Brain Drain in Developing Countries

Frédéric Docquier, Olivier Lohest, and Abdeslam Marfouk

An original data set on international migration by educational attainment for 1990 and 2000 is used to analyze the determinants of brain drain from developing countries. The analysis starts with a simple decomposition of the brain drain in two multiplicative components, the degree of openness of sending countries (measured by the average emigration rate) and the schooling gap (measured by the education level of emigrants compared with natives). Regression models are used to identify the determinants of these components and explain cross-country differences in the migration of skilled workers. Unsurprisingly, the brain drain is strong in small countries that are close to major Organisation for Economic Co-operation and Development (OECD) regions, that share colonial links with OECD countries, and that send most of their migrants to countries with quality-selective immigration programs. Interestingly, the brain drain increases with political instability and the degree of fractionalization at origin and decreases with natives' human capital. JEL classification codes: F22, O15, J24

The international migration of skilled workers (the so-called brain drain) has attracted considerable attention. Industrial countries such as Canada, Germany, and the United Kingdom worry about the emigration of their talented workers, but it is the detrimental consequences of the brain drain for developing countries that are usually stressed in the literature. By depriving developing countries of human capital, one of their scarcest resources, brain drain is usually seen as a drag on economic development. Yet recent theoretical studies emphasize several compensatory effects, showing that a limited but positive skilled emigration rate can be beneficial for sending countries (Commander, Kangasniemi, and Winters 2004; Docquier and Rapoport 2007; Beine, Docquier, and Rapoport 2001, forthcoming; Schiff 2005 provides a critical appraisal of this literature). However, without reliable comparative data

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on international migration by educational attainment, the debate on the causes and consequences of the brain drain has remained essentially theoretical.

With the rapid evolution of international migration and the policy issues at stake, the international community must be prepared to address the major challenges raised by the brain drain. Assessing the economic impact of emigration by skilled workers requires better knowledge of the educational structure of international migration and its determinants.

This article seeks to characterize the distribution of the brain drain from developing countries in 1990 and 2000 and its main determinants using the new harmonized comprehensive data set on migration stocks and rates by educational attainment recently built by Docquier and Marfouk (2006). Generalizing the pioneering work of Carrington and Detragiache (1998), their method consists of collecting census and registry data on the structure of immigration in all Organisation for Economic Co-operation and Development (OECD) countries. In a first step, aggregating these data allows for evaluating the stock of emigrants from all developing countries to OECD countries by level of schooling. In a second step, comparing the number of migrants to that of natives (defined here as residents and emigrants) in the sending country in the same education group gives a relative measure of the emigration rate by educational attainment for 1990 and 2000.

Section I presents the data set on the brain drain, as measured by the emigration rate of post-secondary-educated workers, and describes the average brain drain from developing countries by income group and country size. Between 1990 and 2000, the stock of skilled immigrants in OECD countries increased by 64 percent. The rise was stronger for immigrants from developing countries (up 93 percent), especially from Africa (up 113 percent) and Latin America and the Caribbean (up 97 percent). Although the number of skilled workers from developing countries increased, emigration rates decreased slightly. What at first looks like a paradox can be explained by the general rise in educational attainment in many developing countries between 1990 and 2000. The new brain drain measures are then compared with those in previous studies, showing how they resolve many important sources of bias.

Section II decomposes the brain drain into two multiplicative components: the degree of openness, measured by the average emigration rate of working-age natives, and the schooling gap, measured by the relative education attainment of emigrants compared with natives. On average, there is a negative correlation between openness and schooling gap, implying that a high brain drain usually accompanies either strong permeability or a high schooling gap, but not both. This justifies decomposing the brain drain into these two components and investigating their individual determinants.

A preliminary descriptive analysis reveals interesting regularities in the data. On the one hand, openness is strongly affected by country size: small countries exhibit higher average emigration rates than large countries do. On the other hand, the schooling gap is closely related to the average level of schooling among

natives: poor countries exhibit higher schooling gaps. Bilateral schooling gaps vary across destination countries, so destination choices affect the intensity of the brain drain. Other things being equal, the brain drain is stronger in small and poor countries sending most of their emigrants to countries with quality-based immigration policies.

Section III uses ordinary least squares and instrumental variable regression models to analyze the determinants of openness and the schooling gap. The degree of openness increases as country size declines, as natives' human capital and political instability increase, as colonial links strengthen, and as geographic distance to the major OECD countries declines. The schooling gap depends on natives' human capital, the type of destination country (with or without selective-immigration programs), on distances and religious fractionalization at origin. A rise in human capital stimulates openness and reduces the schooling gap. The second effect dominates: other things being equal, the brain drain is stronger in poor countries where the average level of schooling is low. All these findings improve the understanding of the sources of the brain drain.

I. A New Data Set on Skilled Migration

The analysis builds on the new international migration data set developed by Docquier and Marfouk (2006). The data set was used to compute absolute and relative emigration data by educational attainment for developing countries for 1990 and 2000. First, absolute emigration stocks by educational attainment are computed for every country. Next, these numbers are expressed as percentages of the total labor force born in the sending country (including migrants) with the same education level.

Stocks of Skilled Emigrants

Emigration statistics provided by origin countries, when available at all, do not give a realistic picture of emigration (see Wickramasekera 2002). Data on emigration can be captured only by aggregating harmonized immigration data collected in many receiving countries. Detailed information about the origin and skill of immigrants can usually be obtained from national censuses and registries. The Docquier–Marfouk data set is based on data collected in all OECD countries. It counts as migrants all working-age (25 and older) foreign-born individuals living in an OECD country. The total number of working-age emigrants from country i of skill s in year t is denoted by $M^s_{i,t}$.

Three levels of schooling are distinguished. Low-skill workers, with a primary education; medium-skill workers, with a secondary education; and high-skill workers, with a post-secondary education. The brain drain is defined as the migration of high-skill workers.

The Docquier–Marfouk data set devotes special attention to data homogeneity and comparability. To this end, several methodological choices were made (see Docquier and Marfouk 2006 for details).

- Considering the working-age population (ages 25 and older) maximizes comparability between immigration data and data on educational attainment in source countries and excludes the large number of students who emigrate temporarily to complete their education.[1]
- Restricting the set of receiving countries to the OECD area focuses attention on emigration from developing countries to industrial countries and between industrial countries. While there is a brain drain outside the OECD area as well, based on (less detailed) census data collected from various non-OECD countries, it is estimated that 90 percent of high-skill international emigrants are living in OECD countries.
- Holding receiving countries constant between 1990 and 2000 allows comparisons over time. Consequently, Czechoslovakia, Hungary, the Republic of Korea, Mexico, and Poland are considered receiving countries in 1990 although they were not then members of the OECD. The number of adult immigrants in the OECD increased from 41.8 million in 1990 to 59.0 million in 2000, and the number of skilled immigrants increased from 12.5 million to 20.4 million.
- Defining migration primarily on the basis of the concept of the foreign-born population rather than citizenship better captures the decision to emigrate and is time invariant. Information about the origin country of migrants is available in the large majority of OECD countries, representing 52.1 million immigrants in 2000 (88.3 percent of the total). Information on citizenship is used for the remaining countries (Italy, Germany, Greece, Japan, and the Republic of Korea). While the definition of foreign born is not fully comparable across countries, efforts were made to homogenize the concepts.
- Using direct data on educational attainment for 24 countries for 2000 and data from Labor Force Surveys, which provide less detailed information about immigrants' origins, for three countries (Belgium, Greece, and Portugal), means that the educational structure can be obtained or estimated for 27 countries representing 57.9 million immigrants (98.1 percent of the total).[2] For migrants whose educational attainment is not described, the educational structure is extrapolated from the Scandinavian countries for Iceland and from the rest of the OECD for Japan and Korea.

Skilled Emigration Rates

Relative emigration measures are obtained by comparing the emigration stocks to the total number of people born in the source country (residents plus emigrants, which together equal natives) and belonging to the same educational category. Calculating the brain drain as a proportion of the total educated

1. Carrington and Detragiache (1998) also considered individuals ages 25 and older.
2. Figures for 1990 are detailed in Docquier and Marfouk (2006).

labor force provides a better measure of the pressure imposed on the local labor market. Thus, for example, the emigration of 150,000 skilled Egyptians (4.5 percent of their educated labor force) exerts less pressure on the Egyptian labor market than the emigration of 2,500 skilled Seychellians (56 percent of their educated labor force) exerts on the Seychelles labor market. The term *emigration rate* is thus used to refer to relative stock data and not to immigration flows.

Denoting by $N^s_{i,t}$ the number of residents in country i, of skill s (with $s = h$ for skilled workers) in year t, the skilled emigration rate $m^h_{i,t}$ is defined as:

$$m^h_{i,t} \equiv \frac{M^h_{i,t}}{N^h_{i,t} + M^h_{i,t}}. \tag{1}$$

Evaluating $N^s_{i,t}$ requires data on the size and the skill structure of the working-age population in the countries of origin. Population data by age are provided by the United Nations Population Division (http://esa.un.org/unpp).

Population data are split across educational groups using international human capital indicators. Several sources based on education attainment and enrollment variables can be found in the literature. These data sets suffer from important shortcomings. Those published in the 1990s reveal a number of suspicious features and inconsistencies. And all of them are subject to serious comparability problems because of the variety of educational systems around the world. Three major competing data sets are available: Barro and Lee (2001), Cohen and Soto (2007), and de la Fuente and Domenech (2002). The first two sets depict the educational structure in both developed and developing countries. De la Fuente and Domenech focuses only on 21 OECD countries.

Statistical comparisons of these data sets reveal that the highest signal to noise ratio is obtained in de la Fuente and Domenech. For developing countries Cohen and Soto's set outperforms Barro and Lee's in growth regressions. However, Cohen and Soto's data underestimate official statistics in many developing countries. Generally speaking, Cohen and Soto predict extremely low levels of human capital in Africa[3] (the share of post-secondary educated is lower than 1 percent in a large number of African countries) and in a few other non-OECD countries.[4] The Barro and Lee estimates seem closer to the African census data obtained for a dozen countries. As the brain drain is particularly important in African countries, the Barro and Lee indicators are used when available.

3. For this reason, Cohen and Soto (2007) exclude African countries from their growth regressions.

4. According to the 1996 South African census, the share of educated individuals amounts to 7.2 percent. Cohen and Soto report 3 percent (Barro and Lee report 6.9 percent). The Kenyan 1999 census gives 2 percent while Cohen and Soto report 0.9 percent (1.2 for Barro and Lee). In Cyprus the 2001 census gives 22 percent while Cohen and Soto give 4.6 percent (17.1 percent in Barro and Lee).

Consequently, the Docquier–Marfouk data set relies on de la Fuente and Domenech's indicators for OECD countries, Barro and Lee's measures for most non-OECD countries, and adjusted Cohen and Soto's estimates for countries not in Barro and Lee. For countries for which no data are available, the skill structure of the neighboring country with the closest enrollment rates or GDP per capita is applied. This method gives good approximations of the brain drain rates, broadly consistent with anecdotal evidence.

The Brain Drain in Developing Countries

Following the 2000 World Bank income classification our analysis distinguishes 54 low-income countries, 58 lower-middle-income countries, and 40 upper-middle-income countries. Among these, three groups are of particular interest: small island developing countries, landlocked developing countries, and the least developed countries as defined by the United Nations.

Table 1 gives an overview of absolute and relative emigration rates by country group in 1990 and 2000. In 2000 developing countries accounted for 64.5 percent of total immigrants and 61.6 percent of skilled immigrants in the OECD, 15 percentage points higher than in 1990.

About three-quarters of these immigrants live in one of the three most important host countries with selective-immigration policies (Australia, Canada, and the United States). One-fifth of them live in 1 of the 15 member countries of the European Union (EU15). These percentages vary across origin groups: small island countries send many migrants to selective-immigration countries; least developed and landlocked countries send more migrants to the EU15. These destination choices are linked to geographic distances and historical ties. Most small island countries are located in the Caribbean and the Pacific and thus send many migrants to the United States or Australia and New Zealand. Many landlocked countries are located in Africa and have strong colonial links with European countries.

In every group the proportion of skilled workers among migrants (on average 33 percent for developing countries) is much higher than the proportion of skilled workers among residents (on average 6 percent). Hence, skilled emigration rates (on average 7.3 percent) are much higher than average emigration rates (on average 1.5 percent). These average levels hide a strong heterogeneity across states. The brain drain is extremely small (below 1 percent) in countries such as Bhutan, Oman, and Tajikistan, while it exceeds 85 percent in Grenada and Jamaica.

Between 1990 and 2000 the average emigration rate rose from 1.1 to 1.5 percent. Although the proportion of skilled migrants increased, the skilled emigration rate decreased from 7.7 to 7.3 percent as the general level of schooling increased in developing countries.

The highest brain drain rates are observed in small island developing countries and in the least developed countries, and the lowest rates in large and landlocked developing countries. Setting aside small island economies, the

TABLE 1. Descriptive Statistics by Country Group, 1990–2000

Group of origin	Emigration structure			Skilled emigrants by destination			Labor force structure (region of origin)			Emigration rates	
	Total emigrants (ages 25 and older, thousands)	Skilled emigrants (ages 25 and older, thousands)	Share of skilled (%)	In selective-immigration countries (%)	In EU15 countries (%)	In rest of OECD (%)	Total labor force (ages 25 and older, thousands)	Skilled labor force (ages 25 and older, thousands)	Share of skilled (%)	Total (%)	Skilled (%)
2000											
World[a]	59,022	20,403	*35*	73	21	6	3,187,233	360,614	11	1.8	5.4
High-income countries	19,206	7,547	*39*	68	24	8	666,246	200,607	*30*	2.8	3.6
Developing countries	38,083	12,576	*33*	76	19	5	2,520,987	160,008	*6*	1.5	7.3
Low-income countries	6,544	2,948	*45*	77	21	1	898,768	36,332	*4*	0.7	7.5
Lower-medium-income countries	17,053	6,089	*36*	77	17	6	1,298,233	76,981	*6*	1.3	7.3
Upper-medium-income countries	14,486	3,539	*24*	75	20	5	323,987	46,694	*14*	4.3	7.0
Least developed countries	2,510	853	*34*	69	29	2	245,974	5,635	*2*	1.0	13.1
Landlocked developing countries	1,271	470	*37*	63	33	4	129,988	8,892	*7*	1.0	5.0
Small developing islands	4,001	1,504	*38*	90	9	1	24,979	2,041	*8*	13.8	42.4
Large developing countries (>40 million)	19,828	6,926	*35*	82	13	5	2,050,014	117,433	*6*	1.0	5.6

(Continued)

TABLE 1. *Continued*

Group of origin	Emigration structure			Skilled emigrants by destination			Labor force structure (region of origin)			Emigration rates	
	Total emigrants (ages 25 and older, thousands)	Skilled emigrants (ages 25 and older, thousands)	Share of skilled (%)	In selective-immigration countries (%)	In EU15 countries (%)	In rest of OECD (%)	Total labor force (ages 25 and older, thousands)	Skilled labor force (ages 25 and older, thousands)	Share of skilled (%)	Total (%)	Skilled (%)
1990											
World[a]	41,845	12,462	*30*	76	17	7	2,369,431	209,225	*9*	1.6	5.0
High-income countries	18,165	5,613	*31*	74	17	9	586,069	139,458	*24*	3.0	3.9
Developing countries	19,402	5,804	*30*	79	17	4	1,783,362	69,767	*4*	1.1	7.7
Low-income countries	3,454	1,267	*37*	77	21	1	677,539	21,291	*3*	0.5	5.6
Lower-medium-income countries	8,740	2,883	*33*	81	14	5	938,974	34,948	*4*	0.9	7.6
Upper-medium-income countries	7,208	1,654	*23*	77	19	4	166,848	13,528	*8*	4.1	10.9
Least developed countries	1,384	373	*27*	70	29	2	185,034	3,092	*2*	0.7	10.8
Landlocked developing countries	444	150	*34*	69	29	3	73,330	1,613	*2*	0.6	8.5
Small developing islands	2,595	866	*33*	91	9	1	19,371	1,059	*5*	11.8	45.0
Large developing countries (>40 million)	9,312	2,890	*31*	83	13	4	1,430,178	50,707	*4*	0.6	5.4

[a]Sum of emigrants from high-income countries, developing countries, and dependent territories and emigrants who did not report their country of birth.

Source: Docquier and Marfouk 2006.

highest average brain drain rates are observed in Sub-Saharan Africa (13 percent), Latin America and the Caribbean (11 percent), and the Middle East and North Africa (10 percent).

Comparison with Previous Studies

The Docquier–Marfouk data set generalizes the work of Carrington and Detragiache (1998, 1999), which was the first serious effort to compile a harmonized international data set on migration rates by education level. Carrington and Detragiache used 1990 U.S. Census data and general OECD statistics on international migration to construct estimates of emigration rates at three education levels for 61 developing countries.[5] Although their study clearly initiated new debates on skilled migration, their estimates suffer from important shortcomings:

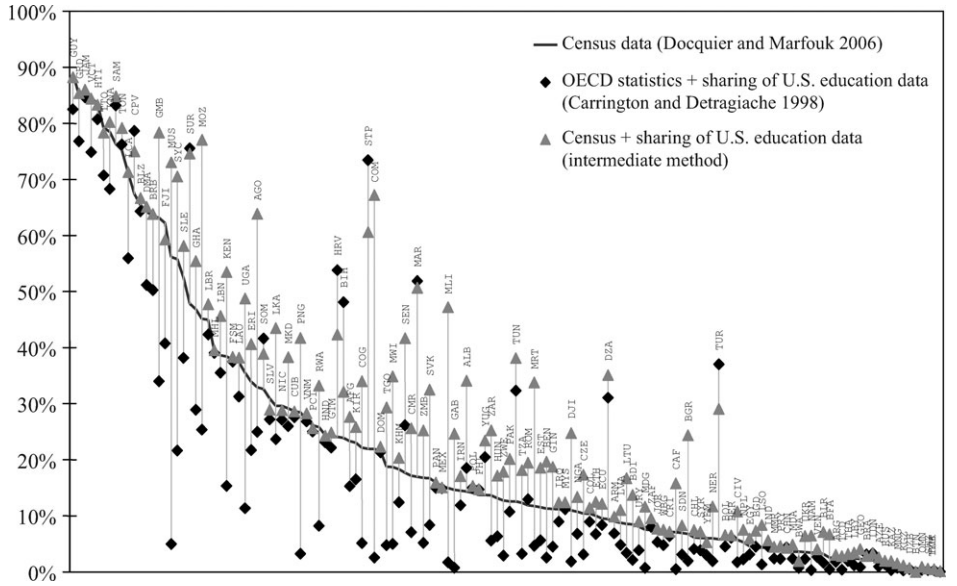
- The numbers of immigrants by country of origin are taken from U.S. Census data and from OECD statistics for the remaining countries. Although census data give an accurate picture of U.S. immigration, OECD statistics report the number of immigrants for the major origin countries only (top-10 or top-5 sending countries). This led to underestimates of immigration for a large number of sending countries, whose data were aggregated and considered as residual in the entry "other countries." This underreporting bias is reinforced by the fact that 1990 immigration data were missing for three OECD countries (Greece, Iceland, and Turkey) and that three countries (Mexico, Poland, and Slovakia) became OECD members after 1990.
- Although data based on country of birth are available from many national censuses, the OECD classifies European immigrants by citizenship. This is another source of underreporting bias as the number of foreign-born people is usually much higher than the number of foreign citizens (twice as large in the Netherlands and Sweden, for example).
- OECD statistics give no information on immigrants' age, making it impossible to isolate those ages 25 and older. This introduces an overreporting bias when the aim is to consider skilled workers.
- Carrington and Detragiache applied the education structure of U.S. immigrants to immigrants in other OECD countries. For example, Surinamese migrants to the Netherlands are assumed to be distributed across educational categories in the same way as Surinamese migrants to the United States. Since U.S. immigration policy differs from that of many other countries, this assumption is highly tentative, especially for countries with a low migration rate to the United States.

5. Adams (2003) used the same methodology to compute brain drain rates from 24 countries in 2000.

The Docquier–Marfouk (2006) study, which collected census, registry, and survey data from all OECD countries, enables the size of these biases for developing countries to be evaluated. A comparison shows that the brain drain is highly overestimated in countries such as Algeria, Morocco, São Tomé and Principe, Suriname, Tunisia, and Turkey. In transposing the educational structure observed in the United States, Carrington and Detragiache (1998, 1999) and Adams (2003) obtain emigration rates of post-secondary-educated workers for North Africa and Turkey of 35 to 45 percent. The Docquier–Marfouk data set gives much lower skilled emigration rates for these countries of 5 to 20 percent. The brain drain is underestimated in many Sub-Saharan African countries, such as The Gambia, Kenya, Mauritius, and Seychelles, and in small countries sending a small number of emigrants to OECD countries, such as Mauritius. The over- and under-estimation biases range from 51.5 percent for São Tomé and Principe to −51.2 percent for Mauritius.

Figure 1 shows skilled migration rates evaluated under these three measurement methods: Docquier and Marfouk (2006), based on national census and administrative data; Carrington and Detragiache (1998) and Adams (2003), based on OECD statistics and U.S. educational attainment data; and an intermediate method based on census and administrative data on the number of

FIGURE 1. Skilled Emigration Rates under Three Measurement Methods; all Developing Countries, 2000



Note: Country codes follow the International Organization for Standardization classification (see www.iso.org/). Countries are ranked in descending order according to the Docquier and Marfouk (2006) method. *Source*: Authors' analysis based on data from Docquier and Marfouk (2006).

migrants and U.S. educational attainment data on education. In comparison to Docquier–Marfouk, Carrington and Detragiache and Adams underestimate the brain drain for a large majority of countries, while the third method overestimates the brain drain.

II. Openness and Schooling Gaps: Some Stylized Facts

The highest skilled emigration rates are observed in small and poor countries (see table 1). Although many factors help to explain the intensity of the brain drain, country size and development levels are key determinants. A simple multiplicative decomposition of the skilled emigration rate can help to explain the distribution of the brain drain across countries. Denoting by $M^s_{i,\,t}$ the number of working-age emigrants from country i of skill s ($s = h$ for high-skill workers and $s = l$ for low-skill workers) in year t and by $N^s_{i,t}$ the corresponding number of residents, the skilled emigration rate $m^h_{i,t}$ can be decomposed as following:

$$(2) \qquad m^h_{i,t} \equiv \frac{M^h_{i,t}}{N^h_{i,t} + M^h_{i,t}} \equiv \left(\frac{\sum_s M^s_{i,t}}{\sum_s N^s_{i,t} + M^s_{i,t}} \right) \times \left(\frac{M^h_{i,t}}{\sum_s M^s_{i,t}} \Big/ \frac{N^h_{i,t} + M^h_{i,t}}{\sum_s N^s_{i,t} + M^s_{i,t}} \right)$$

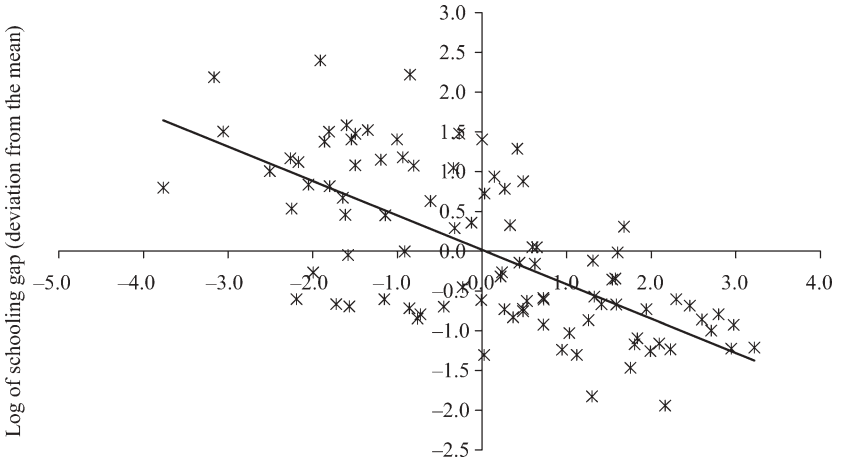
The first multiplicative component is the ratio of emigrants to natives—the average or total emigration rate of all types of individuals. It reflects the degree of openness of the sending country. The second multiplicative component is the ratio of the proportion of skilled emigrants by the same proportion among natives. This ratio reflects the schooling gap between emigrants and natives. This ratio is always higher than one, indicating that emigrants are more educated than natives in all developing countries.

Consider a hypothetical world in which emigration is proportional to population and the skill structure of emigration is identical to that of the native population. The schooling gap would then be equal to one and all countries would exhibit the same degree of openness. From the decomposition (brain drain = openness index × schooling gap), the brain drain would be homogeneous across countries.

Obviously, observations depart from that hypothetical situation: average emigration rates and schooling gap are strongly heterogeneous. As the next section shows, these two components are closely related to the characteristics of sending countries as well as to proximity variables and characteristics of the main destination countries. First, however, consider four stylized facts related to the process of emigration by skilled workers.

Stylized fact 1: Average emigration rates and schooling gaps are negatively correlated. Figure 2 plots the log of the emigration rate and the log of the schooling gap in 2000. Both variables are expressed as differences from the sample mean. Average emigration rates and schooling gaps are negatively

FIGURE 2. Average Emigration Rate and Schooling Gap



Source: Authors' analysis based on data from Docquier and Marfouk (2006).

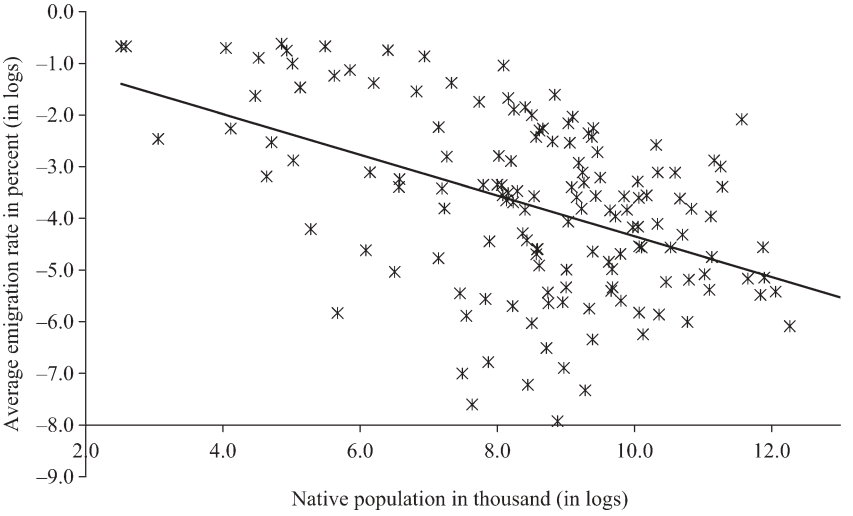
correlated. The majority of observations fall in the top left panel (low emigration rates and high schooling gaps) and bottom right panel (high emigration rates and low schooling gaps). A small number of observations fall in the top-right panel, but they are quite close to one of the axes.

This means that no developing country has both strong openness and a high schooling gap. If a country suffers from a large brain drain it is either because it is very open or because the positive self-selection of migrants is strong. This justifies the decomposition and the analysis of the specific determinants of these two components.

Stylized fact 2: Average emigration rates decrease with country size. There is an obvious link between population size in country of origin and number of migrants abroad. In absolute numbers the main emigration countries are the largest ones (China, India, Mexico, Philippines, and Turkey) while the smallest number of emigrants come from small countries (Maldives, Nauru, Palau, Tuvalu, and Vanuatu). However, an increase in population generates a less than proportional increase in emigration. As is well documented in the literature, the average or total emigration rate decreases with population size in the country of origin. Thus the degree of openness is decreasing in the population size at origin.

In 2000, the average emigration rate to the OECD ranged from 0.1 percent (for Bhutan, Chad, Lesotho, Niger, Oman, Swaziland, and Turkmenistan) to 53.7 percent (Grenada). The correlation between the log of native population size and average emigration rate is −53 percent (figure 3). In 2000, seven countries had average emigration rates above 40 percent (Dominica, Grenada, Guyana, Saint Kitts and Nevis, Samoa, Suriname, and Tonga): their average

FIGURE 3. Average Emigration Rate and Country Size



Source: Authors' analysis based on data from Docquier and Marfouk (2006).

size was 0.237 million and none had a population above 1 million. Among the eight countries with a population above 100 million (China, India, Indonesia, Brazil, Russia, Pakistan, Bangladesh, and Nigeria), the emigration rate was 1 percent or lower.

Small countries have the highest emigration rates (table 2). Small island developing economies (average population of 1.3 million) exhibit an average emigration rate of 13.8 percent, compared with 1 percent for large developing countries (population of more than 40 million). Obviously, country size is not the unique determinant of openness, as revealed by the strong dispersion of the scatter plot in figure 3. However, differences in country size are important and explain a substantial fraction of the disparities across income groups. Average country sizes are 38 million for low-income countries, 40 million for lower-middle-income countries, and 15 million for upper-middle-income countries. Unsurprisingly, upper-middle-income countries exhibit the highest openness index.

Stylized fact 3: Schooling gaps decrease with natives' rising human capital. An interesting major regularity concerns the educational structure of emigration. It is natural that the proportion of educated among emigrants increases with the general level of education of the native population. The most educated diasporas originate from countries where the proportion of educated natives ranges from 10 to 20 percent (such as Jordan, Libya, Mongolia, Oman, Panama, the Philippines, South Africa, and Venezuela). Less educated diasporas come mainly from very poor countries (such as Angola, Guinea-Bissau, Mali, Mozambique, and Tuvalu). Six countries had a schooling gap greater than 30 (Lesotho, Malawi, Mozambique, Niger, Rwanda, Uganda): their

TABLE 2. Decomposition of Skilled Emigration Rates, 1990–2000

	Decomposition			Openness by destination (%)			Schooling gap by destination		
	A	B	C						
Group of origin	Brain drain (%) A = B × C	Openness (%)	Schooling gap	To selective-immigration countries	To EU15 countries	To rest of OECD	To selective-immigration countries	To EU15 countries	To rest of OECD
2000									
World[a]	5.3	1.8	3.0	1.0	0.6	0.2	3.8	1.9	1.9
High-income countries	3.6	2.8	1.3	1.4	1.1	0.3	1.7	0.8	0.9
Developing countries	7.3	1.5	4.9	0.9	0.5	0.1	6.1	3.0	3.0
Low-income countries	7.5	0.7	10.4	0.4	0.3	0.0	13.0	6.2	6.2
Lower medium-income countries	7.3	1.3	5.7	0.7	0.4	0.1	7.7	2.9	3.2
Upper-medium-income countries	7.0	4.3	1.7	2.8	1.2	0.3	1.9	1.2	1.2
Least developed countries	13.1	1.0	13.0	0.5	0.5	0.0	16.9	8.6	9.9
Landlocked developing countries	5.0	1.0	5.2	0.5	0.4	0.1	6.7	4.0	2.4
Small island developing economies	42.4	13.8	3.1	11.4	2.3	0.1	3.3	1.8	2.6

(Continued)

TABLE 2. *Continued*

	Decomposition			Openness by destination (%)			Schooling gap by destination		
	A	B	C						
Group of origin	Brain drain (%) A = B × C	Openness (%)	Schooling gap	To selective-immigration countries	To EU15 countries	To rest of OECD	To selective-immigration countries	To EU15 countries	To rest of OECD
Large developing countries (>40 million)	5.6	1.0	5.8	0.7	0.2	0.1	6.8	3.6	4.5
1990									
World[a]	5.2	1.6	3.3	0.9	0.5	0.1	4.6	1.7	2.4
High-income countries	3.9	3.0	1.3	1.6	1.0	0.4	1.8	0.7	0.9
Developing countries	7.7	1.1	7.1	0.6	0.4	0.1	9.7	3.7	5.0
Low-income countries	5.6	0.5	11.1	0.3	0.2	0.0	16.4	5.6	6.4
Lower medium-income countries	7.6	0.9	8.3	0.5	0.3	0.1	11.8	3.6	5.3
Upper-medium-income countries	10.9	4.1	2.6	2.7	1.3	0.2	3.2	1.7	2.4
Least developed countries	10.8	0.7	14.5	0.3	0.4	0.0	22.3	8.8	11.3
Landlocked developing countries	8.5	0.6	14.1	0.3	0.3	0.0	19.3	9.5	12.8
Small island developing economies	45.0	11.8	3.8	9.6	2.6	0.1	4.4	2.6	5.4
Large developing countries (>40 million)	5.4	0.6	8.3	0.4	0.2	0.0	10.6	3.9	7.0

[a]Sum of emigrants from high-income countries, developing countries, and dependent territories and emigrants who did not report their country of birth.

Source: Authors' analysis based on data from Docquier and Marfouk (2006).

skilled average was 0.6 percent. Among the 10 countries where the schooling gap is below 1.5, the skilled average was 16 percent (much higher than the average of 6 percent for all developing countries).

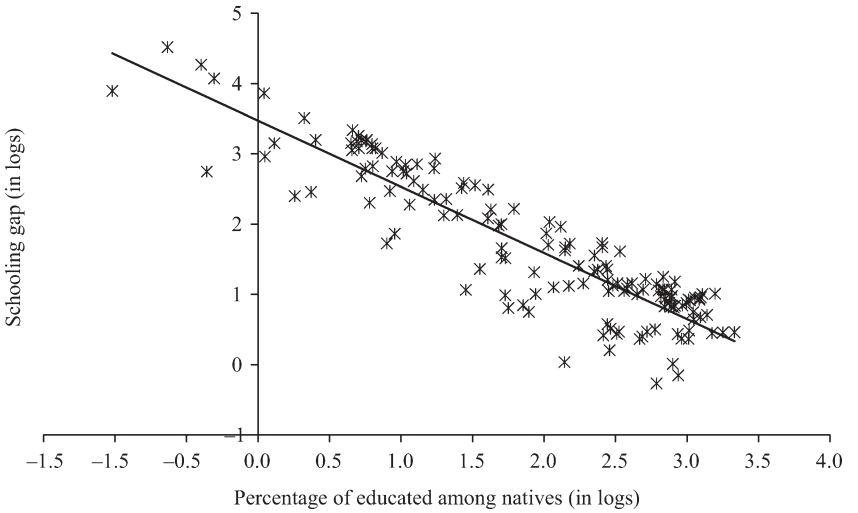
An increase in the education level of the native population generates a less than proportional increase in the education level of emigrants. Thus, the schooling gap decreases with a rising human capital level in the country of origin.[6]

In 2000, the schooling gap ranged from 1 in Turkey and Mexico to 92 in Niger. The correlation between the log of the schooling gap and the log of the proportion of educated among natives is −90 percent (figure 4).

The average schooling gap obviously decreases with national income (see table 2). Low-income countries have an index of 10.4, least developed countries an index of 13, and upper-middle-income countries an index of 1.7 (slightly above the average for high-income countries). This regularity explains why, other things being equal, poor countries tend to suffer more from brain drain.

Stylized fact 4: Schooling gaps depend on destination choice. The choice of destination affects the size of the brain drain (see table 2). Remember that about three-quarters of skilled emigrants from developing countries live in selective-immigration countries (Australia, Canada, and the United States; see table 1). Thus, average emigration rates to selective-immigration countries are unsurprisingly stronger than those to the EU15 and the rest of the OECD, where immigration policies focus mainly on family reunion and asylum seeking.

FIGURE 4. Schooling Gap and Natives' Human Capital



Source: Authors' analysis based on data from Docquier and Marfouk (2006).

6. This relationship goes beyond a pure tautological composition effect (i.e. when 100 percent of natives are skilled, the skilled emigration rate equals the average emigration rate and the schooling gap is equal to one).

"Bilateral" schooling gaps also vary across destinations. On average, the schooling gap observed in selective-immigration countries was about twice as large as the gap observed in EU15 and other OECD countries in 2000. Thus, countries that send many migrants to North America and Australia are likely to exhibit stronger schooling gaps than the others.

Although many economic and institutional factors may explain these differences (skill premia, welfare programs, etc.), increasingly quality-selective immigration policies are likely to play an important role. Since 1984, Australian immigration policy has officially privileged skilled workers, with candidates being selected according to their prospective contribution to the Australian economy. Canadian immigration policy follows similar lines, resulting in an increased share of highly educated people among the selected immigrants. For example, in 1997, 50,000 professional specialists and entrepreneurs immigrated to Canada along with 75,000 additional family members, representing 58 percent of the annual immigration flow. In the United States, since the Immigration Act of 1990 and the American Competitiveness and Work Force Improvement Act of 1998, the emphasis has been on the selection of highly skilled workers through a system of quotas favoring candidates with academic degrees and specific professional skills. The annual number of visas issued for highly skilled professionals (H-1B visas) increased from 110,200 in 1992 to 355,600 in 2000, with the entire increase due to immigration from developing countries. About half these workers now come from India. As argued in Antecol, Cobb-Clark, and Trejo (2003), except for immigrants from Central American countries, the U.S. selection rate is higher than the Canadian or Australian ones.

In 1990, the differential between selective-immigration countries and the EU15 was even stronger. The evolution of the differential is partly due to the fact that a growing number of EU15 countries (including France, Germany, Ireland, and the United Kingdom) have recently introduced programs to attract a qualified labor force through the creation of labor-shortage occupation lists (see Lowell 2002). German Chancellor Schröder announced plans in February 2000 to recruit additional specialists in information technology and by August 2001 German information, communication, and technology firms had the opportunity to hire up to 20,000 non-EU specialists for up to five years. In 2002, the French Ministry of Labor established a system to induce highly skilled workers from outside the EU to live and work in France, and the French government is replacing passive immigration policy with a selective-immigration policy.

III. Empirical Analysis of the Determinants of the Brain Drain

This section examines the determinants of average emigration rates and schooling gaps using empirical regressions. In a two-equation system, the dependent variables are the logistic transformation of the average emigration rate and the log of the schooling gap. The dependent variable is $\ln[m/(1-m)]$, where

$0 < m < 1$ is the emigration rate. This increasing monotonic transformation expands the range of the variable from (0,1) to $(-\text{inf}, +\text{inf})$.

Potential Explanatory Variables

The economics literature on international migration distinguishes many potential determinants of labor mobility. The regressions here use five sets of explanatory variables that are common in the empirical literature and that capture traditional proximity and push–pull factors. Because current emigration stocks depend on past as well as present decisions about migration, the average level observed over a long period is used for each explanatory variable when the data are available.

The first set, country size at origin, includes the log of the *native population* (residents plus emigrants), and a dummy variable for *small island developing economies*. Population is the average of the annual number of people residing in the home country during 1985–2000 and the total number of working-age emigrants living in an OECD country in 1990 and 2000. Data on population size are from World Bank (2005) and data on emigrants are from the Docquier–Marfouk data set. Although emigrants are likely to exhibit different mortality and fertility patterns than natives, using the native population rather than resident population minimizes the risk of endogeneity. An obvious reverse causality occurs between migration and the resident population. Residents include the immigrant population since immigrants cannot be split by age group and education level in non-OECD countries. The small island developing economies dummy variable is based on the recent United Nations classification.[7]

A second set of variables accounts for the level of development of the sending country using the log of the proportion of *post-secondary-educated natives*. Again, using natives rather than residents reduces the risk of endogeneity. However, the recent literature on brain drain and human capital formation suggests that natives' human capital may depend on emigration prospects (Mountford 1997; Stark, Helmenstein, and Prskawetz 1997; Beine, Docquier, and Rapoport 2001, forthcoming). The risk of reverse causality is important and requires using instrumentation techniques. Also considered are the log of *gross national income (GNI) per capita* in purchasing power parity, a dummy variable for the *least developed countries*, and a dummy variable for *oil exporting countries*. The native proportion of those with a post-secondary education comes from the Docquier–Marfouk data set. Data on GNI per capita are from World Bank (2005) and are averaged for 1985–2000. The dummy variable for least developed countries is based on the recent United Nations definition.

The third set captures the sociopolitical environment at origin. These are created from a mixture of two data sets on governance and fractionalization. These data sets provide many insights on the potential push factors for emigration. Data on governance are given in Kaufmann, Kraay, and Mastruzzi (2003)

7. See http://www.un.org/special-rep/ohrlls/ohrlls/default.htm.

for 1996, 1998, 2000, 2002, and 2004. From the six available indicators in this data set, two are used: *political stability and absence of violence* and *government effectiveness*.[8] The first indicator measures perceptions of the likelihood that the government in power will be destabilized or overthrown by unconstitutional or violent means, including domestic violence and terrorism. The second indicator measures the quality of public service provision, the quality of the bureaucracy, the independence of the civil service from political pressures, and the credibility of the government's commitment to policies. Both are normally distributed between −2.5 (bad governance) and 2.5 (good governance).[9] All the available scores are averaged for each country. Indicators of *religious fractionalization* from Alesina et al. (2003) are also used. This variable gives the probability that two randomly selected individuals from a given country share the same religion. The indicator ranges from about 1 percent to 83 percent. In developing countries, religious diversity often gives rise to conflicts (Hindus and Muslims in India; Catholics, Orthodox, and Muslims in the former Yugoslavia) or discrimination. Although some studies consider governance as an endogenous variable, political and governance indices are treated as exogenous here.

The fourth set of variables accounts for geographic and cultural proximity between developing and OECD countries. Since Greenwood (1969), many studies have stressed distance as a proxy for the monetary and psychic costs of migration. Three variables are distinguished for this purpose: *distance from selective-immigration countries* (Australia, Canada, and the United States), *distance from the EU15* members, and a dummy variable for *landlocked developing countries*, which suffer from a lack of territorial access to the sea, remoteness, and isolation from world markets. Colonial links, by implying better information about the destination country and thus lower migration costs, also affect the cultural distance between former colonies and destination countries. A dummy variable is used if the sending country is a *former colony of an OECD country* or if it shares the *same language as a selective-immigration country*. The data come from Clair et al. (2004). Finally, to control for the choice of destination, a dummy variable is included if the *main destination* is a selective-immigration country or if the *main destination is an EU15 member state*.

Econometric Issues

The empirical model consists of two equations, one for the average emigration rate and one for the schooling gap. Although dependent variables are available for both 1990 and 2000, most or the explanatory variables are time-invariant (either by nature or because levels observed over a long period are averaged).

8. They are strongly correlated with the four remaining variables and with Transparency International's corruption perception index (www.icgg.org/corruption.cpi_2003.html).

9. Under certain circumstances a country's rating might exceed these thresholds.

Because it would be impossible to understand the effect of time-invariant variables—the variables of primary interest—using a panel regression model with country fixed effects, cross-section empirical models were estimated on 2000 data.[10]

In a first stage, the general model is estimated with all the potential determinants in both equations. The standard ordinary least squares (OLS) regressions are used with White-corrections for heteroskedasticity (model OLS-1). Eliminating nonsignificant variables gives the first set of OLS-robust estimators (model OLS-2). To account for the potential endogeneity of the educated proportion of the native population, the parsimonious model is then estimated using a two-stage least square procedure with instrumentation of the educated proportion of the native population (model IV-1). The excluded instruments are the lagged proportion of the educated among natives, and the amount of public education expenditures.[11] To allow comparisons between these models, the same sample size of 108 cross-country observations is used. Finally, a new parsimonious model is estimated using the instrumental variable technique when the sample size is maximized. This model (IV-2) is based on 125 observations for the first equation and 123 for the second.

Empirical Findings

The first two parsimonious models provide very similar and robust results (table 3). The sign and significance levels of all coefficients are stable, with R^2 of about 70 percent and 90 percent, respectively. The exogeneity test[12] in the IV-1 model reveals that the educated proportion of the native population cannot be considered exogenous in the first equation. This is consistent with the new brain drain literature, which posits the positive impact of migration prospects on human capital formation in developing countries. There is no endogeneity problem in the second equation. The Sargan test and Hansen *J*-test of overidentification confirm that both excluded instruments are relevant and valid.

Consequently, the IV models seem appropriate for the first equation of openness. The OLS models provide good results for the second equation. The parsimonious model IV-2 uses the largest number of observations. Adding 20 percent of additional observations gives similar predictions for the majority

10. The model was also estimated using random-effect panel techniques and seemingly unrelated regressions. Results are similar and available on request from the authors. The Hausman test rejects the random-effect hypothesis compared with the fixed-effect model. Hence, the random-effect model is clearly a second-best option. Pooling 1990 and 2000 data or working with 1990 data also gives similar results.

11. Public expenditures in primary education (in U.S. dollars) is used. Other tests based on expenditures in secondary and tertiary education give similar results.

12. A Durbin-Wu-Hausman test is used for the first equation. Since the regressions indicate the presence of heteroskedasticity in the second equation of the schooling gap, a C-test was used to obtain a valid endogeneity statistic in a heteroskedastic-robust context (see Baum and Schaffer 2003).

TABLE 3. Cross-Section Regression Results (2000 data)

	OLS-1 General model		OLS-2 Parsimonious model		IV-1 Parsimonious model		Larger sample model	
Variable	Openness[a]	Schooling gap[b]	Openness[a]	Schooling gap[b]	Openness[a]	Schooling gap[b]	Openness[a]	Schooling gap[b]
Country size								
Native population (logs)	−0.156 (1.79)*	0.019 (−0.58)	−0.178 (2.84)***		−0.173 (2.51)**		−0.153 (2.21)**	
Small island developing economies	0.779 (1.89)*	0.001 (0.00)	0.971 (2.90)***		1.013 (2.57)**		0.693 (1.81)*	
Level of development								
Proportion of post-secondary educated natives × 100 (logs)	0.744 (3.06)***	−0.883 (10.1)***	0.526 (4.05)***	−0.871 (11.4)***	0.663 (4.82)***	−0.795 (8.57)***	0.854 (5.01)***	−0.893 (14.8)***
GNI per capita (logs)	−0.129	−0.144 (1.67)*		−0.091		−0.135 (1.85)*		
	−0.56			−1.6				
Least developed country	−0.083 (−0.17)	−0.040 (−0.28)						
Oil exporting country	−0.650 (−1.57)	0.239 (1.81)*		0.161 (−1.23)		0.152 (−1.38)	−0.853 (2.67)***	0.188 (1.66)*
Sociopolitical environment								
Political stability	−0.082 (−0.39)	−0.002 (−0.03)					−0.300 (2.19)**	−0.061 (−1.66)*
Government effectiveness	0.007 (−0.03)	0.115 (−1.08)						
Religious fractionalization	0.376 (−0.83)	0.545 (3.06)***		0.578 (3.88)***		0.585 (4.05)***		0.509 (3.49)***
Geographic and cultural proximity								
Distance from selective-immigration countries (logs)	−1.143 (3.17)***	0.358 (2.35)**	−1.078 (3.01)***	0.445 (5.18)***	−0.924 (2.86)***	0.475 (5.09)***	−1.105 (3.82)***	0.479 (5.63)***
Distance from EU15 countries (logs)	−0.428 (3.23)***	0.113 (2.06)**	−0.389 (3.83)***	0.130 (2.39)**	−0.377 (2.96)***	0.139 (2.77)***	−0.398 (3.16)***	0.126 (2.37)**
Landlocked developing country	−0.872 (2.49)**	0.137 (−1.19)	−0.793 (2.37)**		−0.721 (2.51)**		−0.710 (2.47)**	
Former colony of an OECD country	0.318 (−1.00)	−0.024 (−0.22)					0.553 (2.12)**	
Main destination = selective-immigration countries	−0.001 (0.00)	0.757 (4.17)***		0.902 (5.89)***		0.920 (2.43)**		0.381 (3.80)***

(Continued)

TABLE 3. *Continued*

	OLS-1 General model		OLS-2 Parsimonious model		IV-1 Parsimonious model		Larger sample model	
Variable	Openness[a]	Schooling gap[b]	Openness[a]	Schooling gap[b]	Openness[a]	Schooling gap[b]	Openness[a]	Schooling gap[b]
Main destination = EU15	0.154 (−0.38)	0.403 (1.80)*		0.537 (3.01)***		0.614 (−1.59)		
Same language as a selective-immigration country	0.122 (−0.39)	0.154 (−1.63)						0.136 (1.80)*
Constant	11.672 (2.96)***	−0.794 −0.48	10.863 (3.31)***	−1.942 (1.89)*	9.052 (2.56)**	−2.100 (1.84)*	9.849 (2.93)***	−2.431 (2.38)**
Observations	108	108	108	108	108	108	125	123
Adjusted R-squared	0.67	0.88	0.68	0.88	0.69	0.89	0.68	0.89
Overidentification test[c]					0.12	0.13	0.33	0.88
Instrument relevance: *p*-value of *F* statistic					0.000	0.000	0.000	0.000
Exogeneity test[d]					0.07	0.26	0.07	0.27

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

Note: Numbers in parentheses are standard errors. Due to heteroskedasticity, the IV method for the schooling gap equation is a general method of moments estimator. Heteroskedastic-robust standard errors for OLS.

[a]Logistic transformation of the average emigration rate.

[b]Schooling gap in logs.

[c]*p*-value of statistic: Sargan test for the openness and Hansen *J* test for the schooling gap.

[d]Exogeneity test of natives of proportion skill. *p*-value of χ^2: Durbin-Wu-Hausman test for the openness and C-test for the schooling gap. List of instruments: lagged level + public expenditures in primary education (in logs).

Source: Authors' analysis based on data from Docquier and Marfouk (2006).

of variables, but it affects the significance of several variables. Eliminating explanatory variables in the parsimonious models retrieves observations from many countries particularly affected by poverty and political instability.

Model IV-2 is thus preferred for the first equation. Model OLS-2 provides interesting insights for the second equation. All the regressions reveal small values for the variance inflation factor, indicating no real collinearity problem in the regressions.[13]

The empirical analysis confirms that *country size* is a key determinant of openness (see stylized fact 2), but has no effect on the schooling gap. The average emigration rate decreases with population size and is significantly larger in *small island developing countries*. This confirms stylized fact 2.

The level of development has a very strong effect on openness rates and schooling gaps. Although some collinearity is observed between natives' level of schooling, GNI per capita, the oil exporting dummy variable, and the least developed country dummy variable, the variance inflation factor is below the tolerated value. The *proportion of post-secondary-educated natives* is the most robust and best predictor of the degree of openness. In developing countries, the higher natives' level of schooling, the higher is the average rate of emigration. This effect can be explained by the fact that educated people can afford to pay emigration costs (self-selection) and are more likely to be accepted in host countries with selective-immigration policies. Natives' level of schooling has a negative impact on the schooling gap. This is compatible with stylized fact 3. The effect on the schooling gap is quantitatively more important than the effect on openness. A simulation exercise reveals that the marginal impact of natives' human capital on the brain drain is always positive, whatever the country size. The lower the natives' level of schooling, the greater is brain drain. That explains why poor regions such as Sub-Saharan Africa and South Asia suffer from the brain drain. After controlling for human capital, *GNI per capita* has a moderately negative impact on the schooling gap under some specifications. Model IV-2 also reveals that *oil exporting countries* exhibit lower emigration rates. The *least developed country* dummy variable is never significant.

The sociopolitical environment has a significant impact on openness. In all regressions the *religious fractionalization* variable has a positive and significant impact on the schooling gap. As fractionalization often induces conflict in developing countries, this suggests that skilled migrants are more sensitive to ethnic and religious tensions. From model IV-2, average emigration rates are also higher in *politically unstable countries*. Government effectiveness as well as many other variables introduced in alternative specifications did not prove to be significant. Fractionalization and political instability are particularly strong in Sub-Saharan African countries.

13. The strongest co linearity concerns the main destination dummies (EU15 and selective-immigration countries).

Proximity significantly affects openness and the schooling gap. The *geographic distance* between origin countries and major destination regions reduces the emigration rate and augments the schooling gap (also comforming to stylized fact 1, that emigration rates and schooling gaps are negatively correlated). Skilled migrants are less sensitive to distance. Lack of territorial access to the sea and remoteness and isolation from world markets strongly reduce the degree of openness of *landlocked developing countries*. Proximity has a strong impact on the brain drain from Central America, Caribbean and Pacific island countries, and, to a lesser extent, Northern Africa.

Unsurprisingly, being a *former colony* has a positive effect on openness. It has no significant impact on the schooling gap. The effect of colonial links is obtained only in the large samples, but it is highly significant.

Countries that send most of their migrants to *selective-immigration countries* experience stronger schooling gaps. When the *main destination is the EU15*, the effect is positive but less strong and the effect is not significant when the sample size is maximized. The literature on migrants' economic assimilation reveals that migrants get a high return on their language skills. Although Chiswick and Miller (1995) among others found a strong correlation between language skills and the earnings of educated migrants, the effect of linguistic proximity with selective-immigration countries on the brain drain is seldom significant.

IV. Conclusion

The article presents new estimates of the brain drain experienced by developing countries based on a new data set that draws on census and register data collected in all OECD countries. The analysis starts with a simple multiplicative decomposition of the brain drain into two components: degree of openness of sending countries, as measured by average or total emigration rate, and schooling gap, as measured by the relative education level of emigrants compared with natives. The approach based on such a decomposition is justified by the facts that no country has both strong openness and a high schooling gap and that these two variables vary with specific determinants.

The degree of openness is found to increase with country smallness, natives' human capital, political instability, colonial links, and geographic proximity to major OECD countries. The schooling gap depends on natives' human capital, the type of destination countries (with or without selective-immigration programs), distances, and religious fractionalization in the country of origin. Geographic proximity and natives' human capital have ambiguous effects on the brain drain (they increase openness and reduce the schooling gap). On the whole, the brain drain is stronger in countries that are not too distant from OECD countries and where the average level of schooling of natives is low.

Taken together these results increase the understanding of the causes of brain drain. Small islands of the Pacific and the Caribbean clearly suffer from

their smallness and proximity to OECD countries. Proximity is also a key determinant of Central American brain drain. Sub-Saharan African countries combine various disadvantages such as a low level of development, high political instability, and religious and ethnic fractionalization. The brain drain results from multiple possible causes, many of which cannot be affected by public interventions (such as proximity, historical links, country size, and fractionalization). Focusing on areas that can be influenced by public policy, such as promoting education and improving the political climate at origin, could help to reduce the brain drain.

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