immigration process, there is a probability that the migration project will have to be postponed or abandonned. Individuals engaging in education investments with the prospect of migration must therefore factor in this uncertainty, creating the possibility of a net gain for the source country. The conditions required for this possibility to materialize have been the subject of a number of theoretical contributions (Mountford, 1997, Stark et al., 1998, Vidal, 1998, Beine et al., 2001).

To account for this within our general framework, assume that the probability of migration depends solely on the achievement of a given educational requirement,

which is observable, and not on individuals' ability, which is not perfectly observable (i.e., migrants are assumed to be randomly selected among those who satisfy some kind of prerequisite with informational content regarding their ability - in our case, education).[10] The model with uncertainty looks like an out-selection model where receiving countries accept a fraction $p > 0$ of skilled candidates and reject all unskilled applications. Alternatively, it can be considered as a model of self-selection in which unskilled workers have no incentive to emigrate while skilled migration is optimal but limited.

Assume moreover that the subjective probability of getting a visa, as seen by a potential migrant, equals the proportion of the educated who effectively emigrated within the previous generation (i.e., at the steady-state). Denoting by p this probability, the lifetime income for educated agents is now given by

$$\begin{aligned} U(ED, NM) &= w_t - cw_t + w_{t+1}h \\ U(ED, MI) &= w_t - cw_t + pw^*h + (1-p)hw_{t+1} - pkw^* \end{aligned}$$

Uncertainty and return migration induce similar effects on the expected return to education, which is lowered in both cases by contrast to the case of certain permanent migration. However, several differences are worth noticing. First, the incentive mechanism here operates even for low values of p (remember that an incentive effect was obtaining with temporary migration only for $\gamma \geq \frac{k\omega}{h(\omega-1)}$). Second, even for $p = \gamma$, uncertainty generates more incentives to educate than temporary migration. The reason for this is straightforward and has to do with the fact that uncertainty reduces expected migration costs. However, uncertainty *per se* cannot be seen as a source of knowledgege diffusion.

At the steady state, the condition for skilled migration being optimal is the same as under certainty (i.e., $1 < \omega(1 - \frac{k}{h})$), but now education is worthwhile for people for whom:

$$c < c_p \equiv h - 1 + ph\left[\omega(1 - \frac{k}{h}) - 1\right]$$

Clearly, we have $c_p = c_n$ when $p = 0$ and $c_p = c_o$ when $p = 1$.

As in the case of temporary migration, there is a possibility of beneficial brain drain for the sending country partly to the incentive effect. The proportion of educated workers in the country becomes $P_p = \frac{(1-p)c_p}{1-pc_p}$. This proportion P_p can be lower or higher than P_n. A beneficial brain drain can be obtained for some ranges of p,

[10] Our simplified model assumes homogenous skill within educational groups. The size of the incentive effect would be different with heterogenous skills (see Commander et al, 2002). In reality, immigration authorities may be combining education with other selection devices such as tests of IQ or host-country language fluency. Would IQ be a perfect signal of ability and the only criterion retained, migration could only be detrimental to human capital formation at home. Still, and to the extent that IQ or other tests are imperfect signals of ability, an incentive effect exist for intermediate skilled workers (the probability to emigrate potentially increases with ability).

providing that the derivative of P_p with respect to p is positive at $p = 0$. We obtain:

$$\left[\frac{\partial P_p}{\partial p}\right]_{p=0} = (h-1)(h-2) + h(\omega - 1) - k\omega \lesseqgtr 0$$

Note that this derivative corresponds to the numerator in $\left[\frac{\partial P_\gamma}{\partial \gamma}\right]_{\gamma h(\omega-1)=k\omega}$.

As in previous cases, liquidity constraints are likely to lower the size of the incentive effect. If $c_p > c_L$, the incentive effect will be limited to agents with education costs comprised between c_n and c_L. A similar constraint applies if $c_p > c_M$.

What is the empirical evidence on this "prospect" channel? To the best of our knowledge, the first study to attempt at estimating the growth effects of the brain drain using cross-country comparisons is that of Beine, Docquier and Rapoport (2001); in a cross-section of 37 developing countries, and after controlling for remittances, they found that migration prospects have a positive and significant impact on human capital formation at origin, especially for countries with low initial GDP per capita levels. This was a first but imperfect try since they used gross migration rates as a proxy measure for the brain drain due to the lack of comparative data on international migration by education levels.

In a subsequent study, Beine et al. (2003) then used the Carrington-Detragiache estimates of emigration rates for the highest (tertiary) education as their measure of brain drain; again, they found a positive and highly significant effect of migration prospects on human capital formation, this time in a cross-section of 50 developing countries. They also computed country specific effects, with the following results. First, countries that experienced a positive growth effect (the 'winners') generally combined low levels of human capital and low migration rates, whereas the 'losers' were typically characterized by high migration rates and/or high enrollment rates in higher education (this is quite intuitive, since in this case most migrants are picked up from a stock of people that would have engaged in education even without contemplating emigration). Second, they showed that except for extreme cases such as Guyana and Jamaica, the growth effects of the brain drain were relatively limited: around plus or minus a maximum of 0.2% in terms of annual GDP per capita growth; this is not negligible, however, in a dynamic perspective. Finally, it was also striking that while there were more losers than winners, the latter included the largest countries in terms of demographic size (China, India, Indonesia, Brazil) and represented more than 80% of the total population of the sample. For the most part, these results are apparent on Figure 6; incidentaly, it may be seen from the figure that the within-country result predicted by the theory outlined above (i.e., that some migration should be good as long as it is not excessive) is what comes out at the cross-country level apparent on Figure 6. The X-axis gives the Carrington-Detragiache migration rates for the highly educated and the Y-axis gives the net growth effect of the brain drain as computed by Beine et al. (2003). The variability across countries at given migration rates is due to the impact of other right hand side variables, and the curve itself is adjusted using a second-order polynomial.

[INSERT FIGURE 6]

3.5 Remittances

Migrants' remittances constitute another channel through which the brain drain may generate positive indirect effects for source countries. It is well documented that workers' remittances often make a significant contribution to GNP and are a major source of income in many developing countries. Remittances impinge on households' decisions in terms of labor supply, investment, education (Hanson and Woodruff, 2002, Cox Edwards and Ureta, 2003), migration, occupational choice, and fertility, with potentially important aggregated effects. This is especially the case in poor countries where capital market imperfections (liquidity constraints) reduce the set of options available to members of low-income classes.

The literature on migrants' remittances shows that the two main motivations to remit are altruism, on the one hand, and exchange, on the other hand.[11] Altruism is primarily directed towards one's immediate family, and then decreases in intensity with social distance. By contrast, in principle, no such proximity is required in the case of exchange; the exchange-based theory of remittances posits that remittances simply "buy" various types of services such as taking care of the migrant's assets (e.g., land, cattle) or relatives (children, elderly parents) at home. Such transfers are typically observed in case of a temporary migration and signal the migrants' intention to return. A particular type of exchange takes place when remittances are de facto repayments of loans used to finance the migrants' investments in education and/or migration, with altruism and social norms and sanctions making the intergenerational contract self-enforcing. Hence, it is a priori unclear whether educated migrants would remit more than their uneducated compatriots; the former may remit more to meet their implicit commitment to reimburse the family for funding of education investments, but on the other hand, educated migrants tend to emigrate with their family, on a more permanent basis, and are therefore less likely to remit (or are likely to remit less) than someone moving alone on a temporary basis.

In our basic framework with constant marginal utility of income, remittances have no effect on the marginal cost and gain of education and influence human capital formation only when liquidity constraints are binding. Let us develop this particular case when the distribution of abilities is uniform. Without migration, the share of educated amounts to c_L. With migration opportunities, as some educated agents leave the country, two opposite effects are observed. Initially, the number of educated remaining in the country falls to $c_L - c_M$. If emigrants remit part of their foreign income, liquidity constraints become less binding for recipients in the source country. The traditional negative effect can therefore, in principle, be compensated by better access to education for those left behind, with the total effect depending on the

[11] See Rapoport and Docquier (2004) for a comprehensive survey of the theoretical and empirical literature.

amounts transferred and on recipients' location on the ability axis.

McCormick and Wahba (2000) obtain the result that highly-skilled migration may benefit to those left behind in a trade-theoretic model where migration, remittances and domestic labor-market outcomes are jointly determined and multiple equilibria arise, with the high-migration equilibrium pareto-dominating the low-migration equilibrium. In a setting closer to the one used throughout this paper, Cinar and Docquier (2004) develop a stylized model where skilled emigrants altruistically remit part of their earnings to relatives in the source country. They assume that each remaining resident receives an identical amount of remittances (which depends on the proportion of migrants, the intercountry wage gap, and the altruistic parameter) and characterize the transition path (i.e., the dynamics of transfers) and the long-run equilibrium of this economy.

Assume that at the steady state, this transfer amounts to T. As shown on Figure 7, the effect of remittances is to shift c_L and c_M to the right. With a uniform distribution, and given that $(c_L+T)-(c_M+T) = c_L-c_M$, the proportion of educated and the economy-wide average level of human capital are given by: $P_T = \frac{c_L-c_M}{1-c_M-T}$ and $H_T = 1 + P_T(h-1)$. A beneficial brain drain obtains if $H_T > H_n$, that is, if $T > c_M(\frac{1}{c_L} - 1)$.

[INSERT FIGURE 7]

In other words, for a beneficial brain drain to obtain through remittances, the transfer received by each remaining resident must be relatively high so that a large share of the population gains access to education. This do not seem to portray the evidence from remittance data available in developing countries. Although remittances are generally positively correlated with donors' incomes, meaning that skilled emigrants are presumably important remitters, the results from household surveys are mixed. At an aggregate level, Faini (2002) shows that migrants' remittances decrease with the proportion of skilled individuals among the emigrants and concludes that "this result suggests that the negative impact of the brain drain cannot be counterbalanced by higher remittances". This does not imply that remittances by skilled migrants are negligible, especially if the proportion of temporary migrants increases; for example, Kangasniemi et al (2004) show that nearly half (45%) of Indian medical doctors working in the UK remit income to their home country and that remitters transfer on average 16% of their income.

Instead of sending remittances to relatives at home, migrants may return after they have accumulated savings abroad and use such savings for promoting investment projects (generally in small businesses). There is much evidence that low-skill workers migrate with the aim of accumulating enough savings so as to access to self-employment and entrepreneurship (e.g., Mesnard, 2004, and Mesnard and Ravallion (2001) for Tunisia, Dustmann and Kirchkamp (2002) for Turkey, Ilahi (1999) for Pakistan, Woodruff and Zenteno (2001) for Mexico, or McCormick and Wahba (2001) for Egypt). The latter study offers additional insights in that it shows that in the case of literate migrants, both the amount of savings and the migration duration have a

significant positive effect on the probability of entrepreneurship upon return, while the first proposition only holds true for illiterate migrants; this suggests that skill-acquisition may be more important for relatively educated migrants than the need to overcome liquidity constraints. In terms of our notations, increases in the stock of physical capital through repatriated savings and acquisition of entrepreneurial skills can be modeled as a negative shock on the risk premium, π, which rises the stock of capital per worker, thus increasing local wages and decreasing the incentives to emigrate.

3.6 Network effects

Our analysis has so far focused on the long run steady state. In the short run, with unanticipated migration, emigration of educated workers is a net loss to the home country. As time goes by, however, successive cohorts adapt their education decisions and the economy-wide average level of education partly (as in Figure 8a) or totally catches up, with a possible net gain in the long run (as in Figure 8b) thanks to the various channels detailed above. On the transition path, additional effects are likely to operate. In particular, there is a large sociological literature emphasizing the creation of migrants' networks that facilitate the movement of goods, factors, and ideas between the migrants' host and home countries. In this section we consider two types of network effects: networks that facilitate trade, FDI and technology diffusion, and networks that facilitate further migration.

[INSERT FIGURE 8]

An important socio-economic literature has emerge recently to analyze the consequences of the constitution of migrants' network on migration patterns. For example, Massey, Goldring and Durand (1994) outline a cumulative theory of migration, noting that the first migrants usually come from the middle ranges of the socioeconomic hierarchy, and are individuals who have enough resources to absorb the costs and risks of the trip, but are not so affluent that foreign labor is unattractive. Family and friends then draw on ties with these migrants to gain access to employment and assistance in migrating, substantially reducing the costs and risks of movement to them. This increases the attractiveness and feasibility of migration for additional members, allowing them to migrate and expanding further the set of people with network connections. Migration networks can then be viewed as reducing the cost, and perhaps also increasing the benefits of migration (Bauer et al., 2002, Munshi, 2003, and McKenzie and Rapoport, 2004, find strong evidence of such network effects); in other words, migration incentives become endogenous once network effects are introduced.

Building on this idea, Kanbur and Rapoport (2004) introduce networks effects at destination in a standard model of selective migration. In the spirit of Carrington et al. (1996), they assume that migration costs, k, are decreasing with the size of

the network at destination, that is, with the number of migrants already emigrated abroad. As explained above, the role of migrants' networks is to diffuse information on job availability and provide hospitality and help in job search. Hence, past migration progressively raises the expected return to education (net of migration costs) and, therefore, domestic enrollment in education. For a given p or γ, this raises the optimal number of individuals engaging in education and the share of educated workers remaining in the country. In this sense, migrant networks have positive effects on human capital formation and serve to mitigate the short-run detrimental effects of the brain drain.

Another type of network effect consists in the creation of business and trade networks; such a "diaspora externality" has long been recognized in the sociological literature and, more recently, by economists in the field of international trade (Rauch and Trindade, 2002, Rauch and Casella, 2003). In many instances indeed, and contrarily to what one would expect in a standard trade-theoretic framework, trade and migration appear to be complements rather than substitutes (e.g., Gould, 1994). Interestingly, such a complementarity has been shown to prevail mostly for trade in heterogeneous goods, where ethnic networks help overcoming information problems linked to the very nature of the goods exchanged (Rauch and Casella, 2002, Rauch and Trindade, 2002). How is the relationship of substitutability or complementary between trade and migration impacted by the skill composition of migration, however, remains unclear. In the same vein, whether FDI and migration are substitutes (as one would expect) or complements remains an unanswered question, although many case-studies suggest that migrants' networks favor what sociologists have labelled "brain circulation" or "brain exchange" (e.g., Saxeenian, 2001, Arora and Gambardella, 2004).

In terms of our notations, and as in the case of repatriated savings, such migrant networks favoring knowledge diffusion and foreign direct investment can be modeled as a negative shock on the risk premium, π, with similar effects on the capital/labor ratio and, thus, on domestic wages and incentives to invest in education.

4 Policy issues

Our discussion is based on a simplified model combining liquidity constraints and uncertain migration prospects (solution are indexed by pl). Since this kind of model relies on out-selection immigration policies, we consider that migration costs are zero ($k = k^{'} = 0$). Similar conclusion would be obtained by combining self-selection (hence, positive migration costs) and return migration.

Without public intervention our model can be summarized by

$$\begin{aligned} c_{pl} &\equiv Min\left[c_O; c_M\right] \\ P_{pl} &= \frac{(1-p)c_{pl}}{1-pc_{pl}} \end{aligned}$$

with $c_O = c_n + ph\Omega$ is the open economy critical level of ability, $\Omega = \omega - 1$ measures the foreign wage premium, $c_n = h - 1$ is the critical agent in a closed economy, and $c_M = 1 - \phi$ is the critical threshold of education cost when liquidity constraints are binding. The foreign wage premium is endogenous and decreases with the domestic proportion of educated (P_{pl}).

In this framework, we analyze the role of emigration (or immigration) policies, education policies, and fiscal policies on the interplay between migration and human capital formation. These policies are appreciated in terms of gdp per capita (or equivalently, the average level of human capital, $H_{pl} = 1 + (h-1)P_{pl}$) or in terms of income for uneducated individuals ($I_{pl} = 2w$). Basically, these two social objectives can be assimilated to efficiency and equity. We have $\frac{\partial P_{pl}}{\partial c_{pl}} = \frac{1-p}{(1-pc_{pl})^2} > 0$; hence, for a given p, the average level of human capital increases with the critical ability. Focusing on efficiency consists in maximizing c_{pl}.

4.1 The optimal rate of migration

Without public intervention, maximizing the proportion of educated means maximizing the welfare of uneducated agents. The efficient and equitable solution coincide.

We use a diagram representation in the plan (Ω, p).

If liquidity constraints are not binding, a beneficial brain drain emerges if $P_{pl} > c_n$, or equivalently

$$\Omega > \Omega_{BB}(p) \equiv \frac{(h-1)(2-h)}{h\left[1-p(2-h)\right]}$$

which is an increasing and convex function of p (depicted as the BB curve).

Liquidity constraints are binding if $c_{pl} > c_n$, i.e. if

$$\Omega > \Omega_{LL}(p) \equiv \frac{2-h-\phi}{ph}$$

depicted as the LL curve.

When liquidity constraint are binding, a beneficial brain drain emerges when $\frac{(1-p)c_M}{1-pc_M} > c_n$, or equivalently $p < p_b \equiv \frac{2-h-\phi}{(1-\phi)(2-h)}$. Interestingly, p_b is the intersection between LL and BB.

The optimal rate of migration depends on Ω which is itself and endogenous variable depending on human capital accumulation, and hence on migration perspective. At $p = 0$, the foreign wage premium amounts to Ω_n. If $\Omega_n > \Omega_{BB}(0) = (h-1)(2-h)/h$, there is a room for a beneficial (limited) brain drain. Several path of migration premium can be represented diagrammetically. In each case (i.e. for each Ω_n), the optimal migration rate corresponds to the minimal value of the Ω-locus. For limited values of p, the proportion of educated increases and the foreign wage premium decreases with p. For higher p, the proportion of educated decreases. The optimal migration rate lies between 0 and the BB curve (depicted as the bold curve). If liquidity constraints are binding, the incentive effect of migration vanishes and the optimal

rate of migration is constrained by the LL curve. In countries where $\Omega_n > \Omega_{BB}(0)$, brain drain is always detrimental. The proportion of educated and the welfare of unskilled workers decreases with p. The optimal rate of migration is zero.

RESULT I: the optimal migration rate is zero for countries with low foreign wage premia (low h or high risk premium). It increases with Ω in intermediate countries where liquidity constraint are not binding. It decreases with Ω in poor countries where liquidity constraints are binding.

4.2 Education policies

Consider that the government levies a local tax (expressed in percent of educated workers' wages, τwh) on both educated and uneducated adults remaining in the country. The tax is used to finance an education subsidy (expressed in percent of the local wage, θw) allocated to each young opting for education. The critical abilities become

$$\begin{aligned} c_O^\tau &= h - 1 + \theta + ph(\Omega + \tau) \\ c_M^\tau &= 1 - \phi + \theta \\ c_{pl}^\tau &= Min\left[c_O^\tau, c_M^\tau\right] \end{aligned}$$

The education policy plays a double role in the debate on the brain drain effects. First, for a given pair (τ,θ), the condition for a beneficial brain drain is modified. Second, brain drain requires budgetary adjusments (increasing taxes or reducing subsidies).

Consider that the the closed economy government budget is balanced under the pair (τ_n,θ_n). The budget constraint implies that $\tau_n h = m\theta_n(h - 1 + \theta_n)$, where m is the number of children per adult. Assume also that the liquidity constraints are not binding in the closed economy: $c_\tau = h-1+\theta_n < 1-\phi+\theta_n$. Without fiscal adjustment (an international aid allows the government to keep the policy rule (τ_n,θ_n)), how does the education policy affect the impact of the brain drain?

If liquidity constraints are not binding ($c_O^\tau \leq c_M^\tau$), a beneficial brain drain emerges ifor equivalently

$$\Omega > \Omega_{BB}^\tau(p) \equiv \frac{(h - 1 + \theta_n)(2 - h - \theta_n)}{h\left[1 - p(2 - h - \theta_n)\right]} - \tau_n$$

Compared to the economy without taxes and subsidies, the BB curve shifts downward: $\Omega_{BB}^\tau(p) < \Omega_{BB}(p)$. This is clearly the case for high value of p (at $p = 1$). This is also the case for small values of p, at least when the skill premium is sufficiently high (at $p = 0$, using the budget constraint, $\Omega_{BB}^\tau(0) < \Omega_{BB}(0)$ requires $\theta > \frac{(3-2h)-m(h-1)}{1+m}$ which decreases with h and m; if $m = 0$, a sufficient condition to get this condition is $h > 4/3$)

Liquidity constraints are binding if $c_O^\tau > c_M^\tau$, i.e. if

$$\Omega > \Omega_{LL}^\tau(p) \equiv \frac{2-h-\phi}{ph} - \tau_n$$

Compared to the economy without taxes and subsidies, the LL curve shifts downwards. In the constrained case, a beneficial brain drain emerges if $p < p_b^\tau \equiv \frac{2-h-\phi}{(1-\phi+\theta_n)(2-h-\theta_n)}$. If the subsidy is sufficiently high ($\theta_n > \phi - h + 1$), p_b^τ is higher than p_b, the critical migration rate without education policy.

RESULT II: if the closed economy fiscal policy can be maintained, the education policy reinforces the likelyhood of a beneficial brain drain (see figure)

However, brain drain requires decreasing the subsidies by $\Delta\theta$, and/or increasing taxes by $\Delta\tau$. The optimal policy option depends on the social objective pursued by the government. Reducing subsidies lowers the proportion of educated in both the constrained and unconstrained case:

$$\begin{aligned} \Delta c_O^\tau &= -\Delta\theta \\ \Delta c_M^\tau &= -\Delta\theta \end{aligned}$$

By contrast, increasing taxes stimulates education decisions in the unconstrained case but has no influence on human capital accumulation in the constrained case:

$$\begin{aligned} \Delta c_O^\tau &= ph\Delta\tau \\ \Delta c_M^\tau &= 0 \end{aligned}$$

Hence, if the government purpose is to maximize the stock of human capital (and the gdp per capita), increasing taxes appears to be the best option.

Alternatively, if the objective is to maximize the income of unskilled workers (now defined as $I_{pl} = w(2-\tau h)$), the optimal option is ambiguous. Increasing taxes is better in terms of gross wages but induces direct fiscal losses for uneducated workers. If human capital externalities are not too large, reducing subsidies is the best option.

RESULT III: the fiscal adjusment to the brain drain raises a tradeoff between efficiency (maximizing gdp per capita) and equity (maximizing th welfare of unskilled workers). The solution depends on the social welfare function of the government.

4.3 The case for a Bhagwati tax

Consider that the government is allowed to levy a tax (expressed in percent of educated workers' wages at home, $\tau^* wh$) on emigrants. This tax can be used to finance a lump-sum transfer to the young (expressed in percent of the wage rate at home, $T^* w$) or an education subsidy to those opting for education (expressed in percent of the wage rate at home, $\theta^* w$). The critical abilities become

$$\begin{aligned} c_O^{\tau^*} &= h - 1 + ph\Omega + \theta^* - ph\tau^* \\ c_M^{\tau^*} &= 1 - \phi + \theta^* + T^* \\ c_{pl}^{\tau^*} &= Min\left[c_O^{\tau^*}, c_M^{\tau^*}\right] \end{aligned}$$

Contrary to domestic taxes, a tax on brain reduces the incentive to educate. If it is redistributed as an education subsidy to the young, it is (at least partly) balanced by a new incentive effect. Both education subsidies and lump-sum transfers make liquidity constraints less binding.

The budget constraint is more complex. The number of taxpayers is given by $Nc_{pl}^{\tau^*}p$ where N denotes the number of young in the previous period. As m measures the number of children by adult, the number of young living in the origin country in the current period amounts to $N(1-c_{pl}^{\tau^*}p)m$. At the steady state, the budget constraint is given by

$$c_{pl}^{\tau^*}ph\tau^* = (1-c_{pl}^{\tau^*}p)m\left[T^* + c_{pl}^{\tau^*}\theta^*\right]$$

where $(1-c_{pl}^{\tau^*}p)m$ clearly measures the factor of growth of the population (fertility minus net emigration). The rate of growth is assumed to be positive; hence $(1-c_{pl}^{\tau^*}p)m > 1$.

When is a Bhagwati tax socially optimal and how should it be redistributed?

First, suppose the tax is used to finance an education subsidy ($T^* = 0$), it affects the critical abilities as follows

$$\begin{aligned} c_O^{\tau^*} &= h - 1 + ph\Omega + \left[\frac{1-(1-c_{pl}^{\tau^*}p)m}{(1-c_{pl}^{\tau^*}p)m}\right]ph\tau^* \\ c_M^{\tau^*} &= 1 - \phi + \frac{ph\tau^*}{(1-c_{pl}^{\tau^*}p)m} \end{aligned}$$

Alternatively, if the tax is used to finance a lump-sum subsidy ($\theta^* = 0$), the critical abilities become

$$\begin{aligned} c_O^{\tau^*} &= h - 1 + ph\Omega - ph\tau^* \\ c_M^{\tau^*} &= 1 - \phi + \frac{c_{pl}^{\tau^*}ph\tau^*}{(1-c_{pl}^{\tau^*}p)m} \end{aligned}$$

When the government maximizes the stock of human capital (and thus the critical ability $c_{pl}^{\tau^*}$), we have to distinguish between constrained and unconstrained equilibria. In most cases, finding the critical ability requires solving an implicite function (second order polynomial). However, intuitive results can be obtained by comparing the effect of $ph\tau^*$ in the equations. In the unconstrained case ($c_{pl}^{\tau^*} = c_O^{\tau^*}$), a Bhagwati tax always reduces the critical level of ability $c_O^{\tau^*}$. Even in the case of a detrimental brain drain, the tax reinforces the efficiency loss. The decrease is lower when the tax is redistributed as an education subsidy. In the constrained case ($c_{pl}^{\tau^*} = c_M^{\tau^*}$), the Bhagwati tax increases the stock of human capital. The efficiency gain is stronger when the tax redistributed as an education subsidy.

When the governement maximizes uneducated workers' income ($I_{pl} = w\,[2 + T^*]$), two effects are obtained. First, by decreasing the average level of human capital, the Bhagwati tax reduces the local wage w. This effect is stronger if the tax is redistributed as a lump-sum transfer to the young. However, in case of lump-sum transfer T^*, unskilled workers share the gain from migration with emigrants. If spillover effects are not too large, uneducated workers have a clear interest in setting a Bhagwati tax and redistributing its product in a lump-sum way.

RESULT IV: In terms of efficiency, a Bhagwati tax is detrimental in the unconstrained equilibrium and beneficial in the constrained equilibrium. In both cases, redistributing the tax as an education subsidy is better than as a lump-sum transfer. In terms of equity, redistributing the Bhagwati tax as a lump-sum transfer is desirable as long as spillover effects are not too large. Redistributing the tax as an education subsidy is always detrimental.

5 Conclusion

The main conclusion to draw from the above analysis is that for any given developing country, the optimal migration rate of its highly educated population is likely to be positive. Whether the current rate is greater or lower than this optimum is an empirical question that must be addressed country by country. This implies that countries that would impose restrictions on the international mobility of their educated residents, arguing for example that emigrants' human capital has been largely publicly financed, could in fact decrease the long-run level of their human capital stock. This also suggests that rich countries should not necessarily see themselves as free riding on poor countries' educational efforts. The difficulty is then to design quality-selective immigration policies that would address the differentiated effects of the brain drain across origin countries without distorting too much the whole immigration system; this could be achieved, at least partly, by designing specific incentives to return migration to those countries most negatively affected by the brain drain, and promote international cooperation aiming at more brain circulation.

On a final note, it is important to underline that what seems crucial at this stage is to extend the empirical research on the growth effects of highly skilled migration for source countries. Two main directions are required: case-studies on the sectoral impact of the brain drain, as suggested by Commander, Kangasniemi and Winters (2004); and extension of the cross-country comparisons. In particular, due to data limitations, existing empirical studies (Beine et al., 2001 and 2003) are based on cross-section regressions, meaning that they neglect the dynamics of migration rates as well as the dynamics of education levels; in addition, in the absence of a time series dimension, it is impossible to control for individual-country effects in the regression estimates. Given the strong heterogeneity of developing countries in terms of sizes, levels of development, etc., such country-fixed effects are likely to play some role in the value of the estimates. However, the new estimates computed for 1990 and

2000 by Docquier and Marfouk (2004) should make it possible for further empirical research to go part of the way towards addressing these concerns satisfactorily.

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Figure 1: Distribution of highly-skilled immigrants by age of entry - USA 2000

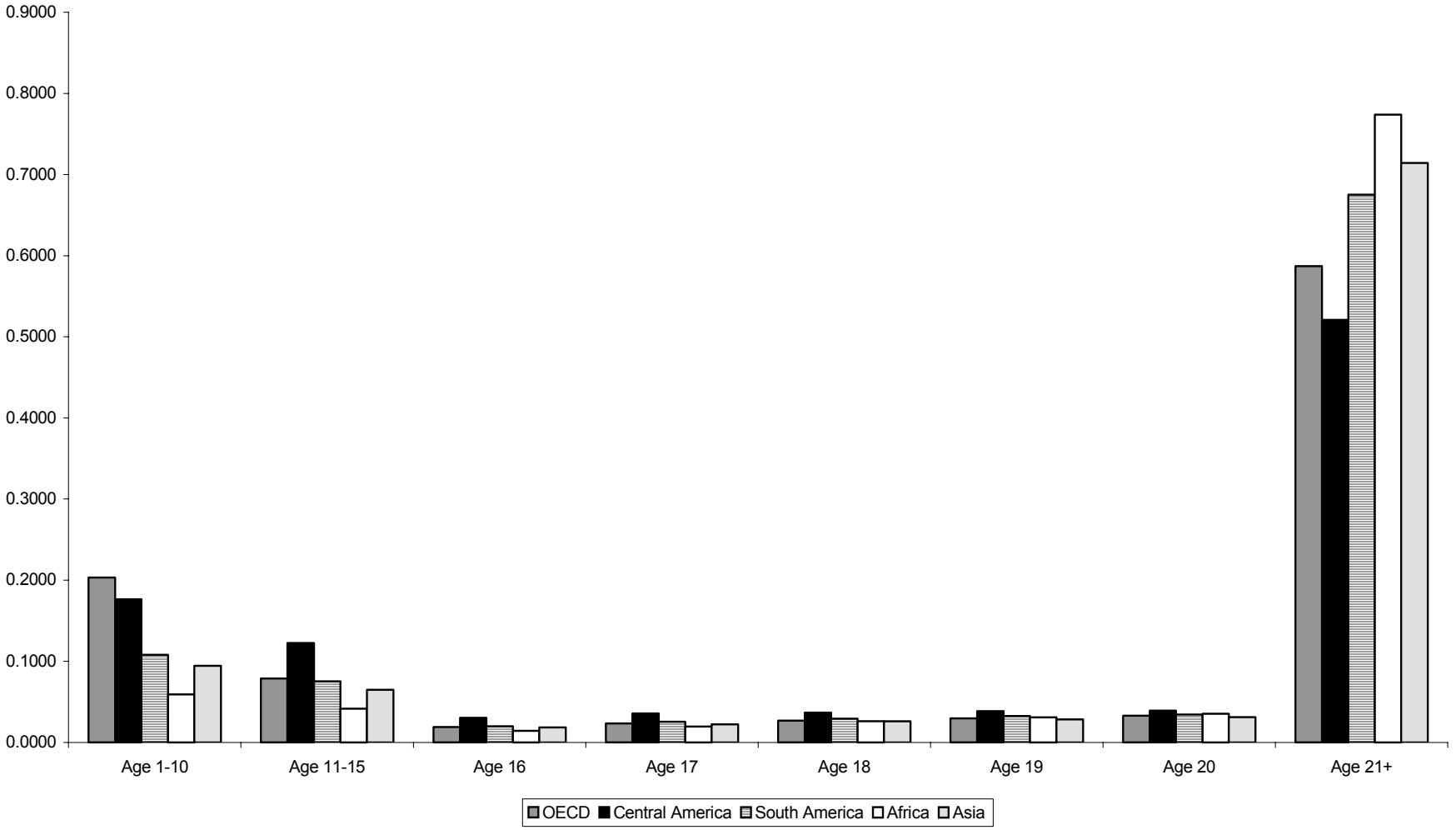


Figure 2. Share of working-aged immigrant arrived before age 16

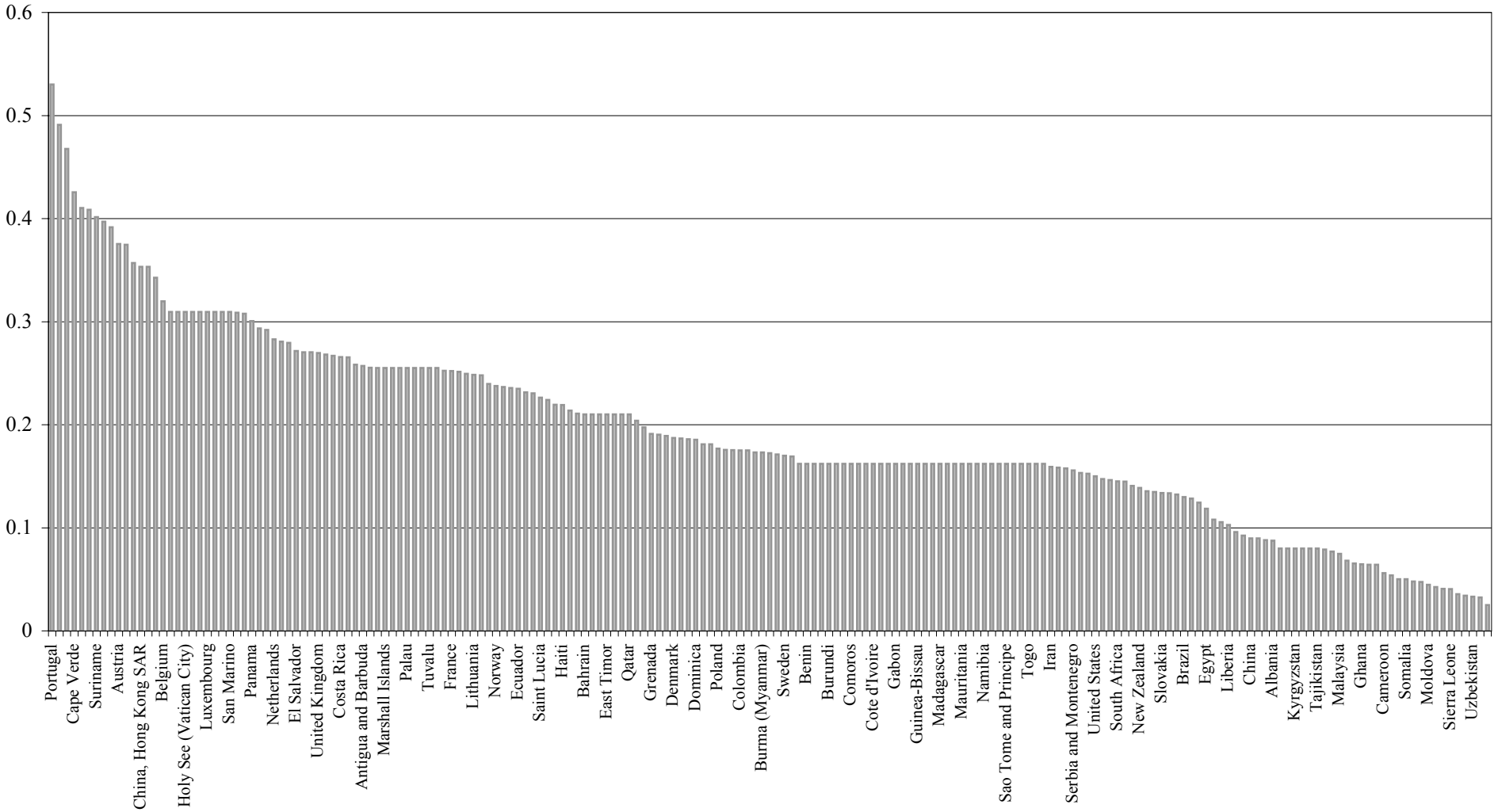


Table 1. Data by country group in 1990 and 2000

	Basic migration rate in 1990		Basic migration rate in 2000	
By Country size	**Total**	**Skilled**	**Total**	**Skilled**
Large countries (Pop>25 million)	1.2%	4.1%	1.3%	4.2%
Upper-Middle (25>Pop>10)	2.9%	9.8%	3.1%	8.9%
Lower-Middle (10>Pop>2.5)	5.1%	14.2%	6.0%	13.9%
Small countries (Pop<2.5)	9.9%	37.8%	10.4%	27.5%
By Income group	**Total**	**Skilled**	**Total**	**Skilled**
High Income countries	3.1%	3.7%	2.9%	3.6%
Upper-Middle Income countries	3.2%	8.4%	4.3%	8.0%
Lower-Middle Income countries	3.2%	12.2%	3.3%	7.8%
Low Income countries	0.4%	4.9%	0.5%	6.2%
(UN Least developed countries)	*(0.8%)*	*(11.0%)*	*(1.0%)*	*(13.4%)*
By region	**Total**	**Skilled**	**Total**	**Skilled**
America	2.3%	2.9%	3.4%	3.4%
Northern America	*0.9%*	*1.0%*	*0.8%*	*0.9%*
Caribbean	*12.7%*	*42.7%*	*15.8%*	*43.4%*
Central America	*7.6%*	*13.5%*	*11.9%*	*16.9%*
South America	*1.1%*	*4.6%*	*1.6%*	*5.2%*
Europe	3.3%	6.0%	4.1%	7.1%
Eastern Europe	*1.0%*	*2.3%*	*2.3%*	*4.4%*
Northern Europe	*6.7%*	*14.1%*	*6.9%*	*13.6%*
Southern Europe	*5.4%*	*7.9%*	*6.8%*	*11.2%*
Western Europe	*3.5%*	*5.5%*	*3.4%*	*5.5%*
Africa	1.3%	10.4%	1.6%	11.2%
Eastern Africa	*0.9%*	*16.3%*	*1.1%*	*20.2%*
Middle Africa	*0.8%*	*11.6%*	*1.0%*	*15.4%*
Northern Africa	*2.9%*	*8.3%*	*3.1%*	*8.2%*
Southern Africa	*0.7%*	*8.7%*	*1.1%*	*7.4%*
Western Africa	*0.6%*	*10.8%*	*1.0%*	*15.2%*
(Sub-Saharan countries)	*(0.7%)*	*(12.0%)*	*(1.0%)*	*(13.5%)*
Asia	0.7%	5.2%	0.8%	5.6%
Eastern Asia	*0.4%*	*3.9%*	*0.5%*	*4.0%*
South-central Asia	*0.4%*	*3.9%*	*0.6%*	*5.4%*
South-eastern Asia	*1.3%*	*10.8%*	*1.7%*	*9.9%*
Western Asia	*3.3%*	*7.3%*	*3.6%*	*6.9%*
Oceania	3.7%	5.9%	4.5%	7.0%
Australia and New Zealand	*3.2%*	*4.5%*	*3.8%*	*5.6%*
Melanesia	*3.4%*	*57.2%*	*4.3%*	*42.5%*
Micronesia	*4.0%*	*55.6%*	*7.1%*	*31.9%*
Polynesia	*42.1%*	*96.8%*	*48.6%*	*73.1%*

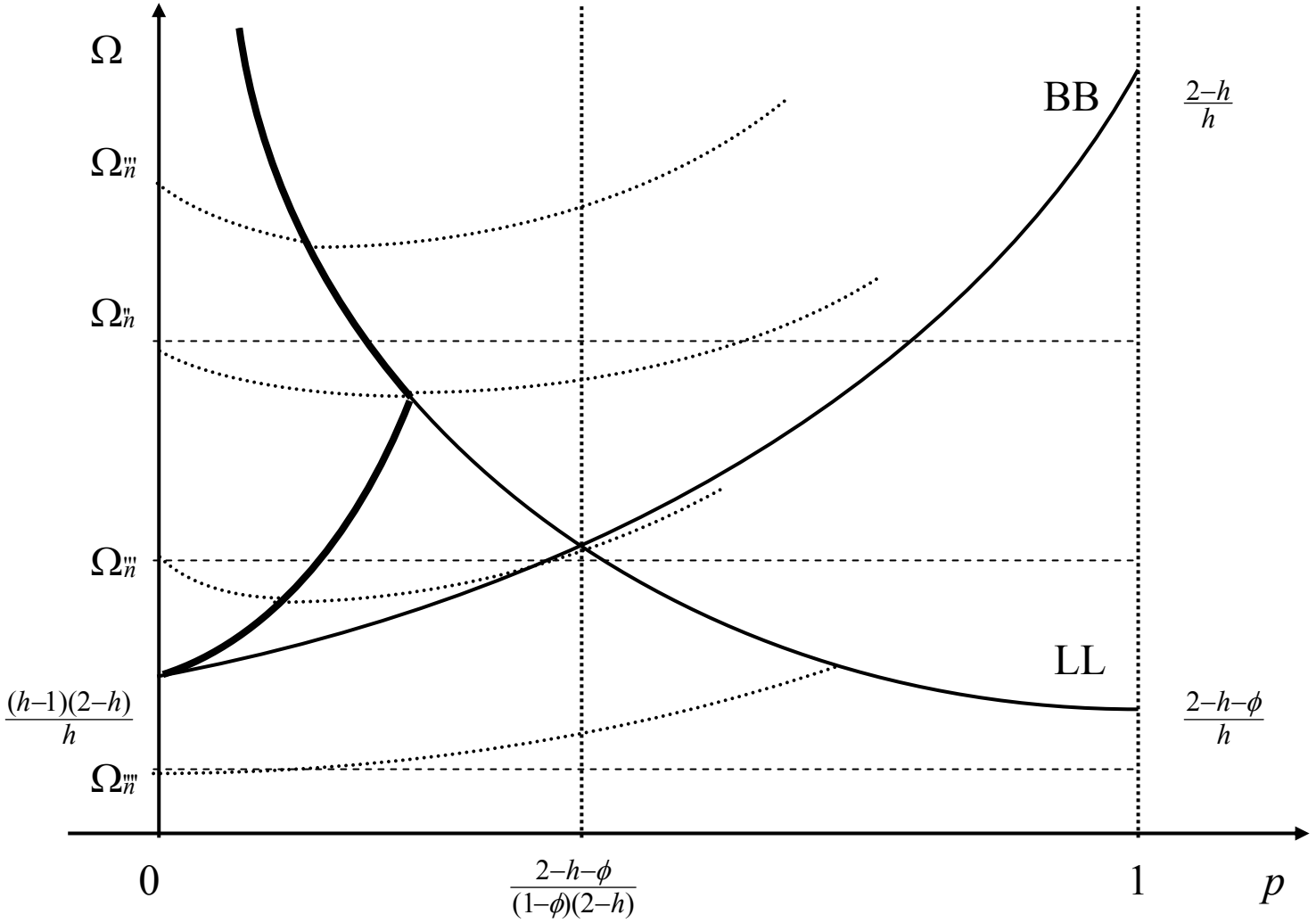
Source: Docquier and Marfouk (2005) + Own calculations for 1990

Table 2. Skilled emigration (stocks and rates) - Top-30 countries in 2000

All middle- and low-income countries						Middle- and low-income countries with population > 4 million					
Highest stocks		**Highest basic rates**		**Highest corrected rates**		**Highest basic rates**		**Highest corrected rates**		**Lowest corrected rates**	
Philippines	1,133,169	Guyana	88.4%	Guyana	85.4%	Haiti	84.1%	Haiti	80.5%	Bangladesh	4.6%
India	1,070,586	Jamaica	85.3%	Jamaica	80.7%	Somalia	52.3%	Somalia	51.0%	India	4.1%
Mexico	925,195	Haiti	84.1%	Haiti	80.5%	Sierra Leone	46.4%	Sierra Leone	45.4%	Egypt	4.1%
China	834,567	Grenada	83.0%	Grenada	79.8%	Ghana	45.6%	Ghana	44.0%	Korea	4.1%
Korea	673,232	St Vinc. & Gren.	82.8%	St Vinc. & Gren.	78.6%	Mozambique	43.0%	Mozambique	38.7%	Yemen	3.8%
Vietnam	507,833	Trinidad and Tobago	80.6%	Trinidad and Tobago	75.9%	Kenya	40.3%	Kenya	38.4%	China	3.6%
Poland	463,293	Saint Kitts and Nevis	74.7%	Saint Kitts and Nevis	68.4%	Lebanon	38.5%	Lebanon	33.7%	Ukraine	3.4%
Cuba	335,551	Tonga	73.8%	Tonga	67.9%	Laos	37.3%	Uganda	33.2%	Paraguay	3.4%
Iran	311,032	Samoa	73.8%	Samoa	62.4%	Uganda	35.4%	Eritrea	31.4%	Nepal	3.4%
Jamaica	296,410	Cape Verde	68.6%	Gambia, The	60.5%	Eritrea	32.5%	Sri Lanka	29.6%	Moldova	3.3%
Russia	292,103	Barbados	67.7%	Barbados	60.1%	Angola	31.4%	Angola	27.7%	Belarus	3.2%
Ukraine	253,909	Saint Lucia	65.4%	Saint Lucia	59.4%	Sri Lanka	31.3%	El Salvador	24.7%	Burma (Myanmar)	3.0%
Colombia	246,647	Belize	65.1%	Antigua and Barbuda	57.9%	El Salvador	31.0%	Nicaragua	24.1%	Venezuela	2.7%
Pakistan	236,315	Antigua and Barbuda	64.9%	Belize	57.8%	Nicaragua	29.6%	Laos	23.3%	Burkina Faso	2.7%
South Africa	185,605	Gambia, The	64.6%	Cape Verde	55.7%	Cuba	28.8%	Papua New Guinea	22.3%	Libya	2.6%
Romania	185,385	Fiji	60.7%	Seychelles	55.1%	Papua New Guinea	27.8%	Senegal	21.3%	Argentina	2.0%
Morocco	178,745	Dominica	59.9%	Dominica	54.8%	Vietnam	27.1%	Rwanda	21.2%	Brazil	2.0%
Turkey	177,856	Seychelles	59.4%	Fiji	53.4%	Honduras	24.4%	Vietnam	20.5%	Chad	2.0%
Brazil	171,267	Mauritius	56.4%	Mauritius	52.0%	Rwanda	24.3%	Honduras	20.3%	Azerbaijan	1.9%
Serbia and Montenegro	169,729	Somalia	52.3%	Somalia	51.0%	Guatemala	24.1%	Cuba	19.8%	Thailand	1.9%
Peru	165,376	Suriname	47.8%	Sierra Leone	45.4%	Croatia	24.0%	Guatemala	19.7%	Indonesia	1.8%
Dominican Republic	163,448	Sierra Leone	46.4%	Ghana	44.0%	Dominican Republic	22.5%	Afghanistan	19.3%	Georgia	1.6%
Nigeria	161,712	Ghana	45.6%	Liberia	41.7%	Senegal	22.4%	Croatia	19.1%	Russia	1.4%
Haiti	158,586	Liberia	44.4%	Mozambique	38.7%	Afghanistan	22.3%	Congo, Rep. of the	18.7%	Kazakhstan	1.1%
Egypt	153,116	Mozambique	43.0%	Kenya	38.4%	Congo, Rep. of the	21.5%	Morocco	17.9%	Uzbekistan	0.7%
Lebanon	137,542	Kenya	40.3%	Suriname	35.4%	Morocco	20.5%	Malawi	17.7%	Saudi Arabia	0.7%
Trinidad and Tobago	130,477	Marshall Islands	39.4%	Lebanon	33.7%	Malawi	20.4%	Dominican Republic	17.6%	Kyrgyzstan	0.6%
Austria	130,290	Lebanon	38.5%	Uganda	33.2%	Togo	18.7%	Togo	16.1%	Tajikistan	0.4%
El Salvador	128,075	Micronesia	37.9%	Marshall Islands	32.6%	Cambodia	18.2%	Cameroon	15.6%	Swaziland	0.3%
Sri Lanka	125,832	Laos	37.3%	Eritrea	31.4%	Slovakia	16.5%	Slovakia	14.6%	Turkmenistan	0.1%

Source: Docquier and Marfouk (2005) + Own calculations

Optimal rate of migration



Optimal rate of migration and education policy (no adjustment)