Skilled migration and growth.
Testing brain drain and brain gain theories

JOSE L. GROIZARD
Universitat de les Illes Balears, Spain
(joseluis.groizard@uib.es)

JOAN LLULL
CEMFI, Spain

Abstract

The economic effects of the migration of skilled workers from developing countries are highly controversial in the theoretical literature. Traditional models on the brain drain phenomenon stress the negative impact on growth, while new models introduce the possibility of a brain gain for labor exporting economies through indirect channels (i.e. increased incentives for those individuals left behind to accumulate human capital), or direct channels (such as remittances, return migration or FDI and trade linkages). Using a new dataset on the educational level of the migration workforce into the OECD, we test the hypothesis of brain gain estimating a growth equation and a human capital equation. We reject the hypothesis of brain gain in all the cases. The results confirm that countries which export high skilled labor to rich economies tend to have a lower level of human capital and, hence, worse economic performance.

Keywords: *human capital formation, international migration, skilled workers, development, source country effects, instrumental variables*

JEL codes: *C30, F22, J24, O15*

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Correspondence to: José L. Groizard, Department of Applied Economics, Universitat de les Illes Balears, Ctra. de Valldemossa km. 7,5, 07122 Palma de Mallorca, Spain.

1 Introduction

Talent is becoming one of the most prized resources in modern economies. Firms and governments in industrialized countries recruit and retain highly skilled individuals from all over the world to face the shortage of specialized workers in certain fields. Migration policies are becoming more selective with regards to qualifications, making migration for skilled workers relatively easier than for unskilled , individuals. The aim of these policies is to cover labor market shortages by foreign workers, especially from those who come from developing countries. As a result, during the 1990s the number of immigrants residing in the OECD area rose by 51 percent. Meanwhile, the rate of growth of the tertiary educated was 71 percent versus a 28 percent of increase of the primary educated. This brain drain entails important risks for long-term growth in the sending countries that need to be addressed carefully.

The lack of harmonized data on migration has kept the debate on the consequences of brain drain for sending economies at a highly theoretical level. While the economic benefits of increasing international migration, in particular for developing countries, are widely accepted in the theoretical literature, the migration of highly skilled workers causes an enormous debate.

On the one hand, conventional wisdom has viewed the flight of human capital as detrimental to sending economies because it reduces the productivity of workers left behind, and may even require extra taxes maintain productivity in the case that education is publicly funded (Grubel and Scott, 1966; Johnson, 1967 and Bhagwati and Hamada, 1974). Moreover, human capital depletion may dampen long term growth, as seen in Lucas' type of endogenous growth models (Miyagiwa, 1991 and Wang and Yip, 1999).

On the other hand, new brain drain literature has challenged previous literature, suggesting the possibility that the brain drain may induce a brain gain for sending economies. Under this view, the possibility to migrate to an economy with higher wages raises the expected return of education of those left behind, thus generating incentives for individuals to undertake investments in education. Under certain conditions, this may compensate for the initial reduction in the human capital stock. Relevant contributions to this stream of literature include Mountford (1997), Stark *et al.* (1997, 1998), Vidal (1998), Beine *et al.* (2001), Stark and Wang (2002) and Stark (2004).

All of these papers are theoretical with the exception of Beine *et al.* (2001), who use OECD data for 36 countries and find that migration positively affects human capital, supporting the brain gain view. However, they do not provide evidence on migration's growth impact, and the dataset used has important weaknesses.

In this paper we present some empirical evidence on the effects of the migration of skilled workers on human capital formation and growth for sending countries and test the new theories that establish a positive link between brain drain and economic performance. We use a new dataset of migration by educational levels (Docquier and Marfouk, 2005), that includes data for more than 170 countries during the period of 1990-2000. The main purpose of this study is to analyze whether brain drain stimulates investment in education and spurs economic growth in origin countries or, alternatively, reduces human capital accumulation and development. To test the hypothesis, we use a system of equations for growth and human capital where average growth of a decade depends on the brain drain and human capital levels at the beginning of the period, and human capital at the beginning of the period depends itself on the skilled emigrants' stock. Furthermore, in order to add consistency to our results, we perform additional regressions to evaluate the sensitivity of the results to changes in variables or measures of the same variables and to misspecifications.

We find strong support for the fact that a higher probability for skilled workers to emigrate dampens human capital investments in the labor exporting economy. Our results imply that any direct beneficial impact of brain drain on growth does not compensate for the detrimental impact of brain drain through human capital.

The paper is organized as follows. In Section 2 we confront the two strands of theoretical literature. In Section 3 we present the brain drain data for all the available countries during the 1990s and protray the extent of brain drain. Section 4 concentrates on the model and estimations. Section 5 includes different robustness checks for the results. Finally, Section 6 concludes.

2 Theories of the brain drain or gain

The conventional view on brain drain (Grubel and Scott, 1966; Johnson, 1967) emphasizes the detrimental effects of the migration of skilled workers on sending economies. According to these models, there is no uncertainty about the probability to emigrate and, hence, the flight of human capital directly affects the composition of the labor force; a reduction in the stock of human capital per worker in the sending economy will reduce the productivity of those left behind, yielding a loss of welfare.

However, welfare losses may also be induced through other channels. For instance, if education is publicly funded, maintaining a human capital stock level will require extra public expenditure and extra taxes for those individuals that remain in the country. Bhagwati and Hamada (1974) depart from competitive markets introducing wage setting by a labor union and publicly funded education. The emigration of highly educated workers directly lowers skilled unemployment, but also increases expected wages, inducing a positive supply effect of skilled workers. National income will decline since skilled emigration has an impact on unemployment in other sectors. Losses depend mainly on the elasticity of substitution between skilled and unskilled workers.

This traditional view can be connected with endogenous growth models, such as done by Lucas (1988), where the aggregate human capital level in a country has an effect on long term growth. Miyagiwa (1991) and Wang and Yip (1999) introduce the phenomenon of brain drain explicitly in an endogenous growth framework where the wage gap between developed and developing countries induces migration and reduces growth through the formation of human capital.

Recently, a new wave of dynamic models has challenged former conclusions, raising the possibility of benefits from brain drain for developing countries[1]. The most common argument is that emigration does not leave the process of human capital formation unaltered. Since poor countries face low rates of return to education, the incentive to acquire education is low. Given emigration, the human capital stock in the sending country will be reduced, but the profitability of acquiring education for the population left behind will rise. The new literature highlights that the benefits of education go beyond the private gains obtained for those who become more educated, and the economy as a whole might enjoy higher benefits.

There are several mechanisms that lead to higher incentives to acquire education. A first approach is to assume that there is uncertainty about the probability to migrate. Mountford (1997), for example, considers an overlapping generations model with three periods where productivity is a function of the level of education. In his model, individuals first decide whether to invest in education or not; then, whether to work in the country or emigrate to work abroad; and finally, they consume and live after retirement. He shows that when the probability to emigrate is low, wages abroad are relatively high with respect to those of the country, and if the proportion of educated workers was previously low, a brain drain may be positive for the accumulation of human capital in the country. If only a fraction of skilled candidates emigrate, and the probability of migration depends not on the individual's ability but on an observable educational requirement,

the migration prospects increase the expected return of education and the proportion of educated workers in the country rises. Other examples of this kind of approach can be found in Stark *et al.* (1998), Vidal (1998), Beine et al. (2001) and Stark and Wang, (2002).

Similar results are obtained using other arguments. For instance, Stark *et al.* (1997) analyze the case of temporary migration with imperfect information. In the model, they consider that worker's productivity is revealed at their destination only after a period of time; before that, candidates only show whether they belong to the educated group or to the uneducated one, and are thus paid according to their group's average productivity. Therefore, relatively low-skilled individuals at their origin perceive the incentive to acquire more education and to migrate in order to receive higher payments as a high-skilled worker. Once their abilities are revealed, low-skilled-but-educated workers return to their original country, increasing the average human capital level due to the additional investments in education undertook prior to migration. In this case, a market failure creates the incentive to invest in education.

Brain drain could also have positive effects through other channels. Examples are remittances, return migration and network creation. Even when human capital stock is reduced, brain drain could be positive for growth if some of those effects overcompensate for this negative externality.

In the case of remittances, it is not clear whether skilled emigrants send more remittances to the home country than non-skilled emigrants. On the one hand, skilled workers tend to emigrate with their families, making international transfers due to an altruistic motives lower. However, on the other hand, some individuals send remittances to pay for services received, for example to repay loans obtained to fund education (hence, in this case, skilled workers will send more international transfers to their country). The effects of remittances are therefore controversial. Some papers, such as that by Cinar and Docquier (2004), emphasize the positive effect of remittances in the case of liquidity constraints for education; in this case, a brain drain can enhance human capital in the country, if it reduces these limitations. However, other papers (e.g. Faini, 2003) show that when there is a high proportion of skilled individuals among emigrants, there is a low volume of remittances to the home country and, hence, remittances cannot compensate for the negative effects of brain drain.

Return migration also has positive implications other than those presented in the paper of Stark *et al.* (1997). For instance, Domingues Dos Santos and Postel-Vinay (2003) present a model where return migration leads to technological diffusion that increases efficiency and compensates for the reduction of productivity of the relatively low skilled labor force; the idea is that skilled returnees contribute to knowledge transmission more than those unskilled.

Finally, the formation of migrant networks creates FDI and trade linkages (Dustmann and Kirchkamp, 2002; Kugler and Rapoport, 2005) which help strengthen the gains from trade and knowledge diffusion, and ultimately spur growth in the sending economy. Javorcik *et al.* (2006) find empirical support to this view.

In conclusion, the extended literature of the effects of brain drain on growth does not clarify the net aggregate effects of the human capital flight for sending economies. Hence, it is an empirical task to detect the final outcome. Nevertheless, the only attempt to provide evidence for the final effect of brain drain in a cross section of countries has been made by Beine, *et al.* (2001, 2004). In their papers, they stress the beneficial brain drain hypothesis; they find that gross migration rate (as a proxy of brain drain) has a positive effect on human capital formation and ultimately on growth rates in the poorest countries. However, they do not provide evidence on the global net effect on growth. Their results, additionally, are likely to be sensitive to using proxies on skilled migration but also to simultaneity and narrow sample biases.

3 Data

The small number of empirical papers of brain drain in the literature is due to the lack of accurate databases on migration rates by education levels. The first attempt to collect data on migration from developing countries classified by level of education is a dataset compiled by Carrington and Detragiache (1998). However, this first approximation has some limitations: First, and the most important, the proportions of emigrants from each sending country are based on the OECD-SOPEMI "Trends in international migration (1995)," where only the major sources of emigrants are presented, therefore underestimating migration from small countries. Second, data on the education level of immigrants is taken only from the US census and extrapolated to the remaining OECD host countries. Finally, the dataset only includes data from 61 developing countries.

Fortunately, a second effort to gather data on brain drain was made, and the contribution of Docquier and Marfouk (2004 in a first release and 2005 in the one used in this paper) surfaced. This dataset presents more variety and accuracy of data than that of Carrington and Detragiache. It still only collects data on migration to OECD countries, since the bad quality of data in developing countries remains a limitation. However, most of the problems of the previous database have been remedied with this new contribution. First, data is compiled directly from the censuses of the OECD countries, so that small and big countries are treated in the same way. Second, immigrants' level of education is provided directly in each census, and in the small number of countries where this information is not available, the levels of the same source country in the neighboring host countries are applied. Migration rates are then constructed using Barro and Lee (2000) data on education. Third, data on 195 source countries in the year 2000 is provided.[2] And, lastly, not only are brain drain rates provided, but also stocks of emigrants by educational levels.[3]

This large set of data allows us to elaborate a sample containing 92 developed and developing countries that are listed in Table A.1 (see Appendix). With this sample, 84% of the world area is covered, 88% of the population is considered, and, with some exceptions in Africa and the Middle East, all larger countries are included. In order to have a representative sample, data for the former USSR, Yugoslavia and Czechoslovakia has been aggregated from the actual countries in the year 2000.

The variable of study of this paper is the migration rate of tertiary educated workers.[4] The necessary condition for a brain gain establishes that human capital must increase *ex-post* when the probability of emigration rises. The variable used in the literature to approximate this probability has normally been the migration rate. Therefore, we closely follow the literature and proxy the brain drain as the fraction of skilled workers from the sending country that are residing in the OECD area. However, a migration rate has another interpretation: it can be considered as the accumulation of emigrants in the process of migration during the last decades, since it is a stock variable. These two interpretations are the basis of the model that will be presented in the next section.

Before starting with the model, however, it is important to put the phenomenon of brain drain in context. A relevant remark is that brain drain is neither an event particular to a specific country, nor far away in time. Its presence in the world is extended to all continents, including many developing countries, and it has intensified during the last decade. Hence, if it is assumed to have a real impact on economic growth, a proper evaluation is needed. For this reason, the model presented in this paper aims to shed light on the sign and the importance of the impact of brain drain on growth. In the next paragraphs, a description of statistics is presented, to exemplify the actual extent of brain drain.

Figure 1. Brain drain rates by regions (2000)
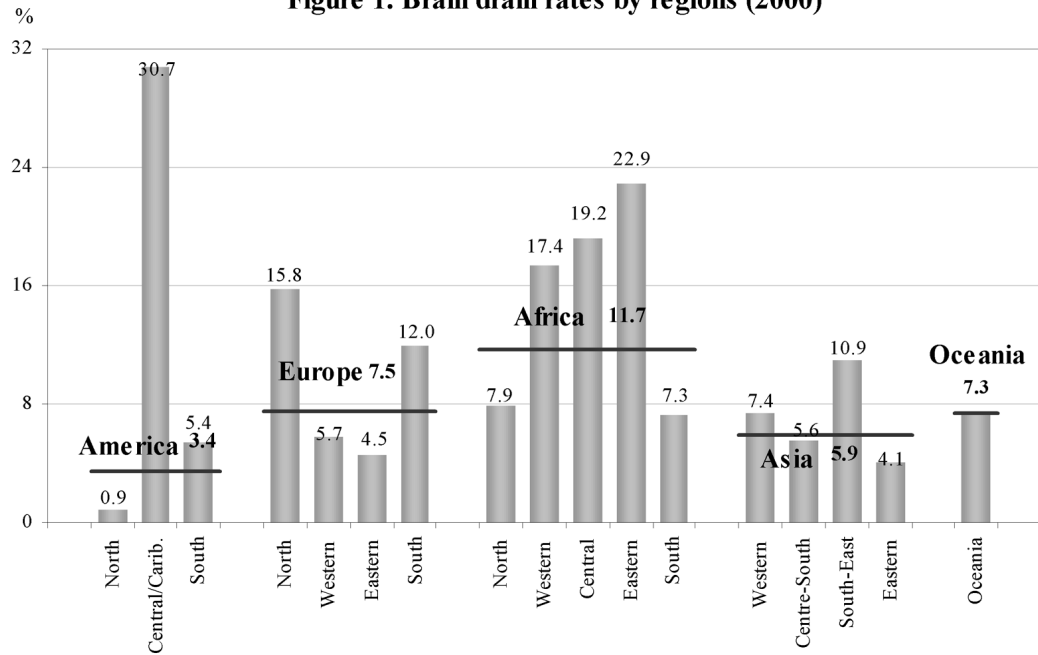
Figure 2. Tertiary educated emigrants as a share of total emigrants (2000)
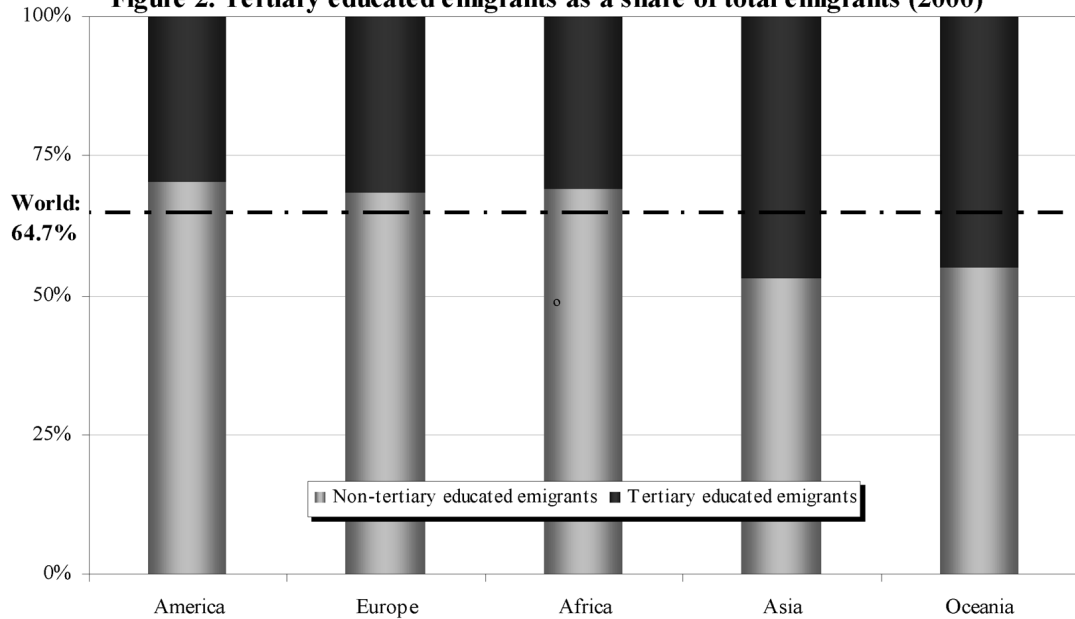
In the year 2000, about 20.4 million of tertiary educated emigrants were living in OECD countries: that represents 5.7% of the total skilled workers in the world. If we restrict this percentage to non-OECD countries, it rises to 7.5%. However, regional distribution is not uniform. In Figure 1, data by continents and regions is presented. 11.7% of skilled workers from the poorest

continent in the world, Africa, are in the OECD, and this percentage is higher for the most deprived central, western and eastern regions. America, despite of tremendously high levels of brain drain in Central America and the Caribbean (especially in the archipelago, with a percentage of 72.7%), is the continent with least brain drain, because of its inclusion of North America. This distribution shows the importance of this investigation, since the phenomenon of brain drain most strongly affects the most underprivileged regions in the world.

Moreover, the importance of brain drain in total world migration is also increasing. In 2000, about 35.3% of emigrants were skilled, approximately less than a third in 1990. Distribution by continents is again heterogeneous. While in Oceania and Asia nearly half of emigrants are highly educated, only 30% are skilled in the other continents (see Figure 2). However, these rates are high in any case, especially considering that in Africa, only 4% of workers are tertiary educated.

If we now turn our view to the sending countries, a list of the top 20 brain drainers is presented in Figure 3. In terms of absolute stocks, the former Yugoslavia is the major source of skilled emigrants, followed by a diverse group of countries including developed and developing countries. In terms of ratios, the countries are mostly from the regions listed above as places suffering from the highest brain drain (the Caribbean and Africa). Here, however, it is important to remark that only sample countries are included. This is not very relevant in the case of stocks, where the only important missing economies are Vietnam, Cuba and Romania, but it is substantial in the case of rates, since 14 small island countries in the Caribbean and the Pacific would have been on the list, if we had considered them in the sample. This exclusion, however, is pertinent: all of these countries are very small non-representative economies that would have had the same weight in the sample, and would probably have biased the results.
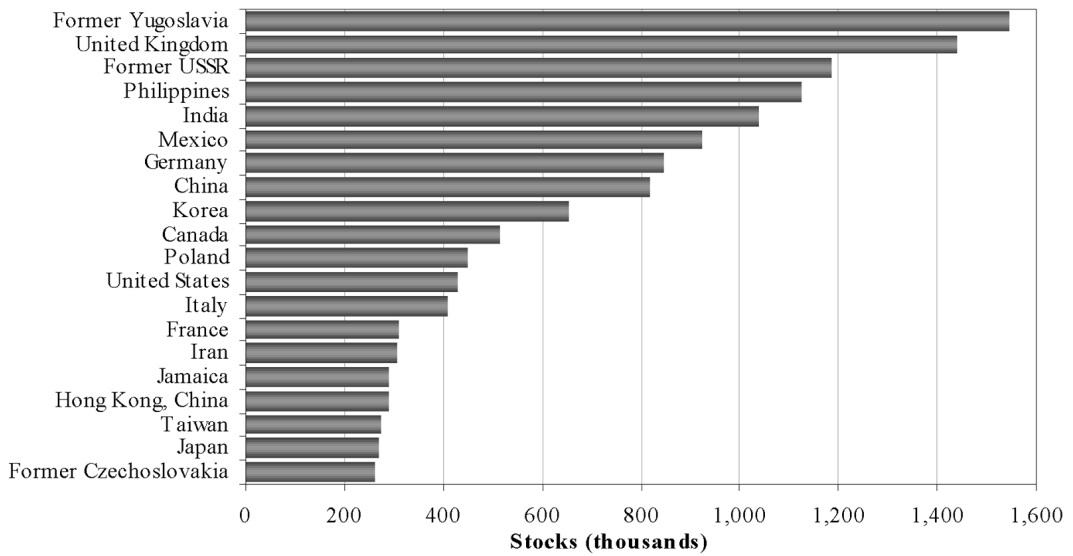
Another key issue to keep in mind is the timing of the phenomenon. During the 1990s, the number of tertiary educated emigrants living in the OECD area increased by about 8 million; this amount, represents 41% of tertiary educated workers living in the OECD in 2000. This percentage is higher in Africa, where the share is higher than a half (Figure 4). That is, in just a decade many developing countries saw a massive flight of their human capital to richer economies.

Finally, the last point to consider is who emigrates toward OECD economies? Does income level have something to do with the probability to emigrate? In a simple exercise, Figure 5 suggests a hump shaped profile of emigration by level of income: only a small proportion of immigrants in the OECD area are from the poorest quartile of income countries, the two quartiles in the middle cover nearly half of the immigrants, and the richest quartile contains a little over a third. Countries in the richest quartile, however, are also the recipients of immigrants, so that net migration is relatively small. Hence, controlling for the effect of immigration on net migration of the richest countries, one can interpret that individuals in the poorest countries do not have enough income to face the cost of emigration. In middle income countries, individuals have money and incentives to emigrate. Finally, in the richest countries, there is a lot of mobility of skilled individuals, but the stock of human capital is not reduced.
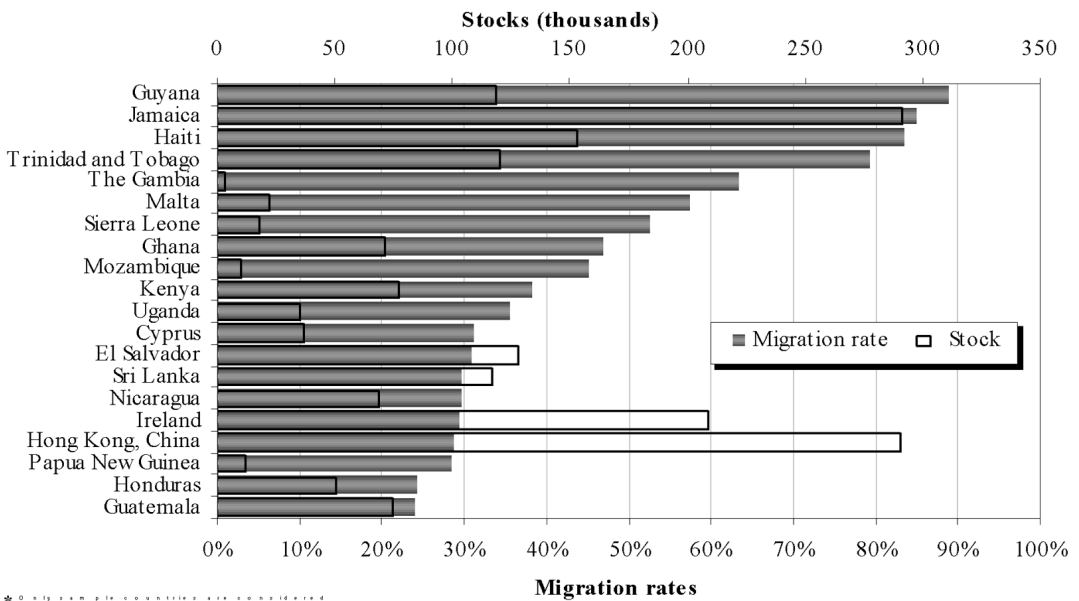
The purpose of this paper is to estimate the join effect of brain drain on human capital and real GDP per capita growth during the 1990s. Hence, human capital and growth are the two other relevant variables in the analysis. On the one hand, for human capital, following the same criterion used by Docquier and Marfouk (2005) to construct migration rates, we use the database of Barro and Lee (2000) of school attainment, where tertiary educated workers are those with more than 13 years of schooling. On the other hand, we use the Dollar and Kraay (2002) dataset for growth data. These and the control variables used in the model are described in Table A.2 (see Appendix). Moreover, a summary of statistics is presented in Table 1.

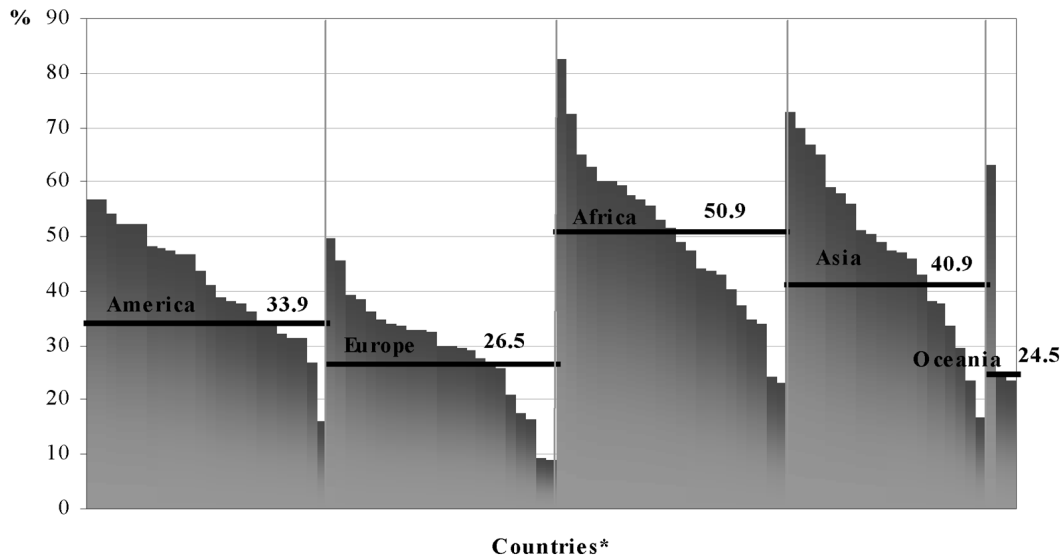# Figure 3. Top 20 of countries* with highest brain drain (2000)

A. Stocks

B. Rates

* Only sample countries are considered

**Figure 4. Flow of tertiary educated emigrants in 90s
as a % of the stock in 2000**

America 33.9

Europe 26.5

Africa 50.9

Asia 40.9

Oceania 24.5

Countries*

* Only sample countries are considered

Figure 5. Tertiary educated emigrants by quantiles of GDP p.c. (2000)

Poorest quartile
5%

Unknown
3%

High income
quartile
38%

Medium-low
income quartile
31%

Medium-high
income quartile
23%
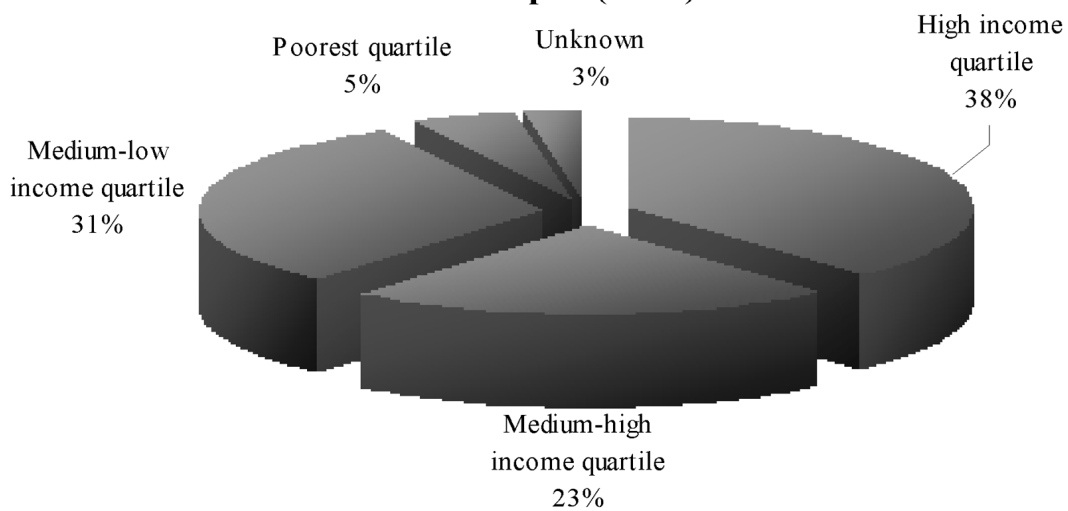
Figure 6. Kernel density of the main variables

All countries

Sample countries

Logarithm of brain drain rate

Logarithm of human capital rate

Growth rate of GDP per capita

——— Kernel density   - - - - - Normal distribution
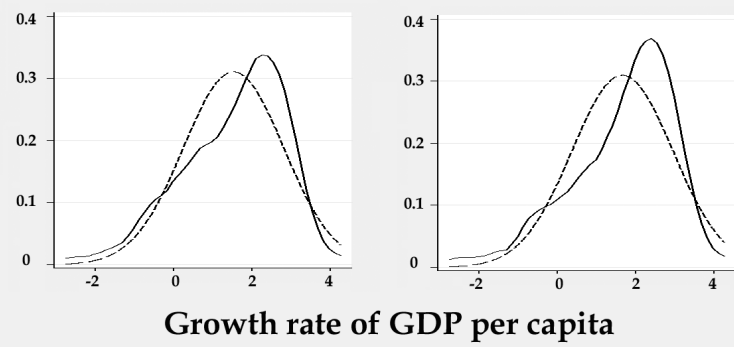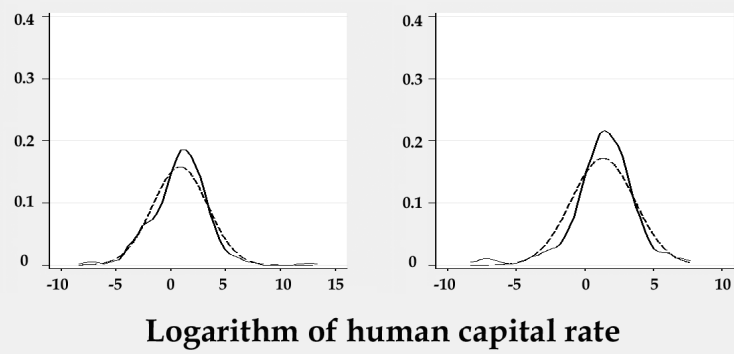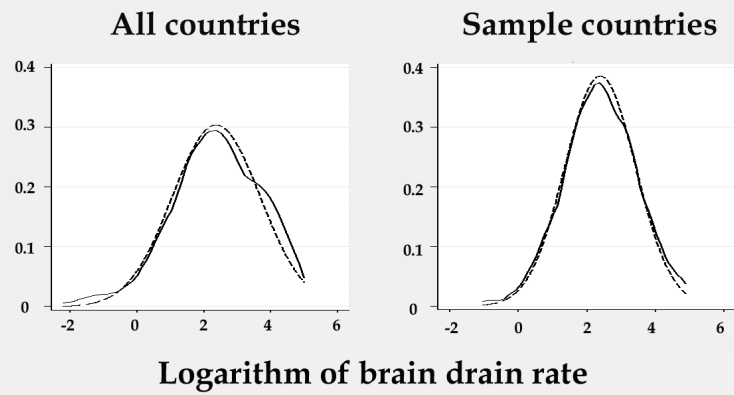
Table 1. Summary of statistics

Variable	Mean	Standard deviation	Minimum value	Maximum value
GDP p.c. growth in 90s	1.3	2.3	-7.7	7.0
Human capital in 1990	1.7	1.3	-2.3	3.8
Brain drain in 1990	2.4	1.0	-0.7	4.5
GDP p.c. in 1990	8.1	1.1	5.9	9.8
Investment/GDP	17.6	8.9	1.3	37.2
Government stability	7.5	1.0	3.6	9.7
Population growth	0.02	0.01	0.00	0.07
Ethnic fractionalization	0.41	0.27	0.00	0.93
Inflation	0.2	0.4	0.0	2.6
Percentage of muslims	0.14	0.24	0.00	0.69
School hours per year	976	128	666	1,600
Migration rate	4.8	6.8	0.1	33.4
Area	12.4	2.0	5.8	16.9
Openness	-1.1	0.8	-3.4	0.5
FDI	1.1	1.4	-0.1	10.6
Government expenditure/GDP	-2.0	0.4	-3.4	-1.2

To conclude, the distribution of the main three variables is shown in Figure 6; in the first column the distribution of the full data available is drawn, whereas in the second column, we restrict the sample to the 92 observations used in the estimations. The distribution of brain drain rates is approximately log-normal, in particular when only sample countries are considered. In the case of all countries, some more observations are accumulated in the upper tail, which are those cited above when discussing Figure 3. In the case of growth, the distribution shows a bit more kurtosis than a normal distribution, since more observations are concentrated in the center of the distribution. Finally, the distribution of the logarithm of human capital shows, in both cases, asymmetry to the right.

4 Model and estimation

4.1 The model

The main purpose of this paper is to test the sign and the importance of the effects of brain drain on growth. As explained in Section 2, there are many theoretical reasons to expect either sign when it comes to the global effect of brain drain or brain gain on economic development. These different arguments can be classified in two types, and, in each variety, there are opinions for positive and for negative effects. The two kinds of arguments are: On the one hand, those that induce a direct effect of brain drain on growth, such as return migration, remittances, FDI and trade linkages, or knowledge diffusion; on the other hand, those that see growth being affected via an increase or decrease in human capital (traditional theories argue that human capital is reduced, whereas new brain gain models defend the possibility of a positive net effect when there is uncertainty about the probability of emigration).

Since we want to clarify the growth consequences of brain drain, we have to stress the global effect. This implies the obligation to jointly test both types of arguments. Hence, our model has to take into account both the direct and the indirect (through human capital) effects of brain

drain on economic growth. The way to look at this double effect is by estimating a system of two equations as described below.

First, a growth equation is needed. We follow Bils and Klenow (2000) to estimate the growth effect of human capital, regressing annual GDP per capita growth in the 90s against the stock of skilled workers residing in the country (human capital) and abroad (brain drain). Both human capital and migration are considered in the beginning of the decade of study. Here, we have to apply the second interpretation of migration rates explained at the beginning of the previous section: a migration rate (the same applies for human capital stock) is the result of the process of migration (or human capital formation) during the last decades. Therefore, what we want to show is whether or not there is a long term relationship between human capital/brain drain and economic growth. If theories of brain gain included in the first group are correct, then a positive direct effect will be observed when controlling by human capital as well as the typical control variables used in the literature for growth regressions.

Moreover, we need a human capital equation with which we can test the long-run relationship of human capital and brain drain and where indirect effects can be observed. Here, both interpretations of migration rates apply: On the one hand, one could test whether or not a higher probability to emigrate motivates individuals to invest more in human capital, implying a higher level of human capital at the end of the day. On the other hand, given that both human capital and brain drain stocks are the result of a process of decades, testing the existence of a positive or negative relationship between the migration of skilled workers and the stock of human capital *ex-post* is also possible. Therefore, a positive effect of brain drain on human capital is a necessary (but not sufficient) condition of brain gain.

In conclusion, we want to test both the signs of the two effects separately and the global effect of brain drain on growth. However, there is a qualitative difference between direct and indirect effect: indirect effect is a clear effect that operates through a clear channel; direct effect is the result of the union of several effects which could cancel each other. Moreover, some of the control variables can absorb one or more effect, so that the value and sign of the coefficient can vary considerably across different regressions.

The growth equation is:

$$gy_i = \beta_0 + \beta_1 \ln h_i^{1990} + \beta_2 \ln m_i^{1990} + \beta_3 \ln y_i^{1990} + \delta' X_i + e_i^y \tag{1}$$

where gy_i is the annual GDP per capita growth in the 1990s, $\ln h_i^{1990}$ is the logarithm of human capital in 1990, $\ln m_i^{1990}$ is the logarithm of the brain drain rate in 1990, $\ln y_i^{1990}$ is the logarithm of GDP per capita in 1990, X is a set of explanatory variables that includes investment rate, government stability, ethnic fractionalization, population growth and inflation, e_i^y is the error term, and $\left(\beta_0, ... \beta_3, \delta'\right)'$ is the vector of coefficients to be estimated.

The human capital equation is:

$$\ln h_i^{1990} = \xi_0 + \xi_1 \ln m_i^{1990} + \varphi' Z_i + e_i^h \tag{2}$$

where Z is a set of explanatory variables that includes the Muslim fraction of population and the number of school hours per year at primary school, $\ln m_i^{1990}$ is the same as before, e_i^h is the error term, and $(\xi_0, \xi_1, \varphi')'$ is the vector of coefficients to be estimated.

4.2 Identification and instruments

This model assesses joint determination of two effects of brain drain on growth. The accumulation of skilled emigrants has direct effects on growth, but at the same time affects human capital

formation, which in turn affects growth. Therefore, the system has to be estimated simultaneously in order to identify these two different consequences.

Initially, the two exogenous variables in the model are human capital and GDP growth. The second is only the dependent variable of one of the equations, so it could be determined recursively. However, human capital and migration are in both equations, so we should have variables in Z that are not in the growth equation, in order to identify $\beta_1, \xi_1,$ and β_2. Moreover, these variables have to be exogenous not only in the human capital regression but also in the growth regression, since when solving the problem by substitution we need there to be no correlation with any of both terms.

We have considered a large pool of variables in this identification strategy. At the end, two variables were determined to be relevant for human capital but exogenous in both equations: the logarithm of the proportion of Muslims in the population and the amount of school hours per year.

The proportion of Muslims has the aim to capture different propensity of different societies to invest in education. Religious beliefs and moral issues have a strong influence on family decisions regarding education. For instance, in certain countries women are not allowed to receive tertiary education, or even if it is permitted, it is morally reprehensible. It is true that other societies deal with similar issues, but even if it were identifiable, there is not a lot of variety across countries. In fact, a regression of the proportion of Muslims against human capital provides a highly significant negative coefficient, as shown below. It is clear that the proportion of Muslims is an exogenous variable in the human capital equation. In the growth equation, it is also exogenous when controlling by institutional quality. If one does not control by institutional quality, religion has something to do with the history of development of the countries, and, hence, with their institutions. However, once institutional maturity is controlled for, there are no other elements in the error term that could be correlated with the proportion of Muslims in the population[5].

The total amount of hours of school per year is a measure of the opportunity cost of education. The idea is that in developing countries, families can undertake education of their children only when there is enough remaining time for them to work and help parents to sustain the family. Therefore, where there are too many hours of school, the poorest families have to remove their children from school, meaning that they never acquire tertiary education. Regarding exogeneity, the unique relation with fixed effects of economic growth is due to human capital formation, making it a valid variable to solve the problem of identification.

We have considered other concepts as control variables, but it proved difficult to find valid variables which were exogenous in both equations. We first wanted to control by educational policies with a variable of (predetermined) education expenditure, but it never passed the Sargan test. Also, other opportunity cost variables were considered, such as other measures of school duration (e.g. total days per year, or years of compulsory school), but they were irrelevant in terms of significance, probably due to their lesser variability across countries. Percentage of population living in the main cities or level of urbanization were also considered (both to proxy physical distance to the universities), but they are not exogenous since they are correlated with the error term of the growth equation. Other measures of female exclusion from education were also considered, such as other religions (small variation in the sample), ethnic groups (most ethnic groups live only in one or two countries), or fertility rates, since women tend to be excluded early from education when fertility is high and early (it is endogenous in the growth equation). Finally, all measures of benefits from education are clearly correlated with growth, such as, e.g. income per capita (included in the growth equation so it would become an endogenous variable if it had been considered (revisar).

Endogeneity problems of the control variables were the main objective in this selection. To test the exogeneity of these instruments, we estimate by 2SLS the growth equation using human

capital with these two control variables, and then perform Sargan tests. In the standard model, the p-value is 0.944, and in the different specifications that are shown below it ranges from 0.605 to 0.899. Therefore, these variables are fully compatible as exogenous instruments, making them valid control variables to identify human capital.

We also cared about the relevance of instruments in the human capital formation. For that reason, a first stage regression is presented:

$$\ln \hat{h} = \underset{[0.766]^{***}}{4.014} - \underset{[0.572]^{***}}{2.298} \ln musl - \underset{[0.0007]^{***}}{0.002} \, hours \tag{3}$$

$$R^2 = 0.2183; \; obs = 92 \; ; \; F-test = 9.61 \qquad \text{\scriptsize(standard errors in brackets)}$$

As can be seen, the relevance and sign of effects are exactly as expected.

Despite these two initial endogenous variables, another variable, independent in both equations, has been treated as endogenous: brain drain. Because it is predetermined, one could defend its weak exogeneity in the human capital equation, but reverse causality could appear. Hence, we have considered the need to instrument for brain drain. Again, two instruments have been introduced: total migration rate to OECD and the logarithm of the area in square km.

The total migration rate of the sending country is a measure of so-called ethnic networks and is related to the migration cost. Integration in the host country entails settlement, job search, etc.; the presence of fellow citizens makes integration simpler, and, for that reason, individuals consider the size of the community of their compatriots when making the decision to emigrate. Hence, countries with higher total migration rates tend to also have higher migration rates of tertiary educated workers. With regard to exogeneity, it is clearly the case in the human capital equation. In the growth equation, one can consider that the only way in which migration rates affect growth is through the same channel as the direct effect of brain drain on development. Moreover, Sargan tests are performed, and, as is shown below, it can be considered as exogenous.

The area of the sending countries is introduced to capture the size of the countries and is a variable that proxies legal limitations on emigration. In some OECD countries, quotas or other numerical-qualitative restrictions to entry have been in place in the past, so that small countries are less bound than big countries. Hence, the higher the size of a country, the lower the brain drain rates are expected to be. Exogeneity is clear since there are no theories that relate the area of a country to their human capital or growth.

We have selected these two instruments in the large set of variables under consideration. We followed three lines to search instruments of migration: cost of emigration, benefits of migration and legal limitations. As in the case of human capital, it is difficult to find benefits that are exogenous in the growth equation; we found one but it did not pass the Sargan test in the human capital equation: the purchasing power parity[6]. In the case of cost, we wanted to proxy three different costs: physical and cultural distance and difficulty of integration (total migration rate). The cultural distance was proxied by colonial past, but its exogeneity is not clear since there are theories that relate colonial past with present growth. Physical distance was measured using the aerial distance from the capital of the sending country to that of the destination, but its links with trade relationships make its exogeneity doubtful. Finally, we wanted to proxy legal limitations to immigration in OECD with some size measure; initially, we considered population, but it is endogenous in both equations, which led us to consider area instead.

As in the case of human capital, we have separately regressed equations (1) and (2) by 2SLS, and using brain drain with the variables described above. Next, we performed Sargan tests. In the case of the growth equation, p-value is 0.110, and in the case of the human capital equation, 0.223.

Concerning relevance, the first stage regression is the following:

$$\ln \hat{m} = \underset{[0.615]^{***}}{5.079} + \underset{[0.011]^{***}}{0.049} \; mrate - \underset{[0.046]^{***}}{0.236} \; \ln area \tag{4}$$

$$R^2 = 0.4674; \; obs = 92; \; F-test = 41.94 \qquad \text{\small (standard errors in brackets)}$$

Again, the relevance and sign of the variables is as expected.

Finally, we also performed Sargan tests for the growth equation estimated by 2SLS, and using both human capital and brain drain. In the standard model the p-value is 0.613, while with robustness checks it ranges from 0.375 to 0.583. Human capital, however, only has one endogenous variable on the right hand side, brain drain, therefore the result is the one described above.

4.3 Estimation and results

In the previous two subsections, we have introduced the model and resolved the way in which we face identification and endogeneity of brain drain problems. Now is the moment to see the estimations and comment on the results. This is shown in Table 2. Equations (1) and (2) are estimated simultaneously by 2SLS[7].

In regression one (two first columns of results), the benchmark model is presented. On the one hand, in the set of variables included in matrix X in equation (1) we have introduced investment over GDP, government stability, population growth, ethnic fractionalization and inflation as control variables[8]. On the other hand, the set of variables Z in equation (2) includes the two variables described above to solve the problem of identification, i.e. proportion of Muslims and hours of school per year.

In the other columns, different robustness checks are introduced in order to see the extent of changes in the results and, most importantly, to observe whether sign and significance changes when using other control variables. Robustness checks are included in the growth equation, and the variables used, one for each specification, are: openness (measured as exports plus imports as a share of GDP), FDI flows, government expenditure (consumption) as a share of GDP and a dummy for Asian countries to capture regional effects[9].

This result can be interpreted in two ways. Let us consider a coefficient in the middle, say -0.6. On the one hand, one could consider that an increase of 1% in the probability of emigration of skilled workers would lead to a reduction in human capital by 0.6%. On the other hand, one could assume that an emigration process during the last decades has led to a general reduction of human capital. In any case, at the end of the day, if the brain drain rate of skilled workers is, say, 20% and the human capital rate is, for instance, 25%, a rise of brain drain to 22% (an increase of 10%) will be followed by a reduction of human capital of approximately 23.5% (a fall of 6%).

Moreover, human capital has a significant positive impact on growth in all specifications. In combination with the negative effect of brain drain on human capital, this is a sufficient condition for harmful brain drain via human capital.

The first result to consider is that the brain gain hypothesis via human capital is rejected in all specifications. Coefficients range from -0.568 to -0.635.

Table 2. Estimation results for the system

	(1)	(2)	(3)	(4)	(5)
	Growth equation	Growth equation	Growth equation	Growth equation	Growth equation
Human capital in 1990	1.268	1.589	1.462	1.441	1.654
	[0.753]*	[0.923]*	[0.848]*	[0.763]*	[0.861]*
Brain drain in 1990	0.145	0.473	-0.060	0.225	0.279
	[0.294]	[0.359]	[0.338]	[0.299]	[0.333]
GDP p.c. in 1990	-1.651	-1.556	-2.061	-1.650	-2.030
	[0.799]**	[1.074]	[0.959]**	[0.805]**	[0.903]**
Investment/GDP	0.048	0.064	0.028	0.042	0.038
	[0.031]	[0.039]	[0.038]	[0.032]	[0.034]
Government stability	1.173	1.191	1.231	1.246	1.143
	[0.276]***	[0.301]***	[0.306]***	[0.277]***	[0.294]***
Population growth	-1.134	-21.891	-10.213	-9.355	-18.001
	[27.457]	[34.585]	[31.623]	[27.715]	[31.528]
Ethnic fractionalization	-1.990	-1.805	-2.028	-1.805	-1.686
	[1.054]*	[1.111]	[1.140]*	[1.061]*	[1.145]
Inflation	-1.448	-1.612	-1.617	-1.552	-1.662
	[0.717]**	[0.794]**	[0.783]**	[0.720]**	[0.780]**
Openness		-1.034			
		[0.436]**			
FDI			0.283		
			[0.218]		
Government expenditure/GDP				-0.806	
				[0.559]	
Asia					0.903
					[0.574]
Constant	3.751	0.418	7.086	1.287	6.329
	[5.211]	[7.701]	[6.376]	[5.442]	[5.886]
R-squared	0.35	0.36	0.31	0.37	0.28
	Human capital equation	Human capital equation	Human capital equation	Human capital equation	Human capital equation
Brain drain in 1990	-0.572	-0.635	-0.621	-0.579	-0.568
	[0.128]***	[0.133]***	[0.130]***	[0.128]***	[0.128]***
Percentage of Muslims	-2.304	-2.179	-2.289	-2.211	-2.304
	[0.449]***	[0.459]***	[0.451]***	[0.456]***	[0.449]***
Schooling (hours/year)	-0.002	-0.001	-0.001	-0.002	-0.002
	[0.001]*	[0.001]	[0.001]	[0.001]*	[0.001]*
Constant	4.874	4.790	4.715	4.879	4.869
	[0.855]***	[0.865]***	[0.858]***	[0.854]***	[0.855]***
R-squared	0.38	0.40	0.40	0.38	0.39
Observations	92	87	89	91	92
Global effect	-0.58	-0.54	-0.97	-0.61	-0.66
W-test	1.76	0.60	2.74	1.84	1.87
Prob>chi2	0.19	0.44	0.10	0.18	0.17

Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. System estimated by 2SLS. Endogenous variables: GDP p.c. growth, human capital and brain drain. Instruments for brain drain: total migration rate and area, both in logs. Comments on Sargan tests in the text. Wald tests for significance of the global effect are displayed in the bottom of the table.

The second result is that direct effect is not significant in any specification. This does not necessarily mean that theories of brain drain or gain via channels other than human capital are wrong, but possibly that they compensate each other. For instance, in all specifications, direct effect is positive (although not significant) except when FDI flows are included as a control variable; this could be interpreted as the presence of a positive direct effect through the creation of FDI linkages, which is compensated by other negative indirect effects.

Thirdly, one would want to test the global effect of brain drain on economic growth, since some theories of positive brain drain suggest that positive direct effects compensate for the externality produced by the reduction of human capital per worker. For this purpose, we calculate $\beta_1 \cdot \xi_1 + \beta_2$ from equations (1) and (2) and then a Wald test is performed to see whether or not is significantly different from zero. This is displayed at the bottom of Table 2. In all specifications, global effect is negative, ranging from -0.54 to -0.97; however, it is only significant when FDI is included as a control variable (this corresponds to what is commented above).

Finally, we want to see whether this effect is homogeneous across countries. For this, OLS regressions are performed for sub-samples. On the one hand, the poorest countries' sub-sample includes those economies with a GDP per capita lower than 15% of the average of G-7 in 1990; on the other hand, there is a sub-sample formed by OECD countries. Results are plotted in Figure 7, and estimated equations are the following:

$$\text{Full sample} \quad \left(R^2 = 0.3868; \; obs = 92\right) \tag{5}$$

$$\ln \hat{h} = \underset{[0.674]^{***}}{4.789} - \underset{[0.097]^{***}}{0.515} \ln m - \underset{[0.523]^{***}}{2.303} \ln musl - \underset{[0.0007]^{**}}{0.0016} \, hours$$

$$\text{Poorest countries} \quad \left(R^2 = 0.4178; \; obs = 36\right)$$

$$\ln \hat{h} = \underset{[0.944]^{***}}{3.774} - \underset{[0.160]^{***}}{0.645} \ln m - \underset{[0.639]^{***}}{2.560} \ln musl - \underset{[0.0009]}{0.0009} hours$$

$$\text{OECD countries} \quad \left(R^2 = 0.4607; \; obs = 28\right)$$

$$\ln \hat{h} = \underset{[0.546]^{**}}{1.398} - \underset{[0.084]^{**}}{0.201} \ln m - \underset{[0.101]^{***}}{1.295} \ln musl - \underset{[0.0005]^{***}}{0.0017} \, hours$$

In the full sample regression, the coefficient is -0.515 while, in the case of poorest countries, the coefficient falls to -0.645. Hence, this result suggests that the negative impact of brain drain on human capital is stronger in the poorest countries. In the case of OECD countries, the effect is smaller. This is not surprising since human capital flows from OECD countries are replaced by human capital inflows, given that these countries are the host countries under consideration here.

5 Analysis of robustness

Cross-country growth regressions have been criticized in the past as non-robust to changes in variables, country sample and time periods analyzed. In this section, we perform a battery of tests to check the robustness of our findings. First, we look at wider measures of education to proxy the average level of human capital. In addition, we analyze the immediate effects of brain drain on school enrollment and consider alternative measures of brain drain. We also adjust the period of time considered from 1990 to 2000 and extend the analysis of the sample for those countries that have available data. Using these alternatives, we ran the regression of equation (2) again, using OLS for our previous sample. Results are displayed in Table 3.

Alternative measures of human capital are not easy to find. There are not a lot of statistical sources providing data on human capital at a country level. Therefore, we have used the same

Figure 7. Human capital versus brain drain
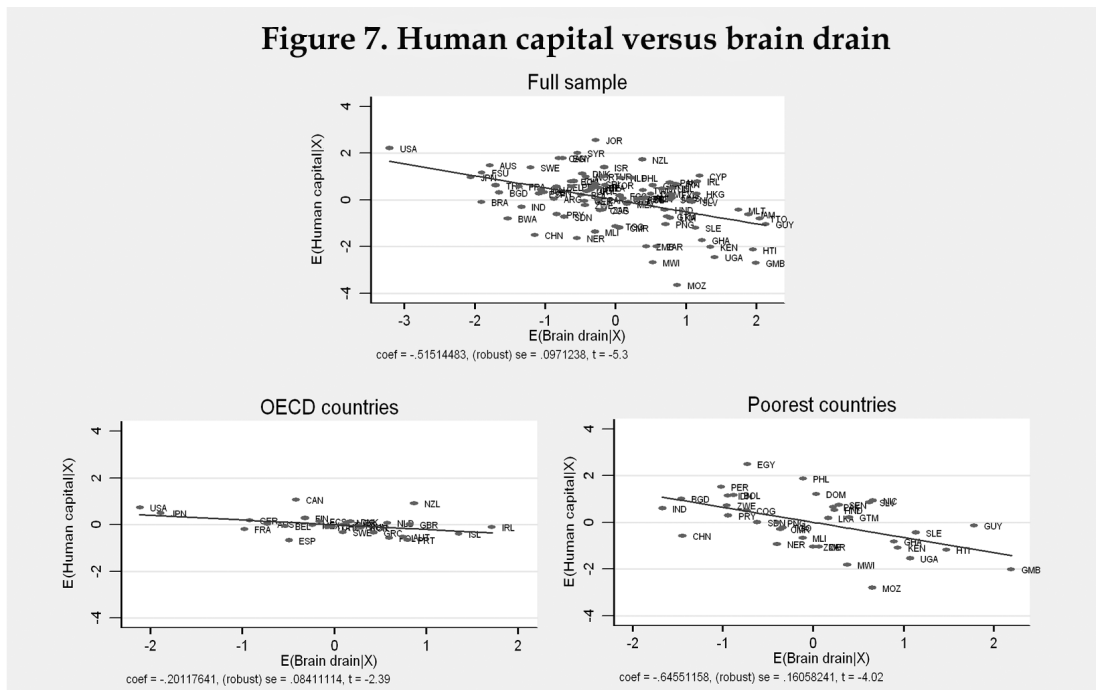
Barro and Lee (2000) database to find a variable of human capital different from the attainment rate of post-secondary education, and we have used the average years of education of population older than 25 years. Results confirm that the migration of skilled workers in 1990 reduced the total years of education of the labor force that remained at home[10]. Thus, there is no support for the brain gain hypothesis using an alternative measure for human capital.

Another concern arises with the fact that human capital is a stock variable. In previous sections, one of the two interpretations of brain drain that are given considers migration rates as a probability of emigration. This interpretation is related to several theoretical models that predict changes in the human capital formation process when the probability of emigration changes. However, considering human capital as stock and brain drain as a probability, both in the year 1990, may not be more than a good approximation, since migration rates had been relatively constant in the past decades. Hence, to see whether a higher probability of emigration of skilled workers in general leads individuals to invest more in education, we introduce enrollment rates at tertiary level schools (a flow variable) as a dependent variable in our OLS regressions of equation (2)[11]. In this case, theories could predict a positive reaction, maybe temporal, to attend school, opening the door to a weak brain gain hypothesis even when *ex-post* human capital is reduced. This occurs in models where a brain gain effect exists that is, nevertheless, dominated by the brain drain effect. However, Column 2 of Table 3 shows that this relationship is still significantly negative. One possible explanation for this surprising outcome could be that the incentive to acquire education is not transmitted to the same cohort of individuals, but to the younger individuals. To check this idea, we have replaced tertiary enrollment rates by secondary enrollment rates in the same equation. The OLS regression (Column 3) again reproduces a similar effect: the larger the brain drain rate in 1990, the lower the proportion of individuals that attend school at secondary level. This is, hence, evidence against the brain gain mechanism.

Table 3. Robustness analysis

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Human capital				Brain drain	
Year	1990			2000			2000	
Dependent variable / Measure of brain drain	YEARS OF EDUCATION DOCQUIER MARFOUK (2005), 1990	ENROLLMENT TERTIARY LEVEL DOCQUIER MARFOUK (2005), 1990	ENROLLMENT SECONDARY LEVEL DOCQUIER MARFOUK (2005), 1990	YEARS OF EDUCATION DOCQUIER MARFOUK (2005), 2000	ENROLLMENT TERTIARY LEVEL DOCQUIER MARFOUK (2005), 2000	ENROLLMENT SECONDARY LEVEL DOCQUIER MARFOUK (2005), 2000	ATTAIMENT TERTIARY LEVEL OECD (COHEN SOTO, 2001), 2000	ATTAIMENT TERTIARY LEVEL OECD (BARRO LEE, 2000), 2000
Percentage of Muslims	-1.607 [0.286]***	-1.953 [0.534]***	-1.170 [0.326]***	-1.320 [0.265]***	-1.673 [0.417]***	-1.096 [0.314]***	-1.55 [0.444]***	-1.468 [0.399]***
Schooling (hours/year)	-0.001 [0.000]**	-0.001 [0.001]	-0.001 [0.001]	-0.001 [0.000]	-0.001 [0.001]	-0.001 [0.000]	-0.001 [0.001]	-0.002 [0.001]***
Brain drain	-0.131 [0.050]***	-0.424 [0.109]***	-0.112 [0.062]*	-0.184 [0.044]***	-0.59 [0.104]***	-0.206 [0.062]***	-0.505 [0.110]***	-0.529 [0.099]***
Constant	2.885 [0.392]***	4.508 [0.758]***	5.020 [0.644]***	2.857 [0.374]***	5.419 [0.891]***	5.411 [0.445]***	3.95 [0.823]***	5.258 [0.754]***
Observations	89	88	89	89	88	88	83	100
R-squared	0.42	0.26	0.20	0.41	0.32	0.27	0.33	0.33

Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. Variables difinition and source are in the text.

In Columns 4 to 6, we check whether our results are sensitive to changes in the period analyzed. Since data for migration and human capital are available for 2000, we re-estimate specifications shown in Columns 1-3, substituting the variables of interest for those in the year 2000. We find that none of the brain drain proxies affect the different education variables positively. Moreover, all of their coefficients are negative and significant at a 1 per cent level, with the exception of the last column, which is not significant.

We address another concern regarding the methodology used in Docquier and Marfouk (2005) to identify and measure skilled workers across countries. A first question arises because a great number of countries do not provide data on human capital and certain adjustments, made to increase the number of observations, can lead a bias. Other concern is derived from the methodology to measure human capital levels. OECD have computed migration rates for skilled individuals residing in OECD area in 2000, restricting the adjustments to increase the number of countries and using two different methodologies to measure educational levels: the one provided by Cohen and Soto (2001) and the Barro and Lee's (2000) one. We have estimated equation (2) using these migration rates in order to guarantee that results are also robust to alternative measures of brain drain, and those are the regressions 7 and 8 of Table 3

Finally, one could think that the inclusion in the sample of some small countries with very high rates of brain drain[12] would change the final outcome. In the regression of equation (2) by OLS, we can raise the sample up to 109 observations. Results are the following[13]:

$$\ln \hat{h} = \underset{[0.726]^{***}}{5.276} - \underset{[0.097]^{***}}{0.378} \ln m - \underset{[0.458]^{***}}{1.801} \ln musl - \underset{[0.0007]^{***}}{0.003} \, hours \qquad (6)$$
$$R^2 = 0.2736; \quad obs = 109$$

Hence, results are similar to those with the more restricted sample; signs are the same and there are only slight differences in magnitude. Moreover, we also re-run specification in columns 1 to 8 including all available countries (outcome not presented). The country sample increases to 176 observations (in the case of the model of Column 7). In none of the equations is there a positive and significant coefficient of the brain drain proxy. Moreover, results are similar to those displayed in Table 3.

To conclude, these different robustness regressions complement evidence discussed in Section 4, suggesting that there is neither a positive effect of brain drain on human capital levels, nor on schooling rates across countries.

6 Conclusions

New theories on brain gain suggest that, under certain conditions, the migration of skilled workers generates positive effects that compensate for the negative externality of the reduction of human capital. This paper is especially concentrated on those effects that introduce changes in individuals' decisions to pursue education, thus affecting the human capital formation process. However, other types of direct effects are also considered in the model.

To test these hypotheses, we look at the relationship between economic growth, human capital and the migration of skilled workers. A system of equations is constructed to jointly estimate both effects, and to calculate the global effect of brain drain on growth. The first result derived from estimations of the system is a negative relationship between human capital and brain drain; this evidence rejects the hypothesis of brain gain and suggests that brain drain (in the sense of negative externalities) occurs when skilled workers emigrate abroad. The second result is that different direct effects of brain drain on growth compensate each other, making a zero coefficient in some cases plausible. Finally, the global effect is negative, but its significance is weak; this suggests

that the direct effect compensates for the negative externalities of human capital reduction, even though this effect is not large enough to offset all of the negative consequences of skilled workers' flight.

This evidence concludes against the brain gain hypothesis, and seems to question previous empirical findings on the nexus between international migration and human capital formation. Our findings are based on migration data of a higher quality than that used in other studies (Beine *et al.*, 2001, 2004). Moreover, this paper simultaneously estimates the global effect of brain drain on growth, incorporates solutions to endogeneity problems, and checks robustness to different specifications and variables.

Conclusions taken for previous sections warn about the negative consequences of brain drain on the economic growth of sending economies. As is suggested at the end of Section 4, these negative effects are likely to be large when the home country is poor. This result turns migration into an important issue for the development of the countries. Hence, migration policies, especially those dealing with skilled migration, should be considered as development policies which require further investigation.

Sending economies need to be aware of which policies can help avoid the negative consequences of human capital flight, so that these policies can be introduced. The fact that there are some positive implications of brain drain (even though they do not offset negative externalities) should be kept in mind in policy making, and the target should be to avoid an excess of negative externalities. For instance, temporary migration could be positive, as skilled individuals would obtain more skills and experience abroad; however, the reduction of human capital would not be permanent. When temporary migrants return home, they will be more productive, and this rise of productivity will compensate for the temporary brain drain.

Appendix

Table A.1. List of countries included in the sample

Algeria	Ex-USSR	Japan	South Africa
Argentina	Ex-Yugoslavia	Jordan	Spain
Australia	Ex-Czechoslovakia	Kenya	Sri Lanka
Austria	Finland	Korea, Rep.	Sudan[2,4]
Bangladesh	France	Malawi	Sweden
Belgium[3]	Gambia, The	Malaysia	Switzerland
Bolivia	Germany	Mali	Syrian Arab Rep.
Botswana	Ghana	Malta[2]	Taiwan
Brazil	Greece	Mexico	Thailand
Cameroon	Guatemala	Mozambique	Togo
Canada	Guyana	Netherlands	Trinidad & Tobago
Chile	Haiti	New Zealand	Tunisia
China	Honduras	Nicaragua	Turkey
Colombia	Hong Kong[2,3]	Niger	Uganda
Congo, Dem.Rep.	Hungary	Norway	United Kingdom
Congo, Rep.	Iceland	Pakistan	United States
Costa Rica	India	Panama	Uruguay
Cyprus[2,3]	Indonesia	Papua-New Guinea	Venezuela, R.B.
Denmark	Iran	Paraguay	Zambia
Dominican Rep.	Ireland	Peru	Zimbabwe
Ecuador	Israel	Philippines	
Egypt	Italy	Sierra Leone	
El Salvador	Jamaica	Singapore[2]	

* The super index is the number of the equation of Table 3 from which
the country is excluded.

Table A.2. Variable description and definitions

Variable name	Description	Economic counterpart	Source
GDP p.c. growth 90s	Annual growth rate of GDP per capita 1990-2000 (Average of the decade, in %)	Growth of GDP per capita	Dollar and Kraay (2002)
Human capital in 1990	Individuals with more than 13 years of school attainment as a share of the total population over 25 (Logs, in %)	Human capital	Barro and Lee (2000)
Brain drain in 1990	Individuals with more than 13 years of school attainment living in OECD countries as a share of the individuals with this level of education (Logs, in %)	Brain drain	Docquier and Marfouk (2005)
GDP p.c. 1990	GDP per capita PPP. Constant 1985 $. Extended cross-sectionally as described in Kraay, Loayza, Serven and Ventura (2000) (Logs)	Convergence	Dollar and Kraay (2002)
Investment/GDP	Inestment as a fraction of GDP, both in constant 1985 $ at PPP (Average 90s, in%)	Investment	Dollar and Kraay (2002)
Government stability	ICRG rate for government stability (ranges from 0 (instable) to 12 (stable)) (Average 90s)	Institutional quality	International Country Risk Guide
Population growth	Annual growth rate of population over 25 1990-2000 (Logs of 1+rate, average decade)	Population growth	Docquier and Marfouk (2005)
Ethnic fractionalization	Probability that two randomly selected individuals belongs to a different ethnic group	Ethnic conflict / tensions risk	Alesina et al.(2003)
Inflation	1+inflation rate, inflation rate measured as annual percent change in CPI if available, otherwise annual percent change in GDP deflator (Logs of 1+rate, average 90s)	Inflation	Dollar and Kraay (2002)
Proportion of Muslims	Percentage of muslims in the population (In logs)	Cultural propensity to invest in education	Our own elaboration with Alesina et al. (2003)
Schooling (hours/year)	School hours per year at primary level	Oportunity cost of education	Barro and Lee (2001)
Openness	(Exports + Imports)/GDP. Numerator and denominator are in constant local currency units (Logs, average 90s)	Openness	Dollar and Kraay (2002)
FDI	FDI inflows over GDP (Average 90s, in %)	FDI	Dollar and Kraay (2002)
Government expenditure	Government consumption as a share of GDP, current local currency (Logs, average 90s)	Government expenditure	Dollar and Kraay (2002)
Asia	Dummy for asian countries	Regional effects	-
Total migration rate	Total migration rate (In %)	Cultural linkages	Docquier and Marfouk (2005)
Area	Area (Km^2)	Quotas' restriction	-

Notes

[1]Docquier and Rapoport (2004) summarize the traditional and new models in a unified analytical framework. Also, Commander et al. (2004) and Schiff (2005) provide two different critical reviews of the literature.

[2]A smaller number of countries has available data for the year 1990, because some of the countries were grouped in the former USSR, Yugoslavia or Czechoslovakia.

[3]For a deeper description of the methodology to elaborate the dataset, see Docquier and Marfouk (2005).

[4]Tertiary educated workers are defined as population over 25 years old with more than 13 years of school attainment.

[5]For instance, Barro and McCleary (2003) use religious composition in population as an instrument in a growth equation.

[6]Since income is considered at PPP, it is exogenous in the growth equation and captures the difference in the value of wages among countries. Hence, if two individuals emigrate to the OECD and earn the same wage, the one from a country with a lower PPP conversion factor to the exchange rate will be richer in her country.

[7]We considered the possibility of estimating the system by 3SLS. However, Hausman tests of systematic difference of coefficients of 2SLS and 3SLS rejected the null hypothesis of non-systematic differences, which means that if 2SLS were consistent, 3SLS would not be so.

[8]See Table 1 for descriptions.

[9]See Table 1 for descriptions.

[10]See Column 1 of Table 5.

[11]Data is extracted from World Bank (2006), Education Statistics on-line, http://www1.worldbank.org/education/edstats/.

[12]See reasons and details for their exclusion in Section 3.

[13]For comparable results with the restricted sample see equation (5), in the first line (full sample).

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