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ABSTRACT

Skilled Migration: The Perspective of Developing Countries*

This chapter focuses on the effects of skilled migration on developing countries. We first present new evidence on the magnitude of the "brain drain" at the international level. Using a stylized model of education investment in a context of migration, we then survey the theoretical and empirical brain drain literature in a unified framework. Finally we use a particular specification of the model to discuss a number of policy issues from the perspective of developing countries.

JEL Classification: F22, J61

Keywords: migration, brain drain, economic development

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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. Globalization indicators reveal that between 1990 and 2000, the world Export/GDP ratio has been multiplied by 1.5 and the FDI/GDP ratio by three (WTO, 2004). During the same period, the total number of foreign-born individuals legally residing in the OECD member countries has also been multiplied by 1.4, with a larger increase for highly skilled migrants ($\times 1.64$) than for low skilled migrants ($\times 1.14$) (Docquier and Marfouk, 2006).

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 is 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, it is obvious that a number of "externalities" also have to be factored in. First, skilled migrants are net fiscal contributors and their departure therefore represents a fiscal loss for those left behind (fiscal externality). Second, skilled 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 unskilled workers' productivity and wages and lead to higher inequality in the home country. Third, think of an economy where human capital is the engine of growth and education decisions engender both intragenerational and intergenerational externalities (Lucas, 1988); in such a setting, brain drain migration will negatively affect the home country's current economic performance as well as its growth prospects. And fourth, as demonstrated in various new economic geography (e.g., Hoffmann, 2003) and new growth (e.g., Klenow and Rodriguez-Clare, 2005) frameworks, skilled labor is key to attracting FDI and fostering R&D activities (technological externality).

At the same time, skilled migrants continue to affect the economy of their origin country after they have left, be it through remittances, return migration, or participation in business and scientific networks. Putting all these channels together and taking account of the various externalities listed above within a single model is a very complex if not impossible task. In this chapter, we make the simplification that the impact of highly-skilled migration on source countries may ultimately be captured through its effect on the long-run level of the human capital stock there; this

simplification will allow for a unified treatment of the different channels mentioned above.

The rest of this chapter is organized as follows. Section 2 provides updated figures on the size and distribution of the brain drain at the international level. This is based on immigration data collected from OECD countries for 1990 and 2000 by Docquier and Marfouk (2006) (henceforth DM) and on the corrections for age of entry of Beine, Docquier and Rapoport (2007a). These data show that the brain drain has gained in magnitude over the period covered but that substantial differences remain across regions and countries. In Section 3 we develop a stylized model of brain drain migration and human capital formation that allows for presenting the recent and less recent findings of the brain drain literature in a fully harmonized framework. We first present the relatively pessimistic view of the early brain drain literature, and contrast it to more recent models exploring various channels through which developing countries may experience a social gain from the brain drain. Section 4 uses a particular specification of the model to discuss a number of policy issues from the perspective of developing countries. Section 5 concludes.

2 How big is the brain drain?

There is clear evidence that the brain drain has increased dramatically since the 1970s. 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 due to a combination of changes on the supply side (e.g., skill-biased technological progress, human capital agglomeration effects) that contribute to positive self-selection among migrants and of quality-selective immigration policies on the demand-side. Quality-selective immigration policies were first introduced in Australia and Canada in the 1980s in the form of point-systems before being gradually adopted by other OECD countries. In the U.S., the Immigration Act of 1990 and the substantial relaxation of the quotas for highly-skilled professionals (H1-B visas) represent an major step in that direction, while European countries such as France, Germany, Ireland or the UK have recently adopted policies aiming at attracting a qualified workforce (OECD, 2002).

Until very recently, 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 Detra-

giache 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.[1] 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 the immigrants' origin country for the top 5 or 10 sending countries only. For small countries not captured in these statistics, the figures reported in the CD database are therefore biased: the total number of emigrants is under-estimated, and in some cases one is (mis)led to conclude that 100% of a given country's workers who immigrated to an OECD member-country 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 most African countries and of many Asian countries. Third, the CD data 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 its neighboring countries). Finally, recall that all foreign-born individuals residing in an OECD country are defined as immigrants independently of their 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 Mexican immigrants.

In an attempt to extend Carrington and Detragiache's work, Docquier and Marfouk (2006) 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, Register and Survey data reporting educational levels and countries of birth were used for all OECD countries. On this basis, Docquier and Marfouk (2006) published emigration rates by education level for 195 countries in 2000 and 174 countries in 1990. Their estimates address two of the above-mentioned problems arising from the CD database: under-reporting for small countries, and transposition of the US immigration education structure to the rest of the OECD countries (and, in addition, they provide data for a second year, 2000). Aggregating over countries, it appears from the DM database that the total number

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

of adult immigrants living in the OECD area and aged 25 or more may be estimated at 59 million for 2000 and 41.8 million for 1990. Emigration rates by education levels are then obtained by comparing the number of emigrants to the population from which they are drawn (taken from Barro and Lee (2001)), giving average emigration rates to the OECD of 1.1%, 1.8% and 5.4% respectively for low-skill, medium-skill and high-skill workers.

Table 1 compares total and skilled-emigration rates in 1990 and 2000 by region, income group (using the 4-group classication of the World Bank) and country size (for countries with population higher than 25 million, between 10 to 25 million, between 2.5 to 10 million, and lower than 2.5 million). It shows that average migration rates are strongly decreasing with country size, which is hardly surprising as small countries tend to be more open 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 and/or for which the transferability of human capital is problematic) exhibit the lowest rates. Finally, the analysis by region shows that the regions most affected are Africa, Central America and, due to small-size effects, the Pacific and the Carribean.

[INSERT TABLE 1]

After excluding high-income countries from our sample, the left panel of Table 2 gives the data for developing countries only. Obviously, the size of the brain drain depends on whether it is measured in absolute or relative terms. In terms of absolute numbers (see Column 1), the Philippines, India, Mexico, China, Vietnam and Poland appear as the major sending countries. In terms of emigration rates (that is, as percent of the native-born skilled labor force), the rankings are of course very different. Columns 2 and 3 show the 30 countries for which emigration rates among the highly-skilled are respectively the highest and the lowest in 2000. The brain drain appears very strong in small countries, with emigration rates as high as 80% in some Pacific and Carribean islands. By contrast, Eastern-European and South-American countries exhibit relatively low brain drain levels. It is also noteworthy that India, China, Brazil are among the least affected countries in relative terms despite their important contribution to the overall stock of skilled migrants at the world level.

[INSERT TABLE 2]

The DM data set considers as skilled immigrants all foreign-born workers with university or post-secondary training living in an OECD country. Such a definition based on the country of birth does not account for whether education has been acquired in the home or in the host country. Depending on the objective for which the data are going to be used, such a definition could appear either too inclusive or too exclusive. For example, it would seem appropriate (or even too exclusive) if one

wants to measure the extent of a country's "skilled diaspora". Conversely, it may seem too inclusive if one wants to estimate the fiscal cost of the brain drain for the source country, in which case only people with home-country higher education should be considered as skilled emigrants. Building on DM estimates, Beine, Docquier and Rapoport (2007a) used 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 who left their home country after age 12, 18 or 22, and to do so for 1990 and 2000.

On the right panel of Table 2 (columns 4 to 6), we compare the uncorrected DM rates (referred to as 0+) with the corrected rates excluding migrants who left their country before age 18 or 22 (referred to as 18+ and 22+). For a better illustration of the phenomenon, we present data only for countries with total population higher than 4 million. Controlling for familial migration does not significantly affect the rankings, as may be seen from the Table. The corrected rates are by construction lower than those calculated without age-of-entry restrictions. The correlation between corrected and uncorrected rates is very high and the country rankings by brain drain intensities are only mildly affected by the correction. Skilled emigration is highest (higher than 30 percent) in countries that suffered from civil war and political instability during the last decades (e.g., Haiti, Somalia, Ghana, Sierra Leone, Lebanon) and is particularly strong in Central America and Sub-saharan Africa.

3 Theory and evidence

This section provides an overview of the theoretical and empirical literature on the consequences of highly-skilled emigration for developing countries.[2] Roughly, three generations of economics research on the brain drain may be distinguished.

The first generation dates back to the late 1960s and includes mainly descriptive papers (see for example Grubel and Scott, 1966, and the collection of papers in Adams, 1968) and welfare analyses within standard trade-theoretic frameworks (Johnson, 1967, Berry and Soligo, 1969). Basically, these early contributions conclude to an essentially neutral impact of the brain drain on source countries. This is due to the general belief that the negative externalities at work are small if not "negligible" (Grubel and Scott, 1966, p. 270), to the fact that skilled emigrants may leave behind them part of their assets which complement remaining skilled and unskilled labor in the production process (Berry and Soligo, 1969), or simply to the role of remittances and other positive feedback effects that act to compensate those left behind for any real loss the brain drain may cause. From a broader perspective, these studies (with the exception of Berry and Soligo) generally emphasize the benefits of free migration to the world economy as a whole and tend to disregard "nationalistic" and "outdated" claims about the alleged losses of developing countries.

[2]Commander, Kangasniemi and Winters (2004a) also survey this literature.

The second generation of brain drain studies is in sharp contrast with the previous one. Under the leadership of Jagdish Bhagwati, a series of alternative models were developed throughout the 1970s to explore the welfare consequences of the brain drain in more reallistic institutional settings. Domestic labor markets rigidities (Bhagwati and Hamada, 1974), informational imperfections (Hamada and Bhagwati, 1975), as well as fiscal and other types of externalities (Bhagwati and Hamada, 1974, Bhagwati and Rodriguez, 1975, Rodriguez, 1975, McCulloch and Yellen, 1977) were introduced to emphasize instead the negative consequences of the brain drain for those left behind. Consequently, skilled emigration was viewed as contributing to increased inequality at the international level, with rich countries becoming richer at the expenses of poor countries.[3] About twenty years later, the first papers to investigate the migration-human capital formation relationship in an endogenous growth framework rested on similar arguments and also emphasized the negative effects of the brain drain (e.g., Miyagiwa, 1991, Haque and Kim, 1995). Together with the literature of the 1970s, these papers constitute what we may term the "traditional" or "pessimistic" view.

Finally, a third generation of brain drain research has emerged since the mid-1990s around the idea that migration prospects can foster domestic enrollment in education in developing countries, raising the possibility for a brain drain to be beneficial to the source country (e.g., Mountford, 1997, Stark et al., 1998, Beine et al., 2001). These studies look at how the country's stock of human capital is built up and how migration modifies the incentive structure faced by developing countries' residents when making their education decisions. This literature is mainly theoretical but also includes a small number of empirical studies. At the same time, the various feedback effects underlined in the early literature (remittances, return migration and business networks) have also given rise to an important literature, also contributing to nuance the negative view still dominant in many academic and international forums.

In the next section, 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. For the sake of simplicity, we assume that a composite good is produced at each period of time according to a linear production function, $Y_t = w_t L_t$. We do not model capital accumulation and set the interest rate to zero. The labor supply, L_t, sums up skilled

[3] An additional feature of this strand of the literature is to examine different possible taxation schemes that could compensate the sending countries for the losses incurred, for example through a "tax on brains" (later coinded "Bhagwati tax") to be collected on skilled emigrants' earnings abroad and redistributed within the country of origin (Bhagwati and Dellalfar, 1973, McCulloch and Yellen, 1975, Bhagwati, 1976). See also the special issue of the Journal of Public Economics on "Income taxation in the presence of international personal mobility", August 1982.

and unskilled labor. Normalizing the number of efficiency units offered by an unskilled individual to 1, a skilled individual is assumed to offer $h > 1$ such units.

The scale factor w_t measures the wage rate per efficiency unit of labor. It is endogenous and time-varying. To formalize the spillover effects associated to human capital formation, we assume that w_t is an increasing function of 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 (we write $H_t = 1+P_t(h-1)$, with P_t the share of skilled workers and $h > 1$ their relative productivity). Hence, the domestic wage rate per efficiency unit of labor is given by:

$$w_t \equiv w(H_t)$$

with the derivative $w^{'} > 0$.

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 their 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 the exogenous skill premium h. Utility is linear in consumption, there is no discounting of income and no domestic savings. In the following we will assume for simplicity an uniform distribution of education costs and, consequently, restrict the values of h to the interval $]1, 2[$ in order to obtain interior solutions.[4]

Without migration, the lifetime income of an uneducated agent is given by $w_t + w_{t+1}$. 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 domestic 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:

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

[4]Given that $c \in [0, 1]$, the restriction $h < 2$ ensures that the proportion of educated is lower than unity 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 our setting, the impact of migration on remaining residents is related to the way it affects the composition of the labor force. Obviously, the relationship between social welfare and skilled emigration is likely to depend on other channels. For example, skilled emigration may cause a loss of social capital (Schiff, 2002) or have redistributive effects we are abstracting from in this paper.[5] We focus instead on the impact of the brain drain on the source country's average stock of human capital, our proxy for the country's long-run economic potential.

3.2 The traditional view

As explained above, the literature of the 1970s developed a pessimistic view of the brain drain. Careful examination of these models reveals that their central conclusions rest on a number of critical assumptions. In particular, it is assumed that: (i) Migrants self-selected out of the general population, (ii) There is free international mobility of skilled labor and, therefore, no uncertainty regarding future migration opportunities for the educated, and (iii) There is a complete disconnection between emigrants and their country of origin once they have left. Is such conditions, clearly, skilled 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 to 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 entails a cost kw^* which captures transportation, search, assimilation and psychic costs of leaving one's home country. Individuals have to choose whether to educate (ED or NE) and whether to migrate (MI or NM). The lifetime income associated to each pair of decisions is given 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 positive self-selection equilibrium to emerge (i.e., skilled workers only emigrate) is :

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

[5] See however Section 4.2. below where we discuss such redistributive effects when education is publicly financed.

In this case, migration prospects impact on the education cost threshold 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.

There is strong evidence that migration prospects indeed impact on people's decisions to invest in higher education. According to the International Office for Migration (IOM, 2003), the prospects of working abroad have increased the expected return to additional years of education and have led many people to invest in more schooling, especially in occupations in high demand overseas. For example, in their survey on medical doctors working in the UK, Kangasniemi et al. (2004) indicate that the migration premium in the medical professions lies between 2 and 4 (in PPP values); about 30% of Indian MDs surveyed acknowledge that the prospect of emigration affected their effort to put into studies; furthermore, the respondents estimate that migration prospects affect the effort of about 40% of current medical students in India. In the case of the software industry, Commander et al. (2004b) 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.[6]

On the basis of survey and anecdotal evidence (and of introspection, too), one can therefore easily admit that migration prospects stimulate domestic enrollment in education. In a context of free migration and with no feedback effects, however, emigration deprives the country from its educated workforce, the proportion of educated in the remaining population falls to zero, and the average level of human capital of remaining members falls to one. In the presence of a minimal threshold for consumption, migration can be limited by an additional liquidity constraint. Liquidity constraints here are due to the monetary fraction of the migration costs (as psychic 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 so that some educated individuals remain in the home country when the threshold c_M is lower than c_n. In this case, indeed, individuals with education cost between c_M and c_n cannot afford paying for both migration and education but still have an incentive to invest in education (see case 1 on Figure 1). 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 leave the country at the end of period 1 (see case 2 on Figure 1).

[INSERT FIGURE 1]

[6] In current US$, the migration premium is obviously much higher. Many migrants confess that they are unable to compare earnings on a PPP basis. The expected migration premium is likely to lie between the PPP and the current $ values.

In any event, the traditional view posits that once migration opportunities are introduced, the average level of human capital among remaining residents, H_t, decreases, which in turn depresses wages through the various externalities outlined above (Hamada, 1977, Usher, 1977, Blomqvist, 1986). Using a different perspective, Bhagwati and Hamada (1974) developed a model of wage determination in which the departure of skilled workers also reduces unskilled workers' expected earnings. The transmission mechanism involves a non-competitive wage-setting assumed to capture the various labor markets imperfections prevailing in developing countries. Assume that educated wages are determined by workers' unions and incorporate 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 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), 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 is dealt with in Section 4.

We now turn to the potentially beneficial aspects of the brain drain for source countries, starting with the case of temporary migration.

3.3 Temporary migration

As explained, most receiving countries have recently made admission conditions for candidate immigrants more selective. Quality-selective procedures have been put in place and, in addition, many immigration programs targeting the educated and skilled are designed for temporary immigrants. To account for this, assume 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 positive self-selection among migrants: the expected return to education being lowered, fewer people 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 depends on the length of the migration period. In terms of our notations, the lifetime income for educated

agents is now given by:[7]

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

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 does hold, then the prospect of temporary migration stimulates human capital investments at home.

Without liquidity constraints, the condition for investing in education then 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 education costs, the proportion of educated workers in the country becomes:

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

In terms of incentives, the case of temporary migration is similar to the case of permanent migration except that the incentive effect is propotional to γ. In terms of total impact, however, there is a major difference with the case of permanent visas in that the incentive effect now partly benefits the home country. Indeed, the probability P_γ can be lower or higher than P_n. Let us denote by $\gamma^* \equiv \frac{k\omega}{h(\omega-1)}$ the value of γ above which skilled workers start opting for migration and, therefore, above which some migration takes place and impact on education decisions. Formally, a possibility of "beneficial brain drain" emerges if the derivative of P_γ with respect to γ is positive at $\gamma = \gamma^*$. This derivative is given by:

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

If it is positive, then there is an interval of γ for which the temporary migration of skilled workers stimulates human capital formation (i.e., raises the economy-wide

[7]Note that for simplicity we assume migration costs to be identical to 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 during the first years following immigration. Alternatively, we could assume that in case of temporary migration, people incur a migration cost of $k' + \gamma(k - k') \equiv k''$.

average level of human capital).[8] However, liquidity constraints are 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 a profitable investment and this reduces 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 can still 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, the engine of growth in the developing country being the knowledge and technology spillovers somehow carried out by migrants returning from the more advanced economy. 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. In terms of our notations, this is as if return migrants would come back with a productivity gain, $\Theta h > h$, which stimulates human capital formation at home. 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, $H = 1 + P_n(h - 1)$.[9]

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 in order 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 then benefit from their educational investments.

There is limited evidence that return migration is significant among the highly-skilled. In fact, 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 two-thirds in the course of the 1990s, after two decades of impressive

[8] Clearly, for $\gamma = 1$, the effect of the brain drain is unambiguously detrimental.

[9] In a companion paper, Dos Santos and Postel-Vinay (2004) show that a change in immigration policy in the form of an increase in the share of temporary visas, may benefit to the sending countries. Such a change lowers the incentives to acquire education, which in turn lowers the pre-migration stock of human capital at origin, but implies 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.

growth in these countries. 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 before (stay rates of 87% and 82%, respectively) (OECD, 2002). This is confirmed by a recent survey showing that in the Hsinchu Science Park in Taipei, a large fraction of companies have been started by returnees from the USA (Luo and Wang, 2002). In the case of India, the evidence for the software industry is mixed. Saxeenian (2001) shows that despite the quick rise of the Indian software industry, only a fraction of Indian engineers in Bangalore are returnees. On the other hand, a recent comprehensive survey of India's software industry reached more optimistic conclusions and confirmed the presence of network effects and the importance of temporary mobility. The survey, conducted among 225 Indian software firms, showed strong evidence of brain circulation, with 30-40% of the higher-level employees having relevant work experience in a developed country (Commander et al., 2004b).[10]

Such specific experiences apart, return skilled migration remains relatively limited and is often more a consequence than a trigger of growth in the home country.

3.4 Uncertainty

Before 1965, the U.S. immigration policy was based on country-specific quotas. This quota system is now abolished but various types of requirements and restrictions imposed by the U.S. and other countries' 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 the risks involved. Paradoxically, such uncertainty, which is certainly a bad thing ex ante from the individual's perspective, creates the possibility for a brain drain migration to generate a net human capital gain for the home country.

Starting with Mountford (1997), a series of theoretical contributions have explored the conditions required for this possibility to materialize. This has been done in various theoretical frameworks with heterogeneous (Mountford, 1997, Docquier and Rapoport, 1999, Beine et al., 2001) and homogenous agents (Stark et al., 1998, Vidal, 1998). As explained in the introduction of this section, the basic idea is that in a context of uncertainty regarding future migration opportunities and of higher earnings

[10] In their survey on medical doctors working in the UK, Kangasmieni et al. (2004) found that "many" doctors intend to return after completing their training abroad. Note that the survey asks about intentions, not actual returns.

abroad, migration prospects foster education investments (this induces an incentive or "brain" effect) which can compensate the loss from actual emigration (flight or "drain" effect), with the sign of the net effect on human capital formation being positive or negative depending on which effect dominates.[11]

In order to incorporate these approaches 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).[12] The model with uncertainty is similar to an out-selection model where receiving countries accept a fraction $p > 0$ of skilled candidates and reject all unskilled applications. Assume moreover that the subjective probability of receiving a visa, as seen by a potential migrant, equals to the proportion of educated who effectively emigrated among the previous generation. Under these assumptions, 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 lower in both cases than in the case of a certain and permanent migration. However, several differences are worth noticing. First, the incentive mechanism operates even for low values of p (remember that an incentive effect was obtained under temporary migration only for $\gamma \geq \frac{k\omega}{h(\omega-1)}$). Second, at $p = \gamma$, uncertainty generates more incentives to educate than temporary migration (at least at low levels of risk-aversion). The reason for this is straightforward and has to do with the fact that migration costs are incurred with probability $p < 1$ under uncertainty but with probability $p = 1$ in case of temporary migration.

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

[11] In a similar spirit, Katz and Rapoport (2005) develop a framework where expected wages are identical at origin and destination but are charaterized by a higher variance in the origin country. In such a context, education is imparted with an option value thanks to the possibility of migration, and the authors show that more variability raises the expected proportion of educated in the remaining population when individual abilities and domestic shocks are uniformly distributed.

[12] Our simplified model assumes homogenous skills among the educated. The size of the incentive effect would be different with heterogenous skills (see Commander et al, 2004). In reality, immigration authorities may be combining education with other selection devices such as tests of IQ or host-country language fluency. Were IQ a perfect signal of ability and the only criterion retained, migration could only be detrimental to human capital formation at home. Still, to the extent that knowing one's skills is a discovery process or, lternatively, to the extent that IQ or other tests are imperfect signals of ability, migration prospects induce additional incentives to invest in education for some workers with intermediate ability.

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 thanks to the incentive effect. Indeed, the proportion of educated workers in the country becomes $P_p = \frac{(1-p)c_p}{1-pc_p}$, which can be lower or higher than P_n. A beneficial brain drain can be obtained for some ranges of p, providing that the derivative of P_p with respect to p is positive at $p = 0$. We obtain:

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

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 remark 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 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 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. (2007b) used the DM emigration rates by education level to empirically assess the impact of the brain drain on human capital formation in developing countries. They find evidence of a positive impact of skilled migration prospects on gross human capital levels in a cross-section of 127 developing countries. In contrast, Faini (2003) finds a depressing but not significant effect of tertiary emigration on domestic enrollment in higher education, a finding he attributes to the choice of would-be migrants to pursue their studies abroad. As he himself aknowledges, however, his results must be taken with caution as they are based on enrollment data known to raise measurement problems.[13]

Beine et al. (2007b) also computed the net effect of the brain drain using counterfactual experiments: they compare the current proportion of post-secondary educated workers to their erstwhile value would skilled workers be allowed to emigrate at the same rate as unskilled workers. They find that countries combining relatively low levels of human capital and low skilled emigration rates are likely to experience a

[13]Beine et al. (2007), on the other hand, use the improved Barro and Lee data which estimate the proportion of highly educated partly on the basis of census data and partly on the basis of schooling data using an inventory method aimed at limiting measurement errors.

net gain, and conversely. Figure 2 gives the reduced-form net effect of the brain drain on human capital formation in developing countries. The X-axis gives the DM emigration rates for the highly educated and the Y-axis gives the net impact of the brain drain on the proportion of skilled remaining in the country. 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. On the whole, there appears to be more losers than winners, and in addition the former tend to lose relatively more than what the latter gain. Nonetheless, at an aggregate level and given that the largest developing countries are all among the winners (China, India, Indonesia, Brazil), brain drain migration may be seen not only as increasing the total number of skilled workers worldwide but also the number of such workers living in the developing world.

[INSERT FIGURE 2]

3.5 Remittances

Migrants' remittances constitute another channel through which the brain drain may generate positive 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, 2003, 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 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.[14] Altruism is primarily directed towards one's immediate family, and then decreases with social distance. In contrast, 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 implicit commitments to reimburse the family for funding of education investments (and, in

[14] See Rapoport and Docquier (2006) for a comprehensive survey of the theoretical and empirical literature on migrants' remittances.

addition, they have a higher income potential), but on the other hand, they 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.

McCormick and Wahba (2000) obtain the result that highly-skilled migration may benefit 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 the economy.

In our basic framework with constant marginal utility of income, remittances impact on human capital formation only when liquidity constraints are binding. Without migration (and assuming a uniform distribution of education costs), the share of the educated is given by c_L. With migration, 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 amounts transferred and on recipients' location on the cost axis.

Let us denote by T the amount of remittances received by each remaining resident at the steady state. As shown on Figure 3, 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 $T > T^* \equiv c_M(\frac{1}{c_L} - 1)$.

[INSERT FIGURE 3]

In words, this means that 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 is unlikely when migration costs are quite high (as $\partial T^*/\partial k > 0$) and, more generally, does not seem to portray the evidence on remittance behavior in developing countries. Although remittances are generally positively correlated with donors' incomes, meaning that skilled emigrants are presumably important remitters, the results from empirical studies are mixed. Most micro-studies (e.g., Lucas and Stark, 1985, Cox et al., 1998, Brown and Poirine, 2005) find a positive effect of education on the probability of sending remittances and on the amounts remitted after controling for income, which suggests

that remittances have a loan repayment component. However, at an aggregate level, Faini (2007) shows that migrants' remittances decrease with the proportion of skilled individuals among 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 to promote investment projects (generally small businesses). There is much evidence that low-skill workers migrate with the aim of accumulating enough savings to access to self-employment and entrepreneurship (see, e.g., Mesnard (2004) and Mesnard and Ravallion (2001) for Tunisia, Dustmann and Kirchkamp (2002) for Turkey, Ilahi (1999) for Pakistan, Woodruff and Zenteno (2007) for Mexico, or McCormick and Wahba (2001) for Egypt). The latter study also suggests that skill-acquisition may be more important for relatively educated migrants than the need to overcome liquidity constraints.

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 4a) or totally catches up, with a possible net gain in the long run (as in Figure 4b) thanks to the various channels detailed above. On the transition path, additional effects are likely to operate. In particular, there is a large economic and sociological literature emphasizing that the creation of migrants' networks facilitates exchanges of goods, factors, and ideas between the migrants' host and home countries. In this section we consider two types of migrant network effects: networks that encourage trade, FDI inflows and technology diffusion, and networks that encourage further migration.

[INSERT FIGURE 4]

An important socio-economic literature has emerged recently to analyze the consequences of the constitution of migrants' networks 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 working abroad 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 expand further the set of people with network connections. Migration networks can then be viewed as reducing the costs, and perhaps also increasing the benefits of migration (Bauer et al., 2002, Munshi, 2003, and McKenzie and Rapoport, 2007, find strong evidence of such network effects). In other words, migration incentives become endogenous once networks are formed.

Building on this idea, Kanbur and Rapoport (2005) 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.[15] 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. 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, Lopez and Schiff, 1998). 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 Trindade, 2002, Rauch and Casella, 2003). How is the relationship of substitutability or complementary between trade and migration impacted by the skill composition of migration, however, remains unclear. The only empirical study on this question we are aware of is that of Lopez and Schiff (1998), who used episodes of trade liberalization to conclude to a relationship of complementarity between trade and unskilled migration, and conversely for skilled migration.[16]

Similarly, one may ask whether migration and FDI are substitutes (as one would expect) or complements, and whether the skill composition of migration, or the sectoral composition of FDI, impact on the relatiosnhip between the two. Again, the

[15] For this incentive effect to operate, however, education must not only increase one's chances of migration but also allow for accessing to legal, high-skill jobs. In a context where immigration is illegal and migrants can only access unskilled jobs, the prospect of migration can instead reduce education investment. See McKenzie and Rapoport (2006) on Mexico-U.-S. migration, and De Brauw and Giles (2006) on rural-urban migration in China.

[16] Interestingly, a recent theoretical paper (Kar and Beladi, 2004) using a Hecksher-Ohlin framework augmented to allow for non competitive wage settings comes up with predictions just opposite to the empirical findings of Lopez and Schiff.

evidence on these issues is scant. There are certainly many case-studies suggesting that skilled migrants take an active part in the creation of business networks leading to FDI project deployment in their home country. This is the case, in particular, for the software industry (Saxeenian, 2001, Arora and Gambardella, 2005, Commander et al., 2004b). At an agregate level, Kugler and Rapoport (2007) investigate the migration-FDI relationship for U.S.-rest of the world bilateral flows throughout the 1990s. They show that FDIs towards a given country are positively correlated with the initial U.S. immigration stock of that country (for both skilled and unskilled migration) but negatively correlated with the change in immigration stocks during the period studied. >From this they conclude to a relationship of contemporaneous substitutability and of dynamic complementarity between migration and FDI. Interestingly, after disagregating the results by skill level and destination sector, they find significant relationships only for current unskilled migration and current manufacturing FDI, which appear to be substitutes, and for past skilled migration and current FDI in the service sector, which appear to be complements.

4 Policy issues

Our discussion of policy issues is based on a simplified model combining liquidity constraints and uncertain migration prospects (solutions are henceforth indexed by pl). Since this kind of model relies on out-selection immigration policies, we consider that migration costs are zero ($k = k^{'} = 0$). However, similar conclusions would be obtained through combining self-selection (which requires positive migration costs) and return migration.

Without public intervention our model can be summarized by the following equations:

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

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

In this framework, we analyze the role of emigration (or immigration) policy, education policy, and (Bhagwati) tax policy on the interplay between migration and human capital formation. These policies are evaluated in terms of their impact on the average level of human capital, $H_{pl} = 1 + (h-1)P_{pl}$ and in terms of their impact on the income of the unskilled, $I_{pl} = 2w$. Basically, these two social objectives can be assimilated to efficiency and social justice. 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 therefore requires maximizing c_{pl}. Without public intervention, maximizing the proportion of educated also maximizes the welfare of uneducated agents, which means that efficient and socially just solutions coincide.

4.1 Migration policy: the optimal rate of skilled migration

We use a diagrammatic representation in the (Ω, p) plane.

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

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

This expression is an increasing and convex function of p, depicted as the BB curve in Figure 5.

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

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

which is depicted as the LL curve in Figure 5.

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

The optimal rate of skilled migration depends on Ω, which is itself endogenous as it depends on human capital accumulation and, therefore, on migration prospects. Let us define Ω_n as the foreign wage premium prevailing at $p = 0$. If $\Omega_n > \Omega_{BB}(0) = (h-1)(2-h)/h$, then there is room for a beneficial brain drain over some ranges of p. Several paths of migration premium can be represented diagrammatically. In each case (i.e., for each Ω_n), the optimal migration rate corresponds to the minimal value of the (Ω, p) locus. For limited values of p, the proportion of educated increases and the foreign wage premium decreases with p. For a 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 $\Omega_n > \Omega_{BB}(0)$, a brain drain is always detrimental. The proportion of educated and the welfare of unskilled workers decrease with p. The optimal rate of migration is then zero. These results may be summarized as follows:

Remark 1 *As apparent from Figure 5, the optimal migration rate is zero for relatively rich countries, that is, for countries with a low foreign wage premium. It then increases with the foreign wage premium Ω as long as liquidity constraint are not binding, and then decreases with Ω for poor countries where liquidity constraints are binding.*

[INSERT FIGURE 5]
In other words, there is an inverse-U shape relationship between optimal skilled emigration and level of development.

4.2 Education policy

Consider now that the government collects an income tax on both educated and uneducated adults remaining in the country. The tax may be expressed in terms of educated workers' wages, τwh, with τ denoting the tax rate, and is assumed to finance an education subsidy allocated to each young opting for education; the education subsidy may itself be expressed in terms of the local wage, θw. The critical education cost threshold then becomes:

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

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 to obtain is modified. Second, the brain drain requires budgetary adjusments (increasing taxes or reducing subsidies). We address these two effects separetely.

Let us first consider that the government budget in the closed economy 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 liquidity constraints are not binding in the closed economy so that $c_\tau = h - 1 + \theta_n < 1 - \phi + \theta_n$. Without fiscal adjustments (e.g., assuming that international aid allows the government to keep the policy (τ_n,θ_n) unchanged), and assuming first that liquidity constraints are not binding (that is, $c_O^\tau \leq c_M^\tau$), then a beneficial brain drain emerges if:

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

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 values 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 obtain the desired condition is $h > 4/3$). On the other hand, if liquidity constraints are binding, that is, if $c_O^\tau > c_M^\tau$ (this will be the case if $\Omega > \Omega_{LL}^\tau(p) \equiv \frac{2-h-\phi}{ph} - \tau_n$), then compared to the economy without taxes and subsidies, the LL curve will also shift downwards but the condition for a beneficial brain drain to emerge will be:

$$p < p_b^\tau \equiv \frac{2 - h - \phi}{(1 - \phi + \theta_n)(2 - h - \theta_n)}.$$

If the subsidy is sufficiently high ($\theta_n > \phi - h + 1$), then p_b^τ is higher than p_b, the critical migration rate without education policy.

These results may be summarized as follows:

Remark 2 *If the closed economy fiscal policy can be maintained, then education policy reinforces the likelihood of a beneficial brain drain. As apparent from Figure 6, the area for which a beneficial brain drain obtains in the* (Ω, p) *plane (see the area delimited by the solid lines) is larger than in the case without education policy (see the area delimited by the dashed lines).*

[INSERT FIGURE 6]

Secondly, the brain drain generates a fiscal loss that requires fiscal adjustments such as decreasing education subsidies by $\Delta\theta$ and/or increasing taxes by $\Delta\tau$. The optimal policy-mix depends on the social objective of the government. Reducing education subsidies lowers the proportion of educated in both the constrained and unconstrained cases:

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

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

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

Therefore, if the government's objective is to maximize the average level of human capital (efficiency), adjusting through taxes appears to be the best option. Alternatively, if the objective is to maximize the income of unskilled workers, now defined as $I_{pl} = w(2 - \tau h)$, then adjusting through taxes would seem preferable in terms of efficiency but disproportionately harms the uneducated workers; if human capital externalities are not too strong, reducing subsidies is therefore preferable for the sake of social justice.

Remark 3 *The fiscal adjusment to the brain drain raises a tradeoff between efficiency and social justice. The optimal policy mix depends on the social welfare function of the government.*

4.3 The case for a Bhagwati tax

Finally, consider that the government is allowed to collect a tax (expressed in percent of educated workers' wages at home, $\tau^* wh$) on skilled emigrants. We do not discuss here the feasibility of such tax scheme, which obviously requires international tax

cooperation between home and host country governments (see Desai, Kapur and McHale, 2004). Assume that the tax can be used to finance either a lump-sum transfer to the young, T^*w, or an education subsidy to those opting for education (expressed in percent of the wage rate at home, $\theta^* w$.[17]. The critical education cost then becomes:

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

In contrast to domestic taxes, a "tax on brains" (or Bhagwati tax) reduces the incentives to educate. If the proceeds from the tax are redistributed as an education subsidy, this partly compensates the negative incentive effect just described by creating an additional incentive to educate. Both education subsidies and lump-sum transfers make liquidity constraints less binding.

The government's budget constraint becomes more complex. The number of taxpayers is now given by $Nc_{pl}^{\tau^*} p$, where N denotes the number of young in the previous period. As m measures the number of children per adult, the number of young living in the origin country in the current period is equal 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 the demographic growth factor (fertility minus emigration) is assumed to be positive: $(1 - c_{pl}^{\tau^*} p)m > 1$.

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

First, let us assume that the tax revenue is used to finance an education subsidy ($T^* = 0$); this affects the critical education cost thresholds 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 to the young ($\theta^* = 0$), then the critical thresholds become:

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

[17] Allocating a lump-sum transfer to adults would simply reduce the incentive to emigrate, thus reinforcing the effect of the Bhagwati tax..

When the government aims at maximizing the stock of human capital (and, thus, the critical education cost threshold $c_{pl}^{\tau^*}$), we have to distinguish between the constrained and unconstrained equilibria. Finding the critical education cost threshold requires in most cases to solve an implicite function (second order polynomial). However, intuitive results can be obtained by comparing the effect of $ph\tau^*$ in the equations above. In the unconstrained case ($c_{pl}^{\tau^*} = c_O^{\tau^*}$), a Bhagwati tax always reduces the critical cost threshold $c_O^{\tau^*}$. 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. On the other hand, in the constrained case ($c_{pl}^{\tau^*} = c_M^{\tau^*}$), a Bhagwati tax always increases the stock of human capital and the efficiency gain is stronger when the tax is redistributed as an education subsidy.

When the governement maximizes uneducated workers' income ($I_{pl} = w\left[2 + T^*\right]$), 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 this case, unskilled workers share the gain from migration with emigrants. If spillover effects are not too large, then the uneducated have a clear interest in setting a Bhagwati tax and redistributing its proceeds in a lump-sum way. These results may be summarized as follows:

Remark 4 *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 revenue as an education subsidy is more efficient than a lump-sum transfer. In terms of social justice, taxing migrants and redistributing the Bhagwati tax as a lump-sum transfer is preferable as long as spillover effects (human capital externalities) are not too large.*

5 Conclusion

In this paper we proposed an overview of the theoretical and empirical literature on the effects of skilled migration on developing countries. We first presented new evidence on the size of the brain drain at the international level, showing that the phenomenon has gained in magnitude over the last decades and represents a substantial outflow of human capital for many developing countries. We then proposed a stylized model of brain drain migration and human capital formation to capture the various channels through which skilled migration affects developing countries. We insisted on the fact that the stock of human capital from which emigrants are drawn is endogenous to migration, be it through ex-ante (e.g., incentives) or ex-post (e.g., remittances, networks) effects. For each channel, we then explored the conditions under which skilled emigration is detrimental or beneficial to the source country, and summarized the empirical evidence available from case and cross-country studies. Finally, we used a particular specification of the model to discuss a number of policy

issues from the perspective of developing countries, with the following general results. First, the optimal rate of migration displays an inverse U-shaped relationship with the source-country level of development. Second, when education is partly publicly financed through education subsidies, the likelihood of a beneficial brain drain is higher than under purely privately financed education, and optimal fiscal adjustments to the brain drain generally involve an efficiency-equity trade-off. And third, a Bhagwati tax may provide additional benefits to the source countries only if education investments there are liquidity constrained.

The main general conclusion to draw from the above analysis is that for a 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. In many instances, 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, however, is 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.

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Table 1. Data by country group in 2000

	Rate of emigration in %		Share of skilled workers in %	
By country size	**Total**	**Skilled**	**Among residents**	**Among migrants**
Large countries (Pop>25 million)	1.3	4.1	11.3	36.4
Upper-Middle (25>Pop>10)	3.1	8.8	11.0	33.2
Lower-Middle (10>Pop>2.5)	5.8	13.5	13.0	33.1
Small countries (Pop<2.5)	10.3	27.5	10.5	34.7
By income group	**Total**	**Skilled**	**Among residents**	**Among migrants**
High Income countries	2.8	3.5	30.7	38.3
Upper-Middle Income countries	4.2	7.9	13.0	25.2
Lower-Middle Income countries	3.2	7.6	14.2	35.4
Low Income countries	0.5	6.1	3.5	45.1
UN Least developed countries	1.0	13.2	2.3	34.0
By region	**Total**	**Skilled**	**Among residents**	**Among migrants**
America	3.3	3.3	29.6	29.7
Northern America	*0.8*	*0.9*	*51.3*	*57.9*
Caribbean	*15.3*	*42.8*	*9.3*	*38.6*
Central America	*11.9*	*16.9*	*11.1*	*16.6*
South America	*1.6*	*5.1*	*12.3*	*41.2*
Europe	4.1	7.0	17.9	31.7
Eastern Europe	*2.2*	*4.3*	*17.4*	*34.2*
Northern Europe	*6.8*	*13.7*	*19.9*	*43.2*
Southern Europe	*6.6*	*10.7*	*10.8*	*18.2*
Western Europe	*3.3*	*5.4*	*23.4*	*39.3*
Africa	1.5	10.4	4.0	30.9
Eastern Africa	*1.0*	*18.6*	*1.8*	*40.8*
Middle Africa	*1.0*	*16.1*	*1.6*	*30.9*
Northern Africa	*2.9*	*7.3*	*7.5*	*19.6*
Southern Africa	*1.0*	*6.8*	*8.7*	*62.1*
Western Africa	*1.0*	*14.8*	*2.4*	*42.0*
Asia	0.8	5.5	6.3	46.8
Eastern Asia	*0.5*	*3.9*	*6.3*	*55.5*
South-central Asia	*0.5*	*5.3*	*5.0*	*52.5*
South-eastern Asia	*1.6*	*9.8*	*7.9*	*51.4*
Western Asia	*3.5*	*6.9*	*11.4*	*22.9*
Oceania	4.3	6.8	27.8	45.0
Australia and New Zealand	*3.7*	*5.4*	*32.7*	*49.2*
Melanesia	*4.5*	*44.0*	*2.7*	*45.0*
Micronesia	*7.2*	*32.3*	*7.1*	*43.6*
Polynesia	*48.7*	*75.2*	*7.1*	*22.7*

Source: Docquier and Marfouk (2006)

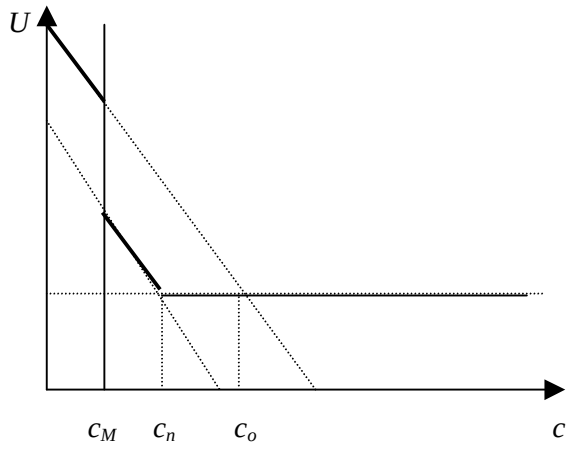
Table 2. Skilled emigration - Top-30 countries in 2000

All middle-income and low-income countries						Middle- and low-income countries with population above 4 million					
Highest stocks 0+		**Highest rates 0+ in %**		**Lowest rates 0+ in %**		**Highest rates 0+ in %**		**Highest rates 18+ in %**		**Highest rates 22+ in %**	
Philippines	1126513	Guyana	89.0	India	4.3	Haiti	83.6	Haiti	78.3	Haiti	73.7
India	1037768	Grenada	85.1	Burma	4.0	Sierra Leone	52.5	Sierra Leone	51.1	Sierra Leone	48.4
Mexico	923017	Jamaica	85.1	Paraguay	3.9	Ghana	46.8	Ghana	44.9	Mozambique	43.7
China	816916	St Vinc&Gren	84.5	China	3.8	Mozambique	45.1	Mozambique	44.4	Ghana	42.3
Vietnam	506459	Haiti	83.6	Moldova	3.6	Kenya	38.4	Kenya	35.7	Kenya	33.4
Poland	449778	Trinidad-Tobago	79.3	Botswana	3.6	Laos	37.4	Uganda	32.7	Uganda	30.7
Cuba	332707	St Kitts&Nevis	78.5	Ukraine	3.6	Uganda	35.6	Somalia	31.4	Somalia	29.9
Iran	308774	Samoa	76.4	Namibia	3.4	Angola	33.0	Angola	29.2	Angola	26.4
Jamaica	291169	Tonga	75.2	Venezuela	3.4	Somalia	32.6	Sri Lanka	26.1	Sri Lanka	24.1
Russia	290208	Saint Lucia	71.1	Belarus	3.2	El Salvador	31.0	Laos	25.7	Rwanda	23.9
Taiwan	275265	Cape Verde	67.4	Burkina Faso	2.6	Sri Lanka	29.6	Rwanda	24.7	Laos	21.9
Ukraine	249155	Belize	65.5	Argentina	2.5	Nicaragua	29.6	El Salvador	23.3	Afghanistan	20.4
Colombia	233563	Dominica	64.2	Chad	2.4	Cuba	28.7	Nicaragua	22.8	Nicaragua	19.4
Pakistan	222534	Barbados	63.5	Thailand	2.4	Papua N.G.	28.5	Afghanistan	21.5	Croatia	18.9
Romania	177076	Gambia	63.2	Libya	2.4	Vietnam	27.1	Croatia	20.7	El Salvador	18.3
Turkey	174437	Fiji	62.2	Georgia	2.3	Rwanda	25.8	Papua N.G.	19.8	Malawi	18.0
Brazil	168367	Mauritius	56.1	Brazil	2.3	Honduras	24.4	Cuba	19.4	Papua N.G.	17.1
South Africa	168047	Seychelles	55.8	Indonesia	2.1	Guatemala	24.2	Vietnam	19.0	Cuba	17.0
Peru	163758	Sierra Leone	52.5	Azerbaijan	2.0	Croatia	24.1	Honduras	18.9	Vietnam	15.8
Dominican Rep	155179	Suriname	47.9	Russia	1.5	Afghanistan	23.3	Guatemala	18.4	Honduras	15.2
Haiti	152715	Ghana	46.8	Kazakhstan	1.2	Dominican Rep	21.6	Malawi	18.2	Togo	15.0
Egypt	150596	Mozambique	45.1	Maldives	1.2	Togo	18.7	Togo	16.9	Zambia	14.5
Nigeria	149528	Liberia	45.0	Mongolia	1.1	Malawi	18.7	Dominican Rep	15.7	Slovakia	14.4
Serbia & Mont.	149065	Marshall Islands	39.4	Kyrgyzstan	0.7	Cambodia	18.3	Slovakia	15.4	Guatemala	14.1
Morocco	141238	Lebanon	38.6	Uzbekistan	0.7	Senegal	17.7	Zambia	15.1	Dominican Rep	12.8
Lebanon	138237	Kenya	38.4	Bhutan	0.6	Cameroon	17.2	Cameroon	14.6	Senegal	12.5
El Salvador	127710	Micronesia	37.8	Oman	0.6	Morocco	17.0	Senegal	14.1	Serbia & Mont.	12.3
Hungary	124463	Laos	37.4	Swaziland	0.5	Zambia	16.8	Morocco	13.4	Cameroon	12.3
Trinidad-Tobago	120329	Uganda	35.6	Tajikistan	0.4	Slovakia	16.7	Serbia & Mont.	12.9	Morocco	12.1
Guyana	118263	Nauru	34.5	Turkmenistan	0.2	Mexico	15.3	Poland	12.2	Poland	11.2

Sources: Docquier and Marfouk (2006); Beine, Docquier and Rapoport (2007a)

Figure 1. Brain drain, education choices and liquidity constraints

Case 1. A positive share of educated remains



Case 2. All the educated leave

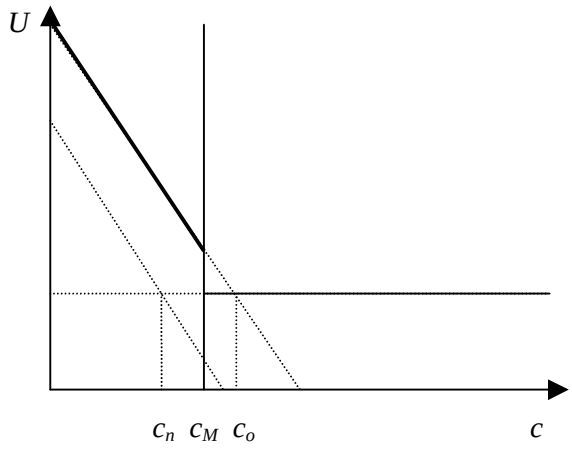


Figure 2. Brain drain and human capital in LDC's
(with 2nd order polynomial trend)

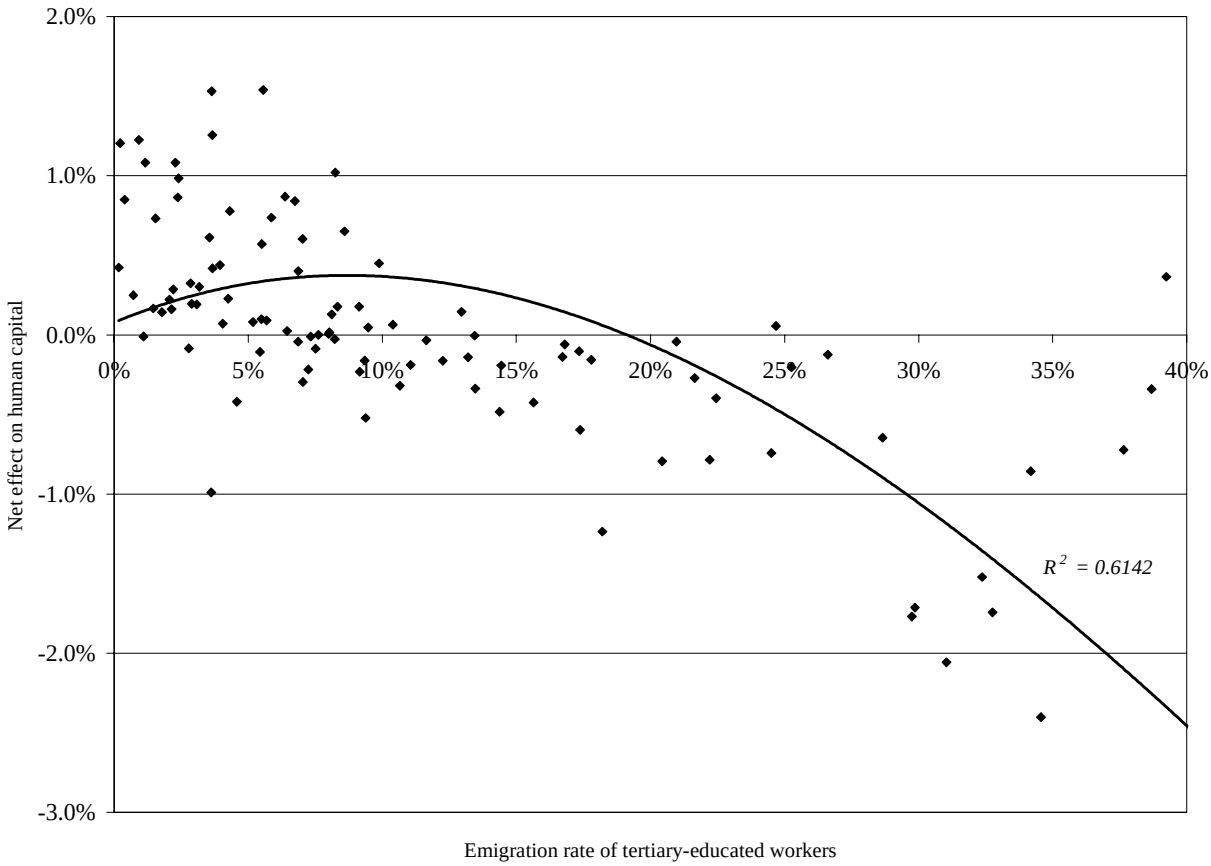


Figure 3. Brain drain and remittances

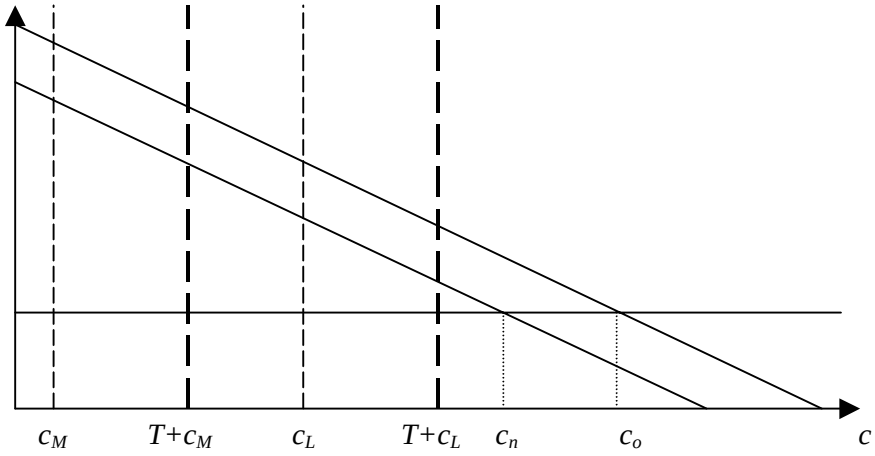


Figure 4. The dynamic impact of brain drain

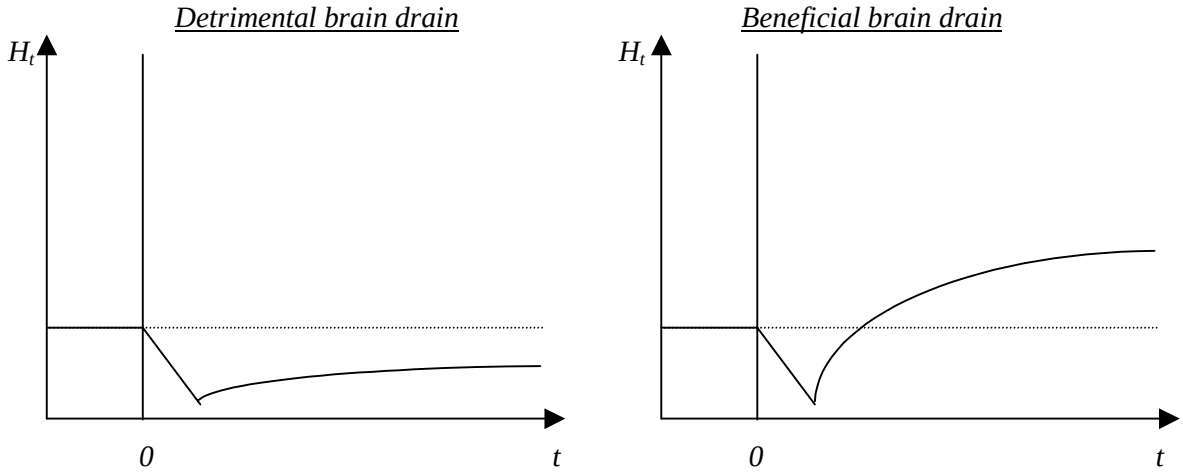


Figure 5. The optimal skilled emigration rate.

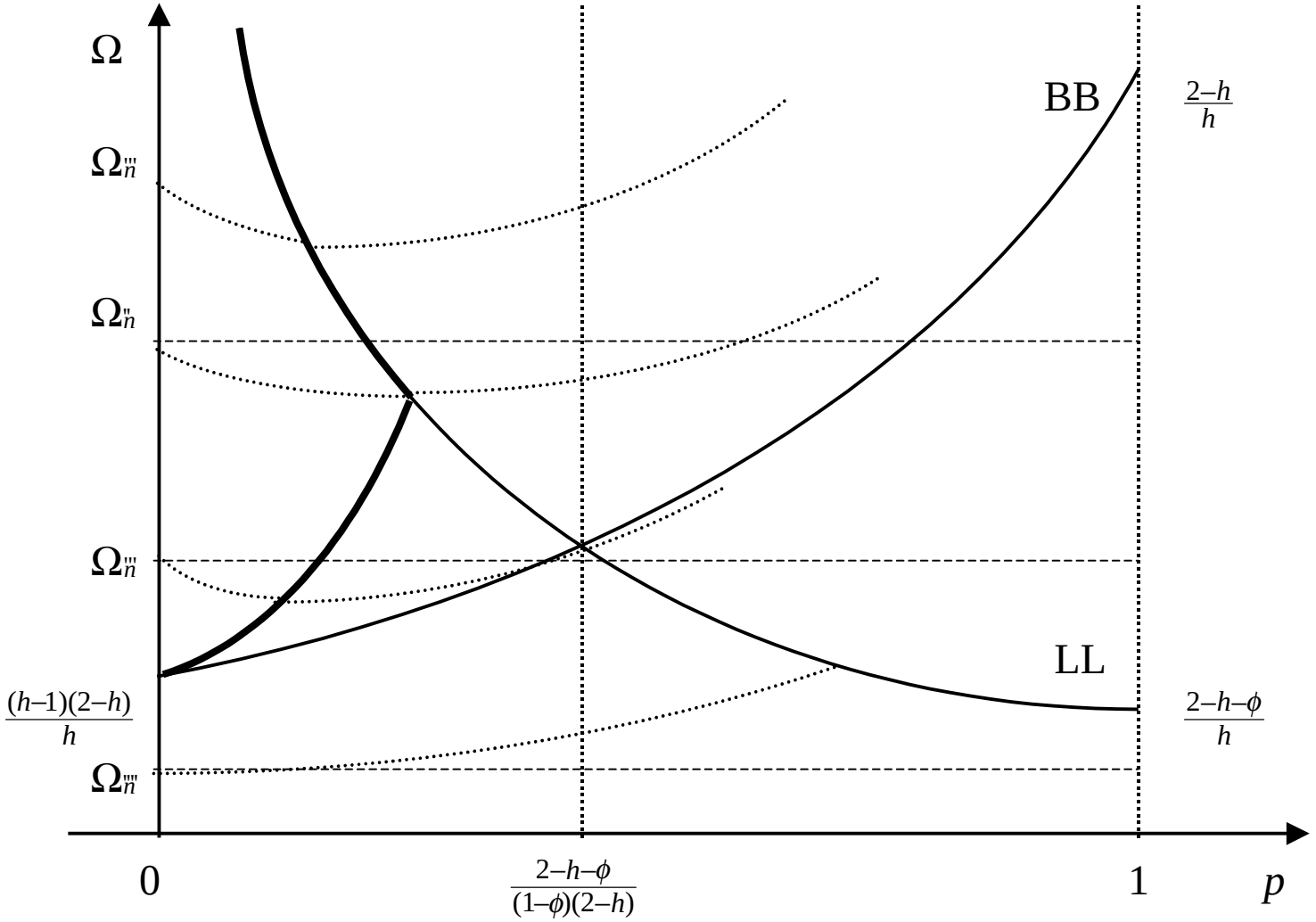


Figure 6. Optimal rate of migration and education policy (without budgetary adjustment)