WPS4775

POLICY RESEARCH WORKING PAPER 4775

Migration and Education Decisions in a Dynamic General Equilibrium Framework

Sebastien Dessus
Charbel Nahas

The World Bank
Development Economics Vice Presidency
November 2008

Policy Research Working Paper 4775

Abstract

With growing international skilled labor mobility, education and migration decisions have become increasingly inter-related, and potentially have a large impact on the growth trajectories of source countries, through their effects on labor supply, savings, or the cost of education. The authors develop a generic dynamic general equilibrium model to analyze the education-migration nexus in a consistent framework. They use the model as a laboratory to test empirical conditions for the existence of net brain gain, that is, greater domestic accumulation of human capital (in per capita terms) with greater migration of skilled workers. The results suggest that although some structural parameters can favor simultaneously greater human capital accumulation and greater skilled migration—such as high ratio of remittances over domestic incomes, high dependency ratios in migrant households, low dependency ratios in source countries, increasing returns to scale in the education sector, technological transfers and export market access with Diasporas, and efficient financial markets—this does not necessarily mean that greater migration encourages the constitution of greater stocks of human capital in source countries.

This paper—a product of Development Economics Vice Presidency (DEC)—is part of a larger effort in the department to analyze policy-relevant topics rigorously with the best available information to support decision making. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at sdessus@worldbank.org.

Migration and Education Decisions in a Dynamic General Equilibrium Framework

Sebastien Dessus and Charbel Nahas[♦]

Keywords: Migration, Education, Brain Gain, Brain Drain, General Equilibrium Models.

[♦] Sebastien Dessus, Lead Economist, was with the Development Economics Policy Review Unit at the World Bank at the time of submission. Charbel Nahas is consultant (www.charbelnahas.org). The views expressed in this paper do not necessarily reflect those of the World Bank Group, its Executive Directors or the countries they represent. The authors are grateful to J. Lewis and M. Schiff for useful suggestions on a previous draft and F. Bourguignon for initial encouragements to pursue this avenue of research.

Migration and Education Decisions in a Dynamic General Equilibrium Framework

I. Introduction

Following a first wave of interest in the 1970s,[1] the literature on the impact of migration on sending countries was recently revived with the rise of international migration – and related financial flows – in the 1990s of skilled workers in particular[2]. A first branch of the literature[3], using micro data (such as household budget surveys), generally concludes that there is a statistically significant impact of migration and remittances on economic welfare, investment and education. A second branch[4], using global general equilibrium models, underlines the importance of remittances in the newly emerging global finance architecture, and suggests potentially large welfare impacts of lower restrictions on migration flows. A third branch, though, estimating reduced forms on cross-country samples, is more nuanced on the net impact of remittances on economic growth[5].

The empirical literature is nevertheless less abundant when it comes to the analysis of migration and brain drain issues at the country-wide level, where policy decisions are most generally made. Indeed, micro-based approaches cannot capture the macro-economic impact of migration decisions, nor can they consistently assess the interdependency of important macro-economic phenomena influenced by migration and remittances[6]. For instance, while migration possibilities and remittances might affect education decisions at the micro level, they can also simultaneously affect relative prices (e.g, the skill premium, the cost of education, or the real exchange rate) – hence the environment in which micro-economic decisions are being made. Furthermore, micro-based approaches are generally static (often in the absence of panel data), limiting the possibility to assess the long term impact of investment and migration decisions on long term macro-economic or demographic outcomes, which will in turn affect the migration and education decisions of next generations. At the other extreme of the spectrum, global

[1] Bhagwati and Hamada (1974).
[2] Docquier and Marfouk (2006).
[3] See Ozzden and Schiff (2006) for a compilation of contributions on these topics.
[4] World Bank (2006).
[5] See Chami et al. (2008) and Beine et al. (2001).
[6] Throughout this note, remittances are defined as the sum of transfers and capital flows influenced by emigration flows.

models are by nature too general to accurately reflect countries' specific structural characteristics, such as education systems, migration and demographic patterns, exposure to foreign competition or the international mobility of factors. Finally, estimated reduced forms cannot disentangle the different effects at play (not to mention senses of causality), prompting criticism on the meaning and interpretation of the results obtained.[7]

In turn, policy recommendations derived from such studies might suffer from various shortcomings, when envisaging the regulation of migration flows as an instrument of economic development. Symmetrically, general development policies ignoring their likely impact on migration flows could possibly produce sub-optimal outcomes.

Thus, this paper attempts to fill in some ways these gaps, through the building of a generic economy-wide dynamic computable general equilibrium model capturing important migration-related features. In particular, the model allows for endogenous education and migration decisions, the latter also influencing the amount of remittances towards the source country. Another important feature is the consideration of the education sector as a specific sector, producing graduates with skilled labor (teachers). This feature, often overlooked in the literature, could be important if one admits that education decisions are not only based on returns, but also on education costs.

In turn, we use this model over a 25-year period to identify conditions for the existence of net brain gain– i.e., higher domestic accumulation of human capital (in per capita terms) with higher skilled migration. Such gains would be generated through second order effects, namely (i) greater incentives to invest in education (the result of higher returns with higher migration possibilities) and (ii) higher investment capacities with higher remittances.[8] Various factors are theoretically candidates to generate or amplify brain gain: high ratio of remittances over domestic incomes, high dependency ratios in migrant households, low dependency ratios in source countries, increasing returns to scale in the education sector, technological transfers and export market access with Diasporas, and efficient financial markets.

[7] Lucas (2003).
[8] See Mountford (1997) and Beine et al. (2008) on the brain gain literature.

Our results suggest that while certain structural parameters can favor simultaneously domestic human capital accumulation and skilled migration, this should nevertheless not prompt to conclude that higher migration necessarily encourage the constitution of higher stocks of human capital in source countries. Indeed, we cannot find, within the realms of likelihood, any conditions within which a change in migration possibilities alone results in higher net accumulation of human capital. Rather, the combination of high migration and high human capital accumulation patterns are due to third factors, and the conclusions obtained from cross-country analysis[9] should thus be interpreted with caution when used for policy making.

The rest of this paper is organized as follows. Section II describes the model and Section III assesses the impact of various parameters on the likelihood of brain gain. Section IV concludes.

II. Modeling Migration and Education Decisions

To frame the migration-education nexus, we consider a small open economy in which agents make simultaneous decisions on education and migration based on contemporary information and assets. Our variable of interest is the domestic accumulation of human capital per capita, a major – if not the most important - driver of development. As embodied in persons, human capital is assumed to be imperfectly mobile across countries, as is physical capital. The latter is internationally mobile in the form of investment flows, but becomes immobile once installed.

Education investment decisions here refer to those allowing the acquisition of sufficient skills to migrate or fulfill domestic skilled jobs. In our framework, we assume that such decisions concern tertiary education expenditures, which are privately financed by households[10].

In logarithmic approximation, the per capita domestic accumulation of human capital h can be written as:

[9] See Beine et al. (2008) for instance on the empirical impact of migration on human capital accumulation.
[10] Alternatively, such expenditures could be financed by public authorities to respond to citizens needs. Given the fact that our model comprises only one representative household financing the government, this would not make any difference as long as the government reacts to the same signals to make its investment decisions. This is obviously not always or everywhere true, but this political economy dimension goes beyond the scope of this paper and would only complicate the discussion. See Docquier et al. (2008) for a discussion on the interaction between public expenditures in education and migration.

$$h = e - m - n \quad (1)$$

where e is the growth rate in the net supply of skilled workers – the output of the tertiary education system[11], m is the share of skilled workers emigrating, and n the population growth rate. e and m are not independent: e results, for a given production function of the education system, from investments in tertiary education, which are influenced by migration. Indeed, both households' income and investment rate in education (whose multiplication equals investment in tertiary education) react to changes in migration patterns.

Households' incomes are directly influenced by migration through various channels. First order effects include the difference between remittances received from the Diaspora (the cumulated sum of past migrations flows) and foregone domestic incomes from households' members migrating. Second order effects include the macro-economic effects of migration on households' income through changes in relative prices (factors prices, real exchange rate). Further, the share of households' income invested in education also depends on migration, through its effects on (i) the remuneration of human capital and (ii) the cost of education. Higher migration possibilities raise the expected remuneration of skilled labor if migration results from a difference in labor remuneration between domestic and foreign markets (Mountford, 1997). Moreover, if migration is not accompanied with a matching declining domestic demand for skilled labor, the lower supply of skilled labor will raise its relative price. Besides, the cost of education depends to a great extent on the price of its main input, teachers, whose remuneration evolves in line with that of skilled labor.

The population growth rate, n, is obviously not independent from the migration rate m, since the departure of migrant workers and their dependents mechanically diminish the population size.[12]

Thus, Equation (1) can be re-written as:

$$h(m) = e(m) - m - n(m) \quad (2)$$

[11] For the sake of simplicity, we assume that the retirement rate of domestic skilled workers is exogenous.
[12] In the long run, the migration rate also structurally affects the natural rate of growth of the population, through its effect on masculinity and fertility rates, see Annex 2. Our calculations, not reported in the paper, nevertheless suggest that the impact of migration on the natural rate of population growth is not to be felt within the 25-year period of simulation.

so as to reflect the influence of migration on skilled labor supply and population growth rates, and a brain gain would occur if an increase in the migration rate from *m* to *m'* is such that:

$$h(m') > h(m) \quad \text{or equivalently} \quad [e(m') - n(m')] - [e(m) - n(m)] > m' - m \qquad (3)$$

In others words, a brain gain occur if the migration-induced change in the per capita supply of skilled workers growth rate exceeds the change in the migration rate itself. But the response of the former variables to migration is not trivial, as discussed above. Thus, in order to analyze the various interactions between education and migration, we develop a generic general equilibrium (GE) model, and use it as a laboratory to test the impact of various conditions (parameters) on the possibility to generate brain gain.

The CE model developed for this study is a typical dynamic-recursive neoclassical model with endogenous prices, market clearing (on both goods and factors markets), and imperfect substitution between domestic and foreign goods. Its specificity comes from the fact that physical and education investment decisions, migration and related remittances are all treated as endogenous variables. Another important feature is the treatment of the education sector as a specific sector, producing graduates mostly with skilled labor (teachers). Other features of the model are more common to the GE literature, and discussed below in non-mathematical terms. [13]

Sectors' supply is modeled using nested Constant Elasticity of Substitution (CES) functions, which describe the substitution and complement relations among the various inputs. Producers are cost-minimizers and constant return to scale is assumed in all sectors, including education[14]. Output results from two composite goods: intermediate consumption and value added, with low substitution possibility between the two. The intermediate aggregate is obtained by combining all products in fixed proportions. The value-added is decomposed in three substitutable parts: skilled labor, unskilled labor, and capital, all of which are fully employed. The degree of substitutability between these three factors of production is set to unity.[15]

[13] See Beghin et al. (2002) for a mathematical discussion of this class of models.
[14] This assumption is relaxed in the next section, to analyze the impact of increasing returns to scale in the education sector on the possibility of net brain gain.
[15] The production function is therefore similar to a Cobb-Douglas.

Income from labor and capital accrue to the representative household. Households' total disposable income (the sum of factors' incomes and remittances[16] minus direct taxes and social contributions) is allocated to consumption and savings using the Extended Linear Expenditure System (ELES) specification. This specification allows for the existence of incompressible per capita levels of consumption (e.g. basic education for the youth, health education for the elderly) of the different products. In turn, dependency ratios influence households' savings rate: the higher the former, the lower the latter.

Once their total value is determined (see below), government and investment demands are disaggregated into demands for products and services at the sector level according to fixed coefficient functions.[17]

Import demand results from a CES aggregation function of domestic and imported goods. Export supply is symmetrically modeled as a Constant Elasticity of Transformation (CET) function. Producers decide to allocate their output to domestic or foreign markets in response to relative prices. This last rule similarly applies for migration decisions: workers (both skilled and unskilled) arbitrate between the decision to migrate or stay home depending on the differential between real foreign and domestic labor remunerations, with imperfect substitution between the two reflecting preferences and migration costs.

Several macro-economic constraints are introduced in this model:

First, the small country assumption holds: thus, imports and exports prices on world markets are exogenous, as is the foreign remuneration of labor for migrants. Capital flows are endogenous and reactive to the remuneration of aggregate capital (human and physical) over its replacement cost, see below, plus some exogenous trends reflecting the growth in world's savings. Remittances are determined in proportion of the Diaspora's income (with a growth in remunerations abroad set exogenously), and hence the trade balance (exports minus imports) is also endogenous to insure the equilibrium of

[16] Thus, remittances are fully fungible with other sources of income, as not assigned to any particular use.
[17] Typically, government expenditures are constituted of government services (other services), investment expenditures in physical capital of equipment goods (industry) and construction services (other services), while investment expenditures in human capital only comprise education services. The latter, to deliver its services, employs mostly skilled labor (teachers), whose wage bill constitute half of total production costs in the education sector (and 3/5 of its value added). See the Social Accounting Matrix in Annex 1.

the balance of payments.[18] The size of the Diaspora is the sum of cumulated past migration flows, with a depreciation factor reflecting migrants' progressive disconnection with their country of origin.[19]

Second, the model imposes fixed real public expenditures and savings, to reflect the government's choice of delivering a given amount and quality of public services and ability to borrow. Public receipts thus adjust endogenously to achieve the predetermined government net position, through a change in net transfer from households to government.[20]

Third, investment is determined by the availability of savings, the latter originating from households, government and abroad. The model's endogenous growth dynamics results from this closure rule. A change in savings influences accumulation of physical and human capital in the following period. Savings are (myopically) invested in human or physical capital depending on their relative remunerations over replacement costs (respectively the price of education services and investment goods), or Tobin's Q-ratios. The remuneration of human capital retained by agents to make their choice is the average of foreign and domestic remuneration of skilled labor weighted by the migration rate. From a functional standpoint, investment decision is modeled using a CES function, which captures the choice for households to invest either in physical or human capital.

The availability of skilled and unskilled workers at any given period of time is determined by educational investment decisions made in earlier periods and demographic trends. Contemporaneous decisions to migrate eventually determine the supply and use of domestic labor for domestic economic activities. The stock of physical capital is determined by the sum of past investment expenditures, minus some depreciation, through the perpetual inventory method.

[18] Foreign reserves are assumed constant and the nominal exchange rate is the numeraire of the model.
[19] We assume that all migrants – skilled or unskilled - severe ties with their country of origin after 50 years. Although it is likely that skilled workers' remuneration abroad exceeds that of unskilled workers abroad, we assume that the former do not remit more than the latter. Hence the change in the composition of the stock of migrants between skilled and unskilled has no impact on the level of remittances.
[20] In real life, this offsetting mechanism does not exist, and other fiscal instruments must be used such as indirect or direct taxes. But this type of modeling is interesting from an analytical perspective as a net transfer to household is considered to be the less distortionary fiscal instrument. Hence the analysis of any given tax reform is not complicated by the effect of replacing it with another distortionary one.

III. Results

The generic model is used in this section as a laboratory to explore the migration-education nexus in general, and the likelihood for net brain gain in different settings in particular. As a first step, we calibrate the model with parameters describing what could possibly be an 'average' or 'stylized' developing economy. The calibration necessitates three set of parameters: (i) a Social Accounting Matrix (SAM), which portrays the main economic flows between the different agents at one point in time, (ii) some behavioral parameters (such as elasticities of substitution), and (iii) some exogenous variables.

The SAM is reported in Annex 1. It portrays a developing economy which produces agricultural goods, industrial goods, education, and other services, with intermediate inputs, capital, unskilled and skilled labor. All sectors but education are in competition with the rest of the world on both imports and exports markets. Imports exceed exports (40 vs. 32.5 percent of GDP) and the trade balance is financed with remittances (7.5 percent of GDP). The latter goes directly to the representative household, to complement his labor and capital incomes. The household consumes the equivalent of two-thirds of GDP, pays direct taxes (10 percent of GDP), and saves the remainder to invest in physical capital (20 percent of GDP) and tertiary education (2 percent of GDP). One year of tertiary education costs the equivalent of the GDP per capita for each student and one-sixth of the pool of students graduates each year, once accounted for total duration of tertiary studies, repetitions and drop-outs. One-fifth of the cohort aged 15-19 is at the university. The government finances primary and secondary education, for 4 percent of GDP.

The country is in the midst of its demographic transition (a natural growth rate of 2 percent per year and a dependency ratio of 2:5 between active and total populations), and initially records migration rates equivalent to 1 percent of total labor supply (and a bit less than 1 percent of total population, see below). One third of active migrants are skilled workers and the same proportion of skilled workers is to be found in the active Diaspora. The latter, including dependents, represents 7.5 percent of the country's population. Thus, each member of the Diaspora remits the equivalent of the GDP per capita in the source country.

World prices of goods and services stay unchanged throughout the 25-year simulation period, but for skilled workers, who see their real international remuneration increase by 3 percent annually. The physical capital stock is twice the GDP in the first period, and depreciates by 5 percent every year. The initial proportion of skilled workers in labor supply is set to 1:5, and the education premium per year of additional schooling to 10 percent.

Would-be migrants react modestly to changes in relative remunerations between their source country and the rest of the world. A 10 percent increase in the wedge between domestic and foreign remuneration increases the flow of migrants by 2 percent. Agents also react moderately to changes in physical vs. human capital returns over their costs. A 10 percent increase in the wedge between physical and human capital remuneration increases the share of savings invested in physical capital by 5 percentage points. Other behavioral parameters are common for the GE literature.[21]

Baseline simulations

We simulate this stylized economy over a 25-year period (S1). Its GDP grows by 3.4 percent every year. Its population, once accounting for emigration, effectively grows at the average rate of 1.2 percent. Sustained with growing remittances and declining dependency ratios, investments in both physical and human capital grow more rapidly (5.1 and 5.6 percent respectively) than GDP. Workers get more educated and more productive with higher physical capital. The greater supply of skilled workers reduces the skill premium, and thus relative education costs. The share of skilled workers migrating increases (from 2.3 percent initially to 2.7 percent by the end of the 25-year period), though not sufficiently to affect the share of skilled workers staying in the country in proportion of total population, which roughly doubles in 25 years, from 5.5 to 10.0 percent. Therefore, increased migration rates of skilled workers are accompanied in the present setting with a net accumulation of human capital in the source country.

[21] Given the low level of product disaggregation (4 products), elasticities of substitution between domestic and foreign goods are assumed moderate, at 2.0 for both imports and exports. See McDaniel and Balistreri (2003).

Baseline simulation results

Migration Possibilities	Low (S1)	Medium (S2)	High (S3)
Annual growth rates			
Population	1.2%	1.1%	1.1%
Real Gross Domestic Product	3.4%	3.3%	3.2%
Per capita real disposable income	2.7%	2.8%	2.8%
Per capita domestic human capital	2.5%	2.2%	1.8%
Real physical investment	5.1%	5.1%	5.0%
Real educational investment	5.9%	6.0%	6.1%
Labor supply, unskilled	1.1%	1.1%	1.1%
Labor supply, skilled	3.7%	3.4%	3.0%
Wage, unskilled	2.4%	2.4%	2.4%
Wage, skilled	0.0%	0.4%	1.0%
Physical capital remuneration	-1.6%	-1.6%	-1.6%
Educational investment costs	0.1%	0.4%	0.7%
Physical investment costs	0.1%	0.1%	0.2%
Consumer price index	0.1%	0.2%	0.2%
Others			
Proportion of domestic skilled workers after 25 years	10.0%	9.2%	8.4%
Skilled workers migration rate after 25 years	2.7%	4.2%	6.1%
Elasticity of per capita domestic human capital accumulation to skilled migration			-0.54

*Unless otherwise specified. Source: authors' calculations.

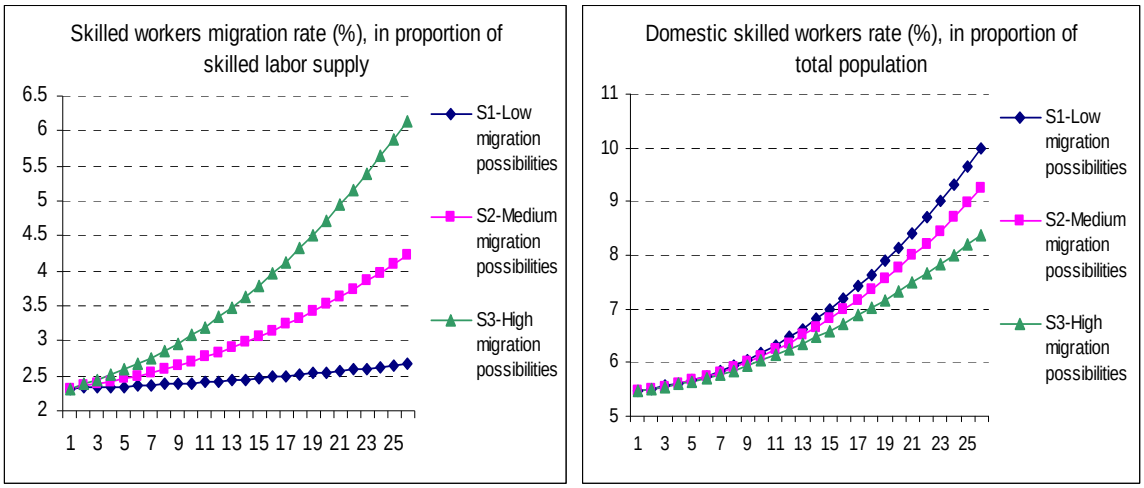
This conjunction of events, which can be very robust as we will see below, does not, however, necessarily reflect a causal relationship from migration to human capital accumulation. This hypothesis is tested by raising, in a second and third simulations (S2, S3) migration possibilities (multiplying the substitution elasticity by 5 and 10, for both skilled and unskilled workers, from 0.2 to 1 and then 2), leaving everything else unchanged. As a result, migration flows grow more rapidly, as do per capita education expenditures under the influence of higher remittances and higher wages for skilled workers. Per capita disposable incomes grow more rapidly as well, and thus increased migration can be considered as welfare improving for both migrants (as pulled by greater income opportunities abroad) and households staying in the country.

But these second-order effects are nevertheless insufficient to offset the direct (first-order effect) loss of skilled workers. A 3.4 percentage point increase in the migration rate results in a 1.6 percentage point decrease in the proportion of skilled workers in the population after 25 years. Another measure of the same phenomenon is the

elasticity of per capita domestic human capital accumulation to the average skilled migration rate which is negative, at -0.5.

Various factors indeed reduce the possibility for net brain gain, including increased education costs (with higher wages for skilled workers), increased dependency ratios (as migrants leave with less dependents), and insufficient increases in savings, which all contribute to make additional education expenditures insufficient to replace foregone skilled workers. As a matter of fact, educating new students to replace skilled workers migrating with higher migration possibilities (S3 vs. S1) would require raising further education expenditure by approximately a third. By the end of the simulation period, this would mean an additional 1 percentage point of GDP to train another 1 percent of the total population.

Chart 1: The simulated impact of increased skilled migration on domestic human capital



Source: authors' calculations.

The results discussed above obviously depend on the choice of initial conditions (SAMs) and behavioral parameters retained. In the next paragraphs, we vary a number of parameters to create the conditions for net brain gain, and discuss the likelihood of such parameters.

These varying parameters are of different nature. Some reflect different "states of the world", or conditions in countries receiving migrants. This is for instance the case for higher remittances per migrant - which could reflect larger income gap between source and destination countries; or higher dependency ratios in migrant households – reflecting more open immigration policies in destination countries; or the capacity of Diaspora to

initiate technology transfers and to provide greater market access for source countries' exports. These different external conditions can also be influenced at the margin by policies: reduction in remittances fees, reunion policies, circular migration agreements or the development of institutional business links between the Diaspora and the source countries. Others reflect a different position of the source country on the path of development and demographic transition. Finally, some reflect different conditions in source countries, education and financial systems in particular (on which policies can have influence), as well as investment behaviors.

Higher Remittances per Diaspora Member

In baseline simulations, initial remittances per Diaspora member equal GDP per capita in the source country (and two-fifth of the GDP per worker in the source country). This amount is also equal to the cost necessary to finance one year of tertiary education per student. As GDP per capita in developed countries is 18 times higher at market exchange rates than that of developing countries (low and middle income countries)[22], this also basically means that each Diaspora member remits 1:18 of its income to his country of origin. In the next simulations (S1r, S2r, S3r), we multiply this amount by 2 (thus, remittances would represent 15 percent of GDP in the initial years of simulation). Indeed, the impact of increased migration on human capital accumulation could possibly be much higher if remittances per migrant were higher. From a policy perspective, such a move could be encouraged by the reduction of remittances fees.[23]

Comparing the new set of simulations S1r, S2r and S3r (where migration possibilities are progressively raised like in the previous section, accounting for higher remittances per migrant) with baseline simulations (S1, S2, and S3) suggest that higher remittances can significantly raise simultaneously incomes, per capita education expenditures and skilled migration rates. But, within this setting, raising possibilities to migrate (comparing S1r with S2r and with S3r) does not lead to a net domestic accumulation of human capital. On the contrary, the proportion of domestic skilled workers in the population declines. Indeed, higher remittances raise households' capacity

[22] See World Bank (2008). The ratios of GDP per capita between high income countries and middle income countries is 1:12, and 1:56 between high income countries and low income countries.
[23] See World Bank (2006) for a discussion of remittance fees and ways to reduce them.

to respond to higher foreign demand for skilled workers as they have the financial ability to invest more in education. In contrast, the domestic demand for skilled labor declines with higher migration possibilities (but in the education sector), as its relative cost increases in comparison with physical capital and unskilled labor. Besides, higher remittances affect export competitiveness through a real exchange rate appreciation and the overall demand for domestic goods and services.

The impact of higher remittances on the likelihood for brain gain

Migration Possibilities	Low (S1r)	Medium (S2r)	High (S3r)
Annual growth rates			
Population	1.2%	1.1%	1.0%
Real Gross Domestic Product	3.9%	3.9%	3.8%
Per capita real disposable income	3.5%	3.6%	3.8%
Per capita domestic human capital	3.5%	3.2%	2.8%
Real physical investment	5.9%	5.9%	6.0%
Real educational investment	6.8%	7.0%	7.2%
Labor supply, unskilled	0.8%	0.7%	0.7%
Labor supply, skilled	4.7%	4.4%	4.0%
Wage, unskilled	3.4%	3.4%	3.5%
Wage, skilled	-0.3%	0.2%	0.8%
Physical capital remuneration	-2.0%	-2.0%	-1.9%
Educational investment costs	0.1%	0.4%	0.8%
Physical investment costs	0.2%	0.3%	0.4%
Consumer price index	0.2%	0.3%	0.4%
Others			
Proportion of domestic skilled workers after 25 years	12.7%	11.8%	10.9%
Skilled workers migration rate after 25 years	2.5%	3.1%	3.9%
Elasticity of per capita domestic human capital accumulation to skilled migration			-0.46

Source: authors' calculations.

Raising further remittances per migrant in proportion of GDP per capita (to a ratio of 4:1 for instance) only marginally affects the picture without changing the overall conclusion. Raising further remittances also becomes questionable from a likelihood perspective. Indeed, at 4 times GDP per capita, migrants from developing to developed countries would broadly remit a quarter of their incomes, and much more if initially originating from middle-income countries. Another possibility for higher remittances is the existence of a much larger initial Diaspora. But it would also induce a lower impact

of migration on additional remittances, as new migration flows would have a lower marginal impact on the size of the Diaspora.

Higher Migrants' Dependency Ratios

In baseline simulations, the dependency ratio of migrant households is assumed lower than the source country average dependency ratio[24]. Indeed, migrants are (in our framework) all active, and migrate before the end of their fertility period. Thus, migration *per se* raises dependency ratios, with a negative impact on per capita incomes and education expenditures. In the next simulations, we equalize migrants' dependency ratios with source country average dependency ratios. Given exogenous demographic trends, households (migrating or not) dependency ratios tend to decline progressively over the 25-year simulation period, from 2.44 to 2.24, mirroring progress achieved on the path of demographic transition. From a policy perspective, equalizing dependency ratios could be favored by family reunion policies.

Comparing the new set of simulations S1d, S2d and S3d (where migration possibilities are progressively raised like in the previous sections, accounting for higher migrants' dependency ratios) with baseline simulations (S1, S2, and S3) suggest that higher dependency ratios in migrants' households marginally favor the per capita domestic accumulation of human capital. But, within this setting, raising possibilities to migrate (comparing S1m with S2m and with S3m) does not lead to a net domestic accumulation of human capital. While higher migrants' dependency ratios increase per capita human capital levels, they do not affect the response of domestic human capital accumulation to increased migration possibilities. This is notably reflected in the fact that elasticities of domestic human capital accumulation with respect to skilled migration remain basically unchanged compared with baseline simulations.

[24] Migrants' dependency ratios (total over active population) stand at 1.8 in initial years, against 2.4 for non-migrant households. In other words, migrant couples have 1.6 children when leaving the country, against 2.8 children for couples staying in the country at the end of their period of fertility.

The impact of higher migrants' dependency ratios on the likelihood for brain gain

Migration Possibilities	Low (S1d)	Medium (S2d)	High (S3d)
Annual growth rates			
Population	0.9%	0.8%	0.7%
Real Gross Domestic Product	3.5%	3.4%	3.3%
Per capita real disposable income	3.1%	3.2%	3.2%
Per capita domestic human capital	2.9%	2.6%	2.2%
Real physical investment	5.2%	5.2%	5.2%
Real educational investment	6.1%	6.2%	6.3%
Labor supply, unskilled	1.1%	1.1%	1.0%
Labor supply, skilled	3.8%	3.5%	3.1%
Wage, unskilled	2.4%	2.4%	2.4%
Wage, skilled	-0.1%	0.4%	0.9%
Physical capital remuneration	-1.7%	-1.7%	-1.7%
Educational investment costs	0.1%	0.4%	0.6%
Physical investment costs	0.1%	0.1%	0.2%
Consumer price index	0.1%	0.2%	0.2%
Others			
Proportion of domestic skilled workers after 25 years	11.0%	10.3%	9.4%
Skilled workers migration rate after 25 years	2.5%	3.1%	3.8%
Elasticity of per capita domestic human capital accumulation to skilled migration			-0.48

Source: authors' calculations.

Raising further the dependency ratio of migrant families – that is, beyond the source country average – could be theoretically envisaged. Yet, within reasonable limits, results suggest that higher dependency ratios in migrant families would only marginally improve the response of domestic human capital accumulation to migration, without changing its sign.

Lower Dependency Ratios in the Source Country

Net brain gain is predicated on the possibility for residents to invest more in education, in response to better incentives (higher return on education) and higher savings with remittances. Such a propensity to invest depends in turn on the share of disposable income which is not allocated to incompressible consumption, and thus on the dependency ratio: the lower this ratio, the higher the propensity to reap emerging investment opportunities in human capital.

In the next simulations, we advance further the position of our average economy on the path of demographic transition (see Annex 2). As such, dependency ratios are

lower (starting at 2.15, against 2.44 in baseline simulations), and slowly increase over the simulation period as the country is aging. As more advanced in its demographic transition, the population also grows naturally less rapidly. For similar educational investments (in proportion of GDP), the country is able to educate a larger share of its population, given lower demographic pressures.

Thus, comparing the new set of simulations S1a, S2a and S3a (where migration possibilities are progressively raised like in the previous sections, accounting for lower dependency ratios) with baseline simulations (S1, S2, and S3) suggest that advanced demographic transition favors both domestic accumulation of human capital and skilled migration. But here again, we can observe that higher migration possibilities (comparing S1a with S2a and S3a) tend to affect negatively the domestic accumulation of domestic capital. Compared with baseline simulations, the response of educational investment to skilled wages is slightly higher, yet far from sufficient to offset the loss of skilled workers migrating.

The impact of lower dependency ratios on the likelihood for brain gain

Migration Possibilities	Low (S1a)	Medium (S2a)	High (S3a)
Annual growth rates			
Population	-0.7%	-0.9%	-1.0%
Real Gross Domestic Product	1.8%	1.7%	1.6%
Per capita real disposable income	3.3%	3.4%	3.5%
Per capita domestic human capital	3.5%	3.1%	2.6%
Real physical investment	3.8%	3.8%	3.7%
Real educational investment	4.9%	5.0%	5.2%
Labor supply, unskilled	-1.9%	-1.9%	-2.0%
Labor supply, skilled	2.8%	2.3%	1.8%
Wage, unskilled	3.9%	3.9%	3.9%
Wage, skilled	-0.6%	0.1%	0.9%
Physical capital remuneration	-2.4%	-2.4%	-2.4%
Educational investment costs	0.0%	0.4%	0.8%
Physical investment costs	0.2%	0.3%	0.3%
Consumer price index	0.2%	0.3%	0.4%
Others			
Proportion of domestic skilled workers after 25 years	14.4%	13.0%	11.6%
Skilled workers migration rate after 25 years	2.8%	3.6%	4.6%
Elasticity of per capita domestic human capital accumulation to skilled migration			-0.50

Source: authors' calculations.

Increasing Returns to Scale in the Education Sector

One underlying theoretical condition often retained to justify the existence of net brain gain is the existence of increasing returns to scale in the education sector. Indeed, increased migration possibilities can be seen as a substitute to direct subsidies to reap the latent positive externalities stemming from a larger pool stock of human capital in the country and in the education sector (Stark and Wang, 2002).

In baseline simulations, constant returns to scale are assumed in all sectors of production, including education services. In other words, doubling education expenditures doubles the number of students graduating. We relax this assumption in the next paragraphs by assuming that doubling education expenditures would triple the number of students graduating. Thus, marginal costs of education are decreasing and higher migration possibilities could favor the emergence of net brain gain.

Comparing the new set of simulations S1e, S2e and S3e (where migration possibilities are progressively raised like in the previous sections, accounting for increasing returns to scale in education) with baseline simulations S1, S2 and S3 suggest that decreasing education costs significantly encourage the domestic accumulation of human capital, as well as the proportion of skilled workers migrating. But, within this setting, raising possibilities to migrate (comparing S1e with S2e and with S3e) does not lead to a net domestic accumulation of human capital, even if the likelihood of net brain gain slightly increases in comparison with baseline simulations (as reflected with higher elasticities). Indeed, productivity gains in the education sector allow producing more graduates with less teachers, thus exerting a strong downward pressure on skilled wages, as the local demand for skilled workers does not increase in similar proportions. Such a pressure is relieved with greater migration possibilities, for a significantly negative net result on the domestic accumulation of human capital.

The impact of increasing returns in education on the likelihood for brain gain

Migration Possibilities	Low (S1e)	Medium (S2e)	High (S3e)
Annual growth rates			
Population	1.2%	1.0%	0.9%
Real Gross Domestic Product	3.5%	3.4%	3.2%
Per capita real disposable income	2.9%	3.0%	3.2%
Per capita domestic human capital	4.1%	3.7%	3.2%
Real physical investment	5.3%	5.3%	5.3%
Real educational investment	5.8%	6.0%	6.2%
Labor supply, unskilled	0.5%	0.4%	0.3%
Labor supply, skilled	5.3%	4.9%	4.3%
Wage, unskilled	3.0%	3.1%	3.2%
Wage, skilled	-1.8%	-1.1%	-0.3%
Physical capital remuneration	-1.7%	-1.7%	-1.7%
Educational investment costs	-0.6%	-0.3%	0.2%
Physical investment costs	0.1%	0.2%	0.3%
Consumer price index	0.1%	0.2%	0.3%
Others			
Proportion of domestic skilled workers after 25 years	14.7%	13.4%	11.8%
Skilled workers migration rate after 25 years	2.5%	3.5%	4.9%
Elasticity of per capita domestic human capital accumulation to skilled migration			-0.40

Source: authors' calculations.

Technological Transfers and Export Market Access with Diasporas

The literature on migration underlines the likely influence of Diasporas to facilitate the transfer of technologies to the source country and develop export markets abroad (see Kapur, 2001). Indeed, the presence of skilled migrants abroad can facilitate the identification of technological and business opportunities.

This mechanism is considered in the next simulations, where we let the price of imported equipment goods (in which new technologies are embodied), and the export price at which the source country can sell its product abroad respectively decline and increase with a larger Diaspora of skilled workers.

Comparing the new set of simulations S1t, S2t and S3t (where migration possibilities are progressively raised like in the previous sections, accounting for the impact of Diasporas on the terms of trade) with baseline simulations S1, S2 and S3 suggest that the influence of skilled Diasporas on the terms of trade significantly encourage the domestic accumulation of human capital, while it reduces migration

pressures. Technological transfers and greater access to export markets indeed improve domestic business opportunities and raise the demand for skilled workers locally. Yet, within this setting, raising possibilities to migrate (comparing S1t with S2t and with S3t) does not lead to a net domestic accumulation of human capital.

The impact of Diaspora on the likelihood for brain gain

Migration Possibilities	Low (S1t)	Medium (S2t)	High (S3t)
Annual growth rates			
Population	1.2%	1.2%	1.1%
Real Gross Domestic Product	3.6%	3.6%	3.5%
Per capita real disposable income	3.2%	3.3%	3.4%
Per capita domestic human capital	2.7%	2.5%	2.2%
Real physical investment	5.7%	5.8%	5.8%
Real educational investment	6.5%	6.6%	6.7%
Labor supply, unskilled	1.0%	1.0%	1.0%
Labor supply, skilled	4.0%	3.7%	3.4%
Wage, unskilled	3.0%	3.1%	3.2%
Wage, skilled	0.3%	0.8%	1.3%
Physical capital remuneration	-1.4%	-1.4%	-1.3%
Educational investment costs	0.5%	0.8%	1.0%
Physical investment costs	0.1%	0.2%	0.2%
Consumer price index	0.2%	0.3%	0.3%
Others			
Proportion of domestic skilled workers after 25 years	10.7%	10.1%	9.4%
Skilled workers migration rate after 25 years	2.4%	3.0%	3.6%
Elasticity of per capita domestic human capital accumulation to skilled migration			-0.48

Source: authors' calculations.

Could this mechanism be pushed further to generate net brain gain? In the previous simulations, we assumed that a 10 percent increase in the size of the Diaspora would lead to a 1 percent change in the prices of imports and exports faced by the source country. This in turn means that raising migration possibilities (from S1e to S3e) would induce an increase (decrease) of 3 percent in the price of exports (imports) for a Diaspora 30 percent higher after 25 years. Interestingly, pushing further this mechanism (using elasticities 3 times higher for the response of technological transfers to the diaspora size) lowers elasticities of domestic human capital accumulation to skilled migration by a

quarter, yet quite insufficiently to generate net brain gain. Furthermore, it induces unrealistically high terms of trade gains for a small change in skilled migration.[25]

Greater Financial Market Efficiency

Another important dimension in the brain gain literature is the existence of financial constraints – or imperfect financial markets – preventing agents to meet the investment opportunities they identify (Beine et al. 2008). This concerns notably education investments in response to emerging migration possibilities.

In the next simulations, we relax this constraint by raising by 4 (from 0.5 to 2) the elasticity of substitution between investment types (physical vs. human capital), depending on remunerations over replacement costs. As such, we analyze here the impact of a first order effect, i.e. the direct response of education expenditures to changes in the remuneration of human capital.

Comparing the new set of simulations S1f, S2f and S3f (where migration possibilities are progressively raised like in the previous sections, accounting for more efficient financial markets) with baseline simulations S1, S2 and S3 suggest that the improved savings' allocative efficiency significantly encourage the domestic accumulation of human capital, as well as the migration of skilled workers. But again, within this setting, raising the possibilities to migrate (comparing S1f with S2f and with S3f) does not lead to a net domestic accumulation of human capital, even if the net brain loss is slightly lower than in baseline simulations. This is reflected in higher (but still negative) elasticities of domestic human capital accumulation with respect to skilled migration, at -0.31.

[25] For instance, with elasticities set at 0.3, an increase in skilled migration rates from 2.6 to 4.5 percent already generates a 13 percent gain in the terms of trade. Such a gain is equivalent to 6.5 percent of GDP. In comparison, higher remittances with higher skilled migration generate a gain of less than 2 percent.

The impact of efficient financial markets on the likelihood for brain gain

Migration Possibilities	Low (S1f)	Medium (S2f)	High (S3f)
Annual growth rates			
Population	1.2%	1.1%	0.9%
Real Gross Domestic Product	3.4%	3.2%	3.1%
Per capita real disposable income	2.7%	2.8%	2.9%
Per capita domestic human capital	3.4%	3.2%	2.8%
Real physical investment	4.9%	4.8%	4.7%
Real educational investment	7.2%	7.6%	8.2%
Labor supply, unskilled	0.8%	0.7%	0.6%
Labor supply, skilled	4.6%	4.4%	4.0%
Wage, unskilled	2.6%	2.7%	2.8%
Wage, skilled	-0.9%	-0.4%	0.2%
Physical capital remuneration	-1.5%	-1.5%	-1.5%
Educational investment costs	-0.3%	0.0%	0.4%
Physical investment costs	0.1%	0.2%	0.3%
Consumer price index	0.1%	0.2%	0.3%
Others			
Proportion of domestic skilled workers after 25 years	12.5%	11.8%	10.8%
Skilled workers migration rate after 25 years	2.5%	3.3%	4.5%
Elasticity of per capita domestic human capital accumulation to skilled migration			-0.31

Source: authors' calculations.

Naturally, given its first order nature, pushing further this mechanism ends up generating net brain gain when the elasticity of substitution between investment types exceeds 5 - that is, when a 10 percent increase in the relative remuneration of education over physical investment generates a 50 percent increase in education expenditures. This is indeed the amount required to compensate the departure of skilled migrants with new students, as discussed with baseline simulations[26].

Is this realistic to envisage such a case? Probably not, given the inertia observed in the allocation of savings across investment types. On the one hand, young students are typically discriminated on developing countries' financial markets (given their lack of collaterals), which casts doubts on the eagerness of banks to sharply increase tuition credits when the increase in skilled workers remuneration is associated with much higher migration (as it further lowers possibility for banks to recover their loans). On the other

[26] The remuneration of skilled labor over its cost is 10 percent higher in S3 than in S1. And a 50 percent increase in education expenditure was estimated to be required to compensate for the drain of skilled workers.

hand, if financed through public subsidies, college tuitions will also be at risk with higher migration, as the tax basis (GDP and imports) shrink with lower populations - thus the difficulty for the government to sharply increase public tertiary education expenditures when migration accelerates.

IV. Conclusion

Our laboratory investigation gives little support to the view that second order effects could realistically compensate the (first order effect) loss of skilled workers migrating, as far as domestic human capital is concerned. Indeed, greater incentives and financial capacity to invest in education are likely to be insufficient to replace foregone skilled workers. The (mere) evidence of net brain drain recorded in some countries[27] is not likely to find its origin in general equilibrium effects, unless these effects materialize under extreme settings or behaviors. One of them stems from an extremely large response of human capital investment to its remuneration, probably mirroring myopic or risk prone investment behaviors. Furthermore, there possibly exist other second-order effects which could reduce the likelihood of brain gain: increased education costs with higher skilled wages; reduced domestic demand for skilled workers with the appreciation of the real exchange rate.

As such, increasing skilled migration possibilities alone is not likely to encourage higher accumulation of domestic human capital, even if it raises per capita incomes in source countries. But several complementary actions can be considered to improve the impact of skilled migration on the domestic accumulation of human capital, including in particular the mobilization of network economies with the Diaspora, the reduction of remittance fees, reunion family policies, the guarantee of college tuition loans, and education subsidies to generate initial economies of scale in the education sector.

[27] Chand and Clemens (2008) using treatment groups methods, observe the existence of net brain gain in Fiji.

References

Bhagwati, J. and K. Hamada (1974), "The Brain Drain, International Integration of Markets for Professionals and Unemployment: A Theoretical Analysis", Journal of Development Economics, Vol. 1, 19-42.

Beghin, J., S. Dessus, D. Roland Holst and D. van der Mensbrugghe (2002), "Empirical Modelling of Trade and the Environment", in Beghin, Roland Holst and van der Mensbrugghe (eds.), Trade and the Environment in General Equilibrium: Evidence from Developing Countries, Kluwer Academic Publishers, Boston.

Beine, M., F. Docquier and H. Rapoport (2001), "Brain Drain and Economic Growth: Theory and Evidence", Journal of Development Economics, 64 (1), 275-89.

Beine, M., F. Docquier and H. Rapoport (2008), "Brain Drain and Human Capital Formation in Developing Countries: Winners and Losers", Economic Journal, 118, 631-652.

Chami, R., A. Barajas, T. Cosimano, C. Fullenkamp, M. Gapen and P. Montiel (2008), "Macroeconomic Consequences of Remittances", Ocasional Paper 259, International Monetary Fund, Washington D.C.

Chand, S. and M. Clemens (2008), ""Skilled Emigration and Sill Creation: A Quasi-Experiment", Working Paper 152, Center for Global Development, Washington D.C.

Docquier, F. and A. Marfouk (2006), "International Migration by Education Attainment", in Ozzden and Schiff (eds.), International Migration, Remittances and the Brain Drain, The World Bank, Washington DC.

Docquier, F., O. Faye, and P. Pestieau (2008), "Is migration a good substitute for education subsidies?", Journal of Development Economics (2008), 86, 263-276.

Faini, R. (2007), "Remittances and the Brain Drain: Do More Skilled Migrants Remit More?", The World Bank Economic Review, Vol. 21 (2), 177-92.

Kapur, D. (2001), "Diasporas and Technology Transfer", Journal of Human Development, 2 (2): 265-86.

Lucas, R. (2005), "International Migration and Economic Development", Edward Elgar Publishing, Cheltenham Glos.

McDaniel, C. and E. Balistreri (2003), “A review of Armington trade substitution elasticities”, Economie Internationale, 94-95, 301-313.

Mountford, A. (1997), “Can a Brain Drain be Good For Growth in the Source Economy?”, Journal of Development Economics, 53 (2), 287-303.

Ozzden C. and M. Schiff (2006), International Migration, Remittances and the Brain Drain, The World Bank, Washington DC.

World Bank (2006), Global Economic Prospects: Economic Implications of Remittances and Migration, Washington D.C.

World Bank (2008), World Development Indicators, Washington D.C.

Annex 1. The Stylized Social Accounting Matrix

The SAM below portrays an imaginary "average" developing economy, with a GDP at market price equal to 100. Thus, its various cells can be interpreted as proportions of GDP. For instance, imports of manufactures (before tariffs) represent 35.7 percent of GDP.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Agriculture	1.0	8.0	0.1	0.0				5.7	0.0		0.0	0.0		3.1
2	Manufactures	1.2	27.2	24.8	0.0				32.5	0.0		13.0	0.0		13.2
3	Other Services	5.1	20.0	13.6	1.0				23.2	20.0		7.0	0.0		16.2
4	Education	0.0	0.0	0.0	0.0				4.0	0.0		0.0	2.0		0.0
5	Unskilled labor	3.1	6.0	25.1	1.0										
6	Skilled labor	0.1	1.1	10.3	3.0										
7	Capital	3.8	8.7	30.8	1.0										
8	Household					35.2	14.4	40.4							7.5
9	Government	0.1	0.9	0.6	0.0	0.0	0.0	3.9	10.0					4.4	
10	Savings								22.0	-14.0					5.0
11	Physical investment										20.0				
12	Education investment										2.0				
13	Tariffs	0.2	4.3	0.0	0.0										
14	Rest of the World	3.4	35.7	0.9	0.0					5.0					

Source: authors' calculations.

Annex 2. Migration and Demographic Patterns

Beyond its direct effects on the size of the population, migration has long lasting indirect effects on the demographic dynamics, through changes in the age and gender structure that impact birth and mortality rates.

Their magnitude depends both on the demographic structure of migrants (in and out migration, sex and age composition but also types of migration opposing permanent to temporary) and on the size of net migration flows in relation to the intensity of the domestic demographic dynamics.

A simple demographic model was thus developed to account for these effects. In a long term perspective, the effects of migration add to (and interfere with) the demographic transition. Two main parameters have been retained to reflect such an interaction: the position of the "demographic cursor" with respect to the demographic transition and the intensity of migration.

These two variables are, to a large extent, independent: the demographic cursor commands fertility and mortality rates for the concerned age and gender categories, while migration affects the percentage of individuals leaving (on a net basis) the country within each age and gender category. The age and gender characteristics retained for migrants focused on young, predominantly male migrants and the parameter "migration" was taken as a simple percentage of the basic pattern. The pace of the demographic transition was aligned with the median scenario of the UN population statistics database and values range from 0 to 1. The initial and final age structures for the population used in the model are presented below:

Demographic Patterns in Different Simulations

	Baseline Simulations	*Lower Dependency Ratios*
Emigration rate for the workforce	1.00%	1.00%
Demographic transition cursor (0% to 100%)	10%	75%
Total emigration rate	0.49%	0.56%
Natural rate of population growth	2.00%	0.26%
Post migration rate of population growth	1.51%	-0.30%
Natural rate of growth for the 15-64	2.01%	0.90%
End of period share of 15-64	64.6%	62.3%
Initial Share of 15-64 years	57.1%	65.4%
Ratio active/dependent for the migrants	118.0%	128.9%
Ratio active/dependent for the residents	90.4%	96.6%

Source: authors' calculations.