Global competition for attracting talents and the world economy

F. Docquier and J. Machado

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Frédéric Docquier [a,b] & Joël Machado [a]

[a] IRES, Université Catholique de Louvain

[b] National Fund for Scientific Research (FNRS)

Abstract: This paper studies the effect of liberalizing the international mobility of college-educated workers on the world economy. First, we combine data on effective and desired migration to identify the net pool of foreign talents (NPFT) of selected high-income countries. So far, the EU15 has poorly benefited from its NPFT while the US has mobilized a large portion of it. Second, we use a micro-founded model to simulate the effects of skill-selective liberalization shocks. In our benchmark model, a worldwide liberalization induces larger long-run income gains for the EU15 (+8.8 percent) than for the US (+5.9 percent). However, less attractive EU countries such as Austria, Belgium, Germany, Greece, Luxembourg and the Netherlands benefit less than the US. In addition, liberalizing high-skilled migration decreases income per worker by 2.5 percent in developing countries. Overall, it increases efficiency (+6.2 percent in the worldwide average level of income per capita) and inequality (+1.2 percentage points in the Theil inequality index). Much greater effects can be obtained if total factor productivity varies with human capital.

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1 Introduction

Two salient features of international labor mobility are that high-skilled people exhibit much greater propensity to emigrate than the less educated, and tend to agglomerate in countries with high rewards to skill (Grogger and Hanson, 2011; Docquier and Rapoport, 2012). Positive selection is due to migrants' self-selection (high-skilled people being more responsive to economic opportunities and political conditions abroad, having more transferable skills, having greater ability to gather information or finance emigration costs, etc.), and to the skill-selective immigration policies conducted in the major destination countries. The global competition to attract talents is tough because inflows of high-skilled workers make immigration not only economically more advantageous, but also politically acceptable in destination countries. The reasons are that high-skilled workers bring valuable knowledge which is key to stimulate productivity levels and growth (Peri *et al.*, 2013; Peri, 2012), do not compete with nationals for the welfare state and other public services (Chojnicki, 2011), integrate faster in the labor market (Miller and Neo, 1997; Amuedo-Dorantes and de la Rica, 2007) and assimilate better in the society (Dustmann, 1996; de Palo *et al.*, 2006). So far, the US has been leading the race, attracting PhD candidates and graduates not only from emerging countries, but also from the fifteen members of the European Union (EU15) and other industrialized countries.

There are good reasons to believe that the race to attract talents will get tougher in the coming decades. Intensification will be due to skill-biased technical changes and growing specialization of developed countries in skill-intensive activities, short supply of knowledge and entrepreneurial skills (translating into greater returns to skill and income inequality), aging and the resulting pressure on the welfare states. A growing number of countries have already adopted immigration policies specifically aimed at selecting and attracting high-skilled workers (see Boeri *et al.*, 2012). Examples are the recent introduction of a points-based system in the UK (the Swiss, Dutch and German governments are considering the same option), the new immigration act of 2005 in Germany, the adoption of the EU blue card and the increase in the number of H1B visas in the US. This paper investigates the effects of an increased competition to attract talents on the world economy. We assess its impact on the worldwide supply of human capital and its geographic distribution. We also quantify the short- and long-run impacts on the worldwide average level of income per capita and income inequality are analyzed.

In Section 2, we combine bilateral data on effective and desiring migrants by education level. Effective migrants are those who have already migrated. Desiring migrants are those who have not yet migrated but express the willingness to do so. Adding effective and desiring migrants gives the number of potential migrants. For each country pair, we define the Net Pool of Foreign Talents (NPFT) as the difference between potential entries and potential exits of college-educated workers (i.e. potential immigrants minus potential emigrants). The NPFT is computed at the current economic conditions and can be positive or negative. Expressed as percentage of the college-educated native labor force, the relative NPFT is considered as a measure of the country's attractiveness for human capital. We compute the (absolute and relative) NPFT of selected high-income countries. We show that the EU15 has a large NPFT, although this pool is relatively smaller than the US or Canadian ones. This reflects the fact that Europe is economically less attractive than the US for the highly educated (due to lower skill premium, higher tax rates, etc.). So far, the EU15 has poorly benefited from its NPFT, partly because European immigration policies have been less selective. On the contrary, the US has mobilized a large portion of it.

We then use a micro-founded model to simulate the effects of a worldwide liberalization of high-skilled migration, also referred to as an increased competition to attract talents henceforth. Section 3 provides a non-technical description of the model. The model accounts for the key interactions between human capital accumulation and migration. In particular, the increased competition for attracting talents affects the returns to schooling and education decisions in the world by changing expectations about future migration opportunities. This link between emigration prospects and human capital formation has been identified in the recent literature. Identification strategies rely on survey data on the student population[1], regional heterogeneity in emigration and education patterns[2], quasi-natural emigration shocks[3], or cross-country regressions. All these studies concur that education decisions are closely connected with the intensity of skill-selection in emigration.[4] Our model is parametrized to match the characteristics of the world economy in the year 2000 and to be compatible with official demographic forecasts.

Short-run and long-run effects of various liberalization experiments are presented in Section 4. Overall, a worldwide liberalization of high-skilled migration benefits high-income countries and adversely affects developing countries. It reduces the average income gap between the EU15 and the US. However, the European gains are unevenly distributed: less attractive countries (i.e. countries with smaller relative NPFT) such as Austria, Belgium, Germany, Greece, Luxembourg and the Netherlands benefit less than the US, Canada or

[1]See Gibson and McKenzie (2011) on Tonga and Papua New Guinea or Kangasniemi *et al.* (2007) on medical doctors in the UK.

[2]See Batista *et al.* (2012) on Cape Verde, McKenzie and Rapoport (2011) on Mexico, or Ha *et al.* (2009) on China.

[3]See Chand and Clemens (2008) on Fiji, Shrestha (2013) on Nepal, or Vasilakis (2014) on European football.

[4]See Beine *et al.* (2008), Docquier *et al.* (2008), Easterly and Nyarko (2009), or Beine *et al.* (2011).

Australia. In developing countries, skill-biased emigration prospects stimulate investments in higher education. However, this incentive mechanism is too small to induce a net brain gain. Hence, human capital and income per worker decrease in poor countries. Emigrants are the main beneficiaries of a liberalization policy as shown by a rise in the income per natural in developing regions. Thus, the emigrants' income gains exceed the losses for those left behind in poor countries. Increasing the race to attract talents increases inequality in economic performance, especially if total factor productivity varies with human capital.

2 Potential migration of college graduates

There are several databases documenting the size and structure of effective migration stocks by education level, country of birth and country of destination. In the last decade, there were 111.6 million adult migrants in the world. This included 26 million of college graduates, a vast majority of whom were residing in rich countries (see Artuç *et al.*, 2014). Table 1 documents net immigration stocks (i.e. entries minus exits) of college graduates in EU15 countries, the US, Australia and Canada. They include intra-EU movements, although the latter cancel out at the aggregate EU15 level.

The first two columns of Table 1 show that migration increased the number of college graduates in the United States (+11.6 percent), Canada (+25.8 percent) and Australia (+51.9 percent) in the last decade. On the contrary, the EU15 attracted fewer college-educated immigrants and was unable to retain its own talents. The EU15 exhibited a net deficit of 0.571 million workers, representing 1.0 percent of the college-educated labor force born in Europe. In relative terms, the largest losses were observed in Ireland (-20.8 percent), Portugal (-12.7 percent) and Greece (-8.9 percent). On the contrary, net inflows of college graduates were observed in Luxembourg (+19.8 percent), Sweden (+6.8 percent) and the Netherlands (+4.9 percent).

In parallel, the unique and largely understudied Gallup database identifies the proportion and the characteristics of people who had not yet migrated and expressed a desire to leave their country of birth in the last decade. Around 274.5 million adult workers wanted to leave their country permanently if they were given the opportunity, including 68.1 million college graduates. There are good reasons to believe that "having the opportunity" has not been closely interpreted as "being granted a visa" by many respondents (see Docquier *et al.*, 2014b). However, we consider the desired migration stocks, taken at face value, as upper-bounds of the demographic shock that a complete liberalization of high-skilled migration could induce. Columns 3 and 4 in Table 1 show that letting all *desiring* migrants emigrate would have attenuated human capital disparities between the EU15 and the US in the

2000's, increasing the number of college graduates by 10.2 percent in Europe and 6.2 percent in the US. Net desired migration is positive in the vast majority of high-income countries, implying that the stock of desiring college-educated immigrants exceeds the stock of desiring emigrants. An exception in our sample is Luxembourg, which is rarely reported as a preferred destination by desiring migrants in the Gallup database. In relative terms, the preferred EU15 destinations are Scandinavian countries, Spain, Ireland and France. On the contrary, net desired migration is lower in countries such as Germany, Italy, Belgium or Portugal. These countries either attract fewer desiring immigrants or have more desiring emigrants. Larger levels are obtained for Canada (57.5 percent) and Australia (123.1 percent).

Potential migration is the sum of effective and desiring migrants. Adding up the net stocks of effective and desiring migrants, we identify the Net Pool of Foreign Talents (NPFT) of each country. The NPFT is defined as the difference between potential entries and potential exits of college-educated workers (see column 5). We use it as a proxy for the partial-equilibrium change in human capital that would be induced by a worldwide, skill-selective liberalization of labor mobility. The NPFT is positive in the majority of high-income countries, implying that the stock of potential college-educated immigrants exceeds the stock of potential emigrants. Dividing the NPFT by the college-educated, native-born labor force, we obtain the relative NPFT and consider it as a measure of the country's attractiveness for human capital. Columns 5 and 6 in Table 1 show that overall, the EU15 is less attractive than the United States, and much less than Canada and Australia. Compared to the autarkic (no-migration) situation, letting all potential high-skilled migrants move would have increased the college-educated workforce by 17.8 percent in the US and by 9.3 percent in the EU15 in the last decade. However, the EU15 has not yet mobilized its potential pool of talents, contrary to the US which has attracted about two thirds of it.

Table 1: Net immigration stocks and NPFT in selected countries (2000's)

Country	Net effective migration		Net desired migration		Net Pool of Foreign Talents	
	Absolute	Relative	Absolute	Relative	Absolute	Relative
Austria	-40,528	-3.1%	128,646	+9.8%	88,117	+6.7%
Belgium	50,720	+2.6%	48,112	+2.5%	98,831	+5.1%
Denmark	-31,649	-3.8%	111,272	+13.3%	79,623	+9.5%
Finland	-54,206	-5.5%	218,774	+22.0%	164,568	+16.6%
France	232,408	+2.5%	1,157,422	+12.2%	1,389,830	+14.7%
Germany	-32,884	-0.2%	856,931	+5.6%	824,047	+5.3%
Greece	-113,817	-8.9%	120,153	+9.4%	6,336	+0.5%
Ireland	-120,321	-20.8%	80,386	+13.9%	-39,935	-6.9%
Italy	-289,039	-3.6%	529,638	+6.6%	240,599	+3.0%
Luxembourg	13,746	+19.8%	-2,531	-3.7%	11,215	+16.2%
Netherlands	114,907	+4.9%	180,212	+7.8%	295,119	+12.7%
Portugal	-132,344	-12.7%	50,891	+4.9%	-81,453	-7.8%
Spain	101,970	+2.4%	1,118,610	+26.1%	1,220,581	+28.5%
Sweden	108,164	+6.8%	484,657	+30.3%	592,821	+37.0%
UK	-378,139	-4.5%	807,729	+9.7%	429,590	+5.1%
Total EU15	-571,011	-1.0%	5,890,901	+10.2%	5,319,890	+9.3%
Australia	1,440,055	+51.9%	3,415,750	+123.1%	4,855,805	+175.0%
Canada	2,182,516	+25.8%	4,870,447	+57.5%	7,052,963	+83.3%
USA	9,784,006	+11.6%	5,227,830	+6.2%	15,011,836	+17.8%
Total 18	12,835,556	+8.4%	19,404,928	+12.7%	32,240,493	+21.0%

Notes: 'Net effective migration' = Effective entries minus exits of college graduates, based on the 2000 migration stock data of Artuç *et al.* (2014). 'Net desired migration' = Desired entries minus exits of college graduates, based on the desired migration stock data of Docquier *et al.* (2014a). 'Net Pool of Foreign Talents' = Difference between potential (i.e. effective plus desired) entries and exits of college-educated workers. Absolute measures are net stocks of individuals aged 25 and over. Relative measures are expressed as percentage of the native-born, college-educated population aged 25 and over.

3 A world economy model

To predict the effects of an intensification of the race for attracting talents on the world economy, we use a model that accounts for the behavioral and technological responses to migration policy reforms. Our model encompasses three channels of transmission of migration shocks. First, as stated above, skill-biased changes in emigration prospects stimulate people to acquire tertiary education. This mechanism will be referred to as the *incentive effect* henceforth. The literature has shown that it is important in middle-income and poor countries where tertiary education is perceived as increasing the probability to get a visa. Second, newly educated individuals left behind as well as new migrants moving from poor countries (where the access to and quality of the education system are low) to rich countries (where the access and quality are high) change their fertility and their investment in the basic education (primary and secondary levels) of their offspring. This mechanism will be referred to as the *access-to-education effect*. Finally, movements of human capital can affect cross-country disparities in total factor productivity and wages through the *technology effect*. Quantitative theory (i.e. properly parametrized, micro-founded, general equilibrium models) is an ideal tool to formalize the above-mentioned mechanisms and to predict the effects of skill-selective liberalization shocks on human capital formation, geographic concentration of college-educated workers and the world distribution of income.

We provide here a non-technical description of the model; more details can be found in the Online Appendix or in Docquier *et al.* (2014a) and Delogu *et al.* (2013). Our model assumes two-period lived agents (adults and children) and K countries ($k = 1, ..., K$). Adults are the only decision makers. They maximize their well-being and decide where to live, whether to invest in their own (higher) education, how much to consume, and how much to invest in the quantity and quality (i.e. basic education) of their children. We distinguish between college-educated adults and the less educated ($s = h, l$) and assume that preferences are represented by a two-level nested utility function.

The *outer utility function* has a deterministic and a random component. The utility for a type-s individual moving from country k to country i at time t can be written as:

$$U^s_{ki,t} = \ln v^s_{i,t} + \ln(1 - x^s_{ki,t}) + \ln(1 - e^s_k) + \varepsilon^s_{ki}$$

where $\ln v^s_{i,t}$ is the deterministic utility in destination i, and $x^s_{ki,t}$ is the effort required to migrate from country k to country i. Individuals are heterogeneous in their ability to acquire higher education and in their preference for alternative locations. The individual-specific level of effort required to be of type $s = (h, l)$ in country k is denoted by e^s_k. We have $e^l_k = 0$ for those who do not invest in higher education. For those who decide to invest, we assume that e_k^h follows a Pareto distribution. Basic education is a prerequisite to invest in higher education. The individual-specific random taste shock for moving from country k to i is denoted by ε_{ki}^s and follows a Type-I extreme value distribution. Although ε_{ki}^s and e_k^s are individual-specific, we omit individual subscripts for notational convenience.

The timing of decision is such that individuals decide whether to acquire higher education or not before discovering their migration taste. They educate if the expected benefits from college education exceed the training effort. Hence, global changes in migration policies (such as a skill-selective decrease in visa costs) affect the expected benefits from higher education and stimulate human capital formation. This formalizes the *incentive effect.* After education, each individual discovers her migration type and decides whether to remain in her country of birth or emigrate to another destination.

The (after-migration) *inner utility function* $v_{i,t}^s$ is a Cobb-Douglas function of consumption ($c_{i,t}^s$), fertility ($n_{i,t}^s$) and the proportion of children receiving basic education ($q_{i,t}^s$). In logs, we have:

$$\ln v_{k,t}^s = (1-\theta)\ln c_{k,t}^s + \theta \ln n_{k,t}^s + \theta\lambda \ln q_{k,t}^s$$

where (θ, λ) are preference parameters.

Individuals maximize this function subject to a standard budget constraint that accounts for the time cost to raise children, basic education costs and child labor. When within-country wage ratios between workers and education costs (expressed as percentage of high-skilled wages) are constant, optimal fertility rates and basic education investments are exogenous. Only adults who received basic education when they were young can invest in higher education. This formalizes the *access-to-education* effect. When deciding to emigrate or stay in their home country, individuals anticipate the optimal level of utility attainable in all the possible destinations. Hence, destination choices are governed by differences in income and public provision and quality of basic education.

Finally, education and migration decisions affect the size and the structure of the labor force in all the countries. In the benchmark model, we assume that wages are not affected by migration shocks (partial equilibrium). We also consider a variant of the model in which total factor productivity (TFP henceforth) is an increasing and concave function of the proportion of college graduates in the labor force (with an elasticity equal to 0.32), as in Delogu *et al.* (2013). This formalizes the *technology effect.*[5]

Our model is calibrated to match the characteristics of the world economy in the year

[5]Note that this variant still implies a constant wage ratio between college graduates and less educated workers. In Delogu *et al.* (2013), we relaxed this assumption and assumed that the production function has a constant-elasticity-of-substitution (CES) form. When the parameters of the CES function are properly calibrated, endogenizing wage inequality has a minor effect on the results.

2000 and to be compatible with official demographic projections for the period 2000-2075. One period represents 25 years. Country-specific, technological parameters are chosen to perfectly fit the world distribution of income, i.e. cross-country disparities in GDP per capita and within-country income differences between college graduates and the less educated. In the partial equilibrium model, total factor productivity grows at the same rate in all the countries (+1.5 percent per year).[6] Parameters of the distribution of education costs are such that we perfectly match data on the skill composition of the native and resident working-age populations. Total migration costs are calibrated as residuals of the "migration technology" so as to match the observed size and structure of each migration corridor. Using the same technique, legal/visa migration costs are identified so as to match the data on potential migration described in Table 1. These migration costs are treated as exogenous and assumed to be time-invariant. Other preference parameters are in line with the empirical literature. They are chosen so as to match the empirically estimated levels of the elasticity of migration to income and the average elasticity of college-education investment to high-skilled emigration prospects. Finally, the time-path of exogenous variables is calibrated to fit the official population projections of the United Nations for the 21st century.

Inevitably, such a stylized model omits several important features of the real world (trade, unemployment, redistribution, network externalities, etc.) and badly accounts for the emergence of some developing countries or the effect of the recent economic crisis. However, it accounts for the long-run interactions between human capital accumulation, migration and growth. We believe such a quantitative theory framework is an appropriate tool to predict the medium- and long-run impacts of migration policy reforms.

4 Quantitative analysis

We simulate the effects of a complete removal of legal/visa migration costs for college graduates (but not for the less educated). This is equivalent to implementing a points-based system, granting a permanent visa to each applicant with at least one year of college education. We consider a global shock (i.e. applied worldwide to all the countries) or regional shocks (i.e. liberalization of high-skilled migration to a particular region). We assume the shock occurs in 2025 and is permanent. Implications for high-income countries are discussed

[6] Assuming convergence in TFP or higher growth rates in large emerging countries (such as China or India) would reduce the NPFT of current industrialized countries. Gallup data reveal that China and India are not very attractive despite their growth potential: immigration rates would increase from 0.1 to 0.3 percent in China and from 1.1 to 1.5 percent in India if all desiring migrants were allowed to move. However, China and India account for roughly 8.9 percent of the worldwide stock of college-educated emigrants, and 11 percent of the stock of desiring emigrants. Higher growth rates in these two countries could reduce the number of desiring emigrants to the main destination countries.

in Section 4.1. Section 4.2 presents the effect on income per worker and income per natural in developing countries. Finally, Section 4.3 discusses the effects on the world distribution of income.

4.1 Race for talents and economic leadership

We first investigate the effects of skill-selective liberalization shocks on income per worker in selected high-income countries. Results are presented in Table 2. Three numerical experiments are conducted in this section: a complete removal of legal/visa migration restrictions for college graduates in the EU15 alone (this scenario is labeled as 'EU15' in column 1), in the United States alone (labeled as 'USA' in column 2), or in all the countries of the world (labeled as 'Global'). For the first two shocks, we only discuss the effects observed after 50 years. For the global liberalization shock, we compare the short-run (in column 3) and long-run effects (in column 4). Our benchmark model assumes exogenous wage rates but for the global shock, we also provide results obtained with endogenous TFP (in columns 5 and 6) and identify the *technology effect*.

If the EU15 liberalizes high-skilled immigration alone (column 1), its average income per worker increases by 12.6 percent. This long-run effect accounts for the changes in migration, education and fertility in all the countries of the world. Countries benefiting the most (i.e. more than 10 percent) are the United Kingdom, Ireland, Scandinavian countries, France, Spain and Portugal. The smallest effects are observed in Austria, Belgium, Germany, Greece, Luxembourg and the Netherlands. Gallup data on desired migration reveal that these countries have smaller NPFT. It is worth noticing that income per worker decreases by 1.2 percent in the US and 1.5 percent in Canada. This is due to the fact that Europe would attract some college-educated Americans and other migrants who would have emigrated to North America otherwise.

If the US liberalizes alone (column 2), its average income per worker increases by 9.0 percent in the long-run. This effect is smaller than in the EU15 case because the US have already mobilized a larger portion of its NPFT. Income per worker decreases by 1.7 percent in Canada and 0.8 percent in Australia and the EU15. Countries suffering the most in the EU15 are English speaking countries (-1.4 percent in the United Kingdom and -1.3 percent in Ireland) but also Portugal (-1.7 percent), Italy (-1.1 percent) and France (-1.0 percent). The latter countries suffer from an increased brain drain to the US. It is worth noticing that the Gallup database only documents the preferred destination of desiring migrants and does not permit to identify closer substitutes among destinations. Having data on the n preferred destinations would have allowed us to refine the assessment of the negative externality induced by a regional liberalization on the other regions.

Table 2: Effect of skill-selective liberalization on income per worker

Shock	EU15	USA	Global		Global - Endog. TFP	
	Long-run	Long-run	Short-run	Long-run	Short-run	Long-run
Austria	+6.1	-0.3	+3.7	+4.7	+7.5	+9.4
Belgium	+6.9	-0.3	+2.2	+4.4	+3.6	+7.7
Denmark	+13.3	-0.9	+6.4	+9.9	+13.3	+18.7
Finland	+19.3	-0.7	+12.5	+17.4	+20.4	+25.9
France	+13.5	-1.0	+6.1	+9.1	+11.3	+16.6
Germany	+7.3	-0.4	+3.1	+4.3	+6.2	+8.5
Greece	+7.2	-0.5	+3.0	+5.1	+7.2	+10.7
Ireland	+16.5	-1.3	+7.3	+12.7	+13.6	+21.2
Italy	+9.8	-1.1	+3.0	+6.6	+5.8	+12.0
Luxembourg	+6.6	-0.7	-0.3	+2.5	-1.3	+3.7
Netherlands	+6.6	-0.7	+3.0	+3.3	+6.4	+6.3
Portugal	+17.3	-1.7	+3.0	+10.6	+5.4	+18.9
Spain	+17.8	-0.4	+8.3	+13.5	+19.1	+27.4
Sweden	+17.0	-0.8	+13.3	+14.2	+25.2	+24.7
United Kingdom	+20.9	-1.4	+8.1	+15.1	+18.3	+29.2
Average EU15	+12.6	-0.8	+5.3	+8.8	+11.0	+16.6
Australia	0.0	-0.8	+33.3	+15.8	+57.2	+22.9
Canada	-1.5	-1.7	+31.1	+16.0	+42.8	+20.2
United States	-1.2	9.0	+5.7	+5.9	+7.6	+7.5
Average 18	4.6	4.1	+7.5	+7.8	+12.1	+12.3

Notes: Effects of eliminating visa costs for college graduates on income per worker as percentage of deviation from the benchmark. Short-run: effect in 2025. Long-run: effect in 2075. Endogenous TFP: elasticity of TFP and wages to the proportion of college graduates equal to .32.

Columns 3 and 4 give the short-run and long-run impacts of a worldwide liberalization shock in the benchmark, partial equilibrium model. We find that a complete liberalization of high-skilled migration would benefit more the EU15 (+8.8 percent) than the United States (+5.9 percent) in the long-run. However, in line with desired migration numbers provided in Table 1, the greatest responses are observed for Canada (+16.0 percent) and Australia (+15.8 percent). Gains among European countries are unevenly distributed. They would be smaller than the US gains in some countries (Austria, Belgium, Germany, Greece, Luxembourg and the Netherlands) and much greater in others (Scandinavian countries, the UK, Ireland, Portugal and Spain). Short-run gains are smaller than the long-run ones. The reason is that a skill-selective liberalization stimulates basic education and gradually increases the worldwide stock of college-educated workers, due to the *access-to-education effect*.

Columns 5 and 6 show that the scale of the effects increases under endogenous TFP. The difference between the EU15 and the US becomes even larger in the long-run (+16.6

percent in the EU15 vs +7.5 percent in the US). There are two reasons for this. First, endogenizing TFP amplifies the human capital shock, the latter being greater in the EU15 than in the US in line with Table 1. Second, our specification with endogenous TFP assumes a concave relationship between the TFP level and the proportion of college graduates in the labor force (with an elasticity equal to 0.32). As the EU15 starts with a lower level of human capital, the marginal TFP response to the shock is greater than in the US. Still, a complete liberalization of mobility would have a limited impact on the economic disparities across industrialized countries. The average income per worker in the US currently exceeds the average European level by about 60 percent. Even with endogenous TFP, only a limited portion of this gap (about 9 percentage points) would be curbed if the EU15 and the US mobilized their entire net pool of foreign talents.

4.2 Effect on developing countries

We now investigate the implications of a global liberalization of high-skilled migration for developing countries. Column 1 in Table 3 shows that the average emigration rate of college graduates increases by 15.1 percentage points in developing countries (from 11.5 to 26.6 percent). The largest changes are observed in the poorest regions such as sub-Saharan Africa (+23.1 percentage points) and Middle-East and Northern Africa (+18.9 percentage points). The effect is smaller in middle-income or emerging regions such as China and India (+11.0 percentage points) and the Commonwealth of Independent States (+12.4 percentage points). Although we only report long-run changes obtained in the partial equilibrium scenario, very similar changes in emigration rates are obtained in the short-run or with endogenous TFP.

Columns 2 to 4 give the long-run effects of the shock on income per worker in the developing world while columns 5 to 7 give the effect on income per natural, defined as the average income of all native-born adults from a given region, wherever they reside. We distinguish between three scenarios, the partial equilibrium one with exogenous TFP and endogenous education choices ('Bench.' in Table 3), one with exogenous TFP and constant higher education investment ('Cst. educ.'), and one with endogenous TFP and education levels ('End. TFP'). The second scenario disregards the *incentive effect* on higher education and only accounts for the *access-to-education effect*. The third scenario supplements the benchmark with the *technology effect*.

In the benchmark scenario, the least pessimistic one for developing countries, income per worker in developing countries decreases by 2.5 percent. The largest effects are obtained in Middle-East and Northern Africa and in Latin America and the Caribbean. This scenario accounts for the *incentive effect*, i.e. for the fact that skill-biased emigration prospects increase the expected returns to schooling and stimulate ex-ante investments in human capital. We disregard this effect in the second scenario and obtain similar albeit more pessimistic results. Hence, endogenizing higher education attenuates the loss for developing countries but does not reverse the effects. Under a worldwide liberalization of high-skilled migration, the brain drain shock is too large to generate "net brain gain" effects. This is in line with Beine *et al.* (2008) who show that the brain drain induces exponential losses of human capital when the emigration rate exceeds 10 to 15 percent. Not surprisingly, the adverse effect on income per worker is magnified under endogenous TFP, as the proportion of college graduates falls in developing countries.

Table 3: Long-run effect of a global liberalization on developing regions

	ΔBD[a]	Income per worker[b]			Income per natural[b]		
	Bench.	Bench.	Cst. educ.	End. TFP	Bench.	Cst. educ.	End. TFP
DEV	+15.1	-2.5%	-3.6%	-5.0%	5.3%	3.4%	5.2%
CHIND	+11.0	-0.8%	-1.5%	-1.7%	5.3%	4.1%	5.8%
MENA	+18.9	-4.4%	-6.2%	-9.4%	6.9%	4.2%	7.5%
ASIA	+15.9	-1.7%	-2.7%	-3.3%	3.9%	2.4%	4.2%
LAC	+16.3	-2.1%	-3.4%	-4.3%	2.6%	1.1%	1.8%
SSA	+23.1	-0.4%	-2.8%	-2.5%	12.0%	7.1%	13.0%
CIS	+12.4	-0.5%	-1.1%	-1.8%	7.6%	6.6%	7.7%

Notes: [a]Long-run deviation in high-skilled emigration rates (brain drain) in percentage point; [b]Long-run effects of eliminating visa costs for college graduates on income (per worker or per natural) as percentage of deviation from the benchmark. "Bench.": benchmark, partial equilibrium model; "Cst. educ.": no effect of emigration prospects on investment in higher education; "End. TFP": elasticity of wages to the proportion of college graduates equal to .32. Regions: DEV = all developing countries; CHIND = China and India; MENA = Middle East and Northern Africa; ASIA = Rest of Asia; LAC = Latin America and Caribbean; SSA = Sub-Saharan Africa; CIS = Commonwealth of Independent States.

A different picture is obtained when focusing on income per natural. The income gain experienced by the new migrants exceeds the income loss for those left behind. Income per natural increases by 3.4 to 5.3 percent in the developing world. The rise is important in sub-Saharan Africa. Hence, the inequality and poverty implications of a complete liberalization of high-skilled migration are *a priori* uncertain. A Pareto-improving situation could be obtained if new college-educated migrants remitted a large share of the income gain to the less educated left behind. Such an outcome is however unlikely to be observed because on average, actual migrants only remit a few percent of their income, and this propensity to remit could become even smaller as the ratio of emigrant to stayer increases.

4.3 Effect on the world distribution of income

Finally, this section examines the effect of skill-selective liberalization reforms on the world economy. Results are depicted on Figure 1.[7]

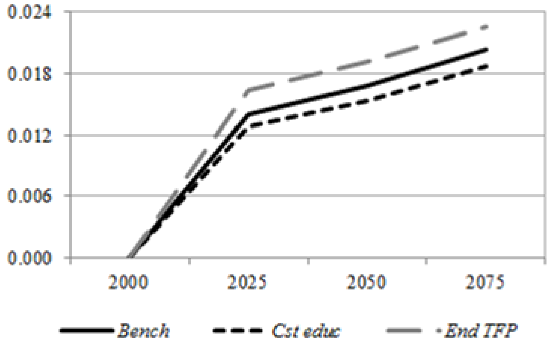
Figure 1a shows the impact on the world proportion of migrants while Figure 1b gives the effect on the world proportion of college graduates, both expressed as percentage point of deviation from the baseline. In the benchmark, partial equilibrium model, a global liberalization of high-skilled migration increases the world proportion of migrants by 1.5 percentage points in the short-run and by 2 percentage points in the long-run. The worldwide proportion of college graduates increases by 0.5 percentage points in the short run and by 1.0 percentage point in the long-run. This is not negligible as the baseline proportions of college-educated are equal to 11.2 percent in 2025 and 15.8 percent in 2075. The short-run change in human capital is entirely due to the *incentive effect*. Then, new educated adults invest more in the basic education of their offspring and have fewer children; this gradually increases the proportion of young adults having access to higher education. With exogenous higher-education decisions, the effect on human capital is negligible and exclusively due to the assimilation of new migrants in terms of investment in basic education of their children; this slightly reduces the effect on the world proportion of migrants. With endogenous TFP, the incentive effect on higher education and the world proportion of migrants are slightly greater as skilled emigration decreases wages in origin countries and increases them in destination countries.

We now focus on the world distribution of income. The effect on the world average level of income per capita as percentage of deviation from the baseline (usually referred to as the efficiency effect) is presented on panel 1c. A skill-selective liberalization of high-skilled migration increases the worldwide average income per worker by 2.4 percent in the short-run and by 6.2 percent in the long-run. Comparing the benchmark with the constant education scenario in partial equilibrium, about 3/4 of the short-run efficiency gain is due to the reallocation of college-educated workers from low-income to high-income countries and only 1/4 is due to the *incentive effect*. Over time, the *access-to-education effect* gradually increases the stock of college graduates. With endogenous TFP, the productivity gap between poor and rich countries increases. Overall, this boosts efficiency gains (+4.0 percent in the short-run and +8.8 percent in the long-run).

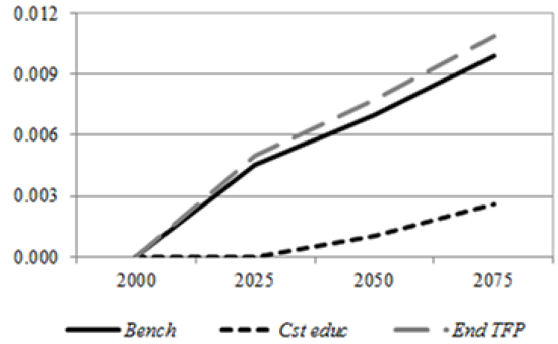
As explained in the previous sections, liberalizing high-skilled migration reduces human capital and the pre-transfer level of income per worker in developing countries, and increases them in high-income countries. Figure 1d gives the effect on the Theil index of inequality

[7] A partial liberalization of college-educated workers' mobility could also be simulated. As shown in Delogu *et al.* (2013), even though the effects are non-linear in the liberalization rate they are almost proportional to it.

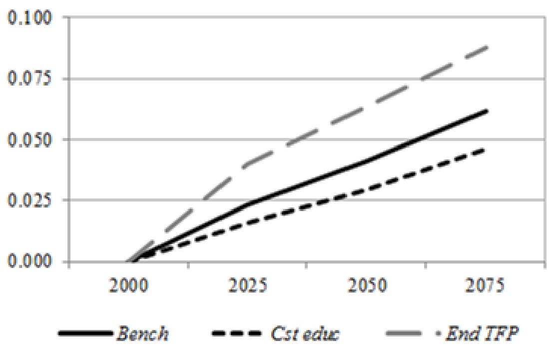
Figure 1: Effects of skill-selective liberalization of labor mobility on the world economy



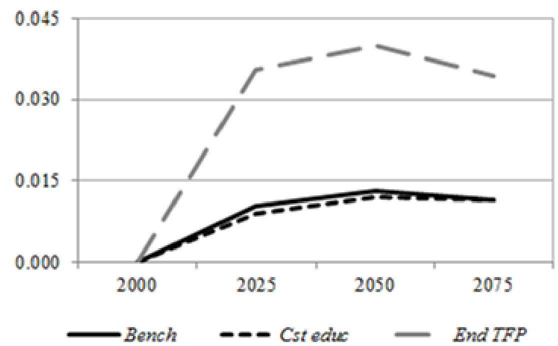
(a) Proportion of migrants



(b) Proportion of college grad.



(c) GDP per capita



(d) Theil inequality index

in percentage point deviation from the baseline. In partial equilibrium, the Theil index increases by 1.0 percentage points in the short-run and by 1.2 percentage points in the long-run. The effect is almost identical if higher education decisions are exogenous. On the contrary, the effect can be magnified by the *technology effect*: in the short-run, the Theil index increases by 3.5 percentage points with endogenous TFP. The increased mobility raises wages in developed (receiving) countries while it decreases the income of stayers in developing (sending) countries, thereby reinforcing the income gap between poor and rich regions.

5 Conclusion

The race to attract talents is likely to get tougher in the future. In this paper, we use a unique database on desired migration to quantify the net pool of foreign talents (NPFT) of the major industrialized countries. We show that the EU15 has a large NPFT, although this pool is relatively smaller than the US, Canadian or Australian ones. So far, the EU15 has poorly benefited from it while the US has mobilized a large portion of it. We then use a quantitative theory model to simulate the short-run and long-run impacts of skill-selective liberalization shocks on the world economy. Overall, a worldwide liberalization of high-skilled migration benefits high-income countries and adversely affects developing countries. It reduces the average income gap between the EU15 and the US. However, the European gains are unevenly distributed: less attractive countries such as Austria, Belgium, Germany, Greece, Luxembourg and the Netherlands benefit less than the US, Canada or Australia. In developing countries, skill-biased emigration prospects stimulate the investment in higher education. However, this incentive mechanism is too small to induce a net brain gain. Human capital and income per worker thus decrease in developing countries. Still, the income per natural increases for all the developing regions, highlighting the fact that the increase in emigrants' income exceeds the loss of the stayers'. Pareto-improving transfer schemes could be imagined but would be difficult to implement. Increasing the race to attract talents increases inequality, especially if total factor productivity varies with human capital.

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Appendix for Online Publication

Global competition for attracting talents and the world economy*

Frédéric Docquier [a,b] & Joël Machado [a]

[a] IRES, Université Catholique de Louvain

[b] National Fund for Scientific Research (FNRS)

1 Analytical description of the model

Our model endogenizes wages, emigration, fertility and (higher and basic) education decisions. We want it to be compatible with some salient stylized facts on emigration and human capital formation. First, macrodata show large cross-sectional variations in the proportion of college graduates $H_{k,t}$ and strong persistence over time in each country. Second, an endogenous share of high-skill and low-skill individuals decides to emigrate to another country but all emigrants do not choose the same destination. Some migration corridors are empty while other corridors exhibit bidirectional migration flows. Third, investment in college education is done under uncertainty about the future place of work: expectations about the size and structure of migration (i.e. emigration prospects) matter for education. A more detailed exposition of the model can be found in Delogu *et al.* (2013).

1.1 Aggregates

We use the following notations for aggregate variables at time t:

- $N^s_{k,t} \in \Re$: number of working-age natives of type $s = (h, l)$ from country k (h for college graduates and l for the less educated)

*We acknowledge financial support from the ARC convention on "Geographical Mobility of Factors" (convention 09/14-019). Corresponding author: Frédéric Docquier, IRES, Collège Léon Dupriez, Place Montesquieu, 3, bte L2.06.01, B-1348 Louvain-la-Neuve, Belgium (frederic.docquier@uclouvain.be).

- $N_{k,t} \in \Re$: number of working-age natives from country k, computed as $(N^h_{k,t} + N^l_{k,t})$

- $\pi_{k,t} \in [0,1]$: fraction of eligible adults investing in higher (college) education

- $H_{k,t} \in [0,1]$: share of college graduates in the native population, computed as $N^h_{k,t}/(N^h_{k,t}+ N^l_{k,t})$

- $N^s_{kj,t} \in \Re$: number of type-s emigrants from k to j

- $x^s_{kj,t} \in [0,1]$: total effort required to emigrate from k to j ($x^s_{kk,t} = 0$)

- $\ln v^s_{k,t} \in \Re$: log of the deterministic level of ("inner") utility that can be reached in the location k by adults of type s

- $L^s_{k,t} \in [0,1]$: number of working-age (after-migration) residents of type s, computed as $\equiv \sum_i N^s_{ik,t}$

- $h_{k,t} \in [0,1]$: share of college graduates in the resident population, computed as $L^h_{k,t}/(L^h_{k,t} + L^l_{k,t})$

- $p^s_{k,t} \in [0,1]$: skill-specific emigration rate from country k, computed as $\sum_{i\neq k} N^s_{ki,t}/N^s_{k,t}$

- $n^s_{k,t} \in \Re$: fertility rate of type-s adults residing in country k (we assume $n^h_{k,t} = 1$)

- $n_{k,t} \in \Re$: average fertility rate in country k, computed as $h_{k,t}n^h_{k,t} + (1 - h_{k,t})n^l_{k,t}$

- $q^s_{k,t} \in [0,1]$: proportion of children of a type-s parent receiving basic education (we assume $q^h_{k,t} = 1$)

- $q_{k,t} \in [0,1]$: average proportion of children with basic education, computed as:

  $$\frac{h_{k,t}n^h_{k,t} + q^l_{k,t}(1 - h_{k,t})n^l_{k,t}}{n_{k,t}}$$

  This variable also represents the proportion of adults who are eligible for higher education in the next period.

- $w^s_{k,t} \in \Re$: wage rate in country k for type-s workers

1.2 Outer (random) utility function

We assume that preferences are represented by a two-level nested utility function. As for the outer utility function, we use a random utility model with two sources of heterogeneity. We use it to endogenize higher education ($\pi_{k,t}$) and emigration ($p^s_{k,t}$) decisions. Working-age individuals have heterogeneous abilities to acquire higher education, and heterogeneous preferences over destination countries. The *outer utility function* has a deterministic and a random component:

$$U^s_{kj,t} = \ln v^s_{j,t} + \ln(1 - x^s_{kj,t}) + \ln(1 - e^s_k) + \varepsilon^s_{kj} \tag{1}$$

where $e^s_k \in [0, 1]$ is the individual-specific effort to be of type $s = (h, l)$ in country k, and $\varepsilon^s_{kj} \in \Re$ is the individual-specific random taste for migrating from k to j.

As standard in the migration literature, we assume that the random component of utility ε^s_{kj} follows a Type I-Extreme Value distribution (also known as the double-exponential distribution) with a scale parameter $\mu > 0$. As far as the higher education cost is concerned, no effort is required if the individual does not acquire higher education ($e^l_k = 0$). On the contrary, investing in higher education requires a positive level of effort ($e^h_k > 0$). The distribution of this effort is affected by parental investments in basic education. For all individuals who did not receive basic education when young, the effort to get college education is equal to one ($e^h_k = 1$). Given our logarithmic utility function, it is never optimal for them to acquire higher education. For those who received basic education when young, we have $e^h_k \in]0, 1[$. We assume that the monotonic and increasing transformation of the education effort, $\tau^h_k \equiv \left(1 - e^h_k\right)^{-1} \in [0, \infty]$, follows a Pareto distribution. The country-specific CDF is given by $G_k(\tau) = 1 - \left[\frac{\overline{\tau}_k}{\tau}\right]^\alpha$ where $\overline{\tau}_k > 0$ is the lower bound of the distribution of effort in country k and $\alpha > 0$ determines the slope of the CDF. Parameter $\overline{\tau}_k$ is country-specific and reflects access to higher education; it is likely to be large in poor countries with low urbanization rates and low levels of public spending for college education.

The timing of decisions is the following. First, individuals who received basic education discover their education type ($e^s_{k,t}$). They do not know their migration type ($\varepsilon^s_{kj,t}$) but know its distribution. Given their expectations about $v^s_{j,t}$ and $x^s_{kj,t}$, they decide whether to acquire higher education or not. Second, they discover their migration type ($\varepsilon^s_{kj,t}$) and decide whether to emigrate or to stay in the home country.

1.3 Higher education decisions

Basic education is a prerequisite for investing in college, but not all eligible individuals find it optimal to acquire higher education. In the first stage, individuals acquire higher education if the expected utility gain from being college educated exceeds the effort cost. Under the Type I Extreme Value distribution, de Palma and Kilani (2007) derived the expression for the ex-ante expected utility. Using their theorem, the expected utility of choosing type s is given by

$$\begin{aligned} E\left(U^s_{kj,t}\right) &= E\left[\ln v^s_{j,t} + \ln(1-x^s_{kj,t}) + \varepsilon^s_{kj}\right] + \ln(1-e^s_k) \\ &= \ln \sum_{i=1}^{I} e^{\left[\ln v^s_{i,t} + \ln(1-x^s_{ki,t})\right]/\mu} + \ln(1-e^s_{k,t}) \end{aligned}$$

Investing in college education is optimal if $E\left(U^h_{kj,t}\right) > E\left(U^l_{kj,t}\right)$, i.e.

$$\tau^c_{k,t} \leq \frac{\sum_{i=1}^{I}(v^h_{i,t})^{1/\mu}(1-x^h_{ki,t})^{1/\mu}}{\sum_{i=1}^{I}(v^l_{i,t})^{1/\mu}(1-x^l_{ki,t})^{1/\mu}} \equiv \frac{(v^h_{k,t})^{1/\mu} + (V^h_{k,t})^{1/\mu}}{(v^l_{k,t})^{1/\mu} + (V^l_{k,t})^{1/\mu}} \tag{2}$$

where $v^s_{k,t}$ determines the component of expected utility affected by the home country characteristics, and $(V^s_{k,t})^{1/\mu} \equiv \sum_{i\neq k}(v^s_{i,t})^{1/\mu}(1-x^s_{ki,t})^{1/\mu}$ is the component related to emigration prospects. The effect of emigration prospects is large if the levels of $V^s_{k,t}/v^s_{k,t}$ are large. This is the case if the origin country is poor relative to other countries and if emigration costs are small. In a closed economy framework ($x^s_{ki,t} = 1\ \forall s, i \neq k$), the critical level of effort below which college education is beneficial is determined locally ($\tau^c_{k,t} = (v^h_{k,t}/v^l_{k,t})^{1/\mu}$). In an open economy (i.e. when $V^s_{k,t} > 0$), the expected return to education is clearly affected by emigration prospects.

Property 1 (incentive effect). Emigration prospects stimulate incentives to acquire higher education if the expected education premium abroad is greater than in the country of origin $\frac{V^h_{k,t}}{V^l_{k,t}} > \frac{v^h_{k,t}}{v^l_{k,t}}$.

Using (2) and the Pareto distribution, the proportion of college graduates among native adults is equal to the product of the predetermined proportion of eligible adults who received basic education ($q_{k,t-1}$) by the endogenous fraction of them who find it optimal to invest in higher education ($\pi_{k,t}$). We have:

$$H_{k,t} \equiv q_{k,t-1}\pi_{k,t} = q_{k,t-1}\left[1 - \left(\overline{\tau}_k \frac{(v^l_{k,t})^{1/\mu} + (V^l_{k,t})^{1/\mu}}{(v^h_{k,t})^{1/\mu} + (V^h_{k,t})^{1/\mu}}\right)^{\alpha}\right] \tag{3}$$

It follows:

Property 2 (access-to-education effect). The average responsiveness of investment in college education to skill-biased emigration prospects depends on past education levels ($q_{k,t-1}$) and access to higher education ($\overline{\tau}_k$).

The effect of emigration prospects on the proportion of college graduates thus varies across countries with the lagged enrollment rate in basic education and with access to higher education ($\overline{\tau}_k$). The latter is likely to depend on the country's development level, urbanization rate, public spending on tertiary education, etc. Below, we will show that the enrollment rate in basic education depends on the lagged proportion of college graduates (i.e. college-educated invest more in the education of their children). This explains the strong persistence in human capital data and implies that a shock in emigration prospects induces gradual effects on the world economy.

1.4 Emigration decisions

In the second stage, education has been determined and individuals choose to emigrate to country j if $\ln v^s_{j,t} + \ln(1 - x^s_{kj,t}) + \varepsilon^s_{kj}$ exceeds the level attainable in any other location. Following McFadden (1984), under the Type I Extreme Value distribution, the probability to emigrate can be expressed as a logit expression. The emigration rate and emigrant-to-stayer ratio are given by:

$$\begin{aligned}
\frac{N^s_{kj,t}}{N^s_{k,t}} &= \frac{e^{\left[\ln v^s_{j,t}+\ln(1-x^s_{kj,t})\right]/\mu}}{\sum_{i=1}^{I} e^{\left[\ln v^s_{i,t}+\ln(1-x^s_{ki,t})\right]/\mu}} = \frac{(v^s_{j,t})^{1/\mu}(1-x^s_{kj,t})^{1/\mu}}{\sum_{i=1}^{I}(v^s_{i,t})^{1/\mu}(1-x^s_{ki,t})^{1/\mu}} \\
\frac{N^s_{kj,t}}{N^s_{kk,t}} &= \frac{e^{\left[\ln v^s_{j,t}+\ln(1-x^s_{kj,t})\right]/\mu}}{e^{\left[\ln v^s_{k,t}\right]/\mu}} = \left(\frac{v^s_{j,t}}{v^s_{k,t}}\right)^{1/\mu}(1-x^s_{kj,t})^{1/\mu} \qquad (4)
\end{aligned}$$

These expressions show that skill-specific emigration rates are endogenous and comprised between 0 and 1. Equation (4) states that the ratio of emigrants from country k to country j over the stayers in country k (i.e. agents born in k who remain in k), is an increasing function of the utility achievable in country j and a decreasing function of the utility in the country of origin k. The proportion of migrants from k to j also decreases with the bilateral migration cost $x^s_{kj,t}$. Heterogeneity in migration tastes implies that emigrants select all destinations for which $x^s_{kj,t} < 1$. If $x^s_{kj,t}$=1, the corridor is empty. All corridors such that $x^s_{jk,t}, x^s_{kj,t} < 1$ exhibit bidirectional migration flows. In addition, the aggregate emigration rate ($p^s_{k,t}$) and the ratio of emigration rates ($\rho_{k,t}$) from country k are jointly determined and given by the following expressions:

$$\begin{aligned} p^s_{k,t} &\equiv \frac{\sum_{i\neq k} N^s_{ki,t}}{N^s_{k,t}} = \frac{(V^s_{k,t})^{1/\mu}}{(v^s_{k,t})^{1/\mu} + (V^s_{k,t})^{1/\mu}} \\ \rho_{k,t} &\equiv \frac{p^h_{k,t}}{p^l_{k,t}} = \frac{(V^h_{k,t})^{1/\mu}}{(V^l_{k,t})^{1/\mu}} \left[\frac{(v^h_{k,t})^{1/\mu} + (V^h_{k,t})^{1/\mu}}{(v^l_{k,t})^{1/\mu} + (V^l_{k,t})^{1/\mu}} \right]^{-1} \end{aligned} \tag{5}$$

The ratio of emigration rates increases with $V^h_{k,t}$ and decreases with $V^l_{k,t}$. From (3) and (5), we have $sgn\left(\frac{\partial H_{k,t}}{\partial V^s_{k,t}}\right) = sgn\left(\frac{\partial \rho_{k,t}}{\partial V^s_{k,t}}\right)$ and $sgn\left(\frac{\partial H_{k,t}}{\partial v^s_{k,t}}\right) \neq sgn\left(\frac{\partial \rho_{k,t}}{\partial v^s_{k,t}}\right)$:

Property 3 (incentive effect). Emigration-driven expected utility shocks ($\Delta V^s_{k,t}$) induce a positive correlation between human capital formation ($H_{k,t}$) and the ratio of emigration rates ($\rho_{k,t}$). Local expected utility shocks ($\Delta v^s_{k,t}$) induce a negative correlation between $H_{k,t}$ and $\rho_{k,t}$.

In particular, shocks increasing the expected utility of college graduates abroad (e.g. greater skill selection in the major destination countries) have a positive effect on human capital formation ($H_{k,t}$) and on the positive selection of emigrants (as reflected by the ratio of emigration rates $\rho_{k,t}$). Shocks increasing the expected utility of the less educated abroad have a negative effect on both variables.

1.5 Inner utility function

The *inner utility function* $v^s_{k,t}$ is a Cobb-Douglas function of consumption ($c^s_{k,t}$), fertility ($n^s_{k,t}$) and the proportion of children receiving basic (primary and secondary) education ($q^s_{k,t}$), i.e.

$$\ln v^s_{k,t} = (1-\theta)\ln c^s_{k,t} + \theta \ln n^s_{k,t} + \theta\lambda \ln q^s_{k,t},$$

with $(\theta, \lambda) = (.3, .6)$ in line with the existing quantitative literature on fertility and education. Raising a child requires a time cost ϕ and providing a child with basic education induces paying a monetary education cost which is proportional to the high-skilled wage rate. In poor countries, we allow non-educated children to work and earn a wage which is proportional to the low-skilled wage rate.

The utility function is maximized subject to a budget constraint and $q^s_{k,t} \leq 1$. With a Cobb-Douglas function, a fraction $(1-\theta)$ of the full-time equivalent wage rate is devoted to consumption: With $\theta = .3$, we have

$$\ln v^s_{k,t} = 0.7 \ln w^s_{k,t} + \ln \Omega^s_{k,t} \tag{6}$$

where $\ln \Omega_{k,t}^{s} \equiv \theta \ln n_{k,t}^{s} + \theta\lambda \ln q_{k,t}^{s} + (1-\theta)\ln(1-\theta)$ depends on fertility and basic education decisions.

Property 4 (access-to-education effect). We assume that the wage ratio between college graduates and the less educated and the wage ratio between children and low-skilled adults are exogenous. Basic education costs are proportional to the high-skilled wage rate. Under this set of hypotheses, skill-specific fertility rates ($n_{k,t}^{s}$), basic education investments ($q_{k,t}^{s}$) and the residual terms $\Omega_{k,t}^{s}$ follow an exogenous time path.

Using the set of hypotheses of Property 4, a migration policy reform only affects disparities in *inner utility* if wages are endogenous. In addition, relocating people from poor countries (high fertility and low investment in basic education) to rich countries (low fertility and high investment in basic education) gradually changes the dynamics of the world population.

1.6 Technology

We assume the following production function:[1]

$$Y_{k,t} = A_{k,t}\left[\sigma_k L_{k,t}^{h}(1-\phi n_{k,t}^{h}) + L_{k,t}^{l}(1-\phi n_{k,t}^{l})\right] \tag{7}$$

where $A_{k,t}$ denotes total factor productivity, σ_k measures the relative productivity of college graduates (affecting the skill premium) and $(1-\phi n_{k,t}^{s})$ denotes the labor supply of type-s adults. Younger workers are employed in the informal sector, the hidden part of the economy.

This production function assumes a perfect substitutability between college graduates and the less educated. The wage rates for college graduates and the less educated are given by $w_{k,t}^{h} = A_{k,t}\sigma_k$ and $w_{k,t}^{l} = A_{k,t}$, respectively. We will consider two scenarios on the level of total factor productivity. The first assumes that it grows at the same exogenous rate of 1.5 percent per year. This partial equilibrium scenario does not allow for the technology effect. The second assumes the same exogenous growth rate plus an elasticity of $A_{k,t}$ to the share of college graduates in the labor force equal to 0.32 (*technology effect*). Both scenarios thus imply a constant wage ratio between high-skilled and low-skilled workers. However, Delogu *et al.* (2013) considered a CES technology and showed that liberalizing migration has a limited impact on the wage ratio between high-skilled and low-skilled workers.

[1] Assuming that output is proportional to labor, our model has no physical capital. We have in mind a globalized economy in which physical capital follows people. In addition, we showed in Docquier *et al.* (2014) that accounting for imperfect substitution between low-skilled and high-skilled workers or between immigrants and natives has a negligible impact on the results.

1.7 Parametrization

The model is calibrated on the year 2000 and the horizon of our simulations is 2075 (one period represents 25 years).

First, we use cross-country data on the skill structure of the labor force (Artuç *et al.*, 2014), GDP per capita (World Development Indicators) and returns to schooling (Hendricks, 2004). In all the countries, skill-specific wage rates are calibrated to perfectly match data on GDP and returns to schooling in the year 2000. For subsequent years, we assume that the wage rates are growing at the same rate in all the countries (1.5 percent per year) in the absence of policy reforms. Policy reforms can affect between-country disparities in wages if total factor productivity is endogenous.

Under the identifying assumptions that $n^h_{k,t} = q^h_{k,t} = 1$, we calibrate $n^l_{k,t}$ and $q^l_{k,t-1}$ to perfectly match the average fertility rate ($n_{k,t}$) and proportion of natives with secondary education ($q_{k,t-1}$) in the year $t = 2000$. This determines $\ln \Omega^s_{k,t}$ in (6). For subsequent years, $n^l_{k,t}$ and q^l_k are adjusted to match the UN demographic projections. We calibrate the trajectory of the young workers' wage rates to match the time path for $n^l_{k,t}$, and the trajectory of basic education costs to match the time path for $q^l_{k,t}$.

Third, we identify the migration technology. Bertoli *et al.* (2013) found an elasticity of bilateral migration to the wage ratio ($w^s_{j,t}/w^s_{k,t}$) between 0.6 and 0.7. Plugging (6) into (4), the elasticity in our model equals $0.7/\mu$. By choosing $\mu = 1$, the responsiveness of migration to wage disparities is in line with the empirical literature. We then use the comprehensive matrices of bilateral migration described in Artuç *et al.* (2014), who provide bilateral migration stocks ($N^s_{kj,t}$) by education level for all country pairs. We identify $(1 - x^s_{kj,t})$ as a residual of (4). Our calibration strategy thus perfectly fits migration data. In the benchmark trajectory of the world economy, we assume that migration costs are constant.

Migration costs sum up the legal costs incurred to obtain a visa and the private costs incurred by migrants to assimilate in the destination country. As in Docquier *et al.* (2014), we use the Gallup World Poll survey data on desired migration to identify the magnitude of private costs ($\underline{x}^s_{kj,t}$). Again, we identify $(1 - \underline{x}^s_{kj,t})$ as a residual of (4) after adding the skill-specific number of individuals who express a desire to emigrate to the effective migration stocks. A skill-selective liberalization of immigration to country j means that $x^h_{kj,t}$ is decreased to $\underline{x}^h_{kj,t}$ for all (k, j).

Fourth, decisions about higher education are governed by the Pareto distribution of education costs. The lower bound of the distribution, parameter $\overline{\tau}_k > 0$, is allowed to vary across countries, and $\alpha > 0$ is assumed to be common to all countries. For a given α, $\overline{\tau}_k$ is calibrated so as to match the proportion of college graduates in the labor force of country k in 2000. We iterate on α to match the elasticity found in the empirical literature on brain drain and human capital formation. To conduct this iterative exercise, we simulate a liberalization of high-skilled migration for all country pairs and select α to have an average short-run elasticity of the pre-migration proportion of college graduates ($H_{k,t}$) to the high-skilled emigration rate ($p^h_{k,t}$) close to .05 in developing countries, as in Beine *et al.* (2008). This requires α =.1.[2] The model can then be used to simulate the effect of immigration policy reforms.

2 Gallup data on desired migration

This Appendix describes the macro-database on desired and potential migration used in the paper. We combine it with the data on effective migration from Artuç *et al.* (2014), henceforth referred to as the ADOP database. We rely on the unique and largely under-studied Gallup World Poll surveys (Gallup, 2010, 2014). They identify the proportion of non-migrants expressing a desire to emigrate permanently to another country. Gallup also provides information on the desire to emigrate temporarily but does not document the desired duration of the stay abroad. We only focus on permanent migration in the benchmark version of the data set. The Gallup survey has been organized on a yearly basis in more than 150 countries since 2005. It documents individual characteristics (such as age, gender and education). The survey includes two relevant questions on intentions to emigrate permanently; these questions were asked in only 142 countries:

- Q1 - *Ideally, if you had the opportunity, would you like to move permanently to another country, or would you prefer to continue living in this country?*
- Q2 - *To which country would you like to move?*

In line with the ADOP database, we only consider respondents aged 25 and over, and distinguish between individuals with college education and the less educated.[3] We aggregate the four first waves of the Gallup survey (i.e. the years 2007 to 2010) and consider that

[2] In Delogu *et al.* (2013), the authors use α=.4 in order to match the long-run elasticity around .20 in Beine *et al.* (2008). They show in a robustness test that the variation of α has only limited quantitative effects while qualitatively the results hold.

[3] The skill structure of the Gallup database is however different from ADOP. The ADOP database defines a high-skilled individual as anyone who has obtained at least one year of college education. In the Gallup survey, education obtained by the respondent is classified using the answer to the question: "What is your highest completed level of education? (Possible answers: Completed elementary education or less (up to 8 years of basic education), Secondary up to 3 year tertiary (9-15 years of education), Completed 4 years of education beyond high school and/or received a 4-year college degree, Don't Know, Refused)". Tertiary educated individuals are defined as those who reply: "Completed 4 years of education beyond high school and/or received a 4-year college degree". Since the propensity to emigrate increases with education, we might overestimate the desire to migrate of both high-skilled and low-skilled individuals.

these four waves represent a single period of observation. This allows us to limit the number of missing cells and increase the accuracy of our estimates. By 2000, these 142 countries represented 97.4 percent of the worldwide adult population (population aged 25 and over covered in the 195 countries included in the ADOP database). The survey covers 287,410 respondents, i.e. an average of 2,024 observations per country. In some cases, the number of respondents is however very small and the raw data needs to be adjusted. Burundi and Namibia are the two extreme examples: only one college-educated respondent was interviewed and expressed a desire to emigrate; our raw desired emigration rate equals 100 percent in these two cases. We also use imputation methods for the 53 countries included in the ADOP database but not in the Gallup survey. It is worth noticing that imputed data accounts for less than 2 percent of the total number of desiring migrants.

Our first step consists of using responses to Q1 to compute the aggregate proportion of individuals who express a desire to permanently leave their country, whatever their preferred country of destination. In the second step, we use responses to Q2 to disaggregate the number of desiring migrants by country of destination.

2.1 Aggregate desired emigration rates

We denote the aggregate proportion of individuals who express a desire to permanently leave their country by d^s_{iT} for individuals of education type s living in country $i = 1, ..., I$. To compute desired emigration rates, we aggregate individual responses to Q1 and weight each observation by the relevant Gallup sample weight. These weights are designed to compensate for the low coverage of certain groups (by gender, race, age, educational attainment, and region) in the whole population. Gallup assigns a weight to each respondent "so that the demographic characteristics of the total weighted sample of respondents match the latest estimates of the demographic characteristics of the adult population available" for the country (Gallup, 2010).

For each origin country i and skill type s, we compute the weighted number of respondents to Q1 ($TR\_Q1^s_i$) and the weighted number of respondents who answered positively to the same question ($YR\_Q1^s_i$). Our *raw* measure of desire to emigrate ($\widetilde{d}^s_{iT}$) is given by

$$\widetilde{d}^s_{iT} \equiv \frac{YR\_Q1^s_i}{TR\_Q1^s_i} \quad \forall i, s \tag{8}$$

For some origin countries, the total number of respondents is small. To correct for small sample bias, we constructed an adjusted measure of the desired emigration rate using origin- and skill-specific reliability rates ($\omega^s_i \in [0; 1]$) and predicted emigration rates ($\widehat{d}^s_{iT}$) for each country of origin:

$$d^s_{iT} = \omega^s_i \widetilde{d}^s_{iT} + (1 - \omega^s_i)\widehat{d}^s_{iT} \tag{9}$$

The reliability rate measures the degree of confidence that we have in the Gallup observations. For college graduates, we consider that the raw measure of desire to emigrate can be fully trusted when it is inferred from at least 50 observations representing at least 0.01 percent of the population at origin (denoted by Pop^h_i). This is the case for 82 countries (out of 142). For the less educated, the minimal number of observations equals 100 and we use the same 0.01 percent threshold for the response rate. Given these criteria, the raw measure of desire to emigrate for the less educated can be fully trusted in 113 cases (out of 142). For these countries, we have $\omega^s_i = 1$ and thus $d^s_{iT} = \widetilde{d}^s_{iT}$.

For the remaining countries, the reliability rate in (9) is smaller than one and computed as a geometric mean of the absolute and relative reliability rates:

$$\omega^h_i = \left[Min\left(1; \frac{TR\_Q1^h_i}{50}\right)\right]^{1/2} \left[Min\left(1; \frac{TR\_Q1^h_i/Pop^h_i}{0.0001}\right)\right]^{1/2} \tag{10}$$

$$\omega^l_i = \left[Min\left(1; \frac{TR\_Q1^l_i}{100}\right)\right]^{1/2} \left[Min\left(1; \frac{TR\_Q1^l_i/Pop^l_i}{0.0001}\right)\right]^{1/2} \tag{11}$$

As for predicted emigration rates ($\widehat{d}^s_{iT}$), we estimate a third-order polynomial relationship between potential emigration rates (i.e. effective + desired) and effective emigration rates. The rationale is that potential and effective migration stocks are affected by many common factors (such as pull/push factors and distances), except migration policies and their effect on the probability of a successful application.

Potential emigration rates are computed using effective emigration rates (m^s_{iT}) and raw emigration rates ($\widetilde{d}^s_{iT}$):

$$\widetilde{p}^s_{iT} = m^s_{iT} + (1 - m^s_{iT})\widetilde{d}^s_{iT}$$

The sample used to estimate the relationship between $\widetilde{p}^s_{iT}$ and m^s_{iT} only includes observations for which the reliability rate ω^s_i is greater than a threshold. For the less educated, our regression sample includes origin countries with at least 50 observations representing at least 0.0001 percent of the population at origin (i.e. countries with $\omega^l_i > 0.22$); this is the case for 141 countries for the less educated (out of 142). For college graduates, the minimal number of observations equals 10 and we use the same relative threshold than for the less educated. The regression sample for college graduates includes 130 countries (out of 142) with $\omega_i^h > 0.15$. We obtain the following results for predicted potential emigration rates:

$$\begin{aligned}\widehat{p}_{iT}^h &= 3.027(m_{iT}^h) - 5.494\left(m_{iT}^h\right)^2 + 3.845\left(m_{iT}^h\right)^3 \\ (N &= 130,\ R^2 = 0.936)\end{aligned}$$

$$\begin{aligned}\widehat{p}_{iT}^l &= 4.893(m_{iT}^l) - 19.278\left(m_{iT}^l\right)^2 + 23.887\left(m_{iT}^l\right)^3 \\ (N &= 141,\ R^2 = 0.835)\end{aligned}$$

All estimated coefficients are significant at the 0.1 percent threshold. The R^2's (and F-stats) of these two regressions are very large.

We can thus compute the predicted desired emigration rates as:

$$\widehat{d}_{iT}^s = \frac{\widehat{p}_{iT}^s - m_{iT}^s}{1 - m_{iT}^s}$$

The correlation rates between raw and predicted desired emigration rates equal 0.81 for college graduates and 0.99 for the less educated. However, adjusting the data eliminates some evident outliers. In most cases, our adjusted measures are slightly smaller than the raw ones. This is due to the fact that countries with small numbers of respondents and/or response rates exhibit unusually large desired emigration rates. On the aggregate, our correction reduces the number of desiring migrants by 42.3 million (i.e. 12.7 percent of the raw total, equal to 331.9 million), including 8.2 million college graduates and 34.1 million less educated adults. As far as college graduates are concerned, 48 percent of this adjustment comes from the United States and 10 percent comes from Italy and Japan, where the relative coverage of the high-skilled population is small. As for the less educated, 48 percent of the adjustment comes from China, 10 percent from Brazil and 7 percent from Nigeria.

For the 53 countries that are not available in the Gallup database, we obviously have $\omega_i^s = 0$ and thus use $d_{iT}^s = \widehat{d}_{iT}^s$. Desired emigration from these totally imputed countries only amounts to 6.3 million adults (i.e. 1.9 percent of the total).

2.2 Bilateral structure

In the second step, we use responses to Q2 to disaggregate the number of desiring migrants by country of destination. We denote by $TR\_Q2_i^s$ the education-specific number of individuals from country i who expressed a desire to emigrate and responded to Q2. $R\_Q2_{ij}^s$ denotes the number of desiring migrants from country i who declared that country j is their preferred destination. A few desiring migrants did not mention a desired destination (i.e. did not respond to Q2) but this is rarely the case. Out of 142 countries, all respondents to Q1 also responded to Q2 in 102 countries; and the proportion of respondents to Q2 exceeds 90 percent in 134 countries. The countries with the smallest response rates to Q2 are Zimbabwe (51.8 percent), Pakistan (56.4 percent) and Australia (67.7 percent). Given these large response rates to Q2, we ignore those who did not respond to Q2 for the computation of the bilateral shares. Finally, a few respondents answered to Q2 and mentioned a preferred destination without responding to Q1. We considered that they responded "Yes" to Q1.

Bilateral matrices of emigration rates are constructed using the following expression:

$$d_{ij}^{s} = d_{iT}^{s} \frac{R\_Q2_{ij}^{s}}{TR\_Q2_{i}^{s}}$$

Two problems had to be solved for computing the bilateral shares. First, some general destination categories aggregate several countries and had to be disaggregated by country. We identified five categories of this sort: "African Countries", "Arab Countries", "Island Nations", "Other Islamic Countries" and "Other Countries". In most cases, we split the number of respondents mentioning these categories proportionally to the distribution of stated desire to emigrate to countries belonging to the same country group.[4] A problem persisted in four cases where no country belonging to the aggregate category was mentioned as a desired destination. In this case, we use the relative distribution of effective migration stocks among countries belonging to the aggregate category involved. Example: a few college-educated Finns mentioned "Other African Countries" as desired destination. These were split using the effective distribution of high-skilled Finns in African Countries available in the ADOP database: 12/126 to Ivory Coast and 114/126 to South Africa. After redistributing these categories, the item "Other Countries" was divided in a similar way using as reference the relative distribution in desired destinations excluding this category.

The second problem concerns the 53 countries that are not covered in the Gallup survey. For these cases, the total emigration rates were totally imputed. This group mainly includes islands and small developing states and represents about 2.6 percent of the world adult population in 2000, and 1.9 percent of the worldwide potential migration stock. For these countries, we imputed the bilateral shares of a similar country belonging to the same region,

[4]Example 1: the number of desired migrants to "African Countries" was divided among the African destination countries mentioned at least by one respondent as the desired destination. Example 2: 0.43 percent of college-educated respondents from Niger mentioned "Arab Country" as their destination. Four Arab countries are mentioned explicitly as destination by respondents (weighted numbers between brackets) from Niger who want to emigrate: Libya (7.34), Morocco (1.13), Saudi Arabia (13.66) and Sudan (0.45). Thus, respondents mentioning "Arab Country" were split between the four countries in proportions 7.34/22.58=0.33, 1.13/22.58=0.05, 13.66/22.58=0.6 and 0.45/22.58=0.02, respectively.

with a similar level of development and a common colonizer. We used the following matching pairs:

- the bilateral shares of the Dominican Republic were used for Antigua and Barbuda, the Bahamas, Barbados, Cuba, Dominica, Grenada, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines,
- the bilateral shares of Cambodia were used for Burma (Myanmar) and East Timor,
- the bilateral shares of Djibouti were used for Ethiopia and Somalia,
- the bilateral shares of Guinea were used for the Gambia and Guinea-Bissau,
- the bilateral shares of Guyana were used for Suriname,
- the bilateral shares of Indonesia were used for Brunei,
- the bilateral shares of Italy were used for San Marino,
- the bilateral shares of Haiti were used for Jamaica,
- the bilateral shares of Hong Kong were used for Macao,
- the bilateral shares of Libya were used for Gabon,
- the bilateral shares of Qatar were used for Oman,
- the bilateral shares of Senegal were used for Benin, Bhutan, Republic of Congo, Mauritius, Seychelles and Togo,
- the bilateral shares of Switzerland were used for Liechtenstein,
- the bilateral shares of Spain were used for Andorra,
- the bilateral shares of Zambia were used for Angola, Cape Verde, Equatorial Guinea, Lesotho, Madagascar, Mozambique, Sao Tome and Principe and Swaziland,
- for Pacific islands (Fiji, Kiribati, Maldives, Marshall Islands, Federated States of Micronesia, Nauru, Palau, Papua New Guinea, Samoa, Solomon islands, Tonga, Tuvalu and Vanuatu), we assumed one third of desiring migrants want to emigrate to New Zealand and two-thirds want to emigrate to Australia,
- we assumed nobody wants to leave the Vatican and Monaco.

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Institut de Recherches Économiques et Sociales
Université catholique de Louvain

Place Montesquieu, 3
1348 Louvain-la-Neuve, Belgique

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