Brain Drain and Brain Waste

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Abstract

We analyze the effects of brain waste on brain drain and self selection. We show that, relatively to a no brain waste scenario, in a brain waste scenario the following effects arise: (1) it weakens the chances of a positive self-selection of skilled migrants; (2) it reduces the possibility of a beneficial brain gain; and (3) it dampens the effectiveness of education policies. Accordingly, brain waste (i.e.: skilled workers working as unskilled), reduces the incentives of individuals to acquire education and of skilled workers to migrate.

Keywords: Brain drain, Brain waste, Illegal migration, international transferability of human capital, self-selection.

JEL Classification: F22, J61.

1 Introduction

The traditional view on brain drain is that international migration leads developing countries to lose high-skilled workers to developed countries, due to higher wages in the latter (Grubel and Scott, 1966 and Bhagwati and Hamada, 1974)\(^1\). In view of that, brain drain is detrimental to poor

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\(^1\)A controversial example of brain drain is that of African doctors that migrate to work in developed countries, i.e.: the developed world has the benefits of African skilled migrants without paying for their education (World Bank, 2006).
countries through a set of negative externalities, for example, reduced productivity of those left behind, higher costs of public goods and loss of the investment made in human capital formation.

Recent contributions, however, have defended that the negative brain drain story does not necessarily need to hold (see for example Docquier and Rapoport, 2007). Accordingly, in a developing economy closed to international migration, the returns to education are very low and this discourages individuals to invest in education. However, if an individual is able to migrate to a high wage developed country, he might have extra incentives to acquire education relatively to autarchy. Migration, in this sense, increases the returns to education. This new view defends that while migration opens the door for a negative brain drain, in some cases this negative effect might be offset by a beneficial brain gain due to an increase in the incentives of natives to acquire human capital. Therefore, migration conduces to a negative brain drain when the increase in the number of people that acquire education does not compensate for the number of skilled people that migrate. Conversely, a positive brain gain arises when the increase in the number of people that acquire education more than offsets the number of skilled people that migrate.

In particular, the brain drain literature presents three main mechanisms that can allow a developing country to achieve a beneficial brain gain: return migration (Dos Santos and Postel-Vinay, 2003 and Stark et al., 1997); remittances (Cox Edwards and Ureta, 2003); and uncertain migration status (Mountford, 1997 and Beine et al., 2001). Accordingly, the possibility of a beneficial brain gain is increased if the flow of skilled workers returnees is sufficiently high (return migration channel); if remittances reduce substantially liquidity constraints in the education of the younger (remittances channel); and if many individuals that have invested in human capital do not migrate because they do not get legal status (uncertain migration status channel).

In this paper, we argue that the beneficial brain gain result is undermined in the presence of brain waste. Brain waste arises when a skilled individual incurs in the costs of education but he does not reap the benefits of human capital acquisition. Accordingly, empirical evidence shows that skilled migrants very often end up working as unskilled (see Coniglio et al., 2006 and Mattoo et al., 2007). With brain waste, then, skilled migrants see a reduction on the rewards to human capital in the

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2 Uncertainty migration status refers to the uncertainty that an individual faces when applying for a legal migration visa. In particular, it is assumed that individuals that do not obtain legal visa do not migrate.

3 See Commander et al. (2004) for a comprehensive review of the various channels through which a beneficial brain gain can arise.
destination country. If migrants internalize the brain waste risk, the education incentives that arise with international migration can therefore be reduced, decreasing the chances for a beneficial brain gain.

The brain waste risk can appear in the presence of two phenomena: illegal migration (Hanson, 2006) and low international transferability of human capital (Chiswick and Miller, 2007). Accordingly, as a result of illegal status, illegal migrants end up working in low skill activities, independently of their skill level. Empirical evidence in fact shows that, relatively to legal migrants, illegal migrants are paid lower wages, have poor working conditions and are more subject to violations of the protections afforded by the destination country labor laws (see Rivera-Batiz, 1999; Kossoudji and Cobb-Clark, 2002; Vayrynen 2003 and Hanson, 2006).

In turn, if the international transferability of human capital is low, a skilled migrant has higher chances of end up working as unskilled (Chiswick and Miller, 2007). In fact, a skilled migrant can only work as a skilled worker in the destination country if his human capital level is recognized in the destination country. For example, it is very common that skilled individuals have to apply for equivalence of their university degree in the destination country (see World Bank, 2006). In addition, the international transferability of human capital seems to be affected by different factors such as the working experience or education acquired in the destination migration country (Yamauchi, 2004 and Ferrer and Riddell, 2008), language skills (Chiswick and Miller, 1992 and Bleakley and Chin, 2004), the country of origin (Matoo et al., 2008) and skin color and height (Hersch, 2008).

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4 Illegal migration can be defined as the immigration that violates the immigration laws of the destination country. For example, an immigrant that enters illegally in a country or an immigrant with an expired visa. Illegal migration is a concern for developed countries mostly because of the numbers involved. For example, Passel (2005) estimates that in the US total illegal immigrant population has increased from 9.3 million in 2002 to 10.3 million in 2004 and that illegal migration flows are around 500,000 per year. Comparable figures have also been found for the EU (Jandl, 2004). Given that illegal migration is seen as something undesirable because of a set of negative externalities for the receiving migration country (for example, the creation of a "grey" economy or increase in crime rates), most developed countries have put in place a set of policies to fight illegal migration. An extreme example of these policies is the debate in the US on the militarization of the Mexico-US border, in order to reduce illegal migration from Mexico to US. In the EU similar measures have been proposed in relation to illegal migrants from the North of Africa.

5 Rivera-Batiz (1999) and Kossoudji and Cobb-Clark (2002) show that illegal immigrants from Mexico in the US have a significant wage penalty relatively to legal migrants and that, as a result, the returns to human capital are much higher for Mexican legal immigrants than for illegal ones.

6 Accordingly, the international transferability of human capital increases when the
A close analysis of the migration policies of developed countries, in particular in the United States (US) and in the European Union (EU), shows in fact a focus on illegal migration (Hanson, 2006) and the international transferability of human capital (World Bank, 2006). At same time, however, many developed countries have launched some type of selective migration policies to attract skilled workers and restrict unskilled migration (Bauer et al., 2000)\(^7\).

The selective migration policies find theoretical support in the literature on self-selection, which main research question is if skilled individuals positively self-select to migration. The dominant view, which finds a high degree of support from empirical work, is that there is a tendency towards a positive self-selection of skilled migrants (Schultz, 1975 and Chiquiar and Hanson, 2005). The positive self-selection is due to the fact that, when compared to the unskilled, skilled individuals have lower migration costs and higher returns from migration\(^8\).

The interest on selective migration policies relates with a public debate in most developed countries on the "quality" of migrants. By "quality" of migrants, politicians and the media usually mean if migrants are skilled or unskilled workers, with the former being the "quality" migrants. Accordingly, by using selective migration policies developed countries expect to attract more skilled workers. The idea behind selective migration policies is that in a globalized world, international competitiveness can only be achieved by attracting the more qualified brains. In the same way that illegal migrants can create negative externalities, it is believed that skilled migrants promote positive externalities for the hosting economy. For instances, skilled migrants promote economic growth through an increase in the stock of human capital stock and in the level of knowledge spillovers.

Selective migration policies face, however, some important challenges. First, selective migration policies are not always effective. In fact, it is not sufficient to be skilled worker to get a legal visa (i.e.: many skilled

\(^7\)Selective migration policies make it easier for skilled workers to get a legal migration visa relatively to unskilled ones. One well known example of a selective migration policy is the Canada’s point system. Note however, that although selective migration policies give preference to skilled workers over the unskilled, not all skilled workers are granted legal visas with these policies. In other words, selective migration policies also screen and select amongst skilled workers.

\(^8\)A recent view, however, defends that the possibility of a positive self-selection is less likely for non-economic migrants (as refugees) and short-term migrants (as seasonal workers). See Borjas (1987) and Chiswick (1999).
workers are denied entry in a country). Accordingly, all selective migration policies select and screen skilled migrants, and as a result many skilled workers are denied entry in a country. Furthermore, the screening of migrants' skills is very costly and very often prone to errors. For example, some "low quality" skill migrants are granted legal visas, while some "high quality" skill migrants are denied entry (World Bank, 2006). In second place, an outcome of selective migration policies is to increase the restrictiveness of migration policies. Restrictive migration policies, however, have as a consequence to increase illegal migration (Hanson, 2006). Third, even when a skilled worker get a legal visa, the international transferability of human capital might not be perfect. In this sense, selective migration policies might clash with a second line of regulation related with the international transferability of skills that eliminates the effects that the former wish to promote.

In this paper we then check the robustness of the positive self-selection and the beneficial brain gain arguments to brain waste. In particular, we compare a scenario with no brain waste with a scenario with brain waste. We show that, relatively to the no brain waste scenario, under the brain waste scenario the following effects arise: (1) it weakens the chances for a positive self-selection; (2) it reduces the possibility of a beneficial brain gain; and (3) it dampens the effectiveness of education policies. Accordingly, brain waste by reducing the returns to human capital it reduces the education incentives of individuals. Therefore, brain waste not only reduces the chances of developed countries to attract skilled-workers, but it can also hurt human capital formation in the developing world.

The previous results seem to be supported by recent empirical evidence. First, Chiquiar and Hanson (2005), Hanson (2006), Mckenzie and Rapoport (2007) and Orrenius and Zavodny (2005) present evidence of a positive self-selection for immigrants with up to nine years of education but of a negative self-selection for immigrants with more than nine years of education. They attribute this pattern, at least in part, to illegal migration and low international transferability of human capital. Second, Mckenzie and Rapoport (2006) and de Brauw and Giles (2006) find evidence of a significant negative effect of illegal migration on schooling attendance and attainments in rural Mexico and in rural China. Accordingly, in a context where the chances to be able to migrate legally are very low (and therefore brain waste risk is higher), the prospect of migration do not necessarily increase education incentives.

The remainder of the paper is organized as follows. In the next section we introduce the base model. Then we present results for the no brain waste scenario. After that we turn to the brain waste scenario and compare it with the no brain waste case. In section five, we analyze
the implications of an education policy by the origin migration country under the two brain waste scenarios. We conclude by first discussing the robustness of our results and then discussing the main implications of brain waste.

2 The Model

The model in this section is based on Docquier and Rapoport’s (2007) stylized model on self-selection and brain-drain. To Docquier and Rapoport (2007), we add the possibility that skilled workers face brain waste when they migrate. As discussed in the introduction, the brain waste might arise either because skilled workers migrate illegally when they do not get legal status, or because there is imperfect international transferability of human capital. In both cases a skilled worker ends up working as unskilled. The brain waste then arises because a skilled worker incurs in the costs to acquire education but the returns to education are equal to those that did not take education, the unskilled.

The world economy is made up of two countries: the origin and the destination migration country. We focus in the origin migration country, which is a small developing open economy, and we treat as exogenous the destination migration country, which is a developed economy (see table 1 for a summary of the parameters used in the model).

By construction, results in terms of brain drain and the education incentives of migration are mostly relevant to developing countries. However, results relative to the self-selection of skilled migrants are also of interest to developed countries.

2.1 Production, Human Capital and Wages

Individuals in the origin country live and work for 2 periods, \( t = 1, 2 \). In the first period, all individuals work as unskilled, but they can also choose to take education simultaneously. Therefore in the first period,

\[ 1<h<2 \quad \text{Skill premium} \]
\[ 0<c<1 \quad \text{Education costs} \]
\[ 0<k<1 \quad \text{Migration costs} \]
\[ 0<\gamma <1 \% \text{ of migrant’s second period working life spent in the destination country} \]
\[ 0<Z<1 \quad \text{Education subsidy rate} \]
\[ 0<T<1 \quad \text{Education tax rate} \]

\begin{table}
\begin{tabular}{|c|l|}
\hline
1<h<2 & Skill premium \\
0<c<1 & Education costs \\
0<k<1 & Migration costs \\
0<\gamma <1 & % of migrant’s second period working life spent in the destination country \\
0<Z<1 & Education subsidy rate \\
0<T<1 & Education tax rate \\
\hline
\end{tabular}
\end{table}

Figure 1: Parameters in the model

In a subsequent section, we discuss the case with more than one destination migration country.
Besides working, an individual chooses either to get education in order to become a skilled worker (S) or to not get education and stay unskilled (U). In the second period, all individuals work according to the skill level acquired in the first stage, but they can decide where to work (in the origin or in the destination country). As explain below, if a skilled individual decides to migrate, he can suffer brain waste, i.e.: a skilled worker is employed as unskilled.

Labor supply in period $t$ in the origin country equals the amount of unskilled and skilled labor available in the economy:

$$L_t = U_t + S_t$$  \hspace{1cm} (1)

We consider a very simple linear production function:

$$Y_t = w_t E_t$$  \hspace{1cm} (2)

Where $w_t$ is the wage rate. In turn, $E_t$ is labor in inefficient units and equals:

$$E_t = U_t + hS_t$$  \hspace{1cm} (3)

Where $h > 1$ is the skilled productivity premium, which is individual specific. Skilled workers are then heterogeneous in productivity$^{10}$.

The stock of human capital can then be written as:

$$H_t = \frac{E_t}{L_t} = \frac{U_t + hS_t}{U_t + S_t} = 1 + P_t (h - 1)$$  \hspace{1cm} (4)

Where $P_t$ is the proportion of skilled workers in the origin country:

$$P_t = \frac{S_t}{U_t + S_t}$$  \hspace{1cm} (5)

With this formalization we want to capture the idea of positive spillovers on human capital formation.

### 2.2 Individual Education Choices: Autarchy

In order to illustrate the education incentives of individuals, we consider first an autarchy scenario with no migration in the second period. If in the first period an individual only works, his wage rate is then $w_1$. In turn, if in the first period an individual besides working also takes education, he has to pay the education costs $cw_1$, with $0 < c < 1$. The parameter $c$ is, then, the opportunity costs of education, which

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$^{10}$We ignore all the issues related with principal-agent wage models, where workers' productivity is imperfectly observed (see Stark et al., 1997).
is individual specific. Therefore, individuals are heterogeneous on the ability to learn.

In the second period all individuals just work. Unskilled workers will earn $w_2$ and skilled workers $hw_2$. As such, the condition to acquire education in autarchy is just:

\[(1 - c) w_1 + hw_2 > w_1 + w_2\]  \hspace{1cm} (6)

In the steady state when $w_1 = w_2 \equiv w$ this condition simplifies to:

\[c < c_{\text{Aut}} \equiv h - 1\]  \hspace{1cm} (7)

Where the sub-script $\text{Aut}$ stands for autarchy. In other words, all individuals with $c < c_{\text{Aut}}$ will acquire education. It can be easily noted that in order to obtain interior solutions we need that $h \in ]1,2[$. If otherwise, all individuals would have incentives to acquire education.

2.3 Individual Migration Choices: Open Economy

In an open economy, in terms of international migration, at the end of period 1 an individual can decide to migrate abroad. In the destination country the wage per-efficiency units for natives is $w^* > w$. We consider $w^*$ to be exogenous to the model. In addition, the wage premium for skilled workers in the destination country is the same as in the origin country (i.e.: $h = h^*)^{11}$.

We consider, however, that skilled workers when migrating can suffer a brain waste. In our model, a skilled worker suffers brain waste if in the destination country he works as unskilled. In this sense, the skilled worker instead of receiving $hw^*$, his earnings are only $w^*$, i.e.: $w^* < hw^*$ (i.e.: brain waste)$^{12}$.

In addition, migration is costly. Migration costs include not only the monetary cost to move from one country to another, but also other costs such as those related with adapting to a new culture and being away from dear ones. Accordingly, we assume that migrants incur in a migration costs of $kw^*$, with $0 < k < 1^{13}$.

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$^{11}$Results are not changed qualitatively if $h \neq h^*$.

$^{12}$Accordingly, results do not change if the wage penalty for brain waste is larger than $w^*$ (this might be especially the case if we are considering illegal migration). For example, is the wage penalty is $\tau w^*$ (with $0 < \tau < 1$), we reach the same conclusions as in the present formalization.

$^{13}$Results are not changed if we assume higher migration costs for the unskilled in relation to the skilled. The same applies if the migration costs are higher for those skilled migrants that suffer brain waste (as a consequence of migrating illegally or imperfect international transferability of human capital).
2.4 No Brain Waste versus Brain Waste

In the second stage an individual migrates if, and only if, the gains from migration are larger than the benefits of not migrating. As usual in the brain drain literature, we consider only one channel for beneficial brain gain: temporary migration\textsuperscript{14}. We then assume that migrants spend a share $\gamma$ of their second period working life in the destination country and $1 - \gamma$ as returnees\textsuperscript{15}.

Additionally, we compare two scenarios in the destination migration country: (1) no brain waste scenario; (2) brain waste scenario. We model the brain waste case as a probability $p_S$ of a skilled worker to work as skilled. As discussed in the introduction, brain waste can arise due to illegal migration or imperfect international transferability of skills. In the first case, $p_S$ can be interpreted, as in Docquier and Rapoport (2007), as the probability of a skilled worker to get legal status. However, contrary to Docquier and Rapoport (2007) where a skilled worker with no legal status does not migrate, a skilled worker that does not get legal status migrates illegally. In the second case, $p_S$ is just the probability of having a perfect international transferability of human capital, i.e.: higher $p_S$ stands for higher international transferability of skills.

In the no brain waste scenario, then, a skilled worker always works as a skilled worker in the destination migration country. This is the case usually consider in the brain drain literature and also in Docquier and Rapoport (2007). Then, for skilled workers, the probability of getting a legal visa and/or working as skilled can be defined as $p_S = 1$.

In the brain waste scenario, skilled workers have a probability $p_S \in (0, 1)$ of working as skilled in the destination country (and a probability $(1 - p_S) \in (0, 1)$ of working as unskilled)\textsuperscript{16}. This might result from skilled workers migrating illegally because they do not get legal status or there is an imperfect international transferability of skills\textsuperscript{17}.

\textsuperscript{14}Temporary migration fits well with the brain waste scenario. For example, if brain waste arises because of illegal migration, then as defended by Chiswick (2001), illegal migration is by nature temporary. This is so, not only because illegal migrants aim at becoming legal, but also because they usually remain in the destination country for shorter periods than legal migrants. Also when skilled migrants suffer brain waste due to lower international transferability of skills they have higher incentives to return home (World Bank, 2006).

\textsuperscript{15}Below we are going to discuss the robustness of our results to the other two beneficial brain gain channels mentioned in the introduction: uncertain migration status and remittances.

\textsuperscript{16}Accordingly, for results in this paper to hold, we just need that $0 \leq p_S < 1$. Also, results do not change if we assume that unskilled workers also suffer some type of brain waste, i.e.: if $0 \leq p_U \leq 1$.

\textsuperscript{17}It is not correct to think that only the unskilled migrate illegally. Coniglio et al. (2006), on a survey on illegal migrants in Italy, report that 30% had secondary school
In this sense, the migration decision here has a different type of uncertainty from the uncertain migration status case discuss in the introduction (see also Docquier and Rapoport, 2007). In the uncertain migration status case, the uncertainty results form the legal status. In our paper, the uncertainty arises from the possibility of brain waste, i.e.: an individual is uncertainty about his earnings in the destination country, but not about his migration decision. However, the uncertainty in relation to earnings introduces a brain waste risk for skilled workers\textsuperscript{18}.

For a given individual, then, the life time income for alternative migration choices, under both the no brain waste and the brain waste scenario, is as follow:

\[
\begin{align*}
I(U, NM) &= w_1 + w_2 \\
I(U, MI) &= w_1 + w^* (\gamma - k) + (1 - \gamma) w_2 \\
I(S, NM) &= (1 - c) w_1 + hw_2 \\
I(S, MI) &= (1 - c) w_1 + w^* (\gamma (1 + p_S (h - 1)) - k) + (1 - \gamma) hw_2
\end{align*}
\]

(8)

Where \(NM\) stands for non-migration and \(MI\) for migration.

3 No Brain Waste

We are going to show that when brain waste does not arise, migration increases the incentives to acquire education, it promotes a positive self-selection and it contributes to a beneficial brain gain\textsuperscript{19}.

3.1 Self-Selection

At the steady state a skilled and an unskilled worker will migrate if and only if, respectively\textsuperscript{20}:

\[
\begin{align*}
S_{p=1} : h \gamma (\omega - 1) &> k \omega \\
U_{p=1} : \gamma (\omega - 1) &> k \omega
\end{align*}
\]

(9 years of schooling), 22% high-school (12 years of schooling) and 5% University (16 or more years of schooling). Hanson (2006) estimates similar education characteristics for illegal migrants from Mexico in the US.

\textsuperscript{18}As we discuss below, allowing for the same type of uncertainty as in the uncertain migration status case (for example letting some potential migrants to give up migration if they do not get legal status) does not change our results.

\textsuperscript{19}In this section we basically reproduce Docquier and Rapoport’s (2007) results. The only difference is that we interpret them in terms of brain waste.

\textsuperscript{20}The subscript \(p = 1\) indicates no brain waste scenario.
Where $\omega = \frac{w^*}{w}$ (the relative wage destination-origin country). From here it results that the relation between skilled and unskilled workers’ incentives to migrate is:

$$S_{ps=1} - U_{ps=1} = \gamma (\omega - 1) (h - 1) > 0$$  (10)

Under the no brain waste scenario, therefore, a skilled worker has always more incentives to migrate than an unskilled worker. However, in order to have a positive self-selection (i.e.: only the skilled migrate) we need that the $S_{ps=1}$ condition is satisfied but the $U_{ps=1}$ condition is not (equation 9). This is the case if $I(U, MI) < I(U, NM)$ and $I(S, MI) > I(S, NM)$, or:

$$\omega (\gamma - k) + (1 - \gamma) < 1 < \omega \left(\gamma - \frac{k}{h}\right) + (1 - \gamma)$$  (11)

We can then see that a positive self-selection is promoted when the returns to skills ($h$) are high$^{21}$.

In order to follow the brain drain literature, in the rest of this section we assume that equation 11 is always satisfied. The positive self-selection condition is necessary for two reasons. First, and as can be seen from equations 9 and 11, we eliminate corner solutions where all individuals migrate. This is so, because unskilled workers do not migrate, and only some skilled workers migrate, given that they are asymmetric on $h$. Second, and as we are going to prove below, migration increases the incentives of individuals to acquire education. As a consequence, this opens the door for a beneficial brain gain.

### 3.2 Education Incentives and Migration

Under the no brain waste scenario only the following individuals will acquire education (compare $I(S, MI)$ with $I(U, NM)$):

$$c < c_{ps=1} = \omega (\gamma h - k) + (1 - \gamma) h - 1$$  (12)

To check if migration increases the education incentives of natives relatively to autarchy, we compare equations 12 and 7:

$$c_{ps=1} - c_{Aut} = \gamma h (\omega - 1) - \omega k > 0$$  (13)

As long as the positive self-selection condition holds (equations 9 and 11), then as expected, the incentives to acquire education under the open migration policy are higher than under autarchy.

$^{21}$Only $h$ can promote a positive self-selection, since it is the only parameter that affects skilled and unskilled workers’ migration decisions asymmetrically; all the other parameters ($\omega, \gamma$ and $k$) work symmetrically for the two groups.
3.3 Brain Drain or Brain Gain?

In the no brain waste scenario, assuming a uniform distribution of abilities, the proportion of educated workers in the origin country is:

$$P_{p_S=1} = \frac{(1-\gamma)P_{p_S=1}}{1-\gamma P_{p_S=1}}$$  \hspace{1cm} (14)

The possibility of a beneficial brain gain emerges if the derivative of $P$ with respect to $\gamma$ is positive at the skilled workers’ threshold level of migration (equation 9):

$$\left[ \frac{dP_{p_S=1}}{d\gamma} \right]_{h\gamma(\omega - 1) = k\omega} = \frac{(h-1)(h-2) + h(\omega-1) - k\omega}{(1-\gamma(h-1))^2}$$  \hspace{1cm} (15)

It is straightforward to note that: first, the sign of the previous expression depends only on the numerator since the denominator is always positive; and second, the sign of the numerator is determined by the parameters $\omega$, $k$ and $h$. In particular, and making $\Delta_{p_S=1} = (h - 1)(h - 2) + h(\omega - 1) - k\omega$, we can show that:

$$\frac{d(\Delta_{p_S=1})}{d\omega} = h - k > 0$$  
$$\frac{d\Delta_{p_S=1}}{dk} = -\omega < 0$$  
$$\frac{d\Delta_{p_S=1}}{dh} = \omega - 2(2 - h) \leq 0$$  \hspace{1cm} (16)

As such, the skill premium ($h$) has an ambiguous effect on brain drain$^{22}$. In turn, high relative wage destination-origin ($\omega$) and low migration costs ($k$) contribute for a beneficial brain gain.

4 Brain Waste

Under the brain waste scenario, a skilled worker has a probability $p_S \in (0, 1)$ of suffering brain waste. We are going to show that results from the no brain waste scenario are weakened. We proceed in the same fashion as above, first looking at self-selection, then education incentives and lastly brain drain.

4.1 Self-Selection

At the steady state the conditions for a skilled and an unskilled worker to migrate are, respectively$^{23}$:

$$S_{p_S \in (0,1)}: \gamma (h (p_S \omega - 1) + \omega (1 - p_S)) > k\omega$$  
$$U_{p_S \in (0,1)}: \gamma (\omega - 1) > k\omega$$  \hspace{1cm} (17)

$^{22}$Accordingly, $h$ only contributes positively for a beneficial brain drain for high $\omega$.

$^{23}$The subscripts $p_S \in (0, 1)$ and $p_U = 0$ indicate brain waste scenario.
The relation between skilled and unskilled workers’ incentives to migrate is therefore:

\[ S_{p_S \in (0,1)} - U_{p_S \in (0,1)} = \gamma (h - 1) (p_S \omega - 1) \]  \hspace{1cm} (18)

It can be easily checked that skilled workers might not have more incentives to migrate than the unskilled ones, i.e.: \( S_{p_S \in (0,1)} \leq U_{p_S \in (0,1)} \). This contrasts with the no brain waste scenario where skilled individuals always have higher incentives to migrate than the unskilled (equation 10). In particular, under the brain waste scenario a positive self-selection is not guaranteed when the probability of getting legal status is low (low \( p_S \)), the relative wage destination-origin is low (low \( \omega \)). Given that migration incentives are primarily influenced by the brain waste parameter (\( p_S \)), we can then assert that brain waste plays an important role in reducing skilled workers incentives to migrate relatively to the unskilled.

What the above tells us is that selective migration policies might not be the more appropriate policy tool to attract skilled workers. Some studies have in fact showed that for example Canada’s selective migration policy has not been very effective in promoting a positive self-selection (Borjas, 1993; Wright and Maxim, 1993; Green and Green, 1995 and Bloom et al., 1995)\(^{24}\). Barret (1998) presents evidence that if a country does not use selective migration policies, it does not necessarily attracts a lower inflow of skilled workers than countries that use such policies. Similarly, a very strict skills equivalence policy for skilled migrants might reduce the incentives for skilled workers to migrate. Our results then point out that the brain waste risk reduces positive self-selection of migrants.

In any case, for having a positive self-selection we need that \( S_{p_S \in (0,1)} \) is satisfied but \( U_{p_S \in (0,1)} \) is not. This is so if \( I (U, MI) < I (U, NM) \) and \( I (S, MI) > I (S, NM) \), or:

\[ \omega (\gamma - k) + (1 - \gamma) < 1 < p_S \omega (\gamma - k) + (1 - p_S) \frac{\omega}{h} (\gamma - k) + (1 - \gamma) \] \hspace{1cm} (19)

Since under the brain waste scenario, skilled workers might not have more incentives to migrate than the unskilled (equation 18), then also the possibility of a positive self-selection is reduced. This is in particular the case when the probability of not suffering brain waste (\( p_S \)) is low. Further note that relatively to the no brain waste scenario, now the skill premium (\( h \)) has an ambiguous effect on self-selection. For one side, \( h \) promotes a

\(^{24}\)Canada’s point system was introduced in 1967. Therefore Canada was one of the first countries to introduce a migration policy based on labor market criteria.
positive self-selection due to the possibility of no brain waste (first term on the right hand side of equation 19: $p_S \omega (\gamma - \frac{k}{\omega})$, but from other side it reduces a positive self-selection due to the possibility of brain waste (second term on the right hand side of equation 19: $(1 - p_S) \frac{\omega}{\omega} (\gamma - k)$\textsuperscript{25}.

For the same reasons as for the no brain waste scenario, in the rest of this section we assume that equation 19 is always satisfied. We want to study education incentives and brain drain when the brain waste scenario supports a positive self-selection since the opposite case is not interesting, i.e.: with a negative self-selection migration does not promote education and brain drain.

## 4.2 Education Incentives and Migration

With the brain waste scenario, only the following individuals will acquire education:

$$c < c_{p_S \in (0,1)} \equiv \omega (p_S (\gamma h - k) + (1 - p_S) (\gamma - k)) + (1 - \gamma) h - 1 \quad (20)$$

The first question we must ask is if migration increases education incentives relatively to autarchy. To do this we compare equation 20 with equation 7:

$$c_{p_S \in (0,1)} - c_{\text{Aut}} = \gamma (h (p_S \omega - 1) + (1 - p_S) \omega) - \omega k ((1 - p_S) + p_S) \quad (21)$$

Then, as for the no brain waste scenario, and as it should be expected, as long as the positive self-selection condition holds (equations 17 and 19), the incentives to acquire education under the brain waste scenario are higher than under autarchy.

More interesting however is to evaluate the education incentives under the no brain waste scenario and under the brain waste scenario. To check this we compare equation 12 with equation 20:

$$c_{p_S = 1} - c_{p_S \in (0,1)} = (1 - p_S) \omega (\gamma (h - 1)) > 0 \quad (22)$$

Relatively to the no brain waste scenario, then, the brain waste scenario reduces the incentives of individuals to acquire education\textsuperscript{26}. The rationale behind this result is that brain waste reduces the returns to

\textsuperscript{25}From equation 19 we can also note that the remaining parameters ($k$, $\tau$, $\omega$, $\rho$ and $\gamma$) cannot affect self-selection, since they promote migration symmetrically for unskilled and skilled workers.

\textsuperscript{26}Note that this depends only on brain waste. Accordingly, temporary migration does not play a role, i.e.: even for $\gamma = 1$ (permanent migration) the previous conclusion holds.
education. This effect seems to be confirmed empirically for illegal migration, as we have discussed in the introduction, by McKenzie and Rapoport (2006) and de Brauw and Giles (2006) for rural migration from Mexico and China.

The disincentive to acquire education, which arises under the possibility of brain waste (resulting from illegal migration or imperfect international transferability of skills), is central in this paper because: first, it is the main force operating behind our results; and second, it is also what makes our results robust to alternative beneficial brain gain channels and to the possibility of amnesties for illegal migrants.

### 4.3 Brain Drain or Brain Gain?

With the brain waste scenario, assuming a uniform distribution of abilities, the proportion of educated workers in the origin country is:

\[
P_{\mu \in (0,1)} = \frac{(1-\gamma)c_{\mu \in (0,1)}}{1-\gamma c_{\mu \in (0,1)}}
\]  

(23)

The possibility of a beneficial brain gain emerges if the derivative of \( P \) with respect to \( \gamma \) is positive at the skilled workers’ threshold level of migration (equation 17):

\[
\left[ \frac{dP_{\mu \in (0,1)}}{d\gamma} \right]_{\gamma(\omega(P_{\mu h}+(1-P_{\mu}))-h)=k\omega} = \frac{(h-1)(h-2)+h(P_{\mu}+1)+\omega(1-P_{\mu})-k\omega(P_{\mu}+1)}{(1-\frac{\gamma(h-1)}{P_{\mu}+1})^2}
\]  

(24)

To analyze the effects of the different parameters on brain drain under the selective migration policy, note first that the sign of equation 24 depends only in the numerator since the denominator is always positive. By computing the derivative of the numerator of equation 24 we obtain the following relations (for the sake of notation, we make the numerator of equation 24 equal to \( \Delta_{\mu \in (0,1)} \)):

\[
\frac{d(\Delta_{\mu \in (0,1)})}{dp_{\mu}} = \omega (h - 1) > 0 \\
\frac{d(\Delta_{\mu \in (0,1)})}{d\omega} = 1 + p_{\mu} (h - 1) - k \leq 0 \\
\frac{d(\Delta_{\mu \in (0,1)})}{dk} = -\omega < 0 \\
\frac{d(\Delta_{\mu \in (0,1)})}{dh} = p_{\mu} \omega - 2 (2 - h) \leq 0
\]  

(25)

Note first that relatively to the no brain waste scenario, under the brain waste scenario not only the skill premium \( (h) \) has an ambiguous influence on brain drain, but now that is also the case for the relative
wage destination-origin ($\omega$)\textsuperscript{27}. In turn, high probability of not suffering brain waste (high $p_S$) and low migration costs (low $k$) can promote a beneficial brain gain. The reverse happens for low $p_S$ and high $k$, i.e.: when brain waste becomes more relevant a negative brain drain might arise.

In this sense, this result may help to explain Beine’s et al. (2008) empirical evidence on brain drain. In particular, Beine et al. (2008) show that the countries with a negative brain drain are mostly located in Africa and Latin America. In addition, available empirical evidence also indicates that these two regions have high rates of illegal migration and low international transferability of skills (Hanson, 2006 and Coniglio et al., 2006). Then, if the brain waste mechanism presented in this paper is at work in Africa and Latin America, illegal migration might be partially responsible for the negative brain drain observed in these regions.

Other central issue is to evaluate brain drain outcomes under the no brain waste scenario and under the brain waste scenario. To check this we compare equation 15 with equation 24:

$$\left[ \frac{dP_{PS=1}}{d\gamma} \right]_{\gamma=0} = k\omega - \left[ \frac{dP_{PS\in(0,1)}}{d\gamma} \right]_{\gamma=(1-\gamma(h-1))} = \frac{\omega(1-p_S)(h-1)}{(1-\gamma(h-1))^2} > 0 \quad (26)$$

We can then see that, relatively to the no brain waste scenario, the brain waste scenario reduces the chances of a beneficial brain gain. Accordingly, under the brain waste scenario, education incentives triggered by migration are weakened relatively to the no brain waste scenario. In this sense, selective migration policies (that screen skilled workers for legal visa, and therefore promoting illegal migration) and restrict equivalence policies for skilled workers in developed countries can affect negatively any positive effects that could potentially come through international migration in developing countries.

5 Education Policy

In this section we analyze if an education policy can increase the chances of a beneficial brain gain relatively to a scenario with no education policy. For simplicity, as in Docquier and Rapoport (2007), we assume that migration costs are zero. The consequence of having $k = 0$ is that, independently of education policy, migration will always promote a beneficial brain gain. However, the important point for education policies is not if

\textsuperscript{27}The influence of $h$ on brain drain depends on $\omega$ and $p_S$, i.e.: $h$ only contributes for a beneficial brain gain for high $\omega$ and high $p_S$. The influence of $\omega$ on brain drain depends on $p_S$ and $k$, i.e.: $\omega$ only contributes for a beneficial brain gain for high $p_S$ and low $k$. 

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migration promotes a beneficial brain gain (since this depends crucially on migration costs), but if an education policy can promote more beneficial brain gain than in the absence of an education policy. Since results for this last issue are not affected by migration costs, we exclude them.

In the education policy scenario, following Docquier and Rapoport (2007), we assume that the government in the origin country collects an income tax on the educated and the uneducated adults that remain in the country. We express this tax in terms of skilled workers’ wages, $Thw$, with $T$ denoting the tax rate. The tax is used to finance an education subsidy, which is allocated to each young opting to take education. We express the education subsidy in terms of the local wage $Zw$, where $Z$ denotes the subsidy rate.$^{28}$

With an education policy, the life income for alternative migration choices is then$^{29}$:

\[
I(U, NM)^T = w_1 + w_2 (1 - Th)
\]
\[
I(U, MI)^T = w_1 + \gamma w^* + (1 - \gamma) w_2 (1 - Th)
\]
\[
I(S, NM)^T = (1 - c + Z) w_1 + hw_2 (1 - T)
\]
\[
I(S, MI)^T = (1 - c + Z) w_1 + \gamma w^* (hp_S + (1 - p_S)) + (1 - \gamma) hw_2 (1 - T)
\]

Under the education policy, the closed economy critical level of education becomes:

\[
c < c^T_{Aut} \equiv h - 1 + Z
\]

In order to obtain interior solutions for the education policy case, we need to assume that $(h + Z) \in [1, 2]$. Otherwise all individuals would have incentives to acquire education.

For the no education policy scenario, in turn, the life time income for alternative migration choices is as in equation 7 with $k = 0$ and the closed economy critical level of education is as in equation 8.

Next we compare the education policy and the no education policy scenarios. This exercise is done for both the no brain waste and the brain waste scenarios. We are going to show that, under the no brain waste scenario, the education policy of the origin country always promotes a higher beneficial brain gain than in the absence of it. However, this result

$^{28}$Implicitly we are assuming that the government budget is balanced and that there is no need for fiscal adjustments due to migration. Introducing these issues would not qualitatively change the results.

$^{29}$The upper-script $T$ refers to the "education policy" case. The upper-script $T = 0$ refers to the "no education policy" case.
might not necessarily hold under the brain waste scenario. Furthermore, under the brain waste scenario the possibility for the education policy to promote a beneficial brain drain is reduced in relation to the no brain waste scenario.

5.1 Education Policy: No Brain Waste Scenario

For the no brain waste scenario, we start by defining the migration conditions for skilled and unskilled workers. In the education and the no education policy scenarios we have respectively:

\[
\begin{align*}
S^T_{ps=1} : \omega &> 1 - T \\
U^T_{ps=1} : \omega &> 1 - hT
\end{align*}
\]

\[
\begin{align*}
S^T_{ps=0} : \omega &> 1 \\
U^T_{ps=0} : \omega &> 1
\end{align*}
\]

As a result, only the following individuals will acquire education:

\[
c < c^T_{ps=1} \equiv \omega \gamma h + (1 - \gamma) h (1 - T) + Z + Th - 1
\]

\[
c < c^T_{ps=0} \equiv h (\omega \gamma + (1 - \gamma)) - 1
\]

From here it is straightforward to find \( P^T_{ps=1} \) and \( P^T_{ps=0} \). To study brain drain, we compute the derivatives of \( P^T_{ps=1} \) and \( P^T_{ps=0} \) with respect to \( \omega \). In both cases the derivatives are evaluated at the skilled workers’ migration threshold level (equation 29):

\[
\begin{align*}
\frac{dP^T_{ps=1}}{d\omega} \big|_{\omega=1-T} &= \frac{(1-\gamma)\gamma h}{(1-\gamma(h+Z-1))^2} > 0 \\
\frac{dP^T_{ps=0}}{d\omega} \big|_{\omega=1} &= \frac{(1-\gamma)\gamma h}{(1-\gamma(h-1))^2} > 0
\end{align*}
\]

Given that these two derivatives are positive, then irrespective of education policy, migration always promotes a beneficial brain gain. As discussed above, the reason for this result is that migration costs are zero. As such, the only interesting thing to know when \( k = 0 \) is if the education policy promotes a higher level of beneficial brain gain than the no education policy case. Comparing the brain drain conditions under the education policy and under the no education policy, we obtain:
\[
\left[ \frac{dP_T}{d\omega} \right]_{\omega=1-T}^{p_S=1} - \left[ \frac{dP_T=0}{d\omega} \right]_{\omega=1}^{p_S=1} = \frac{\gamma^2 h Z (1-\gamma)(1-\gamma(h+Z-1)) + (1-\gamma(h-1))}{(1-\gamma(h+Z-1))^2} > 0
\]

(32)

Therefore, in the open migration policy the education policy always reinforces the possibility of a beneficial brain gain relatively to the no education policy case.

5.2 Education Policy: Brain Waste Scenario

For the brain waste scenario, we also begin by deriving the migration conditions for skilled and unskilled workers. For the education and the no education policy cases these are, respectively:

\[
S_{p_S \in (0,1)}^T : \omega \left( p_S (h - 1) + 1 \right) > h (1 - T)
\]
\[
U_{p_S \in (0,1)}^T : \omega > 1 - h T
\]

\[
S_{p_S \in (0,1)}^{T=0} : \omega \left( p_S (h - 1) + 1 \right) > h
\]
\[
U_{p_S \in (0,1)}^{T=0} : \omega > 1
\]

(33)

Then, only the following individuals will acquire education:

\[
c < c_{p_S \in (0,1)}^T \equiv \omega \left( p_S \gamma h + (1 - p_S) \gamma \right) + (1 - \gamma) h (1 - T) + Z + Th - 1
\]
\[
c < c_{p_S \in (0,1)}^{T=0} \equiv \gamma \omega \left( p_S h + (1 - p_S) \right) + (1 - \gamma) h - 1
\]

(34)

From these two equations we can derive \( P_{p_S \in (0,1)}^T \) and \( P_{p_S \in (0,1)}^{T=0} \) to study brain drain. Accordingly, as above we compute the derivatives of \( P_{p_S \in (0,1)}^T \) and of \( P_{p_S \in (0,1)}^{T=0} \) with respect to \( \omega \) and we evaluate them at the skilled workers’ migration threshold level (equation 33):

\[
\left[ \frac{dP_T}{d\omega} \right]_{\omega=\frac{h}{p_S(h-1)+1}}^{p_S \in (0,1)} = (1-\gamma) \left( \frac{p_S(h-1)+1}{1-\gamma(h+Z-1)} \right) > 0
\]
\[
\left[ \frac{dP_T=0}{d\omega} \right]_{\omega=\frac{h}{p_S(h-1)+1}}^{p_S \in (0,1)} = (1-\gamma) \left( \frac{p_S(h-1)+1}{1-\gamma(h-1)} \right) > 0
\]

(35)

As such also under the brain waste scenario, and due to the absence of migration costs \( (k = 0) \), a beneficial brain gain is promoted independently of education policy. Therefore, again what is important to
analyze is if the education policy increases the level of beneficial brain gain relatively to the no education policy case. To know this we compare the brain drain conditions under the education policy and under the no education policy cases:

\[
\left[ \frac{dP_T}{\partial \omega} \right]_{\omega = \frac{h(1-T)}{pS(h-1)+1}} - \left[ \frac{dP_T}{\partial \omega} \right]_{\omega = \frac{h}{pS(h-1)+1}} = (1 - \gamma) \left( pS \left( h - 1 \right) + 1 \right) \frac{\gamma(Z(\gamma(2-Z)+2)+\gamma^2(h-1)^2+2h(1-\gamma Z)-\gamma(h^2-1)-1)}{(1-\gamma(h+Z-1))^2(1-\gamma(h-1))^2} \leq 0
\]

(36)

Then the education policy under the brain waste scenario, and contrary to what happens with the no brain waste scenario, do not necessarily increases the possibility of a beneficial brain gain relatively to the no education policy case. In particular, equation 36 tends to be negative when the parameters \( \gamma, h \) and \( Z \) are simultaneously very high\(^{30}\). Accordingly, an education policy runs the risk of becoming ineffective: the longer migrants stay in the destination country, since the externalities generated by the education subsidy are lower; the higher the skill premium, given that this works by itself to promote education; and the higher the education subsidy, because the opportunity costs of subsidization become very large.

The brain waste scenario then might reduce the success of education policies. So far, however, we do not know how the brain waste scenario does relatively to the no brain waste scenario. Comparing the effectiveness of the education policy under the no brain waste and the brain waste scenarios, we obtain:

\[
\left[ \frac{dP_T}{\partial \omega} \right]_{\omega = \frac{h(1-T)}{pS(h-1)+1}} - \left[ \frac{dP_T}{\partial \omega} \right]_{\omega = 1-T} = \frac{(1-\gamma)\gamma(1-pS)(h-1)}{(1-\gamma(h+Z-1))^2} < 0
\]

(37)

The role of the education policy is therefore unambiguously weakened under the brain waste scenario relatively to the no brain waste scenario. The rationale for this result is once more that brain waste reduces the returns to education. Accordingly, since brain waste reduces the incentives of individuals to acquire education, it also renders education policies less efficient.

\(^{30}\)To see this note that the sign of equation 36 depends only on the term in the numerator (all the remaining terms are positive). The cross derivative of the numerator in relation to \( \gamma, h \) and \( Z \) equals \(-4\gamma\).
6 Robustness of Results

In this section we discuss the robustness of our results to two other beneficial brain gain channels (uncertain migration and remittances), to the possibility of amnesties for the illegal and to a multi-country world.

Start with uncertain migration. In the case analyzed in this paper, when a potential migrant decides to migrate, he does so independently of his legal status, i.e.: when is profitable to migrate, an individual has no uncertainty about his decision. Suppose, instead, that if a skilled individual does not get a legal visa, he decides with probability \( q_S \) to not migrate and with probability \( (1 - q_S) \) to migrate regardless of the illegality condition. As expected, the skilled individuals with no legal visa that give up of migrating will contribute for a beneficial brain gain. However, this new formulation does not prevent the brain waste risk to arise. Therefore, since the main mechanism in this paper is not affected, results are also not going to be qualitatively altered.

Consider now the case of remittances. Assume that each individual that decides to take education in the origin country receives a remittance \( R \) to finance his education. This case is somewhat similar to the education policy above. The only difference is that now who pays for the education of the young are not taxes from those that remain in the country, but emigrants’ transfers. As such remittances will also contribute to increase the education incentives of individuals in the origin country. However, remittances do not eliminate the brain waste risk that skilled individuals face under illegal migration. Therefore, again results from our central case are going to be basically the same.

Next, we look at amnesties for illegal migrants. Imagine that an individual that does not get legal status spends a share \( \delta \in (0, 1) \) of his working life in the destination country as an illegal and a share \( (1 - \delta) \) as a legal, due to amnesties to illegal migrants. In this case the brain waste risk will be reduced, but not totally eliminated. Therefore once more our results are not going to be changed substantially. Furthermore, politicians in recent years have been more reticent to apply amnesties for illegal migrants. If this tendency continues, the amnesty channel for reducing the brain waste risk will also become weaker.

Finally, we discuss a multi-country world. Suppose that individuals from the origin country can migrate to \( i = 1, 2, ..., n \) destination countries. For simplicity we further assume that all destination countries are symmetric in every respect. Think first of a scenario where all destina-

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31 We do not consider remittances used for other purposes besides education. This would only make a difference if we also introduce credit constrained individuals.

32 We can also interpret \( \delta \) as the probability of receiving an amnesty.

33 Accordingly, migrants tend to prefer countries with higher wages, with more job
tion countries have the brain waste risk (either the no brain waste or the brain waste scenarios). In this case migrants will not have any preference for a particular destination country. However, this can change if destination countries differ in the brain waste risk. Accordingly, skilled workers will prefer to migrate to countries with low brain waste risk. As a result, relatively to a country with high brain waste risk, a country with an lower brain waste risk will be able to attract more skilled workers and therefore to achieve more easily a positive self-selection. In addition, the existence of destination countries with low brain waste risk can also help origin countries to achieve a beneficial brain gain, given that as we have seen above, low migration risk increases education incentives.

7 Discussion

In this paper we have argued that since brain waste affects the returns to education, then, it also affects brain drain and self-selection. In this sense we have compared a no brain waste scenario with a brain waste scenario.

We then showed that, relatively to the no brain waste scenario, the brain waste scenario has several negative effects. For the origin country it reduces the incentives of individuals to acquire education; it weakens the possibility of beneficial brain gain to arise; and it dampens the success of education policies. For the destination country, in turn, it undermines the chances of a positive self-selection. We have also discussed that these results are robust to other beneficial brain gain channels than temporary migration (uncertain migration and remittances), to amnesties for illegal migrants and to a multi-country world.

Our model then carries out some interesting policy implications for developed and developing countries. For developed countries the popularity of selective migration policies might be misleading. In fact, instead of attracting more skilled workers, this policy might on the contrary prevent a positive self-selection since it provokes brain waste for the skilled workers that migrate illegally. The rationale for this result is that selective migration policies, due to the brain waste risk, can reduce the incentives of skilled workers to migrate. In turn, and now from the perspective of developing countries, education policies cannot be seen independently from the migration policies in developed countries, given that the latter affect the former. Accordingly, since brain waste in the destination countries can reduce the incentives of individuals to acquire education in the origin countries, they can also cancel out any positive opportunities, and closer in terms of geographical and cultural distance.

\footnote{In other words, countries with more lower brain waste risk can cancel-out the effects of selective migration policies put in place in other countries.}
effects from education policies in the latter.

References


