LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

n° 2017-16 November 2017

WORKING PAPERS

Globalizing labor and the world economy: the role of human capital

Marco **DELOGU**[1]
Frédéric **DOCQUIER**[2, 3]
Joël **MACHADO**[4]

[1] DISEA, Università degli studi di Sassari, Italy
[2] IRES, Université Catholique de Louvain, Belgium
[3] National Fund for Scientific Research, Belgium
[4] LISER, Luxembourg

www.liser.lu

Globalizing labor and the world economy: the role of human capital*

Marco Delogu [a], Frédéric Docquier [b,d] & Joël Machado [c]

[a] DISEA, Università degli studi di Sassari [b] IRES, Université Catholique de Louvain

[c] Luxembourg Institute of Socio-Economic Research(LISER)

[d] National Fund for Scientific Research (FNRS)

Abstract

We develop a dynamic model of the world economy that jointly endogenizes individual decisions about fertility, education and migration. We then use it to compare the short- and long-term effects of immigration restrictions on the world distribution of income. Our calibration strategy replicates the economic and demographic characteristics of the world, and allows us to proxy bilateral migration costs and visa costs for two classes of workers and for each pair of countries. In our benchmark simulations, the world average level of income per worker increases by 12% in the short term and by approximately 52% after one century. These results are highly robust to our identifying strategy and technological assumptions. Sizable differences are obtained when our baseline (pre-liberalization) trajectory involves a rapid income convergence between countries or when we adjust visa costs for a possible upward bias. Our quantitative analysis reveals that the effects of liberalizing migration on human capital accumulation and income are gradual and cumulative. Whatever is the size of the short-term gain, the long-run impact is 4 to 5 times greater (except under a rapid convergence in income).

Keywords: Migration, Migration policy, Liberalization, Growth, Human Capital, Fertility, Inequality.
JEL Classification: O15, F22, F63, I24.

---

*We are grateful to Michel Beine, Simone Bertoli, Bastien Chabé-Ferret, Guiseppe de Arcangelis, David de la Croix, Gordon Hanson, Freddy Heylen, Giovanni Facchini, Pierre Picard, Giovanni Peri, Lionel Ragot, Hillel Rapoport, Eric Toulemonde and seminar participants for their comments. An earlier version (see Delogu et al., 2014) was presented at the IZA workshop on "Migration and Human Capital" (May 2013), the NORFACE conference in Nottingham (Sept. 2013), the 6th EGIT conference in Düsseldorf (May 2015), and seminars in Bari, Bonn, Geneva, Gothenburg, Louvain-la-Neuve, Luxembourg and Nantes. The authors acknowledge CESifo sponsorship for the participation at the CESifo Economic Studies Conference on Migration held in December 2013 and financial support from the ARC convention on "Geographical Mobility of Factors" (convention 09/14-019). The third author acknowledges funding by the Luxembourg National Research Fund (9037210). Correspondence: Marco Delogu (mdelogu@uniss.it), Frédéric Docquier (frederic.docquier@uclouvain.be), and Joël Machado (joel.machado@liser.lu); [a]DISEA, Via Muroni 25, I-07100, Sassari, Italy; [b]IRES, 3 Place Montesquieu (bte L2.06.01), B-1348 Louvain-la-Neuve, Belgium; [c]Maison des Sciences Humaines, 11 Porte des Sciences, L-4366 Esch-sur-Alzette, Luxembourg.

1 Introduction

The debate over the global efficiency implications of immigration barriers has recently been revived in the academic literature. Some economists argue that immigration restrictions induce enormous effects on the worldwide level of income and global inequality. Most of the studies summarized in Clemens (2011) use static models and assume that a complete liberalization would lead to real wage equalization across countries. On average, they predict that at least 50% of the world population would live in a foreign country after a complete liberalization. Eliminating all restrictions to labor mobility would induce huge efficiency gains in the range of 50 to 150% of world GDP, making it the greatest source of efficiency gains to expect from globalization.[1]

Other studies highlight the global benefits from easing immigration restrictions. Some investigate the economic impact of abolishing migration barriers, using stylized models with two regions (Iranzo and Peri, 2009; Klein and Ventura, 2009). Others treat migration as the outcome of a central planning problem (Benhabib and Jovanovic, 2012; de la Croix and Docquier, 2015) and provide theoretical and numerical predictions, using a stylized representation of the world economy with one developing region and several destination countries. Kennan (2013) develops a model *à* la Heckscher-Ohlin that accounts for the differences in the labor efficiency and human capital endowments of workers. Free trade implies factor prize equalization in efficiency units (i.e., real wages and labor efficiency differ across countries, but wages per efficiency unit are equalized). Allowing migrants to move to the most efficient location doubles the world average labor productivity (i.e., the labor stock in efficiency units). In the long term, the real wage of a randomly selected individual born in a developing country increases by 112 to 125%.[2]

In the above-mentioned studies, the gains from removing migration restrictions arise from the differences in total factor productivity across countries and are magnified by the mobility of physical capital, which "chases" labor. Private migration costs are disregarded or modeled in a simple manner (e.g., calibrated using US interstate transportation costs). However, non-visa costs are likely to be instrumental given that the empirical literature on the determinants of migration has long emphasized the role of geographic, linguistic and cultural distances.[3] For example, psychic and monetary moving costs explain why within-EU migration flows have been limited, despite the large income differences between EU member states and a free mobility agreement, or why large income disparities exist within countries.[4] A study that estimates the size of "incompressible" moving costs for all country pairs is Docquier et al. (2015). Using data on people's willingness to emigrate from the Gallup World Poll survey (see Esipova et al., 2011),

[1]In comparison, removing the remaining barriers to trade and capital flows would generate small increases in world GDP ranging from 0.5 to 4% for trade and from 0.1 to 1.7% for capital (Clemens, 2011).

[2]Kennan (2014) extends the model to two skills and still finds large gains from open borders. The effective supply of unskilled workers more than doubles in a world with open borders. Assuming constant skill premia, income increases by 130% for unskilled workers and by 90% for skilled workers.

[3]The determinants of the size and structure of international migration have been studied in a growing number of papers (Beine et al., 2011; Grogger and Hanson, 2011; Belot and Hatton, 2012; Bertoli and Fernández-Huertas Moraga, 2013; Razin and Wahba, 2015).

[4]In Germany, the average GDP per inhabitant in Hamburg (EUR 47,100) is 2.3 times greater than that in Brandenburg (EUR 20,500). In Italy, GDP per inhabitant is two times larger in Lombardy (EUR 33,500) than it is in Campania or Calabria (EUR 16,400; values for 2008 from Eurostat, 2011). The same ratio is observed in the US between Connecticut (USD 68,167) and Mississippi (USD 32,348; values for 2008; see Bureau of Economic Analysis, 2014).

they identify the worldwide total number of potential migrant workers, i.e., actual plus desiring migrants aged 25 and over, equal to 386 million (and 589.5 million when network effects are considered). They use a calibration strategy to identify total migration costs and visa costs as residuals of the migration technology in a model that jointly endogenizes migration decisions and economic performances. In partial equilibrium or in general equilibrium without technological externalities, they obtain an 11.9% increase in world GDP after a complete liberalization and a semi-elasticity of world GDP to the share of migrants of 1.3.[5] This semi-elasticity is in line with the existing studies considering the skill differences across people (Iregui, 2005; Winters, 2001; Walmsley and Winters, 2005). Hence, their relatively small efficiency effect is explained by the inclusion of incompressible migration costs and not by the technological features of their model.

Most of the literature on the welfare implication of immigration restrictions has adopted a short-run or medium-run perspective, assuming a constant size and skill structure of the world population.[6] Overall, it concludes that the uncertainty surrounding the size of the gains from globalization is large, because both the migration response to abolishing barriers and the global income gains from allowing workers to move are unclear. In line with Docquier et al. (2015), we find that the short-run effects of immigration barriers are limited. However, we argue here that the long-run effects are larger. The reason is that the existing literature has largely disregarded the interdependence between migration decisions and the evolution of the world population.[7] To the best of our knowledge, we are the first to jointly incorporate endogenous migration, fertility and education decisions into a dynamic microfounded macroeconomic model of the world economy. The majority of new migrants move from poor to rich countries and this affects their education and fertility decisions. The prospect of migrating may change the incentives to educate before emigration occurs. This link between emigration prospects and human capital formation has been identified in the macro and micro literatures.[8] Furthermore, exposed to a new environment and different norms at the destination, migrants change their fertility decisions.[9] Compared to their home country, the policies for basic education in the North (such as mandatory education, generous subsidies, greater quality of education, etc.) make basic education much more accessible for the new migrants' offspring, which increases

[5]The semi-elasticity is defined as the percentage of deviation in world GDP divided by the change in the world proportion of migrants.

[6]The recent paper by Desmet et al. (2017) is an exception as it contrasts the short- and long-run impact of an abolition of migration restrictions in a dynamic model accounting for idiosyncratic tastes, location-specific amenities and agglomeration effects. However, it abstracts from endogenous population growth and education decisions.

[7]An exception is Mountford and Rapoport (2011), who develop a stylized model with endogenous education and fertility by individuals in the sending countries and in one representative receiving economy. They show that (exogenous) high-skilled migration shocks may improve the growth rate, and reduce the fertility rate of all the economies in the world.

[8]Identification strategies rely on cross-country regressions (Stark et al., 1997; Mountford, 1997; Beine et al., 2001, 2008; Easterly and Nyarko, 2009; Docquier and Rapoport, 2012), survey data on the student population (Gibson and McKenzie, 2011; Kangasniemi et al., 2007), regional heterogeneity in emigration and education patterns (Batista et al., 2012; McKenzie and Rapoport, 2011; Yi et al., 2009), and quasi-natural emigration shocks (Clemens and Chand, 2008; Shrestha, 2017).

[9]Many studies on internal migration find that it leads to a convergence of fertility rates between migrants and urban natives (see among others, Lee and Pol, 1993 or Brockerhoff, 1995). Convergence is also obtained in studies of international migration, including Stephen and Bean (1992) and Lindstrom and Saucedo (2002) for women of Mexican origin living in the US (see also Chiswick and Miller, 2012 and Fernández and Fogli, 2009).

the pool of young adults who will be eligible for higher education in the future. Consequently, removing migration barriers reduces population growth and improves the skill structure of the world labor force. In such a context, the implications for the world economy are cumulative and gradual.

Our contribution is twofold. First, this paper provides a unified theory of bilateral migration, human capital formation and population growth. Our dynamic framework is an abstract two-class overlapping-generations model (with college graduates and less educated workers) that highlights the major economic mechanisms underlying wage inequality and microfounded decisions about migration, fertility and education. Although the model is large (because 195 countries are included), the mechanisms are transparent. The model has only a few equations per country or country pair and uses consensus microfoundations. It is parameterized to match the recent evolution of the world economy, to fit the demographic projections of the United Nations for the 21^{st} century and to match the current numbers of actual migrants (those who have already migrated) and desiring migrants (those who have not yet migrated but express a desire to do so). The availability of bilateral data on actual and desired migration helps us identify total migration costs and visa costs (i.e., policy-induced costs borne by migrants to overcome the legal hurdles set by national authorities in destination and origin countries) as residuals of the migration technology.

Second, we quantitatively revisit the short- and long-run effects of a complete removal of migration barriers from 2000 onwards using our dynamic framework. This is an improvement with respect to the existing literature, given that, to date, the feedback effects from migration decisions on fertility and education decisions have been disregarded. Our quantitative analysis reveals that the long-run impact of migration restrictions far exceeds its short-run impact. The reason is that relaxing migration barriers stimulates human capital formation and reduces the world population growth rate. In our benchmark scenario, we follow Docquier et al. (2015) and assume that all desiring migrants identified in the Gallup World Poll would migrate if visa restrictions were abolished. In this context, a complete liberalization of labor mobility increases the proportion of international migrants in the world from 3.5 to 12% in the short run. The world average level of GDP per worker increases by 12% when the shock occurs.[10] The semi-elasticity of GDP to migration equals 1.4; this value is slightly greater than the level obtained in previous studies because, in our framework, better migration prospects stimulate the expected return to higher education and investments in college education. Moreover, additional migrants from poor to rich countries also face a new institutional environment that favors investments in the basic education of their offspring. This tends to increase the pool of young adults who can access the higher education system. Consequently, the increase in educational attainment and the change in the world distribution of income are gradual and cumulative. By the year 2100, the effects are four times larger than in the short run (+52% in the worldwide level of GDP per worker). Hence, our analysis shows that large efficiency gains can be expected from removing migration barriers but these large gains mostly arise in the long run and will impact the welfare of future generations. Part of these gains are due to the so-called *brain gain* mechanism, i.e., the effect of emigration prospects on the expected returns to higher education. However, the main portion of these gains is mechanical and due to the increased access to basic education (inducing dynamic effects on population growth and higher education).

[10]Throughout the paper, the GDP per adult worker is the income measure of interest.

We also investigate the effects of partial liberalization reforms, i.e., cuts in legal migration restrictions by less than 100% and show that the efficiency and inequality effects are roughly proportional to the "liberalization rate". We then perform a large set of robustness checks. Overall, our conclusions are very robust to our identifying strategy and to assumptions about the technological environment. The results change only slightly when we deactivate the *brain gain* mechanism or when we consider alternative specifications for the technologies of production and human capital formation. Sizable differences are obtained only under three variants of the model. On the one hand, more optimistic results emerge when we allow network effects to further increase the stocks of immigrants. On the other hand, more pessimistic results are found when the baseline (pre-liberalization) trajectory of the world economy involves a rapid take-off of developing or emerging countries which reduces the gains from "South-North" migration. Efficiency gains are also lower when our estimated visa costs are adjusted for a possible upward bias due to unrealized migration aspirations. In sum, the global costs of migration restrictions are uncertain, somewhere between 4 and 18% in the short run. However, in the absence of a rapid convergence in income of less developed countries, the long-run effects are 4 to 5 times greater than the short-run ones.

The rest of this paper is organized as follows. In Section 2, we describe a microfounded model that links income disparities and decisions about migration, education and fertility. The parameterization of the model is explained in Section 3. Our benchmark results are presented in Section 4. A large set of extensions and robustness checks are discussed in Section 5. Finally, Section 6 concludes.

2 Theory

In this section, we develop an dynamic model describing the interdependencies between bilateral migration flows, human capital formation and population growth. Our world economy model considers the technological and behavioral responses to migration policy reforms. It endogenizes migration flows across countries and encompasses three channels of transmission of migration shocks. First, skill-biased changes in emigration prospects stimulate people to acquire tertiary education. Second, newly educated individuals left behind and 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. Third, movements of human capital can affect cross-country disparities in total factor productivity and wages.

Our model assumes two-period lived agents (adults and children). 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 basic education of their children. Our model abstracts from migrants' remittances, which clearly govern the redistributive effects of migration (e.g., di Giovanni et al., 2015) but have uncertain effects on fertility and human capital accumulation. A discussion of the role of remittances is provided in Section C.3.

We distinguish between college-educated adults and the less educated and assume that preferences are represented by a two-level nested utility function. Working-age individuals have heterogeneous abilities to acquire higher education and heterogeneous preferences over destination countries. However, we omit individual subscripts for notational convenience. To the best of our knowledge, this is the first paper to provide explicit microfoundations to the link between education, fertility and migration in a dynamic multi-country framework with many origin and destination countries.

The number of working-age natives from country k ($k = 1, ..., K$) at time t is denoted by $N_{k,t}$, which divides into $N^h_{k,t}$ college graduates and $N^l_{k,t}$ less educated individuals. The proportion of college graduates in the native population equals $H_{k,t} \equiv N^h_{k,t}/(N^h_{k,t} + N^l_{k,t})$. Each native decides whether to emigrate; $N^s_{ki,t}(s = h, l)$ denotes the number of emigrants from k to i of type s. After migration, the resident labor force of type s is given by $L^s_{k,t} \equiv \sum_i N^s_{ik,t}$, and $h_{k,t} \equiv L^h_{k,t}/(L^h_{k,t} + L^l_{k,t})$ denotes the proportion of college graduates among residents. The skill-specific proportion of emigrants from country k is denoted by $p^s_{k,t} \equiv \sum_{i \neq k} N^s_{ki,t}/N^s_{k,t}$.

The sections below describe the microfoundations of the fertility, education and migration decisions, in addition to income determination. Bilateral migration and higher education decisions are examined in Section 2.1. Fertility and basic education decisions are modeled in Section A.4. Human capital and population dynamics are characterized in Section 2.3. Section 2.4 describes the production technology. The intertemporal equilibrium is defined in Section 2.5.

2.1 Migration and higher education decisions

Individual decisions to emigrate and acquire higher education result from the comparison of discrete alternatives. To model them, we use a logarithmic *outer utility function* with a deterministic and a random component. The utility of an adult of cohort t, born in country k, living in country i, and acquiring (higher) education type s is given by:

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

where $\ln v^s_{i,t} \in \Re$ is the deterministic level of utility that can be reached in location i at period t (explained in Section A.4);[11] this term depends on the adult's level of consumption, and on the number and (basic) education of children. The second term, $\ln(1 - x^s_{ki,t})$, captures the net disutility implied by migration, and $x^s_{ki,t} \leq 1$ captures the net migration cost (which can be negative if amenities in the destination country are large) required to migrate from country k to country i (such that $x^s_{kk,t} = 0$). Hence, the higher are the migration costs $x^s_{ki,t}$, the higher is the disutility of migrating. Migration costs $x^s_{ki,t}$ vary across country pairs and education levels. We distinguish between visa costs and private costs. Private costs, denoted by $\overline{x}^s_{ki,t}$, cover a wide range of hurdles faced by migrants in finding employment, housing, living far from one's community, deciphering foreign cultural norms, adjusting to a new cultural and economic environment, etc. Legal or visa costs represent policy-induced costs borne by the migrant to overcome the legal hurdles set by national authorities at the destination and origin. They are obtained by subtracting the private migration costs from the total migration costs ($x^s_{ki,t} - \overline{x}^s_{ki,t}$).

Individuals are heterogeneous in their ability to acquire higher education and in their preference for alternative locations: ε^s_{ki} and z^h_k are individual-specific. Basic education is a prerequisite

[11] Although Grogger and Hanson (2011) find that a linear utility specification fits well the patterns of positive selection and sorting in the migration data, most studies rely on a concave (logarithmic) utility function (Bertoli and Fernández-Huertas Moraga, 2013; Beine et al., 2013a; Beine and Parsons, 2015; Ortega and Peri, 2013). In our microfounded framework, using a concave function ensures interior solutions for consumption, fertility and education.

for investing in higher education. Thus, only the individuals to whom parents provided basic education when they were young are able to decide whether to invest in tertiary education. The level of effort required to be of type $s = (h, l)$ in country k is denoted by $z_k^s \in [0, 1]$. We normalize $z_k^l = 0$ for those who do not invest in higher education. For those who decide to invest, we assume that $\tau_k^h \equiv \left(1 - z_k^h\right)^{-1} \in [0, \infty]$, a monotonic and increasing function of z_k^h, follows a Pareto distribution with a country-specific lower bound $\overline{\tau}_k > 0$ and a common shape parameter $\alpha > 0$. The individual-specific random taste shock for moving from country k to i is denoted by $\varepsilon_{ki}^s \in \Re$ and follows an iid Type I extreme value distribution (distributional assumptions are developed in Appendix A.1).

The timing of decisions is as follows. In the first stage, individuals who received basic education discover their education type ($z_{k,t}^s$). They do not know their migration type ($\varepsilon_{ki,t}^s$) but know its distribution. Given their perfect expectations about $v_{i,t}^s$ and $x_{ki,t}^s$, they decide whether to acquire higher education. In the second stage, they discover their migration type ($\varepsilon_{ik,t}^s$) and decide whether to emigrate or stay in the home country. The third stage of the utility maximization process determines $\ln v_{i,t}^s$ and is explained in sub-section A.4.

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) prove that conditional and unconditional utility functions coincide. In our augmented framework with endogenous education, the expected utility of choosing education type s is given by:

$$E\left(U_{k,t}^s\right) = \ln \sum_{i=1}^{I} \exp\left(\frac{\ln v_{i,t}^s + \ln(1 - x_{ki,t}^s)}{\mu}\right) + \ln(1 - z_{k,t}^s). \tag{2}$$

An individual chooses to educate if the expected benefits from college education exceed the training effort, i.e., when $E\left(U_{k,t}^h\right) > E\left(U_{k,t}^l\right)$. This condition holds if:

$$\tau_{k,t}^h \leq \frac{\sum_{i=1}^{I}(v_{i,t}^h)^{1/\mu}(1 - x_{ki,t}^h)^{1/\mu}}{\sum_{i=1}^{I}(v_{i,t}^l)^{1/\mu}(1 - x_{ki,t}^l)^{1/\mu}} \equiv \frac{(v_{k,t}^h)^{1/\mu} + (V_{k,t}^h)^{1/\mu}}{(v_{k,t}^l)^{1/\mu} + (V_{k,t}^l)^{1/\mu}}, \tag{3}$$

where $(v_{k,t}^s)^{1/\mu}$ determines the component of expected utility explained by the home country characteristics and $(V_{k,t}^s)^{1/\mu} \equiv \sum_{i \neq k}(v_{i,t}^s)^{1/\mu}(1 - x_{ki,t}^s)^{1/\mu}$ is the component linked to emigration prospects. Remember that $\tau_k^h \equiv \left(1 - z_k^h\right)^{-1}$ is Pareto distributed.

In a closed economy framework ($x_{ki,t}^s = 1\ \forall s, i \neq k$), the critical level of effort below which college education is beneficial is determined locally ($\tau_{k,t}^h = (v_{k,t}^h / v_{k,t}^l)^{1/\mu}$). In an open economy (i.e., when $V_{k,t}^s > 0$), the expected return to education is affected by emigration prospects. From (46), we have that emigration prospects increase the incentives to acquire higher education if $\frac{V_{k,t}^h}{V_{k,t}^l} > \frac{v_{k,t}^h}{v_{k,t}^l}$. The skill structure of emigration costs is a key determinant of $\frac{V_{k,t}^h}{V_{k,t}^l}$; because of skill-selective immigration policies and the greater ability of educated workers to gather information about destination countries, many migration corridors are such that $x_{ki,t}^h < x_{ki,t}^l$ and exhibit positive selection.

As stated above, basic education acquired when young is a prerequisite for investing in higher education when entering adulthood. Let us denote the proportion of working-age individuals who received basic education when young (i.e., in the previous period) in country k by $q_{k,t-1}$. The critical level of effort in (46) determines the fraction of them who find it optimal to acquire higher education. Given the Pareto distribution of the effort needed to invest in education, the proportion of working-age adults deciding to invest in college education is given by:

$$H_{k,t} = q_{k,t-1}\left[1 - \left(\overline{\tau}_k \frac{(v^l_{k,t})^{1/\mu} + (V^l_{k,t})^{1/\mu}}{(v^h_{k,t})^{1/\mu} + (V^h_{k,t})^{1/\mu}}\right)^{\alpha}\right], \tag{4}$$

where $\overline{\tau}_k$, the country-specific lower bound of the Pareto distribution, captures the access to higher education in country k. The implication is that the average responsiveness of investment in college education to 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. In the next sub-section, we show that the enrollment rate in basic education itself depends on the lagged proportion of college graduates because college-educated parents invest more in the basic education of their offspring. This mechanism explains the strong persistence in human capital and implies that a shock in emigration prospects induces gradual effects on the world economy.

Second stage. When education is determined, individuals choose to emigrate permanently to country i if $\ln v^s_{i,t} + \ln(1 - x^s_{ki,t}) + \varepsilon^s_{ki}$ exceeds the level attainable in any other location. Because adulthood represents one period of life, migration flows are basically identical to migration stocks.[12] Under the Type I extreme value distribution, McFadden (1974) shows that the probability of emigrating is governed by a logit expression. The emigration rate is given by:

$$\frac{N^s_{ki,t}}{N^s_{k,t}} = \frac{\exp\left(\frac{\ln v^s_{i,t} + \ln(1-x^s_{ki,t})}{\mu}\right)}{\sum_{j=1}^{I}\exp\left(\frac{\ln v^s_{j,t} + \ln(1-x^s_{kj,t})}{\mu}\right)} = \frac{(v^s_{i,t})^{1/\mu}(1 - x^s_{ki,t})^{1/\mu}}{\sum_{j=1}^{I}(v^s_{j,t})^{1/\mu}(1 - x^s_{kj,t})^{1/\mu}}. \tag{5}$$

Hence, the emigration rate from k to i depends on the characteristics of all potential destinations (i.e., a crisis in Greece affects the emigration rate from Romania to Germany). However, staying rates ($N^s_{kk,t}/N^s_{k,t}$) are governed by the same logit model. It follows that the emigrant-to-stayer ratio is governed by the following expression:

$$\frac{N^s_{ki,t}}{N^s_{kk,t}} = \left(\frac{v^s_{i,t}}{v^s_{k,t}}\right)^{1/\mu}(1 - x^s_{ki,t})^{1/\mu}. \tag{6}$$

In a partial equilibrium model with exogenous wages, this emigrant-to-stayer ratio satisfies the property of Independence of Irrelevant Alternatives (i.e., a crisis in Greece does not affect

[12]Note that in the present framework, migration is permanent and irreversible. Kennan and Walker (2011) use a richer decision framework that allows for sequential migration decisions (i.e., multiple moves). As noted by these authors, the addition of more dimensions complicates the computation exponentially. This is particularly problematic in a large multi-country framework. Nevertheless, we consider temporary migrants in a robustness check.

the emigrant-to-stayer ratio from Romania to Germany). However, in our general equilibrium framework, the Greek crisis affects migration from Greece to Germany, German wages, and the incentives of Romanians to move to Germany. Therefore, our multi-country framework with endogenous wages accounts for such "multilateral resistance" effects.

Skill-specific emigration rates are endogenous and range from 0 to 1. Eq. (49) states that the ratio of emigrants from country k to country i to stayers in country k (i.e., individuals born in k who remain in k) is an increasing function of the utility achievable in destination country i and a decreasing function of the utility in country of origin k. The proportion of migrants from k to i also decreases with the bilateral migration cost $x^s_{ki,t}$. Heterogeneity in migration tastes implies that emigrants select all destinations for which $x^s_{ki,t} < 1$ (if $x^s_{ki,t}$=1, the corridor is empty). Additionally, all corridors for which $x^s_{ik,t}, x^s_{ki,t} < 1$ exhibit bidirectional migration flows.

The aggregate emigration rate ($p^s_{k,t}$) and the skill ratio of emigration rates ($\rho_{k,t}$) from country k are jointly determined and given by the following expressions:

$$\begin{aligned} p^s_{k,t} &\equiv \frac{\sum_{i\neq k} N^s_{ki,t}}{N^s_{k,t}} = \frac{(V^s_{k,t})^{1/\mu}}{(v^s_{k,t})^{1/\mu} + (V^s_{k,t})^{1/\mu}}, \\ \rho_{k,t} &\equiv \frac{p^h_{k,t}}{p^l_{k,t}} = \frac{(V^h_{k,t})^{1/\mu}}{(V^l_{k,t})^{1/\mu}} \left[\frac{(v^h_{k,t})^{1/\mu} + (V^h_{k,t})^{1/\mu}}{(v^l_{k,t})^{1/\mu} + (V^l_{k,t})^{1/\mu}} \right]^{-1}. \end{aligned} \quad (7)$$

The skill ratio of emigration rates increases with $V^h_{k,t}$ and decreases with $V^l_{k,t}$. From (47) and (7), 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 $sgn\left(\frac{\partial H_{k,t}}{\partial v^s_{k,t}}\right) \neq sgn\left(\frac{\partial \rho_{k,t}}{\partial v^s_{k,t}}\right)$. The implication is that emigration-driven expected utility shocks ($\Delta V^s_{k,t}$) induce a positive association 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 association between $H_{k,t}$ and $\rho_{k,t}$.

In particular, shocks that increase 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 the positive selection of emigrants (as reflected by the ratio of emigration rates $\rho_{k,t}$). Shocks that increase the expected utility of the less educated abroad have a negative effect on both variables. This establishes the microfoundation for the link between emigration rates ($p^s_{k,t}$) and pre-migration human capital formation ($H_{k,t}$) in a multi-destination framework (see Stark et al., 1997; Mountford, 1997; Beine et al., 2001, 2008; Easterly and Nyarko, 2009; Docquier and Rapoport, 2012).

2.2 Fertility and basic education decisions

We now endogenize $\ln v^s_{k,t}$ as resulting from the *third stage* of the utility maximization process. Our model mainly focuses on higher education, because it plays a key role in governing the productivity disparities between countries and labor market interactions with the less educated. However, basic education is a prerequisite for accessing higher education. Hence, our model also endogenizes the proportion of children receiving basic (primary and secondary) education, albeit in a simpler manner. Decisions about consumption ($c^s_{k,t}$), fertility ($n^s_{k,t}$) and the proportion of children receiving basic (primary and secondary) education ($q^s_{k,t}$) are governed by a warm-glow motive; adults directly value the quality and quantity of children, but they do not anticipate the future income and utility of their children. Hence, parents are altruistic towards their children but in a more limited sense than in the dynastic model of Becker and Barro (1988).[13] In line with Weil and Galor (2000), de la Croix and Doepke (2003), de la Croix and Doepke (2004) and Galor (2011), our *inner utility function* $v^s_{k,t}$ is a logarithmic function of $c^s_{k,t}$, $n^s_{k,t}$ and $q^s_{k,t}$:

$$\ln v^s_{k,t} = (1-\theta)\ln c^s_{k,t} + \theta \ln n^s_{k,t} + \theta\lambda \ln q^s_{k,t}, \tag{8}$$

where $\theta \in [0,1]$ and $\lambda \in [0,1]$ are preference parameters for fertility and the basic education of children.

Each adult receives a wage rate $w^s_{k,t}$ per unit of time worked. Raising a child requires a time cost ϕ, and providing a child with basic education induces a monetary education cost $e^s_{k,t}$. We allow non-educated children to work and earn a wage $w^c_{k,t}$ per unit of time spent on the labor market (reflecting country-specific, social and institutional norms regarding child labor).

The budget constraint is written as:

$$c^s_{k,t} + n^s_{k,t} q^s_{k,t} e^s_{k,t} = w^s_{k,t}(1-\phi n^s_{k,t}) + n^s_{k,t}(1-q^s_{k,t}) w^c_{k,t}. \tag{9}$$

Each adult maximizes utility (8) subject to $q^s_{k,t} \leq 1$ and the budget constraint (9). Appendix A.4 details the first-order conditions and the condition under which an interior solution emerges. Assuming first an *interior solution* with $q^s_{k,t} < 1$, the optimal fertility rate and investment in basic education are given by:

$$n^s_{k,t} = \frac{\theta(1-\lambda) w^s_{k,t}}{\phi w^s_{k,t} - w^c_{k,t}}, \tag{10}$$

$$q^s_{k,t} = \frac{\lambda}{1-\lambda} \frac{\phi w^s_{k,t} - w^c_{k,t}}{e^s_{k,t} + w^c_{k,t}}. \tag{11}$$

In line with intuition, the fertility rate decreases with the adult's wage rate ($w^s_{k,t}$) but increases with the child's wage rate ($w^c_{k,t}$). Children's basic education increases with the adult's wage rate ($w^s_{k,t}$) but decreases with the education cost ($e^s_{k,t}$) and the child's wage rate ($w^c_{k,t}$).

In the case of a *corner solution* with $q^s_{k,t} = 1$, the fertility rate is:

$$n^s_{k,t} = \frac{\theta w^s_{k,t}}{\phi w^s_{k,t} + e^s_{k,t}}. \tag{12}$$

Countries differ in terms of technology and policies. The endogenous wage ratio between college graduates and the less educated is denoted by $\sigma_{k,t} \equiv w^h_{k,t}/w^l_{k,t}$. The exogenous wage ratio between children and low-skilled adults is denoted by $\omega_{k,t} \equiv w^c_{k,t}/w^l_{k,t}$. The ratio of basic education costs to the high-skilled wage rate is denoted by $\xi^s_{k,t} \equiv e^s_{k,t}/w^h_{k,t}$. These country-specific variables fully characterize the fertility and basic education levels/differentials. Indeed, dividing (10), (11) and (12) by $w^l_{k,t}$, we have:

$$\left(n^l_{k,t}, q^l_{k,t}\right) = \begin{cases} \left(\frac{\theta(1-\lambda)}{\phi-\omega_{k,t}}, \frac{\lambda}{1-\lambda}\frac{\phi-\omega_{k,t}}{\xi^l_{k,t}\sigma_{k,t}+\omega_{k,t}}\right) & \text{if } 1 \leq \frac{(1-\lambda)\xi^l_{k,t}\sigma_{k,t}+\omega_{k,t}}{\phi\lambda} \\ \left(\frac{\theta}{\phi+\xi^l_{k,t}\sigma_{k,t}}, 1\right) & \text{otherwise} \end{cases} \tag{13}$$

[13]The dynastic model is much less tractable, and its properties are highly sensitive to the choice of the elasticities of substitution (Jones and Schoonbroodt, 2010). In addition, Kollmann (1997) demonstrates that the qualitative predictions of the non-dynastic model are strikingly similar to those of a properly calibrated dynastic model.

and

$$\left(n_{k,t}^h, q_{k,t}^h\right) = \begin{cases} \left(\frac{\theta(1-\lambda)\sigma_{k,t}}{\phi\sigma_{k,t}-\omega_{k,t}}, \frac{\lambda}{1-\lambda}\frac{\phi\sigma_{k,t}-\omega_{k,t}}{\xi_{k,t}^h\sigma_{k,t}+\omega_{k,t}}\right) & \text{if} \quad \sigma_{k,t} \leq \frac{(1-\lambda)\xi_{k,t}^h\sigma_{k,t}+\omega_{k,t}}{\phi\lambda} \\ \left(\frac{\theta}{\phi+\xi_{k,t}^h}, 1\right) & \text{otherwise} \end{cases}. \tag{14}$$

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. Substituting the optimal levels of fertility and basic education investment into (8) defines the optimal level of indirect utility, $\ln v_{k,t}^s$. We have:

$$\ln v_{k,t}^s = (1-\theta)\ln w_{k,t}^s + \ln \Omega_{k,t}^s, \tag{15}$$

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 the optimal levels of fertility and investment in basic education. The latter solely depend on the trajectory of country-specific characteristics, reflected by the vector $(\omega_{k,t}, \sigma_{k,t}, \xi_{k,t}^s)$.

2.3 Aggregates and dynamics

The average fertility rate and proportion of children receiving basic education are given by:

$$n_{k,t} \equiv h_{k,t}n_{k,t}^h + (1-h_{k,t})n_{k,t}^l, \tag{16}$$

$$q_{k,t} \equiv \frac{h_{k,t}q_{k,t}^h n_{k,t}^h + (1-h_{k,t})q_{k,t}^l n_{k,t}^l}{n_{k,t}}. \tag{17}$$

Labor is the only production input. The labor supply of type s ($\ell_{k,t}^s$) is determined by migration and fertility decisions, and we assume that low-skilled workers and employed children are perfect substitutes, though their productivity differs by a factor $\omega_{k,t}$:

$$\ell_{k,t}^h = L_{k,t}^h(1-\phi n_{k,t}^h), \tag{18}$$

$$\ell_{k,t}^l = L_{k,t}^l(1-\phi n_{k,t}^l) + L_{k,t}^l n_{k,t}^l(1-q_{k,t}^l)\omega_{k,t} + L_{k,t}^h n_{k,t}^h(1-q_{k,t}^h)\omega_{k,t}. \tag{19}$$

The dynamics of the native population ($N_{k,t}$) are given by:

$$N_{k,t} = L_{k,t-1}n_{k,t-1}, \tag{20}$$

and the proportion of college graduates in the adult population ($H_{k,t}$) is defined in equation (47). Clearly, $N_{i,t}$ is a pre-determined variable, whereas $H_{k,t}$ is not because adults' investment in higher education is determined at time t.

2.4 Production technology

The model has no physical capital and assumes that output is proportional to labor in efficiency units, a CES (constant elasticity of substitution) function of the number of college-educated and less educated employees. It features a globalized economy in which capital "chases" labor, in line with Klein and Ventura (2009) or Kennan (2013).[14] The baseline production function is written as:

$$Y_{k,t} = A_{k,t}Q_{k,t} \text{ with} \tag{21}$$

$$Q_{k,t} = \left(\eta_k {\ell^h_{k,t}}^{\frac{\sigma_s-1}{\sigma_s}} + (1-\eta_k){\ell^l_{k,t}}^{\frac{\sigma_s-1}{\sigma_s}}\right)^{\frac{\sigma_s}{\sigma_s-1}}, \tag{22}$$

where σ_s is the elasticity of substitution between the two types of workers, η_k governs the relative productivity of high-skilled workers, and $A_{k,t}$ denotes total factor productivity. In the benchmark model, the latter variable follows an exogenous time path and grows at the same rate in all countries.

The wage rates are determined by the marginal productivity of labor, which in the CES function case is:

$$w^h_{k,t} = \eta_k A_{k,t}\left(\frac{Q_{k,t}}{\ell^h_{k,t}}\right)^{\frac{1}{\sigma_s}}, \tag{23}$$

$$w^l_{k,t} = (1-\eta_k)\, A_{k,t}\left(\frac{Q_{k,t}}{\ell^l_{k,t}}\right)^{\frac{1}{\sigma_s}}, \tag{24}$$

$$w^c_{k,t} = \omega_{k,t} w^l_{k,t}. \tag{25}$$

The ratio of wage rates between high-skilled and low-skilled workers:

$$\sigma_{k,t} \equiv \frac{w^h_{k,t}}{w^l_{k,t}} = \frac{\eta_k}{1-\eta_k}\left(\frac{\ell^h_{k,t}}{\ell^l_{k,t}}\right)^{\frac{-1}{\sigma_s}}, \tag{26}$$

is therefore endogenous. In our robustness analysis, we consider several variants of the production technology, assuming an infinite elasticity of substitution (linear technology) or technological externalities. We also consider schooling externalities, diversity spill-overs or congestion effects. Under these variants, $A_{k,t}(.)$ varies with the proportion of college graduates in the working-age population ($h_{k,t}$), with an indicator of cultural diversity among workers (as proxied by a birthplace diversity index $Div_{k,t}$), or with the total working-age population ($L^h_{k,t} + L^l_{k,t}$).

2.5 Intertemporal equilibrium

Our benchmark model assumes a CES production function with exogenous levels of total factor productivity. In this context, an intertemporal equilibrium for the world economy can be defined as follows:

[14] Capital adjustments are rapid in open economies. Ortega and Peri (2009) find that flows of immigrants increase one-for-one employment and capital stocks in the receiving country in the short term (i.e., within one year), leaving the capital/labor ratio unchanged. In the long term, this condition also holds in a closed economy with endogenous savings since the steady state interest rate is determined by the intertemporal discount rate of individuals.

Definition 1 *For a set* $\{\theta, \lambda, \phi, \mu, \alpha, \sigma_s\}$ *of structural parameters, a set* $\{\omega_{k,t}, \xi^s_{k,t}, \overline{\tau}_{k,t}, A_{k,t}, \eta_k\}_{\forall k,s,t}$ *of exogenous country-specific institutional, educational and technological characteristics, a set* $\{x^s_{ki,t}\}_{\forall k,i,t,s}$ *of bilateral migration costs and a set* $\{N_{k,t}, q_{k,t-1}\}_{\forall k,t}$ *of predetermined variables or initial conditions, an intertemporal equilibrium is a set of endogenous variables* $\{w^s_{k,t}, \sigma_{k,t}, H_{k,t}, n^s_{k,t}, q^s_{k,t}, N^s_{ki,t}, L^s_{k,t}, h_{k,t}, \ell^s_{k,t}\}_{\forall k,i,t,s}$ *such that (i) wages* $w^s_{k,t}$ *maximize profits, as depicted in (23), (24), (25) and (26), (ii) the proportion of college graduates in the native labor force* $H_{k,t}$ *satisfies (47), (iii) adults' fertility rates and investment in basic education maximize location-specific utility, as depicted in (10) and (11), (iv) the allocation of the world labor force maximizes utility, as depicted in (49), (vi) aggregation constraints* $L^s_{k,t} \equiv \sum_i N^s_{ik,t}$*,* $h_{k,t} \equiv L^h_{k,t}/(L^h_{k,t} + L^l_{k,t})$*, (vi) the labor supply is determined by (18) and (19), and (vii) the evolution of the native adult population is governed by (16), (17) and (20).*

In Section 3 we parameterize the baseline (pre-liberalization) trajectory for the world economy. We then simulate the effects of liberalization shocks in Section 4. More specifically, in our benchmark scenario, a complete removal of legal migration barriers means that $x^s_{ki,t}$ decrease to $\bar{x}^s_{ki,t}$ for all k, i, s and t. Different counterfactual scenarios for the migration costs and desiring migrant stocks are also considered. In the robustness checks, described in Section 5, we consider alternative technological scenarios.

3 Parameterization

The model is calibrated for 2000, the last year for which comprehensive migration matrices by education level are available. The horizon of our simulations is 2100, and one period represents 25 years. Our baseline trajectory is designed to match the evolution of the world economy between 1975 and 2000 and to fit the demographic projections of the United Nations for individuals aged 25 and over for the 2000-2100 period (United Nations, 2011).

3.1 Technological parameters

Mincerian returns to schooling, MR_i, are available for 54 countries around the year 2000 in Hendricks (2004). For the same countries, we use the data in Barro and Lee (2013) and compute the difference in years of schooling, $DY_{k,2000}$, between college graduates and less educated workers. The wage ratio between college graduates and less educated adult workers is then proxied as $\sigma_{k,2000} = (1 + MR_{k,2000})^{DY_{k,2000}}$. For countries for which data are not available, we predict the wage ratio using a log-linear function of the skill ratio in the resident labor force.[15] We then use these wage ratios and data on the population structure to compute the CES labor composite, $Q_{k,2000}$. In line with the labor market literature (see Ottaviano and Peri, 2012), we assume that the elasticity of substitution between college-educated and less educated workers, σ_s, is equal to 2. The preference for college-educated workers, η_k, is calibrated to match the wage ratio in 2000, $\sigma_{k,2000}$. Finally, we use the labor composites, $Q_{k,2000}$, and observed gross domestic product ($Y_{k,2000}$) to retrieve the country-specific productivity level in 2000: $A_{k,2000} = Y_{k,2000}/Q_{k,2000}$.

[15] A simple OLS regression gives $\ln \sigma_{i,2000} = 0.25 - 0.31 \ln \frac{h_{i,2000}}{1-h_{i,2000}}$ with R^2=0.57.

Data on gross domestic product are obtained from the World Development Indicators (World Bank, 2010).

For subsequent periods, η_k is assumed to be constant. In line with Eq. (26), the wage ratio $\sigma_{k,t}$ varies with the skill structure of the labor force. Regarding $A_{k,t}$, we assume that it grows at a constant and homogeneous rate of 1.5% per year (i.e., 45% per period) in all countries, $A_{k,t} = A_{k,t-1}(1 + 0.015)^{25}$. Alternative TFP convergence scenarios are considered in Section 5.

3.2 Preference and institutional parameters

We first consider $\{\theta, \lambda, \phi, \mu, \alpha\}$ as a set of structural parameters, assumed to be identical across countries and time invariant. These parameters are calibrated using insights from the literature. Regarding parameter ϕ, the time-cost of having a child, the evidence in Haveman and Wolfe (1995) suggests that the opportunity cost of a child is equivalent to approximately 15% of the parents' time endowment, which means that the maximal fertility rate equals 6.7 children per adult or 13 per couple. Regarding the altruism parameter θ, the literature provides a range of values between 0.10 in de la Croix and Gosseries (2009), 0.17 in de la Croix and Doepke (2004) and 0.27 in de la Croix and Doepke (2003). Regarding the preference for basic education λ, de la Croix and Doepke (2003) and de la Croix and Doepke (2004) use values of 0.635 and 0.6, respectively, whereas de la Croix and Gosseries (2009) use 0.578. In line with these papers, we use $(\theta, \lambda, \phi) = (0.3, 0.6, 0.15)$. In the robustness analysis, we consider alternative values for θ and λ.

Regarding the scale parameter of the distribution of migration tastes μ, Bertoli and Fernández-Huertas Moraga (2013) find an elasticity of bilateral migration to the wage ratio $(w^s_{j,t}/w^s_{k,t})$ between 0.6 and 0.7. Given the values of the preference parameters and plugging the solution of the maximization problem in (15) into (49), this elasticity equals $(1-\theta)/\mu$ in our model. By choosing $\mu = 1$, the responsiveness of migration to wage disparities in our model is thus in line with the empirical literature.

Parameter α, the common shape parameter of the Pareto distribution of the ability to acquire higher education, governs the responsiveness of higher education decisions to the expected returns to schooling, as shown in (47). We iterated on α (and the vector of $\overline{\tau}_{k,t}$, as explained below) to match the elasticity of human capital formation to the high-skilled emigration rate found in the empirical literature. To conduct this exercise, we simulate several liberalization shocks of high-skilled migration for all country pairs and select α to match the average long-run elasticity of the pre-migration proportion of college graduates to the high-skilled emigration rate equal to 0.20 in developing countries, as in Beine et al. (2008). Setting $\alpha = 0.4$, we obtain an elasticity of 0.21.

Other country-specific characteristics, $\left\{\omega_{k,t}, \xi^s_{k,t}, \overline{\tau}_{k,t}\right\}_{\forall k,s,t}$, are allowed to vary over time to match some moments. Regarding the characteristics that affect fertility and basic education decisions $(\omega_{k,t}, \xi^s_{k,t})$, we first use cross-country data on the skill structure of the resident labor force in 1975 $(L_{i,1975})$ from Defoort (2008) and of the native labor force in 2000 $(N_{i,2000})$ from Artuç et al. (2015). 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 match the average fertility rate $(n_{i,1975} = N_{i,2000}/L_{i,1975})$ and proportion of natives with secondary education $(q_{k,1975})$ in 1975. We calibrate $(\omega_{k,1975}, \xi^l_{k,1975})$ so that the optimal fertility rates of less educated parents match the level observed in 1975 $\left(n^l_{k,1975}, q^l_{k,1975}\right)$. It is worth noting that our worldwide average level of differential fertility $n^h_{k,1975}/n^l_{k,1975}$ is approximately 0.6, which corresponds to the average level reported in Kremer and Chen (1999). Finally, $\xi^h_{k,1975}$ is calibrated to be compatible with $n^h_{k,1975} = 1$ using Eq. (12).

For subsequent periods, $n^l_{k,t}$ and q^l_k are adjusted to match the medium variant of the UN demographic projections (United Nations, 2011). We then calibrate the trajectory of $\omega_{k,t}$ to match the time path for $n^l_{k,t} \forall k, t$. Doing so requires $\omega_{k,t}$ to be 3, 24.8, 44.8 and 44.8% smaller than $\omega_{k,1975}$ in the years 2000, 2025, 2050 and 2075, respectively. With this time path for $\omega_{k,t}$, our labor force projections are in line with the medium demographic projections of the United Nations (4.904, 6.378 and 7.252 billion of individuals aged 25 and over in 2025, 2050 and 2075, respectively). We also assume $\xi^s_{k,t} = \xi^s_{k,1975} \forall k, s, t$. Note that the evolution of these country characteristics determines the trajectory of $\ln \Omega^s_{k,t}$ in (15) and the trajectory of the supply of labor $\left(\ell^s_{k,t}\right)$ from (18) and (19).

Finally, decisions about higher education are governed by the Pareto distribution of the effort cost of acquiring tertiary education. Although α is assumed to be common to all countries, the lower bound of the distribution, parameter $\overline{\tau}_{k,t}$, is allowed to vary across countries. For a given α, $\overline{\tau}_{k,2000}$ is calibrated to match the proportion of college graduates in the labor force of country k in 2000. For subsequent periods, our baseline trajectory assumes that $\overline{\tau}_{k,t} = \overline{\tau}_{k,2000}$ are constant for all k and t. Appendix B.1 shows that our identified institutional parameters exhibit realistic correlations with observations for related variables that are viewed as being traditional determinants in the empirical literature.

3.3 Migration costs

There is no database that measures the magnitude of bilateral migration costs and gives the decomposition of their private and legal parts. Our dual calibration strategy consists of combining original data on effective and desired migration by education level to approximate the number of adults who could respond to a complete abolition of visa restrictions (under the current world income distribution). We first calibrate total migration costs $(x^s_{ki,t})$ as residuals from the migration technology in Eq. (49). We use the data set described in Artuç et al. (2015), which documents bilateral migration stocks for all pairs of countries $(N^s_{ki,2000})$ and the stocks of native stayers $(N^s_{kk,2000})$ by education level in 2000. Because the level of $v^s_{k,2000}$ is governed by preference and institutional characteristics, bilateral migration costs $(1 - x^s_{ki,2000})$ can be recovered for each pair of countries as residuals of (49).

Migration costs represent the sum of the legal costs incurred in obtaining a visa and the private costs incurred by migrants in moving and assimilating to the destination country. Migration costs are smaller for college graduates than for the less educated (see Appendix B.2 for some descriptive statistics). To calibrate private migration costs, we need the bilateral migration stocks that would be observed in a world without legal migration barriers. To obtain these stocks, we aggregate four waves of the Gallup World Poll survey data, the most comprehensive source of data on migration aspirations. The survey includes two relevant questions on desires to emigrate: "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?" and "To which country would you like to move?".

As in Docquier et al. (2015), our benchmark scenario assumes that "having the opportunity" is interpreted by the respondents as the complete absence of policy restrictions to movement. The Gallup survey therefore provides the number of additional immigrants, $A^s_{ki,t}$, that would be observed if migration barriers where lifted. The skill-specific potential migration stocks $\bar{N}^s_{ki,t}$ (also referred to as desiring migrants) are then denoted:

$$\bar{N}^s_{ki,t} = N^s_{ki,t} + A^s_{ki,t}, \tag{27}$$

where $N^s_{ki,t}$ denotes the observed migrant stocks of skill s between country k and country i and $A^s_{ki,t}$ the number of additional immigrants in this bilateral corridor. Assuming that respondents do not internalize general equilibrium effects (i.e., they take current wage rates as referential), we identify private costs in the benchmark counterfactual $(1-\bar{x}^s_{ki,2000})$ as a residual of (49) using the number of uncorrected desiring migrants (i.e., observed and additional immigrants), $\bar{N}^s_{ki,2000}$.

The use of contingent valuation surveys to estimate the migrant stocks that would be observed in a world without restrictions to migration can be criticized (see Clemens and Pritchett, 2016). Most of the papers reviewed in Clemens (2011) obtain migrant stocks by equalizing wages across destinations, disregarding migration costs or calibrating them on transportation costs within specific bilateral corridors. This approach leads to migrant stocks exceeding 50% of the world population. The huge income discrepancies within US States or countries inside the Schengen area however speak against assuming wage equalization.[16] Therefore, while acknowledging the limits of survey data, we use the Gallup data to approximate the number of people who could respond to a complete abolition of visa restrictions.[17] Although the interpretation of the Gallup questions raises potential issues (as discussed in Appendix B.2), there are reasons to believe that the Gallup World Poll Survey provides reasonable estimates of the short-run response to a liberalization, at least before general equilibrium and network effects operate. Some recent empirical studies reveal that the reported aspirations are nicely correlated with the traditional determinants of migration (see, among others, Docquier et al., 2014; Dustmann and Okatenko, 2014; Manchin and Orazbayev, 2016). Moreover, there is a high correlation between migration aspirations at year t and the actual migration flows at year $t+1$ (Bertoli and Ruyssen, 2016), though the size of the actual flows is smaller.

The interpretation of our calibrated migration costs should not be pushed too far because $x^s_{ki,2000}$ includes disparities in non-monetary amenities and does not measure migration costs per se. Nevertheless, we check whether this measure exhibits expected correlations with control variables used in the standard gravity equations (distance, common language, colonial links, etc.) and a proxy for visa restrictions in Appendix B.2. Although internationally comparable migration law data are missing, we check whether the calibrated migration costs are correlated to the "Bilateral Visa Restriction Index" provided by Neumayer (2006). This index measures whether a destination country imposes a visa restriction on travelers from a destination country, and it is likely that countries that impose more restrictive conditions on travelers are also more likely to have more stringent migration laws.

We find that the Visa index is positively and significantly correlated with our total migration cost measure for the less educated individuals. Not surprisingly, the significance of the Visa index

[16] Desmet et al. (2017) obtain that 78.2% of the population migrates if migration costs are lifted in a dynamic model accounting for idiosyncratic tastes, location-specific amenities and agglomeration effects.

[17] In Section 4, we test the robustness of our results by assessing different variants of the number of potential migrants.

coefficient is weaker for the private migration costs. For highly educated individuals, the Visa index is positively and significantly correlated with total migration costs but not with private costs. Moreover, the total migration cost (both for the less and highly educated individuals) also exhibits the desired correlations with most of the standard determinants used in the empirical literature.

Intuitively, the difference between total and private migration costs should be a proxy for the visa restrictions. However, the latter are not significantly correlated to the Visa index. This absence of statistical correlation should not be overstressed for four different reasons. First, the Visa index used is only an imperfect proxy for visa restrictions. For example, following the index, Mexicans do not face a traveling restriction to the United States, whereas Gallup shows a large number of Mexicans desiring to emigrate to the United States. Second, the index may capture the extensive margin of legal restrictions, but not the intensive margin. Desiring migrants in corridors with large networks face smaller costs as they can rely more easily on family reunification programs. In addition, it is generally easier for high-skilled desiring migrants to realize their aspirations, in particular in countries with points-based systems such as Canada, Australia, the UK or New-Zealand. Third, visa restrictions are endogenous: they are more likely to be observed between countries exhibiting large development gaps and greater linguistic/cultural distance (given the imperfect transferability of skills). Finally, the same determinants affect the number of desiring migrants and the calibrated level of migration costs. This induces severe reverse causation and collinearity problems in our regressions.

Our interpretation of the migration intentions provided in Gallup implies that no individuals within a free mobility area, such as the Schengen area, should state a desire to leave their country for another country in the same free mobility area, as there is by definition no mobility restriction within two member states. However, from the Gallup survey it appears that some individuals state a desire to migrate within Schengen area countries (i.e., French respondents stating a desire to move to Germany). Thus, part of the migration costs that our strategy identifies as legal restrictions might actually capture part of the private migration costs. In particular, some individuals that state a desire to move might not have realized their desire yet or consider that "having the opportunity" goes beyond the issuance of a visa (see Appendix B.2 for a discussion on the interpretation of the Gallup data).

In this context, the total number of additional immigrants, $A^s_{ki,t}$, is the sum of constrained individuals, $A^{s,visa}_{ki,t}$, and individuals who are not constrained by policies but have not realized their migration aspiration for other reasons, $A^{s,unc}_{ki,t}$:

$$A^s_{ki,t} = A^{s,visa}_{ki,t} + A^{s,unc}_{ki,t}. \tag{28}$$

The Gallup survey does not allow to dissociate individuals that are constrained by policy restrictions from individuals who are not. Ideally, only the constrained individuals $A^{visa}_{ki,t}$ should be accounted for in our simulations and thus the stock of desiring immigrants, $\hat{N}^s_{ki,t}$, should be:

$$\hat{N}^s_{ki,t} = N^s_{ki,t} + A^{s,visa}_{ki,t} = N^s_{ki,t} + A^s_{ki,t} - A^{s,unc}_{ki,t}. \tag{29}$$

In our benchmark counterfactual scenario, denoted $\bar{N}^s_{ki,t}$, we assume that $A^{s,unc}_{ki,t} = 0$ and thus $A^s_{ki,t} = A^{s,visa}_{ki,t}$. In the alternative counterfactual, denoted $\hat{N}^s_{ki,t}$, we relax the assumption that

$A^{s,unc}_{ki,t} = 0$ and proxy the number of unconstrained migrants in the data. From equation (29), we have that:

$$\hat{N}^s_{ki,t} = N^s_{ki,t} + A^{s,visa}_{ki,t}, \tag{30}$$

$$= (N_{ki,t} + A^s_{ki,t}) \left(1 - \frac{A^{s,unc}_{ki,t}}{N^s_{ki,t} + A^s_{ki,t}}\right), \tag{31}$$

$$= (N_{ki,t} + A^s_{ki,t}) \left(1 - \eta^s_{ki,t}\right), \tag{32}$$

where $\left(1 - \eta^s_{ki,t}\right)$ is the correcting factor that should be applied to the total stock of desiring immigrants (i.e., composed of the observed immigrant stocks and individuals that reply positively to the migration aspiration question in Gallup).

In order to calibrate an average correcting factor that can be applied to all bilateral migration stocks, we rely on desires to migrate within the Schengen area as, by definition, $A^s_{ki,t} = A^{s,unc}_{ki,t}$ (and $A^{s,visa}_{ki,t}$=0) when $k, i \in Schengen$:

$$\eta^s_{Sch} = \frac{\sum_{k,i \in Schengen} A^{s,unc}_{ki,t}}{\sum_{k,i \in Schengen}(N^s_{ki,t} + A^{s,unc}_{ki,t})} = \frac{\sum_{k,i \in Schengen} A^s_{ki,t}}{\sum_{k,i \in Schengen}(N^s_{ki,t} + A^s_{ki,t})}. \tag{33}$$

We then apply this skill-specific correcting factor to all bilateral corridors that are not within the Schengen area albeit imposing that desiring migrant stocks cannot be lower than observed migrant stocks (i.e., the number of additional immigrants cannot be negative) such that:

$$\hat{N}^s_{ki,t} = N^s_{ki,t} + A^{s,visa}_{ki,t} = \max(N^s_{ki,t}; (N^s_{ki,t} + A^s_{ki,t})\,(1 - \eta^s_{Sch})) \text{ if } k, i \notin \text{Schengen}, \tag{34}$$

$$A^{s,visa}_{ki,t} = \max(0; A^s_{ki,t}\,(1 - \eta^s_{Sch}) - \eta^s_{Sch} N^s_{ki,t}) \text{ if } k, i \notin \text{Schengen}, \tag{35}$$

whereas, as before:

$$A^{s,visa}_{ki,t} = A^s_{ki,t} = 0 \text{ if } k, i \in \text{Schengen}. \tag{36}$$

The skill-specific fraction of unrealized migration aspirations for intra-Schengen area movements are $\eta^l_{Sch} = 0.3226$ and $\eta^h_{Sch} = 0.3339$. Applying these values to corridors outside the Schengen area in equation (34) reduces the total number of desiring migrants from 318 to 228 million (i.e., -28.3%) and the number of highly educated desiring migrants from 68 to 50 million (i.e., -26.5%) in the alternative counterfactual (compared to the benchmark counterfactual).

Private costs for the alternative counterfactual $(1-\hat{x}^s_{ki,2000})$ are obtained using the Schengen-adjusted desiring migrants stocks, $\hat{N}^s_{ki,2000}$. The two counterfactual scenarios thus lead to two different sets of private migration costs. Our calibration strategy replicates migration data for the year 2000. For subsequent periods, our baseline scenario assumes that $x^s_{ki,t} = x^s_{ki,2000}$, $\bar{x}^s_{ki,t} = \bar{x}^s_{ki,2000}$ and $\hat{x}^s_{ki,t} = \hat{x}^s_{ki,2000}$ are constant for all k, i, s, and t.

4 Opening borders: Results for alternative levels of migration costs

The sections below describe our main results. Section 4.1 provides the results obtained with our benchmark levels of migration costs whereas Section 4.2 discusses the impact of a liberalization using the Schengen-adjusted visa costs. Alternative interpretations of the Gallup data are presented in Section 4.3. Section C.3 discusses the limits inherent to the absence of remittances in our model.

4.1 Benchmark results

We use our model to simulate the effects of a permanent abolition of migration barriers, i.e., an abolition of legal migration costs, assuming that the shock occurs in 2000. The results for 2000 are therefore fully comparable to those obtained in the static framework with exogenous population size and structure of Docquier et al. (2015). Throughout the paper, we mainly focus on efficiency gains: to what extent is the worldwide level of income per worker enhanced by allowing desiring migrants to move?[18]

We first consider liberalization variants in which, for each pair of countries, the legal costs of migration are reduced by ϑ percent. Hence, ϑ can be interpreted as the liberalization rate. The change in legal migration costs is written as:

$$x^s_{ki,t} \longrightarrow x^s_{ki,t} - \vartheta(x^s_{ki,t} - \bar{x}^s_{ki,t}) \ \ \forall s, k, i, t. \tag{37}$$

Four values of ϑ are considered, 25, 50, 75 and 100%. The latter scenario corresponds to a complete abolition of legal migration restrictions. Our benchmark model assumes that the production function is a CES with elasticity of substitution $\sigma_s = 2$ and that productivity growth is identical across countries. Hence, wages are endogenous.[19] Figures 1.a to 1.d describe the effect of these shocks on the proportion of migrants in the world population, the proportion of college-educated workers in the world population, the worldwide level of GDP per worker and the semi-elasticity of world GDP to the proportion of migrants. The liberalization rate is measured on the horizontal axis, and each curve corresponds to a time period.

Figure 1.a shows that the change in the worldwide proportion of international migrants is almost proportional to the liberalization rate. Deviations from the pre-liberalization baseline trajectory slightly decrease over time due to the gradual decline of the population living in developing countries. In 2000, a complete liberalization increases the worldwide proportion of immigrants from 3.5% to 12% (+8.5 percentage points). A 25% cut in migration barriers increases it to 6% (+2.5 percentage points). By 2100, a complete liberalization raises the average proportion of immigrants by 7.2 percentage points, whereas a 25% cut in migration barriers increases it by 2.4 percentage points.

A key finding of our analysis is that removing migration barriers stimulates the acquisition of human capital. There are three reasons for this result. First, in line with the *brain gain* literature (see Stark et al., 1997; Mountford, 1997; Beine et al., 2001, 2008; Easterly and Nyarko, 2009; Docquier and Rapoport, 2012), increased emigration prospects stimulate the expected return to education; the fraction of young adults acquiring higher education increases from 2000

[18] The inequality effects are discussed in Appendix C.2, being aware that our analysis does not account for redistributive policies (i.e., taxes and transfers). Clearly, liberalizing migration could challenge the financing of public infrastructure and education. For example, Tanaka et al. (2014) show that public spending per student decreased by 11% after a "large episode of immigration in 2008" in Spain.

[19] Variants of the benchmark model with exogenous wages or with endogenous TFP are discussed in Section 5, and the strong robustness of our results to any value of the elasticity of substitution from the range estimated in the literature is provided in Appendix C.1.

onwards. Overall, this *brain gain* effect is somewhat small, as shown in Figure 1.b: the worldwide proportion of college graduates increases from 11.2 to 12% (+ 0.8 percentage points) under the full liberalization scenario. Second, wherever they live, newly educated parents have a higher propensity to educate their children. Third, newcomers in rich countries, educated or not, face a better environment (mandatory schooling, lower education costs, no child labor) for providing basic education to their offspring. The latter two effects are dynamic by nature. Enrollment in basic education increases from 2000 onwards, and the pool of young adults who can access the higher education system becomes larger from 2025 on. Consequently, the rise in educational attainment is gradual and cumulative. By 2100, and under the complete liberalization scenario, the world proportion of college graduates increases by approximately 6.4 percentage points compared to the pre-liberalization baseline trajectory. In parallel, the world average fertility rate and the world population size decrease gradually (i.e., -4.9% in 2100 compared to the baseline). These socio-demographic changes govern the dynamics of the efficiency gains from abolishing migration barriers.

Focusing on GDP and income, Figure 1.c reveals that the efficiency gains are slightly concave in the liberalization rate: reducing migration barriers by 50% allows the realization of slightly more than 50% of the gains that can be achieved under a full liberalization. In 2000 (the short run), a complete liberalization increases GDP per worker by 12% (whereas reducing migration barriers by 25% increases it by 3.6%). The concentration of workers in higher-productivity countries and the gradual accumulation of human capital imply that the economic gains of liberalizing migration flows are cumulative. Hence, by 2100, the effects are four times larger than in the short run: the worldwide level of GDP per worker increases by 52% when migration barriers are totally abolished (and by 18.7% when they are reduced by 25%).

Figure 1.d reveals that the semi-elasticity of world GDP to the proportion of migrants is almost independent of the liberalization rate. In 2000, it is approximately 1.4. This value is slightly above the 1.33 semi-elasticity obtained in the static frameworks of Docquier et al. (2015), Iregui (2005), Winters (2001) or Walmsley and Winters (2005) because our model endogenizes the decision to acquire college education. Removing migration barriers increases the expected returns to schooling from 2000 onwards and the worldwide proportion of college graduates.[20] In addition, given the gradual and cumulative changes in human capital accumulation, the semi-elasticity increases over time. By 2100, the semi-elasticity lies between 7.2 and 7.8 depending on the liberalization rate.

Focusing on the complete liberalization scenario, Tables 1.a and 1.b present the changes in the average proportion of college-educated adults and in the average level of GDP per worker in 11 regions: USA (the United States), EU15 (the 15 initial members of the European Union), CANZ (Canada, Australia, and New Zealand), GCC (the countries of the Gulf Cooperation Council), MENA (the Middle East and Northern Africa), SSA (sub-Saharan Africa), CIS (the Commonwealth of Independent States, ex-Soviet Union), CHIND (China and India), ASIA (the rest of Asia), LAC (Latin American and Caribbean countries), and OTHERS (the remaining countries).[21]

[20] As shown in Section 5.1, simulating the model without this *brain gain* effect reduces the semi-elasticity to 1.3 in 2000, which is in line with previous studies.

[21] We have aggregated the results at the regional level for the sake of clarity and comparability with other studies. The results for selected countries are reported in Appendix C.4.

In the short term, the GDP per worker decreases in all developed regions (see Table 1.a). The effect ranges from -0.3% in the EU15 to -4.3% in GCC and -4.7% in the USA. Conversely, the GDP per worker increases in developing regions. The effect ranges from +0.2% in CHIND and +0.5% in CIS to +9.2% in SSA. These results are driven by the change in the skill composition of the regional labor force and its impact on wages. Human capital decreases in developed regions due to massive inflows of immigrants who are on average less educated than natives. In the long term, the world average proportion of educated workers increases from 16.2% in the baseline trajectory to 22.5% in the full liberalization counterfactual (i.e., by 6.3 percentage points). The accumulation of human capital gradually reduces the negative impact of the immigration shock in developed regions (i.e., in 2100, the decrease in the average GDP per worker is approximately 1.3% in the USA and 0.2% in the EU15).

In developing regions, emigrants are generally positively selected (i.e., emigrants are on average more educated than non-migrants). Through this channel, removing migration barriers tends to decrease human capital in all developing regions, as in the static context of Docquier et al. (2015). However, in our framework with an endogenous formation of human capital, the proportion of college-educated natives in 2000 increases in most regions (see Table 1.b). This increase is generated by the greater incentives of individuals to acquire higher education, which increases the proportion of tertiary educated after the liberalization (see the discussion in Section 5.1 and the results for selected countries in Appendix C.4). However, the positive income responses provided in Table 1.a are also amplified by composition effects: because poorer countries send more emigrants abroad, their demographic weight in the region-wide level of GDP decreases. In the long term, further human capital accumulation and decreases in the average fertility imply cumulative gains in all developing regions. In 2100, the GDP per worker increases by 20.6% in Asia and 39% in SSA compared to the baseline scenario.

Figure 1: World economy response to liberalization under the benchmark model

Figure 1.a: Prop. of migrants (Dev.)

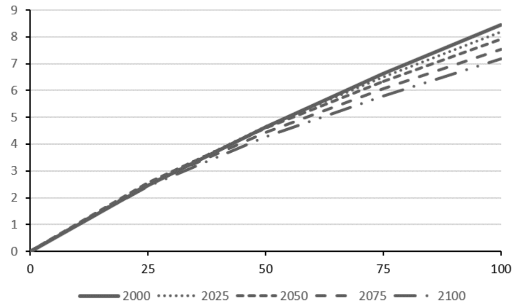


Figure 1.b: Prop. of college-educated (Dev.)

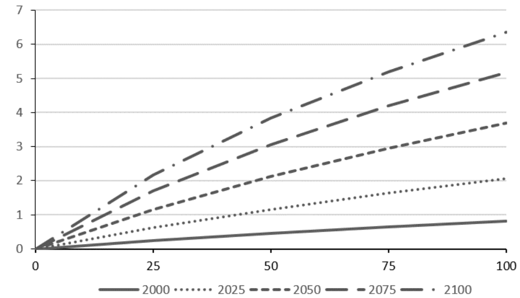


Figure 1.c: GDP per worker (Perc. of dev.)

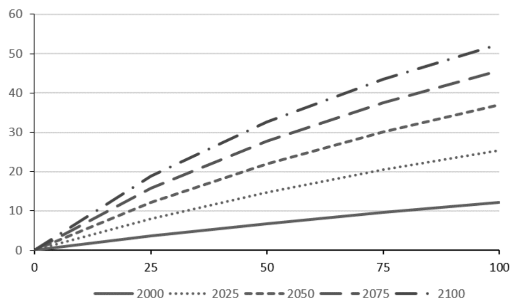


Figure 1.d: GDP-Migration semi-elasticity

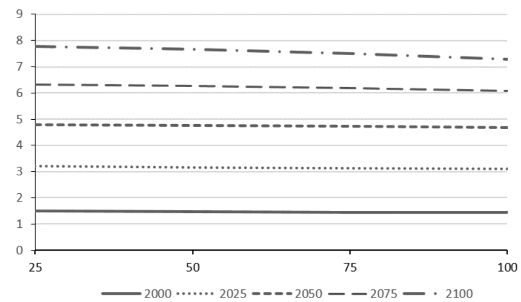


Table 1.a: Regional effects of a complete liberalization
GDP per adult worker

	Baseline (in USD)					Liberalization (Perc. of dev.)				
	2000	2025	2050	2075	2100	2000	2025	2050	2075	2100
WORLD	17,662	23,770	34,487	53,046	80,460	+12.0	+25.5	+37.0	+45.5	+52.0
USA	63,287	92,492	135,262	196,978	285,950	-4.7	-4.9	-2.5	-1.7	-1.3
EU15	39,092	56,853	83,332	122,257	178,368	-0.3	-0.4	-0.2	-0.1	-0.2
CANZ	47,033	68,465	99,957	145,343	210,945	-2.7	-2.5	-1.4	-1.1	-1.0
GCC	49,261	70,577	105,783	156,639	226,862	-4.3	-3.9	-3.1	-2.0	-1.7
MENA	13,802	19,385	28,997	43,759	63,792	+2.5	+3.4	+4.2	+4.5	+4.0
SSA	5,752	7,599	10,793	15,885	23,097	+9.2	+16.8	+24.3	+32.2	+39.0
CIS	14,277	20,753	30,509	44,874	65,464	+0.5	+0.8	+1.0	+1.1	+1.2
CHIND	7,397	10,563	15,335	22,423	32,512	+0.2	+0.4	+0.6	+0.8	+0.9
ASIA	17,123	21,992	30,603	45,424	66,491	+3.6	+8.1	+13.0	+17.1	+20.6
LAC	18,072	25,765	39,400	60,976	90,135	+1.9	+3.3	+4.6	+5.8	+6.8
OTHERS	17,991	26,129	38,786	58,450	87,596	+18.1	+33.9	+47.3	+58.1	+65.7
HIGH	44,656	65,868	98,889	148,349	220,247	+0.8	+2.2	+3.3	+3.3	+2.8
DEV	9,536	13,664	20,247	30,303	44,346	+0.6	+1.6	+2.6	+3.6	+4.7

Note: USA = United States, EU15 = 15 members of the European Union; CANZ = Canada, Australia and New Zealand; GCC = countries of the Gulf Cooperation Council; MENA = Middle East and Northern Africa; SSA = Sub-Saharan Africa; CIS = Commonwealth of Independent States (ex-Soviet Union); CHIND = China and India; ASIA = Rest of Asia; LAC = Latin American and Caribbean countries; OTHERS = Other countries; HIGH = High-income countries; DEV = Developing countries (World Bank classification in 2014).

Table 1.b: Regional effects of a complete liberalization (continued)
Proportion of college graduates in the labor force

	Baseline (as percent)					Liberalization (dev. in pp)				
	2000	2025	2050	2075	2100	2000	2025	2050	2075	2100
WORLD	11.2	11.2	12.9	15.2	16.2	+0.8	+2.1	+3.7	+5.2	+6.3
USA	51.3	52.9	54.8	55.7	55.8	-8.5	-8.9	-5.3	-3.8	-3.0
EU15	21.2	22.9	25.9	29.0	30.1	-0.8	-1.2	-1.0	-0.6	-0.3
CANZ	43.6	45.4	48.9	50.8	50.9	-7.8	-7.8	-6.0	-5.2	-4.6
GCC	12.8	13.0	15.8	17.5	17.3	-2.7	-2.4	-2.1	-1.5	-1.2
MENA	7.8	8.5	11.4	14.5	15.3	+0.2	+0.5	+1.1	+2.0	+2.6
SSA	3.1	3.1	3.7	4.3	4.5	+0.3	+0.5	+0.8	+1.2	+1.4
CIS	17.7	18.6	20.8	22.8	23.0	+0.2	+0.3	+0.4	+0.4	+0.4
CHIND	3.4	3.8	4.7	5.5	5.9	+0.3	+0.3	+0.3	+0.4	+0.5
ASIA	10.2	9.8	11.5	13.5	14.1	+0.1	+0.3	+0.9	+1.5	+2.0
LAC	11.4	12.6	16.8	21.8	23.4	+0.1	+0.2	+0.1	+0.1	+0.1
OTHERS	12.2	12.7	14.4	16.2	16.9	+1.7	+3.2	+4.9	+6.7	+8.1
HIGH	30.1	31.8	35.4	38.2	39.3	-2.3	-2.4	-1.4	-0.8	-0.6
DEV	5.9	6.4	7.9	9.7	10.3	+0.2	+0.2	+0.3	+0.4	+0.5

Note: USA = United States, EU15 = 15 members of the European Union; CANZ = Canada, Australia and New Zealand; GCC = countries of the Gulf Cooperation Council; MENA = Middle East and Northern Africa; SSA = Sub-Saharan Africa; CIS = Commonwealth of Independent States (ex-Soviet Union); CHIND = China and India; ASIA = Rest of Asia; LAC = Latin American and Caribbean countries; OTHERS = Other countries; HIGH = High-income countries; DEV = Developing countries (World Bank classification in 2014).

4.2 Results with Schengen-adjusted visa costs

In this section we consider the impact of a full liberalization using the alternative counterfactual scenario. The change in migration costs is thus written as:

$$x^s_{ki,t} \longrightarrow \hat{x}^s_{ki,t} \ \ \forall s, k, i, t. \tag{38}$$

Given the lower number of additional migrants in the alternative counterfactual scenario (described in Section 3.3), efficiency gains from a liberalization would be reduced to 4.5% (compared to 12%) in the short run and 23.8% (compared to 52%) in the long run as shown in Table 2. Part of this lower effects are due to the lower human capital accumulation. The long-run share of tertiary educated individuals increases by 2.5 percentage points (pp) in this counterfactual, compared to 6.3 pp in the benchmark counterfactual (see right panel of Table 2).

The regional impacts are similar to those observed in the benchmark counterfactual. In the short term, the GDP per worker decreases in all developed regions, at a magnitude close to the one observed in the benchmark case. The effect ranges from -0.4% in the EU15 to -5.0% in the USA. Though the number of additional immigrants is lower, they tend to be less educated. The GDP per worker increases in developing regions, although the impact is lower than in the benchmark counterfactual. The effect ranges from +0.1% in CHIND to +3.2% in SSA. Human capital decreases in developed regions, but this drop is below the one of the benchmark scenario due to the reduced number of additional less educated immigrants.

Though the effects of a liberalization are quantitatively lower in this alternative counterfactual, the mechanisms observed in the benchmark counterfactual scenario are still valid: the impact of the reduction in migration restrictions is gradual and cumulative due to the population dynamics.

Table 2: Impact of a liberalization using Schengen-adjusted visa costs
Deviation from the baseline scenario

	GDP per worker (Perc. of dev.)					Prop. of college graduates (dev. in pp)				
	2000	2025	2050	2075	2100	2000	2025	2050	2075	2100
WORLD	4.5	10.4	15.9	20.2	23.8	0.1	0.6	1.2	1.9	2.5
USA	-2.7	-3.5	-2.4	-1.8	-1.5	-5.3	-6.7	-5.0	-4.1	-3.4
EU15	-0.4	-0.7	-0.8	-0.8	-0.9	-0.7	-1.2	-1.4	-1.5	-1.3
CANZ	-2.4	-2.5	-1.5	-1.2	-1.1	-7.1	-7.7	-6.2	-5.4	-4.6
GCC	-5.0	-4.6	-3.9	-2.8	-2.4	-3.1	-2.8	-2.7	-2.2	-1.8
MENA	0.2	0.4	0.6	0.6	0.4	0.0	0.0	0.2	0.3	0.5
SSA	3.2	6.1	9.1	12.4	15.5	0.0	0.0	0.1	0.1	0.1
CIS	-0.4	-0.7	-0.8	-0.9	-0.9	-0.3	-0.4	-0.5	-0.6	-0.6
CHIND	0.1	0.1	0.2	0.2	0.3	0.1	0.1	0.1	0.1	0.1
ASIA	1.0	2.7	4.8	6.6	8.1	0.0	0.1	0.2	0.5	0.7
LAC	0.7	1.3	1.8	2.3	2.8	0.1	0.0	-0.1	-0.2	-0.2
OTHERS	7.5	14.3	20.7	27.1	32.6	0.5	1.0	1.7	2.5	3.3
HIGH	-0.3	0.1	0.6	0.6	0.3	-1.9	-2.5	-2.3	-2.1	-2.0
DEV	0.3	0.8	1.3	1.9	2.4	0.0	0.0	0.0	0.0	0.1

4.3 Results with different potential migrant stocks

In the benchmark scenario, we computed the stock of potential migrants (i.e., effective + desired migrants) and its bilateral structure, assuming that current migrants do not relocate to another destination, disregarding potential temporary migration and network effects. In this section, we consider three additional variants of the potential migrant stock, in line with Docquier et al. (2015):

- First, we use the same size and structure of desired migration but consider that current migrants do relocate proportionally to the bilateral structure of desired migration. This scenario is labeled "*Reloc*".
- Second, we use the Gallup World Survey and identify the proportion of non-migrants expressing a desire to emigrate temporarily to another country (note that in the Gallup data, many intended migrants are willing to emigrate both temporarily and permanently). We add those who want to emigrate only temporarily to the set of potential migrants, assuming that each temporary migrant stays 30% of an entire career in the destination country, i.e., approximately 12 years. We use the same bilateral structure as for permanent migration. This scenario is labeled "*Temp*".
- Third, we consider network externalities that allow private migration costs to be compressed when the size of the bilateral diaspora increases. Following the existing literature (Beine et al., 2015), the importance of diasporas is larger for less educated than for highly educated workers. We use the same elasticities of private migration costs to the total diaspora size as in Docquier et al. (2015), i.e., -0.05 for college graduates and -0.20 for the

less educated. This scenario implies that once migration policy restrictions are removed, the additional migrants will reduce the private migration cost and hence attract additional migrants:

$$(1 - \bar{x}^l_{ki,netw}) = \quad (1 - \bar{x}^l_{ki,Base}) \left(\frac{1+N^{tot,netw}_{ki}}{1+N^{tot,Base}_{ki}}\right)^{0.20}, \tag{39}$$

$$(1 - \bar{x}^h_{ki,netw}) = \quad (1 - \bar{x}^h_{ki,Base}) \left(\frac{1+N^{tot,netw}_{ki}}{1+N^{tot,Base}_{ki}}\right)^{0.05}. \tag{40}$$

This scenario is labeled "*Network*".

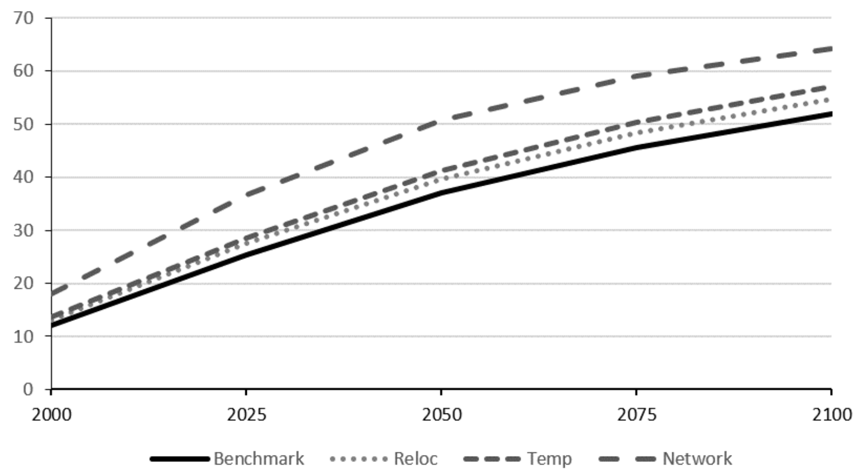
The results of the potential migration variants are depicted in Figures 2. In the first two variants, the order of magnitude of the efficiency effects of liberalizing migration are very similar to those obtained in the benchmark scenario. Larger responses are obtained under the "*Network*" scenario.

Under the "*Reloc*" variant, desired migration is more concentrated in high-income countries than effective migration. Liberalization increases the proportion of immigrants in high-income countries to 36.2% in the short run (compared to 34.5% in the benchmark scenario). Figure 2 shows that the efficiency gains in this scenario are therefore greater. In the short run, the worldwide average level of GDP per worker increases by 13.1% whereas the long-run efficiency gains amount to 54.7% (compared to 12 and 52% in the benchmark scenario). Because migrants concentrate in richer regions, fertility decreases slightly more, and human capital formation is amplified. The higher concentration of less educated immigrants slightly reduces the level of income per worker in the most developed countries compared to the benchmark scenario.

Considering temporary migration increases the number of additional migrants by 41 million in the short run and 105.1 million in the long run compared to the benchmark scenario (this represents an increase of 10.8% in the short term and 12.3% in the long term). In the short term, the average share of immigrants reaches 37.5% in developed countries and 3.8% in developing countries. In 2100, these immigration rates are equal to 22 and 4.4%, respectively. The higher number of migrants reinforces the positive effects of liberalization. Education increases, and a higher number of people move to countries with lower fertility such that the world population is slightly smaller than that in the benchmark scenario. As shown in Figure 2, world GDP per worker increases by 13.6% in the short run (compared to 12% in the benchmark scenario), and the long-run effect reaches 57.1% (compared to 52% in the benchmark).

Network externalities increase the number of global migrants by 56.3% in the short term and by 38.8% in the long term compared to the benchmark scenario. In the short term, the proportions of foreign-born workers reach 46.2 and 6.4% in developed and developing regions, respectively. The size of global efficiency gains increases: changes in the average level of GDP per worker now amount to 18% in the short term, and 64.3% in the long term. Network effects have a stronger impact on the private migration costs of the less educated; this negatively affects the proportion of educated workers in the richest countries. However, lowering emigration costs also triggers greater incentives to acquire education in developing countries. The increase in the worldwide proportion of college-educated adults in 2100 is greater (+7.2 percentage points) than that in the benchmark scenario (+6.3 percentage points).

Figure 2: Robustness to potential migration: impact on GDP per worker



4.4 The role of remittances

Our benchmark simulation does not account for remittances that migrants send back to their home country. The average ratio of remittances to GDP is low in developing countries (3%), and 135 countries exhibit a lower ratio than the mean. However, this ratio is much greater in some countries (36% in Tonga, 34% in Lesotho, 29% in Bosnia, 22% in Jordan, 20% in Samoa, 17% in West Bank and Gaza, 16% in Albania, 15% in Haiti, Yemen and Cape Verde). In many of these countries, the after-liberalization ratio of emigrants to stayers is three to six times larger than in the baseline. This can induce huge changes in the level of remittances and income. Hence, accounting for remittances is likely to affect the size of our effects.

It is however difficult to include remittances for different reasons. First, the literature has emphasized different motives to remit (altruism, exchange of services, risk diversification, reimbursement of loans, etc.) and the weights of these motives vary across countries or country pairs. Second, there is no consensus about who remits more and who receives more (college graduates or the less educated). Survey data collected in Bollard et al. (2011) show that the correlation between the amount remitted and the level of education of emigrants is also country-specific. Third, in a fully micro-founded model, individuals should anticipate remittances in their migration and education decisions, and the amount remitted would itself depend on the size of migration flows. The properties of our model would be much more complex while the literature has not identified robust and general effects of remittances on education decisions and other types of investment. In other words, there is no consensual strategy to include remittances in such a model and to parametrize remittance patterns.

Nevertheless, the role of remittances can be discussed under two sets of assumptions. First, if remittances were entirely used for consumption, accounting for them would not affect the worldwide gains from liberalizing migration. Remittances would reallocate income from donors to recipient countries, and thus induce redistributive effects only (in line with di Giovanni et al., 2015).[22] In Appendix C.3, we estimate the size of these redistributive effects. They are large if

[22] In di Giovanni et al. (2015), repatriating immigrants reduces remittances and thereby the income and utility of individuals in origin countries which is not compensated by the positive market size effect (i.e. a higher number

the propensity to remit is constant. However, they are similar to our benchmark results if the propensity to remit falls with the emigrant-to-stayer ratio.[23]

Second, in our dynamic framework with endogenous population growth and education (i.e., population dynamics), remittances would be partly used for investments in human capital. Hence, accounting for remittances would affect the size of the global efficiency gains resulting from the abolition of migration barriers. However, the literature on the link between remittances and education offers mixed results. On the one hand, Bansak and Chezum (2009) find that remittances increase educational attainment of the remaining children in Nepal. Remittances can also increase the probability of children being sent to better quality private schools (see Salas, 2014 for the case of Peru) or help reducing child labor (see Calero et al., 2009 for the case of Ecuador). On the other hand, part of literature obtains more mitigated results. Acosta et al. (2007) find that the access to remittances is positively related to education outcomes in only 6 out of 11 Latin American countries. Amuedo-Dorantes and Pozo (2010) estimate that the lack of control induced by the emigration of family members more than compensates the positive impact due to the remittances in the Dominican Republic. McKenzie and Rapoport (2011) analyze the impact of migration on education outcomes in rural Mexico; controlling for remittances inflows, they conclude that the emigration of a family member decreases the number of individuals completing high school.

Under the current assumptions of our model, immigrants living in destination countries sending remittances back to the origin country would keep a lower income. This would encourage them to have more children to whom they would provide less education. Hence, this would slow down human capital accumulation in the destination countries. At the same time, the inclusion of remittances eases the budget constraint of individuals residing in developing countries and the recipient households could decide to have fewer children and to educate a higher fraction of them. Human capital accumulation would be reinforced. The magnitude and net effect of human capital accumulation at the world level is however difficult to predict, as many underlying assumptions would need to be made (who remits, who receives the remittances, etc.) and are difficult to calibrate. We thus simply acknowledge that disregarding remittances can imply an overestimation of the effects in the destination countries, and an underestimation of the impact in the origin countries.

5 Opening borders: Robustness to the technological environment

In this section, we assess the robustness of our results to various identifying and technological assumptions. We first examine different variants related to human capital formation in Section 5.1. We then assess the sensitivity to technological non-linearities (associated with human capital, congestion and cultural diversity) in Sections 5.2 and 5.3. Finally, we consider scenarios with faster growth rates for developing countries, African countries and the BRIC countries in Section 5.4. For these robustness checks, we use the benchmark level of visa costs ($\bar{x}^s_{ki,t}$). We focus on

of varieties produced at origin by the repatriated individuals).

[23]The existing literature estimates an elasticity of remittances to the stock of emigrants between -0.5 and -1.0 (see Docquier and Machado, 2015 for an overview of the literature.)

the complete liberalization scenario ($\vartheta = 100$ percent) and provide results for the worldwide level of GDP per worker only.[24]

5.1 Human capital

In this section, we evaluate the robustness of our results to education decisions. In our benchmark model, the endogeneity of education and fertility decisions is the key mechanism governing the difference between the short- and long-term consequences of migration restrictions. Thus, we assess whether our efficiency responses are robust to the inclusion of the *brain gain* mechanism and to the levels of the preference parameters that affect basic education decisions.[25] We simulate the three following variants:

- First, we assume a constant proportion of college graduates among those who received basic education when young. This means that we consider the second term in Eq. (47) to be constant. This scenario is labeled "*No brain gain*".
- Second, we use an altruism parameter, θ, equal to 0.2 (instead of 0.3 in the benchmark model). This scenario is labeled "*Low altr*".
- Third, we use a preference for basic education, λ, that is equal to 0.5 (instead of 0.6 in the benchmark model). This scenario is labeled "*Low educ*".

The results of the human capital variants are depicted in Figures 3.a. The order of magnitude of the efficiency effects is very similar to those obtained under the benchmark model.

Under the "*No brain gain*" variant, the proportion of college graduates is fixed in the short run, and the gradual changes in human capital accumulation are smaller than for the benchmark model. A liberalization increases the long-run fraction of college-educated workers to 20.8% (+4.5 percentage points relative to the baseline) compared to 22.6% under the benchmark scenario (+6.3 percentage points relative to the baseline). When the *brain gain* effects are deactivated, the changes in the world average level of GDP per worker are slightly smaller than those obtained in the benchmark scenario. This robustness check evidences that the global rise in education is mainly triggered by improved access to basic education (i.e., the concentration and assimilation of new migrants in countries where the access to basic education is better and fertility is lower).

Using a smaller altruism parameter ("*Low altr*" scenario) changes the pre-liberalization baseline trajectory of the world economy. It reduces the worldwide average fertility rate to a value close to unity in the long run (compared to 1.14 under the benchmark scenario). Compared to the benchmark, the pre-liberalization population growth rates are smaller, and the worldwide proportion of college-educated workers is greater. The latter is 20.6% in the long term, compared to 16.2% under the benchmark scenario. Liberalization implies a stronger increase in

[24] Appendices C.2 provides a discussion of the impact of liberalization on the worldwide income distribution. Moreover, we evaluate the impact of current migration levels by simulating a counterfactual world without migration in Appendix C.5.

[25] A change in the preference parameters θ and λ implies a re-calibration of the ratio between children and low-skilled adults' wage rate, $\omega_{k,1975}$, and the ratio of basic education costs to the high-skilled wage rate, $\xi_{k,1975}$, in order to match the fertility and basic education decisions in 1975 (see equations 13 and 14).

the share of tertiary educated workers under this scenario (+7.3 percentage points) than under the benchmark scenario (+6.3 percentage points). However, as the number of potential movers decreases, the efficiency gains from removing migration barriers decrease to 48.3% in the long run.

In the "*Low educ*" scenario, decreasing the preference parameter for basic education increases fertility and reduces the proportion of college graduates. These changes also affect the pre-liberalization baseline trajectory of the world economy. By 2100, the proportion of college-educated workers in the new baseline equals 14.2%, compared to 16.2% in the benchmark case. In the long term, liberalization increases the proportion of college-educated workers to 19.9%, which is below the figure obtained under the benchmark scenario (22.6%). Hence, human capital accumulation is decelerated under this scenario, compared to the benchmark. The proportion of college graduates increases by 5.7 percentage points by 2100, compared with 6.4 percentage points in the benchmark. Under the "*Low educ*" scenario, fertility attains 1.25 in the long run under the liberalization compared to 1.14 in the benchmark scenario. A higher population increases the potential benefits that can be obtained by allowing workers to move from poorer to richer countries. In the long term, developed countries host 32% more migrants than in the benchmark scenario. The worldwide level of GDP per worker increases by 53.3% (compared to 52% under the benchmark simulation).

5.2 Technological non-linearities

Our benchmark model assumes a CES production function, exogenous TFP levels, and an unconstrained absorption capacity by the receiving countries. Three alternative scenarios are considered here:

- First, we assume that the elasticity of substitution in production, σ_s, is equal to infinity (i.e., a linear technology). This scenario is labeled "*Linear*".
- Second, we consider the possibility of a positive schooling externality on TFP (see Peri et al., 2015). We assume that the elasticity of TFP to the proportion of college graduates in the labor force equals 0.32. We use $A_{k,t} = A_{k,t}^{Base}(h_{k,t}/h_{k,t}^{Base})^{0.32}$, where $A_{k,t}^{Base}$ and $h_{k,t}^{Base}$ stand for the TFP levels and proportion of college graduates in the baseline trajectory. This scenario is labeled "*Schooling*".
- Third, we account for limited absorption capacity and allow TFP to decrease with the size of the labor force. Ciccone and Hall (1996) recommend using an elasticity of -0.03, representing the share of land income in total income. We use $A_{k,t} = A_{k,t}^{Base}(L_{k,t}/L_{k,t}^{Base})^{-0.03}$, where $L_{k,t}^{Base}$ stands for the total adult population in the baseline trajectory. This scenario is labeled "*Congest*".

The results of the technological variants are depicted in Figures 3.b. In all cases, the order of magnitude of the efficiency effects is very similar to those obtained under the benchmark scenario.

Under the linear technology, the skill premia become exogenous. Hence, efficiency gains are derived only by the new distribution of workers. New migrants move to more developed countries and produce more without affecting the wages of native non-movers. Therefore, efficiency gains are slightly higher than those obtained under the CES production function. After liberalizing migration, the GDP per worker increases by 12.5% in the short run and 53.6% in the long run. The low differences with the CES scenario (+0.5 percentage points and +1.6 percentage points in the short- and long-run respectively) show that endogenizing wages does not substantially impact the results.

Under the "Schooling" scenario, productivity decreases in high-income countries due to the immigration-driven change in the proportion of college graduates. Lower economic performances in developed countries slightly reduce the incentives to emigrate and to acquire college education. For these reasons, the global efficiency gains from removing migration barriers are slightly smaller than those obtained under the benchmark scenario. They amount to 9.9 and 49.5% in the short- and long-run, respectively.

Accounting for "congestion" has a negligible impact on our results. Productivity in traditional immigration countries is negatively affected by congestion, whereas productivity increases in emigration countries due to the lower pressure on their resources. The global efficiency gains are slightly smaller than those obtained in the benchmark scenario (11.3 and 48.6% in the short- and long-run, respectively). The congestion effect implies a decrease in the average income per worker in developed countries and an increase in developing countries.[26]

5.3 Cultural diversity

A recent strand of the literature (Collier, 2013; Borjas, 2015) emphasizes the social and cultural challenges that large inflows of immigrants may induce. The channel underlying this reasoning is that migrants may import "bad" cultural, social and institutional models from their origin country. In doing so, they can contaminate the entire set of institutions in their country of destination, leveling downwards the world distribution of technological capacity. Removing migration barriers can reduce the worldwide level of income per capita if such contagion spill-overs are large enough. However, there is no evidence that such contagion effects are important and unidirectional. Clemens and Pritchett (2016) find that for such negative effects to materialize, the transferability of the origin country's norms would need to be far greater (and the assimilation of migrants far smaller) than those observed at current levels of immigration. At these levels, many studies evidence a positive transfer of technological, political and behavioral norms from rich to poor countries (Spilimbergo, 2009; Andersen and Dalgaard, 2011; Beine et al., 2008; Beine et al., 2013b; Bertoli and Marchetta, 2015). Regarding externalities from poor to rich countries, the empirical literature has provided ambiguous results on the sign and magnitude of this effect. On the one hand, Ortega and Peri (2014) and Alesina et al. (2016) find a positive impact of immigrant diversity on income. On the other hand, Parrotta et al. (2014) find a negative effect.

To address these potential channels, we consider the potential gains and costs from cultural

[26]Desmet et al. (2017) develop a model with population-density dependent agglomeration and congestion effects to which they apply liberalization. In their baseline, the most populated (i.e., poor developing countries) become the most developed and populated regions in the long run. Technological progress increases with the population density and dominates the congestion effects. Opening borders allows developed countries to remain at the production frontier in the future. Free mobility implies that 78.2% of the population emigrates to high-amenity countries and a 353% increase in welfare. However, their model does not consider endogenous fertility and education responses.

diversity in this section. Although cultural diversity may directly impact utility, acting as an amenity or a dis-amenity, we treat its effect only as a shift in TFP. In line with the literature, we proxy cultural diversity using two variants of a birthplace diversity index of the labor force for each country and period. Following Alesina et al. (2016), the first variant, $DivMig_{k,t}$, measures the probability that two randomly drawn immigrants in country k originate from two different birthplaces. This variant focuses on diversity among immigrants and thus excludes the natives of the destination country. In line with Parrotta et al. (2014), the second variant, $DivTot_{k,t}$, measures the probability that any two randomly drawn individuals in country k (including the natives of that country) originate from two different birthplaces. We then allow TFP to vary positively or negatively with this index. We consider three scenarios:

- Our first variant assumes a positive effect of $DivMig_{k,t}$. Such a positive effect has been identified in empirical studies based on aggregate data by country (see Alesina et al., 2016) or US metropolitan areas (see Ottaviano and Peri, 2006). Following Alesina et al. (2016), we assume: $A_{k,t} = A_{k,t}^{Base} \left(DivMig_{k,t}/DivMig_{k,t}^{Base} \right)^{0.15}$. This scenario is labeled "*DivMig benefit*".[27]

- To embrace the view of Collier (2013) and Borjas (2015), our second variant considers a negative effect of birthplace diversity on TFP, and the coefficient used is the opposite of the value from the first variant, which gives: $A_{k,t} = A_{k,t}^{Base} \left(DivMig_{k,t}/DivMig_{k,t}^{Base} \right)^{-0.15}$. This scenario is labeled "*DivMig cost*".

- Our third variant is even more pessimistic; it assumes a negative effect of $DivTot_{k,t}$ on TFP. We follow Parrotta et al. (2014), who find a negative effect of workers' diversity by nationality on the productivity of Danish firms. Using a matched employer-employee database, they identify the effect at the micro level; this effect can be considered pessimistic because it ignores the diversity-driven interactions between firms and/or sectors. Using the estimate that they obtain, we have: $A_{k,t} = A_{k,t}^{Base} \left(DivTot_{k,t}/DivTot_{k,t}^{Base} \right)^{-0.051}$. Parrotta et al. (2014) argue that this negative externality is due to the communication and cooperation costs between workers.[28] This scenario is labeled "*DivTot cost*".

The results of the cultural diversity variants are depicted in Figures 3.c. The birthplace diversity among immigrants ($DivMig_{k,t}$) increases in 125 countries in the short run and 110 countries in the long run. Although the change in the diversity index is heterogeneous across countries, the average is only marginally affected, which explains why the efficiency gains barely change with respect to the benchmark model. Under the "*DivMig benefit*" scenario, using the positive elasticity of productivity to birthplace diversity estimated in the macro literature, the GDP per worker increases by 52.3% in the long run (compared to 52% in the benchmark). Under

[27] The elasticity found in Alesina et al. (2016) is somewhat conservative. More optimistic results are found in Ortega and Peri (2014), who suggest that an increase in the diversity of migrants from 0.05 (the value for Sri Lanka, the country with the lowest diversity index) to 0.96 (the value for the UK) implies a corresponding increase in output per person by a factor of 3.5.

[28] Another channel of transmission advocated by Collier (2013) is trust (or mutual regard). The effect of trust on TFP has been identified in Knack and Keefer (1997), and Alesina and La Ferrara (2002) show that diversity by race reduces trust.

the "*DivMig cost*" variant with a negative elasticity of productivity to birthplace diversity, the increase in GDP per worker is reduced to 51.9% in the long term.

The results are different when we consider natives in the birthplace diversity index ($DivTot_{k,t}$). Under the liberalization scenario, $DivMig_{k,t}$ is only marginally affected in developed countries, though the number of immigrants substantially increases. The changes in $DivTot_{k,t}$ are much more pronounced. The total birthplace diversity index increases in almost all countries (i.e., 190 countries in the short term and 181 countries in the long run). Exceptions are to be found mainly among small island developing states. Using the negative elasticity of -0.051 identified in Parrotta et al. (2014), the TFP level decreases in most countries. The benefits that accrue from liberalization are thus smaller than those obtained under the benchmark scenario. In the short term, the average GDP per worker increases by 4.6% (compared to 12% in the benchmark). In the long term, both scenarios tend to converge. In 2100, the GDP per worker increases by 48.3%, compared to 52% under the benchmark scenario.

5.4 Convergence in TFP

Finally, we analyze the impact of stronger TFP convergence in developing countries on our results. Our baseline exercise assumes that TFP grows at a constant rate of 1.5% per year in all countries. In this section, we consider alternative pre-liberalization scenarios involving TFP convergence towards the US level. In this case, TFP evolves as follows:

$$A_{k,t+1} = A_{k,t}(1.015^{25})(A_{US,t}/A_{k,t})^{b}, \tag{41}$$

where b represents the speed of convergence of TFP in country k towards the TFP level of the United States.[29] We consider three different convergence variants:

- The first assumes that TFP converges in all developing countries at a rate of b =0.22. This value corresponds to an annual convergence rate of 1% (i.e., $0.99^{25} \approx 0.78$ over a 25-year period, implying a 22% decrease in the distance to the frontier). This scenario is labeled "*High DEV*".
- The second assumes that TFP converges only in Africa and the Middle East (SSA & MENA), at a rate of b=0.22. This scenario is labeled "*High Africa*".
- The third assumes that TFP converges only in the BRIC (Brazil, Russia, India and China) countries, at a rate of b=0.22. This scenario is labeled "*High BRIC*".

Assuming that developing countries grow faster than the United States and the rest of the developed world implies that these countries catch up with developed countries in the baseline trajectory. TFP convergence in developing countries therefore reduces the gains that can be obtained from migrating from poor to richer countries. As the cliff between origin and destination countries shortens, the incentives to migrate are reduced, and so are the potential gains from liberalizing mobility. Simultaneously, the attractiveness of developing countries as potential destination countries increases. The first effect clearly dominates. The world migration stock after

[29] Log-linearizing this expression implies: $\ln(A_{k,t+1}/A_{k,t}) = 25\ln(1.015) + b\ln(A_{US,t}/A_{k,t})$.

liberalization now amounts to 698 million in 2100, compared to 855 million in the benchmark scenario. The world average proportion of migrants is 12 and 8.8% in the short- and long-run respectively, which reduces the scope of efficiency gains, as reflected in Figure 3.d. The effect on world GDP peaks at 17.3% in 2025 and then decreases to 12.7% in 2100.

Under the regional convergence scenarios, the effects are similar to those of the previous scenario, though more limited in scope. In the "*High Africa*" variant, the incentives for Africans to emigrate are reduced. In the long run, the share of emigrants from the African continent decreases from 23% in the benchmark scenario to 15.4% in the "*High Africa*" case. The global efficiency gains amount to 36.6% in 2100, which is substantially below the gains obtained in the benchmark scenario (52%). Under the "*High BRIC*" variant, convergence to US TFP levels reduces the incentives to emigrate from these countries and increases their attractiveness. This reduces the potential gains from liberalizing migration. The efficiency gains in the long run are limited to 29.7%.

Figure 3: Robustness checks for the world GDP per worker

Figure 3.a: Human capital

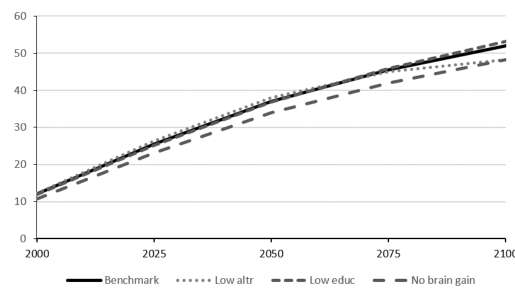


Figure 3.b: Techno. non linearities

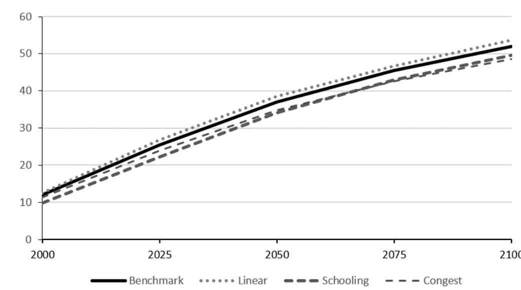


Figure 3.c: Cultural diversity

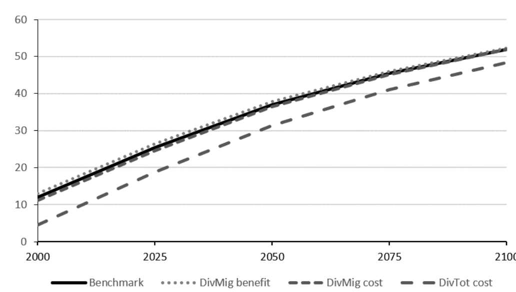
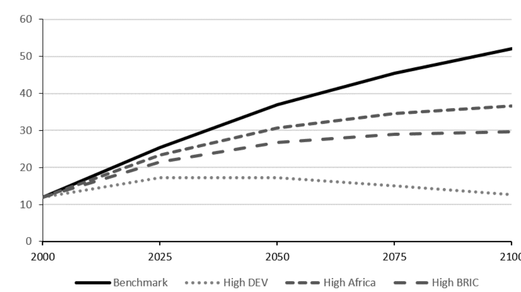


Figure 3.d: Convergence in TFP



6 Conclusion

This paper studies the effect of immigration barriers on the world distribution of income. We develop a theoretical framework that considers education and fertility responses to migration policy reforms. Quantitatively, we show that the efficiency and redistributive effects of immigration restrictions gradually increase over time when population growth and human capital accumulation are endogenized. Under our benchmark model, a complete liberalization of labor mobility increases the world average level of GDP per worker by 12% in the short term and by approximately 52% after one century. The size of efficiency gains decrease once we account for a possible upward bias in visa costs. The world average level of GDP per worker increases by 5% in the short run and 24% in the long run. However, long-run effects remain 4 to 5 times larger than the short-run effects, a result confirmed in most of our robustness checks.

The main reason is that new migrants moving from developing to developed countries face a favorable environment (lower education costs, no child labor) for providing basic education to their children and decreasing their fertility which increases the pool of young adults who are eligible for higher education in the future generation. Some of them will invest in college education and will have a greater propensity to provide education to their own offspring. Hence, the effects on human capital accumulation and income are cumulative: liberalizing migration gradually increases the world proportion of college-educated workers and reduces population growth.

These mechanisms are robust to our identifying assumptions and are also valid in the case of a partial liberalization, provided that the cut in migration restrictions is global (i.e., identical for all country pairs and educational groups). We thus demonstrate that the long-run gains from liberalizing cross-border migration far exceed the short-run effects. In the most likely variants, large efficiency gains can be expected from removing migration barriers, but these large gains mostly arise in the long run and impact the welfare of future generations. This makes it difficult to find redistributive policies to compensate the losers, mainly the current cohorts of low-skilled nationals residing in high-income countries.

Appendices

Appendix A provides additional technical details of the model. It discusses the distributional assumptions of the model, and provides detailed analytical developments. Appendix B discusses the validity of the dual strategy used to calibrate institutional country characteristics and bilateral migration costs. Appendix C presents additional simulations and results. Appendix C.1 shows that our results are robust to different values of the elasticity of substitution between less educated and highly educated workers (σ_s). A discussion of the impact of a liberalization on the worldwide income distribution is provided in Appendix C.2 and the role of remittances is analyzed in Appendix C.3. Appendix C.4 provides results for selected countries of origin and destination under the benchmark levels of visa costs (see Section 3.3). Appendix C.5 simulates the effects of returning all current migrants to their country of birth (i.e., a world without migration).

A Analytical development

We develop a dynamic model accounting for interdependencies between bilateral migration flows, human capital formation and population growth. It assumes two-period lived agents (adults and children). 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 and less educated adults. Working-age individuals have heterogeneous abilities to acquire higher education, and heterogeneous preferences over destination countries. However, we omit individual subscripts for notational convenience.

The number of working-age natives from country k ($k = 1, ..., K$) at time t is denoted by $N_{k,t}$, which divides into $N^h_{k,t}$ college graduates and $N^l_{k,t}$ less educated. The proportion of college graduates in the native population equals $H_{k,t} \equiv N^h_{k,t}/(N^h_{k,t} + N^l_{k,t})$. Each native decides whether to emigrate or not; $N^s_{ki,t}$ (for s=h, l) denotes the number of emigrants from k to i. After migration, the resident labor force of type s is given by $L^s_{k,t} \equiv \sum_i N^s_{ik,t}$, and $h_{k,t} \equiv L^h_{k,t}/(L^h_{k,t} + L^l_{k,t})$ denotes the proportion of college graduates among residents. The skill-specific proportion of emigrants from country k is denoted by $p^s_{k,t} \equiv \sum_{i \neq k} N^s_{ki,t}/N^s_{k,t}$.

Individual decisions to emigrate and acquire higher education result from the comparison of discrete alternatives. To model them, we use a logarithmic *outer utility function* with a deterministic and a random component. The utility of an adult of cohort t, born in country k, living in country i, and acquiring (higher) education type s is given by:

$$U^s_{ki,t} = \ln v^s_{i,t} + \ln(1 - x^s_{ki,t}) + \ln(1 - z^s_k) + \varepsilon^s_{ki}, \tag{42}$$

where $\ln v^s_{i,t} \in \Re$ is the deterministic level of utility that can be reached in the location i at period t (explained in sub-section A.4); this term depends on the adult's level of consumption, number and (basic) education of children. The second term, $\ln(1 - x^s_{ki,t})$ captures the total disutility implied by migration, and $x^s_{ki,t} \leq 1$ captures the net migration cost required to migrate from country k to country i. Migration costs $x^s_{ki,t}$ vary across country pairs and education levels.

A.1 Distributional assumptions

Individuals are heterogeneous in their ability to acquire higher education and in their preference for alternative locations: ε^s_{ki} and z^s_k are individual-specific. Basic education is a prerequisite to invest in higher education. Thus, only the individuals to whom parents provided basic education when they were young will be able to decide whether to invest in tertiary education or not. The level of effort required to be of type $s = (h, l)$ in country k is denoted by $z^s_k \in [0, 1]$. We normalize $z^l_k = 0$ for those who do not invest in higher education. For those who decide to invest, we assume that $\tau^h_k \equiv \left(1 - z^h_k\right)^{-1} \in [0, \infty]$, a monotonic and increasing function of z^h_k, follows a Pareto distribution. The country-specific CDF is given by:

$$G_k(\tau) = 1 - \left[\frac{\overline{\tau}_k}{\tau}\right]^\alpha, \tag{43}$$

where $\overline{\tau}_k > 0$ is the country-specific lower bound of the distribution in country k and $\alpha > 0$ is a common shape parameter governing the responsiveness of higher education decisions to the expected returns to schooling. Parameter $\overline{\tau}_k$ features the access to higher education in country k.

The individual-specific random taste shock for moving from country k to i is denoted by $\varepsilon^s_{ki} \in \Re$ and follows an iid Type-I extreme value distribution, also known as the double exponential distribution:

$$F(\varepsilon) = \exp\left[-\exp\left(-\frac{\varepsilon}{\mu} - \gamma\right)\right], \tag{44}$$

where $\mu > 0$ is a common scale parameter governing the responsiveness of migration decisions to income disparities, and $\gamma \approx 0.577$ is the Euler's constant.

The timing of decisions is the following. In the first stage, individuals who received basic education discover their education type ($z^s_{k,t}$). They do not know their migration type ($\varepsilon^s_{ki,t}$) but know its distribution. Given their perfect expectations about $v^s_{i,t}$ and $x^s_{ki,t}$, they decide whether to acquire higher education or not. In the second stage, they discover their migration type ($\varepsilon^s_{ki,t}$) and decide whether to emigrate or to stay in the home country. The third stage of the utility maximization process determines $\ln v^s_{i,t}$.

A.2 First stage - Higher education decisions

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) proved that conditional and unconditional utility functions coincide. In our augmented framework with endogenous education, the expected utility of choosing education type s is given by:

$$E\left(U^s_{k,t}\right) = \ln \sum_{i=1}^{I} \exp\left(\frac{\ln v^s_{i,t} + \ln(1 - x^s_{ki,t})}{\mu}\right) + \ln(1 - z^s_{k,t}). \tag{45}$$

An individual chooses to educate if the expected benefits from college education exceed the training effort, i.e. when $E\left(U^h_{k,t}\right) > E\left(U^l_{k,t}\right)$. This condition holds if:

$$\tau^h_{k,t} \leq \frac{\sum_{i=1}^{I}(v^h_{i,t})^{1/\mu}(1 - x^h_{ki,t})^{1/\mu}}{\sum_{i=1}^{I}(v^l_{i,t})^{1/\mu}(1 - x^l_{ki,t})^{1/\mu}} \equiv \frac{(v^h_{k,t})^{1/\mu} + (V^h_{k,t})^{1/\mu}}{(v^l_{k,t})^{1/\mu} + (V^l_{k,t})^{1/\mu}}, \tag{46}$$

where $(v^s_{k,t})^{1/\mu}$ determines the component of expected utility explained 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 linked to emigration prospects.

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 ($\tau^h_{k,t} = (v^h_{k,t}/v^l_{k,t})^{1/\mu}$). In an open economy (i.e., when $V^s_{k,t} > 0$ for some s), the expected return to education is affected by emigration prospects. From (46), we have that emigration prospects increase incentives to acquire higher education if $\frac{V^h_{k,t}}{V^l_{k,t}} > \frac{v^h_{k,t}}{v^l_{k,t}}$. The skill structure of emigration costs is a key determinant of $\frac{V^h_{k,t}}{V^l_{k,t}}$.

Basic education acquired when young is a prerequisite to invest in higher education when entering adulthood. Let us denote the proportion of working-age individuals who received basic education when young (i.e., in the previous period) in country k by $q_{k,t-1}$. The critical level of effort in (46) determines the fraction of them who find it optimal to acquire higher education. Given the Pareto distribution of the effort needed to invest in education (τ^h_k), the proportion of working-age adults deciding to invest in college education is given by:

$$H_{k,t} = q_{k,t-1}\left[1-\left(\overline{\tau}_k\frac{(v^l_{k,t})^{1/\mu}+(V^l_{k,t})^{1/\mu}}{(v^h_{k,t})^{1/\mu}+(V^h_{k,t})^{1/\mu}}\right)^{\alpha}\right], \tag{47}$$

where $\overline{\tau}_k$, the country-specific lower bound of the Pareto distribution, captures the access to higher education in country k. This implies that the average responsiveness of investment in college education to emigration prospects depends on past education levels ($q_{k,t-1}$) and access to higher education ($\overline{\tau}_k$).

A.3 Second stage - Migration decisions

When education is determined, individuals choose to emigrate to country i if $\ln v^s_{i,t} + \ln(1 - x^s_{ki,t}) + \varepsilon^s_{ki}$ exceeds the level attainable in any other location. Under the Type I Extreme Value distribution, McFadden (1974) showed that the probability to emigrate is governed by a logit expression. The emigration rate is given by:

$$\frac{N^s_{ki,t}}{N^s_{k,t}} = \frac{\exp\left(\frac{\ln v^s_{i,t}+\ln(1-x^s_{ki,t})}{\mu}\right)}{\sum_{j=1}^{I}\exp\left(\frac{\ln v^s_{j,t}+\ln(1-x^s_{kj,t})}{\mu}\right)} = \frac{(v^s_{i,t})^{1/\mu}(1-x^s_{ki,t})^{1/\mu}}{\sum_{j=1}^{I}(v^s_{j,t})^{1/\mu}(1-x^s_{kj,t})^{1/\mu}}. \tag{48}$$

Staying rates ($N^s_{kk,t}/N^s_{k,t}$) are governed by the same logit model. It follows that the emigrant-to-stayer ratio is governed by the following expression:

$$\frac{N^s_{ki,t}}{N^s_{kk,t}} = \left(\frac{v^s_{i,t}}{v^s_{k,t}}\right)^{1/\mu}(1-x^s_{ki,t})^{1/\mu}. \tag{49}$$

Skill-specific emigration rates are endogenous and comprised between 0 and 1. Equation (49) states that the ratio of emigrants from country k to country i to stayers in country k (i.e., individuals born in k who remain in k), is an increasing function of the utility achievable in the destination country i and a decreasing function of the utility in the country of origin

k. The proportion of migrants from k to i also decreases with the bilateral migration cost $x^s_{ki,t}$. Heterogeneity in migration tastes implies that emigrants select all destinations for which $x^s_{ki,t} < 1$ (if $x^s_{ki,t}$=1, the corridor is empty). Additionally, all corridors for which $x^s_{ik,t}, x^s_{ki,t} < 1$ exhibit bidirectional migration flows, in line with existing data.

A.4 Third stage - Fertility and basic education decisions

We now endogenize $\ln v^s_{k,t}$ as resulting from the third stage of the utility maximization process. Decisions about consumption ($c^s_{k,t}$), fertility ($n^s_{k,t}$) and the proportion of children receiving basic (primary and secondary) education ($q^s_{k,t}$) are governed by a warm-glow motive. The *inner utility function* $v^s_{k,t}$ is a logarithmic function of $c^s_{k,t}$, $n^s_{k,t}$ and $q^s_{k,t}$:

$$\ln v^s_{k,t} = (1-\theta)\ln c^s_{k,t} + \theta \ln n^s_{k,t} + \theta\lambda \ln q^s_{k,t}, \tag{50}$$

where $\theta \in [0,1]$ and $\lambda \in [0,1]$ are preference parameters for fertility and basic education of children.

Each adult receives a wage rate $w^s_{k,t}$ per unit of time worked. Raising a child requires a time cost ϕ, and providing a child with basic education induces a monetary education cost $e^s_{k,t}$. We allow non-educated children to work and earn a wage $w^c_{k,t}$ per unit of time spent on the labor market (reflecting country-specific, social and institutional norms towards child labor).

The budget constraint writes as:

$$c^s_{k,t} + n^s_{k,t} q^s_{k,t} e^s_{k,t} = w^s_{k,t}(1-\phi n^s_{k,t}) + n^s_{k,t}(1-q^s_{k,t}) w^c_{k,t}. \tag{51}$$

Each adult maximizes utility (50) subject to $q^s_{k,t} \leq 1$ and to the budget constraint (51). The first-order conditions are thus:

$$\frac{(1-\theta)\left[\phi w^s_{k,t} + q^s_{k,t} e^s_{k,t} - (1-q^s_{k,t}) w^c_{k,t}\right]}{c^s_{k,t}} - \frac{\theta}{n^s_{k,t}} = 0, \tag{52}$$

$$\frac{(1-\theta)\, n^s_{k,t}\left[e^s_{k,t} + w^c_{k,t}\right]}{c^s_{k,t}} - \frac{\theta\lambda}{q^s_{k,t}} \geq 0. \tag{53}$$

From (51) and (52), the total net cost of children is equal to a fraction θ of the wage rate, and the total consumption is equal to the remaining fraction, $1-\theta$. It follows that:

$$n^s_{k,t} = \frac{\theta w^s_{k,t}}{\phi w^s_{k,t} + q^s_{k,t} e^s_{k,t} - (1-q^s_{k,t}) w^c_{k,t}}, \tag{54}$$

in which $q^s_{k,t}$, the proportion of children receiving basic education, is endogenous.

Assume first that (53) holds with equality (*interior solution* with $q^s_{k,t} < 1$). Combining (52) and (53) gives the optimal fertility rate and investment in basic education:

$$n^s_{k,t} = \frac{\theta(1-\lambda) w^s_{k,t}}{\phi w^s_{k,t} - w^c_{k,t}}, \tag{55}$$

$$q^s_{k,t} = \frac{\lambda}{1-\lambda} \frac{\phi w^s_{k,t} - w^c_{k,t}}{e^s_{k,t} + w^c_{k,t}}. \tag{56}$$

In line with intuition, the fertility rate decreases with the wage rate ($w^s_{k,t}$) and increases with the child's wage rate ($w^c_{k,t}$). Children's basic education increases with the adult's wage rate ($w^s_{k,t}$), decreases with the education cost ($e^s_{k,t}$) and with child's wage rate ($w^c_{k,t}$).

From (56), the condition under which such an interior solution emerges writes as:

$$w^s_{k,t} \leq \frac{(1-\lambda)e^s_{k,t} + w^c_{k,t}}{\phi\lambda}. \tag{57}$$

If (57) does not hold, we have a *corner solution* with $q^s_{k,t} = 1$. Substituting $q^s_{k,t} = 1$ in (52) determines the fertility rate:

$$n^s_{k,t} = \frac{\theta w^s_{k,t}}{\phi w^s_{k,t} + e^s_{k,t}}. \tag{58}$$

Countries differ in terms of technology and policies. The wage ratio between college graduates and the less educated can be denoted by $\sigma_{k,t} \equiv w^h_{k,t}/w^l_{k,t}$. The wage ratio between children and low-skilled adults is denoted by $\omega_{k,t} \equiv w^c_{k,t}/w^l_{k,t}$. The ratio of basic education costs to the high-skilled wage rate is denoted by $\xi^s_{k,t} \equiv e^s_{k,t}/w^h_{k,t}$. These country-specific "institutional" variables fully characterize the fertility and basic education levels/differentials. Indeed, dividing (55), (56), (57) and (58) by $w^l_{k,t}$, we have:

$$\left(n^l_{k,t}, q^l_{k,t}\right) = \begin{cases} \left(\frac{\theta(1-\lambda)}{\phi-\omega_{k,t}}, \frac{\lambda}{1-\lambda}\frac{\phi-\omega_{k,t}}{\xi^l_{k,t}\sigma_{k,t}+\omega_{k,t}}\right) & \text{if } 1 \leq \frac{(1-\lambda)\xi^l_{k,t}\sigma_{k,t}+\omega_{k,t}}{\phi\lambda} \\ \left(\frac{\theta}{\phi+\xi^l_{k,t}\sigma_{k,t}}, 1\right) & \text{otherwise} \end{cases} \tag{59}$$

and

$$\left(n^h_{k,t}, q^h_{k,t}\right) = \begin{cases} \left(\frac{\theta(1-\lambda)\sigma_{k,t}}{\phi\sigma_{k,t}-\omega_{k,t}}, \frac{\lambda}{1-\lambda}\frac{\phi\sigma_{k,t}-\omega_{k,t}}{\xi^h_{k,t}\sigma_{k,t}+\omega_{k,t}}\right) & \text{if } \sigma_{k,t} \leq \frac{(1-\lambda)\xi^h_{k,t}\sigma_{k,t}+\omega_{k,t}}{\phi\lambda} \\ \left(\frac{\theta}{\phi+\xi^h_{k,t}}, 1\right) & \text{otherwise} \end{cases}. \tag{60}$$

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. Substituting the optimal levels of utility and basic education investment into (50) defines the optimal level of indirect utility, $\ln v^s_{k,t}$. We have:

$$\ln v^s_{k,t} = (1-\theta)\ln w^s_{k,t} + \ln \Omega^s_{k,t}, \tag{61}$$

where $\ln \Omega^s_{k,t} \equiv \theta \ln n^s_{k,t} + \theta\lambda \ln q^s_{k,t} + (1-\theta)\ln(1-\theta)$ depends on the optimal levels of fertility and investment in basic education. Given (59) and (60), the latter levels only depend on the trajectory of country-specific "institutional" characteristics, reflected by the vector $(\omega_{k,t}, \sigma_{k,t}, \xi^s_{k,t})$.

B Parameterization

B.1 Calibration of institutional characteristics

Our parameterization strategy uses all the degrees of freedom of the data to identify the structural parameters and country characteristics. Hence, our model cannot produce a test of its assumptions. In order to establish the relevance of our dual calibration method, we examine whether our identified institutional parameters exhibit realistic correlations with observations for related variables that are not matched by our model but viewed as traditional determinants in the empirical literature. Correlations are presented in Table B.1. The first column shows that the calibrated relative income of children is negatively correlated with development, the quality of institutions, the level of public expenditure per student in secondary education, and positively correlated with the share of the population living in rural areas. More importantly, the correlation with the proportion of economically active children is large (58%). Therefore, variable $\omega_{i,1975}$ captures well parents' incentives to rely on child labor. The second column shows that the calibrated cost of basic education decreases with development and increases with the share of population living in urban areas, where access to schooling is more limited. Finally, the effort required to acquire higher education is negatively correlated with development, the quality of institutions, the level of public expenditure per student in secondary and tertiary education, and positively correlated with the share of the population living in rural areas.

Table B.1: Correlation between identified country characteristics and data

	ω_i	ε_i^l	$\overline{\tau}_i$
GNI per capita[a]	-0.49	-0.28	-0.60
Government effectiveness[b]	-0.48	-0.08	-0.53
Political stability[b]	-0.33	-0.12	-0.43
Share of rural population[a]	0.42	0.36	0.60
Economically active children (% of 7-14 years old)[a]	0.58	0.32	0.58
Public education expend. per student (secondary level)[a]	-0.59	-0.01	-0.50
Public education expend. per student (tertiary level)[a]	-0.08	-0.11	-0.16

Data sources: [a]World Bank (2010), [b]Kaufmann et al. (2008).

B.2 Calibration of migration costs

Migration costs are obtained as a residual using observed ($N^s_{ki,t}$) and desiring ($\bar{N}^s_{ki,t}$) bilateral migration stocks data and calibrated values for the country-specific utility ($v^s_{k,t}$) from Eq. (49).

On average, mobility costs are smaller for college graduates than for the less educated. We obtain mean levels equal to 0.941 for college graduates (standard deviation of 0.094), and to 0.973 for the less educated (standard deviation of 0.061). Considering the 1000 largest corridors (representing 92% of the world migration stocks), the mean levels increase to 0.967 and 0.989, respectively.[30]

On average, legal costs represent a greater proportion of the total for college graduates than for the less educated. We obtain a mean share of 4.3% for college graduates (and a standard deviation of 8%), and of 2.2% for the less educated (standard deviation of 4.4%). This confirms that legal costs account for a small proportion of total migration costs. Private moving costs are important and explain why labor mobility is relatively limited despite large income disparities within and between countries. These private costs are more important for the less educated, who usually contemplate a smaller number of potential destinations. Considering the 1000 largest corridors, the mean levels fall to 3.1% and 1.1%, respectively. The data also reveal that 61% of bilateral migration corridors are empty; these corridors are characterized by $x^s_{ki,2000} = 1$ in our model.

We consider that "having the opportunity" is interpreted by the respondents to the Gallup Survey as the complete absence of policy restrictions to movement. However, this interpretation could be challenged. On the one hand, this type of survey data could underestimate the number of additional immigrants as advocated by Clemens and Pritchett (2016). One might indeed argue that some respondents do not express a desire to emigrate because they interpret "opportunity" in light of the possibilities currently available to them. These might be limited to a life-threatening trip with the prospect of a life in the shadow economy at destination. On the other hand, survey data could also overestimate the number of additional migrants and thereby lead to an overestimation of the legal costs and the effects of a complete liberalization. Respondents could for example interpret "having the opportunity" as being the legal (i.e., obtaining a visa) *and* financial/logistical possibility to do so (i.e., financial transfers in order to cover expenses and support at destination to find a job and set up a new life). Even though they reply positively to the question, these respondents would not be able to emigrate in the absence of policy restrictions due to other constraints (e.g. financial constraints, lack of networks, etc...). In addition, some of the respondents that actually have the possibility to move, may not yet have realized this aspiration. These individuals will move eventually, independently on how migration laws are changed. In that sense, the fact that some intra-Schengen area natives declare a desire to move within the Schengen area could point to this type of upward bias.[31]

There are however reasons to believe that the Gallup World Poll Survey, which is the most

[30] We excluded the corridors with at least one negative migration cost. These corridors have as destination country the United States (and origin Antigua and Barbuda, Barbados, Grenada, Guyana, Haiti, Jamaica, Saint Lucia, Saint Vincent and the Grenadines, Tonga, The Bahamas and Trinidad and Tobago) and the Occupied Palestinian Territory (with origins Kuwait and Israel). Additional corridors are: Guyana-Canada, Jamaica-Canada, Trinidad and Tobago-Canada, Suriname-Netherlands, Samoa-New Zealand, Oman-Occupied Palestinian Territory, Kazakhstan-Russia, Guyana-United Kingdom and Jamaica-United Kingdom.

[31] Note that these individuals where not accounted for in our stocks of additional migrants. Our alternative counterfactual, discussed in Section 3.3, corrects this potential upper-bias.

comprehensive source of data on migration aspirations, provides reasonable estimates of the short-run response to a liberalization, at least before general equilibrium and network effects operate. Some recent empirical studies reveal that the reported aspirations are nicely correlated with the traditional determinants of migration (see, among others, Docquier et al., 2014; Dustmann and Okatenko, 2014; Manchin and Orazbayev, 2016). Moreover, there is a high correlation between migration aspirations at year t and actual migration flows at year $t+1$ (Bertoli and Ruyssen, 2016), although the size of the actual flows is smaller.

We do not want to push the interpretation of our calibrated migration costs (i.e., total migration costs, x^s_{ki}, and private migration costs, $\bar{x}^s_{ki,t}$) too far because they include disparities in amenities and other residual factors not explicitly controlled for in the utility term, $v^s_{k,t}$. Nevertheless, we can check the correlation between the calibrated level of the migration costs and control variables used in the migration literature. These include the countries' characteristics (captured here by origin and destination fixed effects (FE)), the typical dyadic characteristics of the bilateral corridor (such as distance, colonial links, common language and contiguity) as well as migration policies (i.e., corridors for which there is a traveling restriction should exhibit larger migration costs). Internationally comparable migration law data is missing. One possible proxy that can be used is the "Bilateral Visa Restriction Index" (henceforth denoted Visa) provided by Neumayer (2006). Based on the November 2004 edition of the International Civil Aviation Associations Travel Information Manual, this variable captures whether the home country (in our case the destination country) imposes a visa restriction on travelers from the target country (in our case the origin country). The index takes a value equal to 1 if a restriction is in place, and 0 otherwise. Even though this proxy is not perfect, it is fair to assume that countries with more stringent migration laws might also impose more restrictive conditions on travelers entrance. A visa requirement for travelers is a first tool for destination countries to control who obtains (legal) entry into the country. We expect distance to be positively correlated with total migration costs while colonial link, contiguity and common language should be negatively correlated. Visa should be positively correlated to total migration costs. Private migration costs should only depend on the dyadic characteristics. The difference between total and private migration costs $(x^s_{ki,t} - \bar{x}^s_{ki,t})$ should then capture the policy restrictions.

Table B.2 shows the results.[32] For the less educated individuals, the usual migration cost proxies exhibit the right sign and are significant (with the exception of the log(distance)) in both regressions (columns (1) and (3)). Visa is positively and significantly correlated with both cost measures, though the significance is weak for private migration costs. For the highly educated individuals, the usual migration cost proxies exhibit the right sign and are strongly significant (with the exception of contiguity) in the regression of total migration costs (in column (2)). Visa is positively and significantly correlated to total costs. Private migration costs (in column (4)) are significantly affected by the usual migration cost proxies (again with the exception of contiguity) but no longer significantly affected by Visa. The difference between the two variables should proxy policy restrictions (columns (5)and (6)). This proxy is however not significantly correlated to the Visa index.

For several reasons, we do not think that the insignificant effect of the visa index on legal migration costs invalidates our calibration strategy. First, results are quite sensitive to the sample chosen and it is not clear which one should be preferred. Second, the Visa index has its flaws. It

[32]We limit the sample to bilateral corridors with at least 100 individuals in order to get rid of outliers.

Table B.2: Benchmark migration costs

	(1)	(2)	(3)	(4)	(5)	(6)
	$x^l_{ki,2000}$	$x^h_{ki,2000}$	$\bar{x}^l_{ki}$	$\bar{x}^h_{ki}$	$x^l_{ki,2000}$ -$\bar{x}^l_{ki}$	$x^h_{ki,2000}$ -$\bar{x}^h_{ki}$
com. language	-0.00349***	-0.0246***	-0.0103***	-0.0483***	0.00681***	0.0237***
	(0.000998)	(0.00579)	(0.00304)	(0.0118)	(0.00262)	(0.00669)
contiguity	-0.0101***	0.000865	-0.0145***	0.0208	0.00446***	-0.0200**
	(0.00172)	(0.00698)	(0.00279)	(0.0162)	(0.00168)	(0.00989)
log(distance)	0.000187	0.00734**	0.000539	0.0203**	-0.000352	-0.0129**
	(0.000416)	(0.00367)	(0.00143)	(0.00961)	(0.00122)	(0.00621)
colonial link	-0.00756***	-0.0266***	-0.0102***	-0.0365**	0.00267	0.00986
	(0.00196)	(0.00905)	(0.00357)	(0.0163)	(0.00267)	(0.00868)
visa	0.00163**	0.00745**	0.00241*	0.00839	-0.000779	-0.000931
	(0.000755)	(0.00364)	(0.00124)	(0.00728)	(0.000781)	(0.00412)
constant	0.998***	0.936***	0.993***	0.842***	0.00457	0.0945**
	(0.00343)	(0.0273)	(0.0105)	(0.0704)	(0.00877)	(0.0451)
Origin FE	Y	Y	Y	Y	Y	Y
Destination FE	Y	Y	Y	Y	Y	Y
Observations	5,415	4,117	5,415	4,117	5,415	4,117
R-squared	0.322	0.547	0.424	0.539	0.420	0.528

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

may capture the extensive margin of legal restrictions, but not the intensive margin. In addition, it is likely not a good proxy in some cases. For instance, USA-Mexico is defined as having no traveling restriction (Visa=0). However, Gallup data shows that 3.9 million additional Mexicans would like to emigrate to the United States if they had the opportunity. Third, visa policies are also endogenous. Particularly attractive destinations need more stringent visa policies in order to control/limit the immigration flows. Stringent visa restrictions are however less useful in countries that are not attractive for immigrants in any case. Finally, the Visa index is positively correlated to distance and the absence of contiguity.[33] As the same determinants affect the number of desiring migrants and the calibrated level of migration costs, this induces reverse causation and collinearity problems in our regressions.

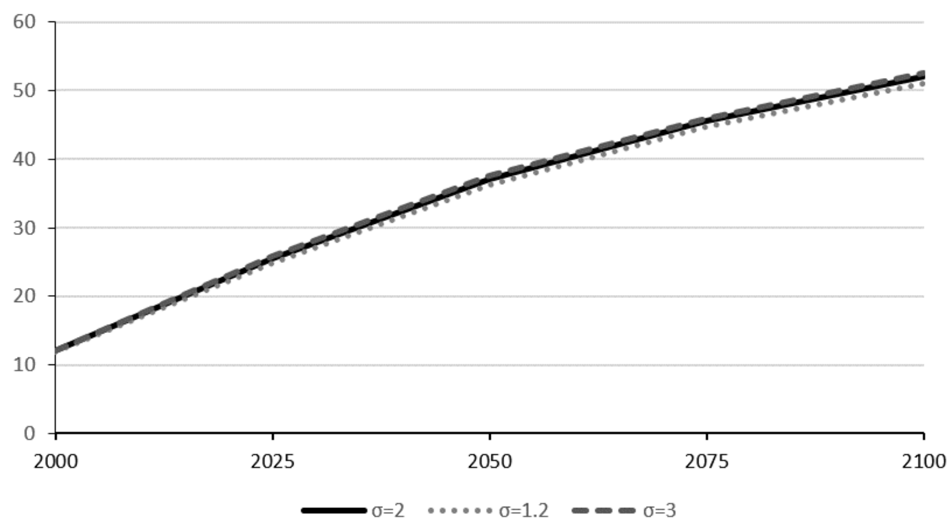
[33]Regressions available upon request.

C Additional results

C.1 Robustness elasticity of substitution

This section analyzes whether results are robust to the elasticity of substitution between less educated and highly-educated workers (σ_s) in the CES function. In the benchmark, we use σ_s=2, the intermediary value from the range estimated in the literature (see Angrist, 1995; Katz and Murphy, 1992; Krusell et al., 2000; Ottaviano and Peri, 2012). As a robustness, we use σ_s=1.2 (close to the value of 1.3 estimated in Borjas, 2003 and Johnson, 1970) and σ_s=3 (as estimated in Ottaviano and Peri, 2012). Figure C.1 shows that results are robust to this choice.

Figure C.1: GDP per worker (Perc. of dev.) with different elasticities of substitution



C.2 World distribution of income

As a by-product of the intertemporal equilibrium, the model endogenizes the level of income inequality among the world citizens. We use the Theil index of inequality and compute it on adults' wages using the following expression:

$$T_t = \sum_{k \in K; s=l,h} SHW^s_{k,t} \ln \left(\frac{SHW^s_{k,t}}{SHN^s_{k,t}} \right) \tag{62}$$

where $SHW^s_{k,t}$ is the share of the world labor income earned by adults of type s living in country k at time t and $SHN^s_{k,t}$ is the share of the world adult population of individuals of type s living in country k at time t.

The benefits from a liberalization mainly accrue to the emigrants originating from poor countries but aggregate gains can be obtained for the host population through the immigration surplus. However, the latter are unequally distributed among categories of workers. Note that in a setup with constant wages the changes in the Theil index are entirely driven by the evolution of the workers' skill distribution. In our benchmark, with endogenous wages, non-migrants are affected and this wage effect is added to the pure skill-distribution effect of the liberalization.

Figure C.2 shows that the distribution of income is less unequal under a full or a partial abolition of migration costs. On the one hand, removing migration barriers allows workers to relocate from poor countries (where inequality is high) to rich countries (where inequality is lower). On the other hand, opening borders makes countries more equal, thereby reducing inequality among states. Table C.1 reports the deviation of the Theil index and of its within- and across- components, for each liberalization scenario that we consider. In the short run, the Theil index decreases by 0.1 percentage points (pp) if migration costs are reduced by 25%, and by 0.8 pp if migration is fully liberalized. By the year 2100, deviations from the baseline scenario are equal to -2.0 and -8.8 pp for a 25 and 100% reduction in migration costs, respectively. Table C.1 details that the within component accounts only for roughly 10% of the overall value of the index, limiting the comparability of our income inequality measure with the ones provided by empirical studies (such as Sala-i Martin, 2006). This is due to the fact that we can only account for two different types of individuals, less- and high-skilled workers. This implies that the within-country distributional impact is limited to two groups only. Even though the within component represents only a small fraction of the total index, it can be noticed that a liberalization increases its value till the year 2025, due to the positive selection in emigration and negative selection in immigration patterns. Note that a similar decreasing trend in inequality (as measured by the Theil index) is also observed for all our robustness scenarios.

C.3 Accounting for remittances

To assess the role of remittances, we adopt here an *ad hoc* strategy. Although we acknowledge the fact that remittances could affect the size of our efficiency gains (through their impact on education, fertility and migration; see discussion in Section 4.4), we assume that these efficiency effects are of second-order importance and only focus on inequality responses.

Our model endogenizes the level of pre-transfer income of all migrants and non migrants. In 2000, we can easily compute the aggregate labor income of all emigrants from any country i

Figure C.2: Theil index

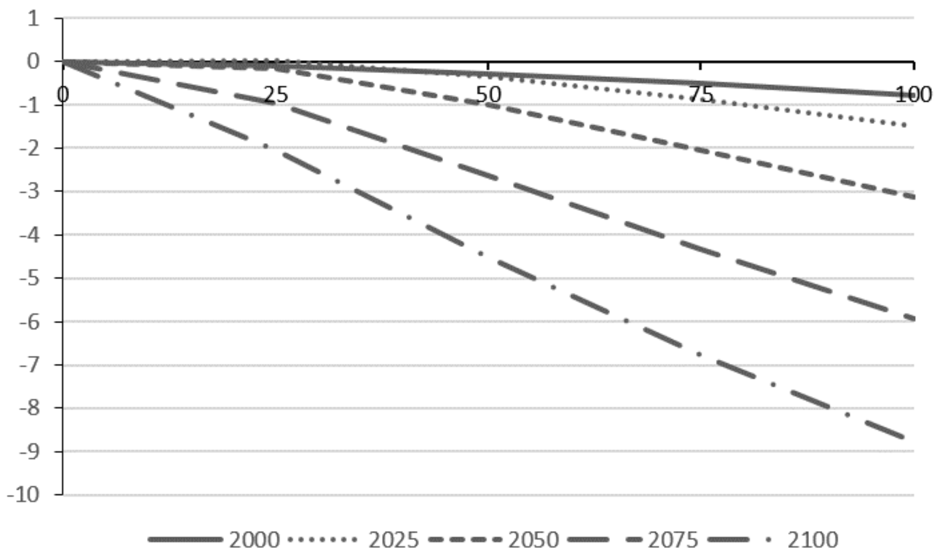


Table C.1: Theil index

	Baseline	Liberalization rate (in pp of baseline)			
Theil total	Level	25	50	75	100
2000	0.427	-0.102	-0.288	-0.518	-0.771
2025	0.439	0.023	-0.349	-0.882	-1.483
2050	0.441	0.023	-0.349	-0.882	-1.483
2075	0.441	-0.981	-2.638	-4.334	-5.929
2100	0.446	-2.032	-4.505	-6.773	-8.777
Theil Across	Share (in %)	25	50	75	100
2000	88.1	-0.219	-0.514	-0.842	-1.183
2025	87.5	0.023	-0.403	-0.961	-1.580
2050	88.4	0.020	-0.698	-1.634	-2.622
2075	89.7	-0.728	-2.211	-3.772	-5.258
2100	90.2	-1.734	-4.012	-6.136	-8.025
Theil Within	Share (in %)	25	50	75	100
2000	11.9	0.117	0.226	0.324	0.412
2025	12.5	0.023	0.055	0.079	0.097
2050	11.6	-0.174	-0.301	-0.405	-0.493
2075	10.3	-0.253	-0.427	-0.562	-0.671
2100	9.8	-0.298	-0.492	-0.637	-0.752

($EMW_{i,2000}$), the aggregate income generated in country i ($Y_{i,2000}$), and calibrate the propensity to remit of emigrants from country i ($r_{i,2000}$) that fits the observed ratio of remittances to GDP ($REM_{i,2000}$) in 2000. This gives $r_{i,2000} = REM_{i,2000}Y_{i,2000}/EMW_{i,2000}$.

Then we simulate the income distribution after a complete liberalization and in all subsequent periods, assuming that $r_{i,2000}$ is constant (high-remittance variant) or that the elasticity of $r_{i,t}$ to the emigrant/stayer ratio equals -0.5 (low-remittance variant):[34] we obtain a new ratio of remittances to GDP, $REM_{i,t} = r_{i,t}EMW_{i,t}/Y_{i,t}$. Results for the average remittances/GDP ratio and for the after-remittance Theil index of inequality in developing countries are depicted in Figures C.3 and C.4.

Figure C.3 provides the changes in the remittances/GDP ratio in developing countries, expressed in percentage point (pp) deviation from the baseline. Under a constant propensity to remit, a full liberalization increases the remittances/GDP ratio in developing countries by 5.8 pp in 2000, and by 5.7 pp in 2100.

As shown in Figure C.4, the decrease in the after-remittance Theil index ('High Rem' curve) is much more pronounced than in the before-remittance index ('No Rem.' curve). However, if the propensity to remit is elastic to the emigrant-to-stayer ratio, the remittances/GDP ratio only increases by 1.5 to 1.8 pp in all the years. The decrease in the after-remittance Theil index ('Low Rem' curve) is quite close to the before-remittance index. In sum, the fall in inequality induced by a liberalization can be accentuated by remittances, but this is the case if and only if the propensity to remit of emigrants is sufficiently inelastic to the emigrant-to-stayer ratio.

Figure C.3: Rem./GDP in developing countries (dev.)

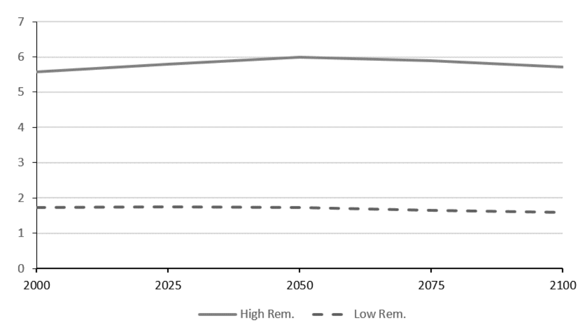
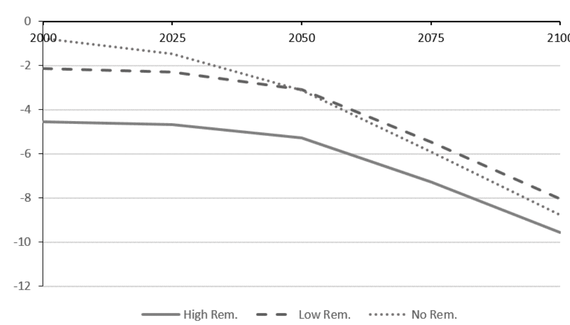


Figure C.4: Theil index with remittances (dev.)



C.4 Country-specific results

This section provides country-specific results for some of the main destination (in the upper panel of Table C.3) and origin (in the lower panel of Table C.3) countries. The 13 destination countries account for 69.1% of total immigration (and 15.3% of total emigration) under the liberalization scenario while the 7 origin countries account for 22.5% of total emigration (and 3% of total immigration). In the main destination countries, a liberalization implies a multiplication of the migrant stocks by a factor between 3.8 (Germany and the United States), 8.1 (Spain) and 10.2 (Italy). The volume of emigrants is multiplied by a factor of 2.6 in China and 4.3 in countries such as India and Bangladesh. This factor attains 17.2 for Tanzania, 20.4 for the Central African Republic and 26.2 for Nigeria (not shown in the tables). These evolutions imply a substantial increase in the total population of most destination countries which exceeds 100% in Australia

[34]This elasticity is compatible with Faini (2007) and Niimi et al. (2010), who find an elasticity of remittances to the stock of emigrants of 0.5. Freund and Spatafora (2008) find an elasticity between 0.65 and 0.75.

and Canada and 280% in the United Arab Emirates in the short run. On the other hand, population decreases between 17 and 30% in most origin countries in 2000. In the long run, these changes are amplified due to population dynamics.

The effect of a liberalization on human capital are presented in Table C.3. The proportion of college graduates in the labor force falls in the short run in most destination countries (with the exception of Russia and Switzerland). The decrease in the proportion of skilled workers lies generally between 0 and 1.5 percentage points (pp; see columns 4 and 5). It is however stronger in countries who currently have selective immigration policies such as Canada (-11.5 pp), the United States (-8.5 pp) and Australia (-3.3 pp). In the long run, human capital accumulation mechanisms allow to compensate for the negative selection among immigrants. In some countries, the decrease in the share of highly educated workers is mitigated (i.e., in Canada and the United States) while in others human capital accumulation implies that it exceeds the share observed under the baseline trajectory (i.e., in the United Kingdom and South Africa). The proportion of skilled workers increases with a liberalization in all the origin countries shown in Table C.3. This is due to the lower positive selection of additional emigrants (see columns 6 and 7 of Table C.3) and higher incentives to invest in education. The effects are cumulative as the share increases over time relative to the baseline scenario. The share of educated emigrants decreases in 6 of the origin countries (Bangladesh being the sole exception). In the African countries, between 17 and 35% of emigrants are skilled in 2000. This ratio drops between 9.1 pp (in the Dem. Rep. of Congo) and 29.8 pp (in Nigeria). The drop is slightly less important for the Asian origin countries. The share of skilled immigrants decreases in most countries in the short- and long-run (with the exceptions of France, Russia and Switzerland; see columns 8 and 9). This drop is particularly notable (between 12 and 30 pp) for the English-speaking countries having a selective immigration policy (such as Australia, Canada, the United Kingdom and the United States).

The evolution in the skill composition of the labor force impacts the wages in our CES benchmark scenario. In the majority of destination countries, where additional immigrants are negatively selected relative to the existing laborforce, wages of less educated workers decrease while wages of higher educated workers increase. The opposite holds for the origin countries, where the emigration of less educated workers implies an increase in the wage of skilled workers (see Table C.4). This wage effects and the new skill distribution of the labor force lead to the changes in average GDP per worker shown in columns 2 and 3 of Table C.4. Most destination countries experience a small drop in the average GDP per worker, lying between 0 and 1%. The decrease in GDP per worker is higher in countries such Saudi Arabia (-6.1%), the United States (-5.3%) and Canada (-4.7%). The dynamics of the model imply that this loss is mitigated in the long run and a liberalization even implies an increase in average GDP per worker in some countries (such as Australia, Switzerland and the U.K.). In the destination countries, a liberalization leads to a slight increase in GDP per worker in the short run (between 0 and 1%) which is amplified in the long run (between 0.1 and 3.3%).

Fertility and primary education decisions are linked to the worker's wage.[35] Fertility de-

[35]In the case of an interior solution to the utility maximization problem, equation 55 indicates that the fertility of less educated individuals is a function of the preference parameters and the country's institutional framework only (i.e $\omega_{k,t}$). However, when the fraction of children who obtain a basic education attains 1 (i.e., the corner solution with $q^l_{k,t} = 1$), fertility is an explicit function of wages trough $\sigma_{k,t}$ (see equations (58) and (59). Hence,

creases with wages while primary education provided to the children increases. Columns 8 and 9 show that the impact on the average fertility is quite limited in most destination countries with exceptions being Saudi Arabia (+1.8%) and English-speaking destination countries such as Canada (+4.3%), the United States (+2.7%), Australia (+0.7%). Less educated immigration increases substantially in these countries such that the average educational attainment of the workers decreases after a liberalization. This distributional effect is the main reason for the observed rise in fertility. Moreover, human capital accumulation neutralizes this impact in the long run. In most destination countries, average fertility is close to the baseline level or even somewhat below it (e.g. -1.8% in Australia). On the other hand, emigration of less educated workers tends to slightly decrease fertility in most origin countries. The change ranges between 0 and -0.2% in the short- and long-run. Basic education provided to children decreases in most destination countries in the short run. Again, the primary reason is the negative selection of the new immigrants relative to the labor force. The countries with the strongest impact are Saudi Arabia (-4.1 pp) and the English-speaking countries: Canada (-8.5 pp), the United States (-6.2 pp) and Australia (-3.8 pp). The decrease in the proportion of educated children is however mitigated over time in most countries as most of them tend to converge to the corner solution where all the children are provided with full basic education (i.e., $q^l_{k,t} = q^h_{k,t} = 1$). In all the selected destination countries, a liberalization increases the proportion of children who receive basic education in the short run. The effect is particularly sizable in Democratic Republic of the Congo (+2.9 pp) and China (+2.4 pp). This initial positive impact is accentuated over time due to the human capital accumulation dynamics. In the long run, the fraction of children with basic education is increased between 1.6 pp in Nigeria and 10.6 pp in Democratic Republic of the Congo.

Table C.5 shows the impact of a liberalization on the population weighted average fertility and average primary education at the regional level. A liberalization decreases the world population by almost 5% in the long run while education substantially increases. In 2100, the fraction of children with basic education increases by 9.5 percentage points while the fraction of individuals with tertiary education increases by 6.3 percentage points relative to the baseline.

as long as a country remains in the interior solution case, average fertility is only affected through the change in the skill distribution of workers.

Table C.3: Evolution of the population structure in selected countries

	ΔL_t (%)		$\Delta h_{k,t}$ (pp)		$\Delta \frac{Em_{h,t}}{Em_{h,t}+Em_{l,t}}$ (pp)		$\Delta \frac{Im_{h,t}}{Im_{h,t}+Im_{l,t}}$ (pp)	
Country	2000	2100	2000	2100	2000	2100	2000	2100
France	21.4	85.1	-1.1	-0.7	-4.9	-7.0	2.5	3.5
Germany	12.0	38.4	-1.1	-0.2	-13.4	-14.3	-2.8	-5.2
Italy	14.1	76.5	-0.8	-1.4	1.1	0.3	-2.5	-1.1
Spain	35.8	124.0	-0.7	-0.9	2.6	3.1	-5.1	-6.1
United Kingdom	21.9	101.7	-0.5	0.3	-15.4	-16.3	-14.9	-12.8
Australia	118.3	312.8	-3.3	-3.0	-15.2	-16.0	-14.5	-20.7
Canada	111.1	260.6	-11.5	-4.4	-5.2	-6.1	-25.1	-28.4
Russia	-7.3	-28.7	0.2	0.6	1.2	1.1	0.2	1.4
Saudi Arabia	163.1	206.3	-3.1	-0.8	-7.9	-10.6	-9.9	-13.5
South Africa	6.9	25.7	-0.1	0.4	-25.7	-28.2	-12.5	-12.9
Switzerland	122.6	386.3	4.3	2.7	-20.6	-24.2	5.5	3.9
United Arab Emirates	288.2	302.3	-1.4	-0.8	2.4	1.8	-6.8	-7.0
United States	34.2	96.0	-8.5	-3.0	-12.6	-12.7	-20.2	-27.2
Bangladesh	-23.9	-74.6	0.2	1.1	0.7	2.7	0.4	1.0
China	-2.7	-13.1	0.4	0.5	-10.9	-11.2	-9.4	-18.9
India	-3.8	-20.7	0.1	0.6	-5.7	-7.6	1.2	3.2
Nigeria	-28.5	-81.6	0.1	0.4	-29.8	-40.0	-1.5	-0.1
Central African Republic	-22.8	-72.8	0.0	0.1	-14.4	-20.6	-3.5	-2.8
Tanzania	-17.6	-64.2	0.2	1.2	-19.2	-28.9	3.4	19.7
Congo, Dem. Rep. of the	-20.4	-69.4	0.3	1.7	-9.1	-7.6	-7.3	-6.8

Table C.4: Results for main countries of destination and origin

Country	ΔGDP (%) 2000	ΔGDP (%) 2100	Δw_l (%) 2000	Δw_l (%) 2100	Δw_h (%) 2000	Δw_h (%) 2100	Δn_{avg} (%) 2000	Δn_{avg} (%) 2100	Δq_{avg} (pp) 2000	Δq_{avg} (pp) 2100
France	-0.6	-0.2	-1.0	-0.6	2.1	0.9	0.2	0.0	-1.4	-0.8
Germany	-0.3	0.0	-0.9	-0.2	2.2	0.3	0.2	-0.1	-1.7	0.0
Italy	-0.5	-0.4	-0.7	-1.1	2.0	2.3	0.2	0.0	-1.2	-1.9
Spain	-0.4	-0.1	-0.6	-0.7	2.3	1.7	0.2	0.0	-1.0	-1.3
U.K.	-0.3	0.0	-0.5	0.3	1.2	-0.6	0.1	0.3	-0.9	0.0
Australia	-1.0	0.0	-2.9	-2.8	4.8	3.8	0.7	-1.8	-3.8	0.0
Canada	-4.7	-0.9	-12.6	-5.4	11.2	3.8	4.3	0.0	-8.5	0.0
Russia	0.1	0.0	0.2	0.5	-0.5	-1.2	0.0	0.6	0.3	0.0
Saudi Arabia	-6.1	-1.2	-4.6	-1.0	12.4	2.0	1.8	-0.5	-4.1	0.0
South Africa	-0.2	0.7	-0.2	0.8	0.3	-1.1	0.0	0.7	-0.2	0.1
Switzerland	2.4	0.8	4.0	2.4	-7.8	-3.6	-0.1	0.2	5.8	3.2
U.A.E	-2.5	-1.6	-2.0	-1.1	5.2	2.8	0.7	0.1	-2.3	-2.2
U.S.A	-5.3	-1.6	-10.5	-4.0	6.8	2.1	2.7	-0.1	-6.2	0.0
Bangladesh	0.6	1.8	0.3	1.7	-2.3	-7.7	-0.1	-0.2	0.4	3.9
China	0.2	0.2	0.3	0.4	-6.3	-7.9	-0.1	0.0	2.4	4.6
India	0.3	0.9	0.2	0.8	-1.0	-3.0	0.0	-0.1	0.3	1.7
Nigeria	0.3	0.8	0.2	0.7	-1.3	-3.7	0.0	-0.1	0.2	1.6
Central African Republic	0.0	0.1	0.0	0.1	-0.2	-0.8	0.0	0.0	0.0	0.2
Tanzania	1.0	2.2	0.5	1.9	-5.9	-14.2	-0.1	-0.2	0.8	5.2
Congo, Dem. Rep. of the	1.0	3.3	1.0	2.1	-13.5	-22.1	-0.2	-0.2	2.9	10.6

Table C.5: Results for main regions

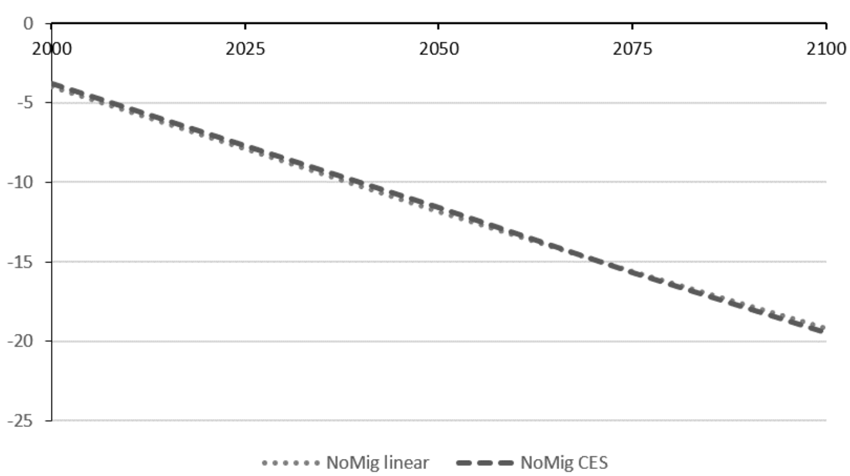
Region	ΔL_{tot} (%) 2000	ΔL_{tot} (%) 2100	$\Delta\ n_{avg}$ (%) 2000	$\Delta\ n_{avg}$ (%) 2100	$\Delta\ q_{avg}$(pp) 2000	$\Delta\ q_{avg}$(pp) 2100	$\Delta \frac{L_{h,t}}{L_{h,t}+L_{l,t}}$(pp) 2000	$\Delta \frac{L_{h,t}}{L_{h,t}+L_{l,t}}$(pp) 2100
WORLD	0.00	-4.9	-1.6	-0.7	2.5	9.5	0.8	6.3
USA	34.2	96.0	2.7	-0.1	-6.2	0.0	-8.5	-3.0
EU15	18.2	75.1	0.2	-0.3	-1.5	-1.4	-0.8	-0.3
CANZ	117.3	290.6	2.7	-0.6	-6.0	0.0	-7.8	-4.6
GCC	156.4	202.0	2.6	-0.1	-4.2	-1.2	-2.7	-1.2
MENA	-11.8	-45.5	-0.5	0.9	0.6	6.4	0.2	2.6
SSA	-15.5	-54.6	-1.2	-1.1	1.7	8.3	0.3	1.4
CIS	-7.5	-29.7	-0.1	0.4	0.5	0.0	0.2	0.4
CHIND	-3.1	-17.6	-0.2	-0.3	1.6	3.1	0.3	0.5
ASIA	-7.8	-29.0	-0.3	-0.4	0.7	6.0	0.1	2.0
LAC	-11.3	-35.4	-0.5	-1.3	-0.1	-3.4	0.1	0.1
OTHERS	-1.5	12.7	-1.4	-1.4	0.7	-3.0	1.7	8.1
HIGH	25.5	96.0	2.0	0.6	-2.5	-0.5	-2.3	-0.6
DEV	-7.1	-30.8	-0.8	-1.0	1.2	3.1	0.2	0.5

C.5 No migration scenario

Several recent studies evaluate the welfare impact of observed levels of migration by simulating a counterfactual world without migration. In a model including trade and remittances, di Giovanni et al. (2015) find that the average non-migrant in an OECD country experiences a welfare decrease of 2.4% while in non-OECD countries the loss is 2%. Repatriating immigrants reduces product variety available in consumption and intermediate inputs in destination countries while origin countries lose incoming remittances. Using a similar counterfactual in a model with market-size effects, Aubry et al. (2016) find that repatriating migrant stocks in 2010 decreases the average utility of non-migrants by roughly 3% in the OECD. They show that most OECD countries benefit from South-North migration, while intra-OECD migration is a zero-sum game with many losers and only few winners. Biavaschi et al. (2016) apply the same data to a different model and find an average welfare decrease of 1.8% at the world level and 3.5% for the OECD countries.

In this section, we apply our model to simulate a similar counterfactual scenario with no migration. Comparing our baseline world to a world without migration, this simulation provides the scale effect of migration. The exercise is performed under the benchmark CES model and the linear production function version of the model. Figure C.5 shows that repatriating all the immigrants to their country of origin reduces average GDP per worker by 3.8% in the short run and around 19% in the long run. In the short run, the average GDP per worker also decreases in developed countries, by 1.9% on average.[36] Our figure is slightly higher than those in existing studies because these models include trade (and hence market size effects) and do not consider endogenous migration, fertility and education responses. The fact that these analysis focus mainly on OECD countries and use migration stocks for the year 2010 also explains part of the differences in results. In the long run, the absence of an emigration option increasingly induces welfare losses relative to the baseline model where (at least part of the) workers can migrate. Our results are very robust to the functional form of the production function.

Figure C.5: GDP per worker - No migration



[36]Additional regional results can be obtained upon request.

References

Acosta, P., Fajnzylber, P., and Lopez, J. H. (2007). The impact of remittances on poverty and human capital: Evidence from Latin American household surveys. World Bank Research Working Paper 4247, Washinghton DC: World Bank.

Alesina, A., Harnoss, J., and Rapoport, H. (2016). Birthplace diversity and economic prosperity. *Journal of Economic Growth*, 21(2):101–138.

Alesina, A. and La Ferrara, E. (2002). Who trusts others? *Journal of Public Economics*, 85(2):207–234.

Amuedo-Dorantes, C. and Pozo, S. (2010). Accounting for remittance and migration effects on children's schooling. *World Development*, 38(12):1747–1759.

Andersen, T. B. and Dalgaard, C.-J. (2011). Flows of people, flows of ideas, and the inequality of nations. *Journal of Economic Growth*, 16(1):1–32.

Angrist, J. D. (1995). The Economic returns to schooling in the West Bank and Gaza Strip. *American Economic Review*, 85(5):1065–87.

Artuç, E., Docquier, F., Özden, Ç., and Parsons, C. (2015). A global assessment of human capital mobility: The role of non-OECD destinations. *World Development*, 65(C):6–26.

Aubry, A., Burzyski, M., and Docquier, F. (2016). The welfare impact of global migration in OECD countries. *Journal of International Economics*, 101(C):1–21.

Bansak, C. and Chezum, B. (2009). How do remittances affect human capital formation of school-age boys and girls? *American Economic Review*, 99(2):145–148.

Barro, R. J. and Lee, J. W. (2013). A new data set of educational attainment in the world, 1950-2010. *Journal of Development Economics*, 104(C):184–198.

Batista, C., Lacuesta, A., and Vicente, P. C. (2012). Testing the "brain gain" hypothesis: Micro evidence from Cape Verde. *Journal of Development Economics*, 97(1):32–45.

Becker, G. S. and Barro, R. J. (1988). A reformulation of the economic theory of fertility. *The Quarterly Journal of Economics*, 103(1):1–25.

Beine, M., Bourgeon, P., and Bricongne, J.-C. (2013a). Aggregate fluctuations and international migration. CESifo Working Paper Series 4379, CESifo Group Munich.

Beine, M., Docquier, F., and Özden, Ç. (2011). Diasporas. *Journal of Development Economics*, 95(1):30–41.

Beine, M., Docquier, F., and Özden, Ç. (2015). Dissecting network externalities in international migration. *JODE - Journal of Demographic Economics*, 81(4):379–408.

Beine, M., Docquier, F., and Rapoport, H. (2001). Brain drain and economic growth: Theory and evidence. *Journal of Development Economics*, 64(1):275–289.

Beine, M., Docquier, F., and Rapoport, H. (2008). Brain drain and human capital formation in developing countries: Winners and losers. *The Economic Journal*, 118(528):631–652.

Beine, M., Docquier, F., and Schiff, M. (2013b). International migration, transfer of norms and home country fertility. *Canadian Journal of Economics/Revue canadienne d'économique*, 46(4):1406–1430.

Beine, M. and Parsons, C. (2015). Climatic factors as determinants of international migration. *Scandinavian Journal of Economics*, 117(2):723–767.

Belot, M. V. K. and Hatton, T. J. (2012). Immigrant selection in the OECD. *Scandinavian Journal of Economics*, 114(4):1105–1128.

Benhabib, J. and Jovanovic, B. (2012). Optimal migration: A world perspective. *International Economic Review*, 53(2):321–348.

Bertoli, S. and Fernández-Huertas Moraga, J. (2013). Multilateral resistance to migration. *Journal of Development Economics*, 102(C):79–100.

Bertoli, S. and Marchetta, F. (2015). Bringing it all back home–return migration and fertility choices. *World Development*, 65(C):27–40.

Bertoli, S. and Ruyssen, I. (2016). Networks and migrants' intended destination. IZA Discussion Papers 10213, Institute for the Study of Labor (IZA).

Biavaschi, C., Burzynski, M., Elsner, B., and Machado, J. (2016). The gain from the grain: Skill-biased migration and global welfare. IZA Discussion Papers 10275, Institute for the Study of Labor (IZA).

Bollard, A., McKenzie, D., Morten, M., and Rapoport, H. (2011). Remittances and the brain drain revisited: The microdata show that more educated migrants remit more. *The World Bank Economic Review*, 25(1):132–156.

Borjas, G. J. (2003). The Labor Demand Curve is Downward Sloping: Reexamining the Impact of Immigration on the Labor Market. *The Quarterly Journal of Economics*, 4(118):1335–1374.

Borjas, G. J. (2015). Immigration and globalization: A review essay. *Journal of Economic Literature*, 53(4):961–974.

Brockerhoff, M. (1995). Fertility and family planning in African cities: The impact of female migration. *Journal of Biosocial Science*, 27(03):347–358.

Bureau of Economic Analysis (2014). Per capita real GDP by state (chained 2009) dollars. Interactive Data- Regional Data- GDP & Personal Income, U.S. Bureau of Economic Analysis.

Calero, C., Bedi, A. S., and Sparrow, R. (2009). Remittances, liquidity constraints and human capital investments in Ecuador. *World Development*, 37(6):1143–1154.

Chiswick, B. R. and Miller, P. W. (2012). Negative and positive assimilation, skill transferability, and linguistic distance. *Journal of Human Capital*, 6(1):35–55.

Ciccone, A. and Hall, R. E. (1996). Productivity and the density of economic activity. *The American Economic Review*, 86(1):54.

Clemens, M. and Chand, S. (2008). Skilled emigration and skill creation: A quasi-experiment. Working Papers 152, Center for Global Development.

Clemens, M. A. (2011). Economics and emigration: Trillion-dollar bills on the sidewalk? *Journal of Economic Perspectives*, 25(3):83–106.

Clemens, M. A. and Pritchett, L. (2016). The new economic case for migration restrictions: An assessment. IZA Discussion Papers 9730, Institute for the Study of Labor (IZA).

Collier, P. (2013). *Exodus: How migration is changing our world*. Oxford University Press.

de la Croix, D. and Docquier, F. (2015). An incentive mechanism to break the low-skill immigration deadlock. *Review of Economic Dynamics*, 18(3):593–618.

de la Croix, D. and Doepke, M. (2003). Inequality and growth: Why differential fertility matters. *American Economic Review*, 93(4):1091–1113.

de la Croix, D. and Doepke, M. (2004). Public versus private education when differential fertility matters. *Journal of Development Economics*, 73(2):607–629.

de la Croix, D. and Gosseries, A. (2009). Population policy through tradable procreation entitlements. *International Economic Review*, 50(2):507–542.

de Palma, A. and Kilani, K. (2007). Invariance of conditional maximum utility. *Journal of Economic Theory*, 132(1):137–146.

Defoort, C. (2008). Tendances de long terme des migrations internationales: Analyse à partir des six principaux pays receveurs. *Population (french edition)*, 63(2):317–351.

Delogu, M., Docquier, F., and Machado, J. (2014). The dynamic implications of liberalizing global migration. CESifo Working Paper Series 4596, CESifo Group Munich.

Desmet, K., Nagy, D. K., and Rossi-Hansberg, E. (2017). The geography of development: Evaluating migration restrictions and coastal flooding. *Journal of Political Economy*, forthcoming.

di Giovanni, J., Levchenko, A., and Ortega, F. (2015). A global view of cross-border migration. *Journal of the European Economic Association*, 13(1):168–202.

Docquier, F. and Machado, J. (2015). Remittance and migration prospects for the twenty-first century. Working Papers P133, FERDI.

Docquier, F., Machado, J., and Sekkat, K. (2015). Efficiency gains from liberalizing labor mobility. *The Scandinavian Journal of Economics*, 117(2):303–346.

Docquier, F., Peri, G., and Ruyssen, I. (2014). The cross-country determinants of potential and actual migration. *International Migration Review*, 48:37–99.

Docquier, F. and Rapoport, H. (2012). Globalization, Brain drain, and development. *Journal of Economic Literature*, 50(3):681–730.

Dustmann, C. and Okatenko, A. (2014). Out-migration, wealth constraints, and the quality of local amenities. *Journal of Development Economics*, 110(C):52–63.

Easterly, W. and Nyarko, Y. (2009). Is the brain drain good for Africa? In *Skilled immigration: problems, prospects and policies*, chapter 11, pages 316–60. Oxford University Press, Oxford.

Esipova, N., Ray, J., and Srinivasan, R. (2011). The world's potential migrants: Who they are, where they want to go, and why it matters. *Gallup White Paper*.

Eurostat (2011). GDP per inhabitant ranged from 28% of the EU27 average in Severoza-Paden in Bulgaria to 343% in Inner London. Eurostat News Release, STAT/11/28, Eurostat.

Faini, R. (2007). Remittances and the brain drain: Do more skilled migrants remit more? *The World Bank Economic Review*, 21(2):177–191.

Fernández, R. and Fogli, A. (2009). Culture: An empirical investigation of beliefs, work, and fertility. *American Economic Journal: Macroeconomics*, 1(1):146–177.

Freund, C. and Spatafora, N. (2008). Remittances, transaction costs, and informality. *Journal of Development Economics*, 86(2):356–366.

Galor, O. (2011). *Unified Growth Theory*. Number 9477 in Economics Books. Princeton University Press.

Gibson, J. and McKenzie, D. (2011). The microeconomic determinants of emigration and return migration of the best and brightest: Evidence from the Pacific. *Journal of Development Economics*, 95(1):18–29.

Grogger, J. and Hanson, G. H. (2011). Income maximization and the selection and sorting of international migrants. *Journal of Development Economics*, 95(1):42–57.

Haveman, R. and Wolfe, B. (1995). The determinants of children's attainments: A review of methods and findings. *Journal of Economic Literature*, 33(4):1829–1878.

Hendricks, L. (2004). A database of mincerian earnings regressions. *Available online at: www.lhendircks.org/Mincer.htm*.

Iranzo, S. and Peri, G. (2009). Migration and trade: Theory with an application to the Eastern-Western European integration. *Journal of International Economics*, 79(1):1–19.

Iregui, A. M. (2005). Efficiency gains from the elimination of global restrictions on labour mobility: An analysis using a multiregional CGE model. In *Poverty, international migration and asylum*, pages 211–238. Palgrave Macmillan UK.

Johnson, G. E. (1970). The demand for labor by educational category. *Southern Economic Journal*, 37(2):190–203.

Jones, L. E. and Schoonbroodt, A. (2010). Complements versus substitutes and trends in fertility choice in dynastic models. *International Economic Review*, 51(3):671–699.

Kangasniemi, M., Winters, L. A., and Commander, S. (2007). Is the medical brain drain beneficial? Evidence from overseas doctors in the UK. *Social Science & Medicine*, 65(5):915–923.

Katz, L. F. and Murphy, K. M. (1992). Changes in relative wages, 1963-1987: Supply and demand factors. *The Quarterly Journal of Economics*, 107(1):35–78.

Kaufmann, D., Kraay, A., and Mastruzzi, M. (2008). Governance matters VII: Aggregate and individual governance indicators 1996-2007. Policy Research Working Paper Series 4654, The World Bank.

Kennan, J. (2013). Open borders. *Review of Economic Dynamics*, 16(2):1–13.

Kennan, J. (2014). Immigration restrictions and skill premia. mimeo, Department of Economics, University of Wisconsin.

Kennan, J. and Walker, J. R. (2011). The effect of expected income on individual migration decisions. *Econometrica*, 79(1):211–251.

Klein, P. and Ventura, G. (2009). Productivity differences and the dynamic effects of labor movements. *Journal of Monetary Economics*, 56(8):1059–1073.

Knack, S. and Keefer, P. (1997). Does social capital have an economic payoff? A cross-country investigation. *The Quarterly Journal of Economics*, 112(4):1251–1288.

Kollmann, R. (1997). Endogenous fertility in a model with non-dynastic parental altruism. *Journal of Population Economics*, 10(1):87–95.

Kremer, M. and Chen, D. (1999). Income-distribution dynamics with endogenous fertility. *American Economic Review*, 89(2):155–160.

Krusell, P., Ohanian, L. E., Ros-Rull, J.-V., and Violante, G. L. (2000). Capital-skill complementarity and inequality: A macroeconomic analysis. *Econometrica*, 68(5):1029–1054.

Lee, B. S. and Pol, L. G. (1993). The influence of rural-urban migration on migrants' fertility in Korea, Mexico and Cameroon. *Population Research and Policy Review*, 12(1):3–26.

Lindstrom, D. P. and Saucedo, S. G. (2002). The short-and long-term effects of US migration experience on Mexican women's fertility. *Social Forces*, 80(4):1341–1368.

Manchin, M. and Orazbayev, S. (2016). Social networks and the intention to migrate. Development Working Papers 409, Centro Studi Luca d'Agliano, University of Milano.

McFadden, D. (1974). Conditional logit analysis of qualitative choice behavior. In Zarembka, P., editor, *Frontiers in Econometrics*, pages 105–42. Academic Press, New York.

McKenzie, D. and Rapoport, H. (2011). Can migration reduce educational attainment? Evidence from Mexico. *Journal of Population Economics*, 24(4):1331–1358.

Mountford, A. (1997). Can a brain drain be good for growth in the source economy? *Journal of Development Economics*, 53(2):287–303.

Mountford, A. and Rapoport, H. (2011). The brain drain and the world distribution of income. *Journal of Development Economics*, 95(1):4–17.

Neumayer, E. (2006). Unequal access to foreign spaces: How states use visa restrictions to regulate mobility in a globalised world. *Transactions of the Institute of British Geographers*, 1(31):72–84.

Niimi, Y., Ozden, C., and Schiff, M. (2010). Remittances and the brain drain: Skilled migrants do remit less. *Annals of Economics and Statistics/Annales d'Économie et de Statistique*, pages 123–141.

Ortega, F. and Peri, G. (2009). The causes and effects of international migrations: Evidence from OECD countries 1980-2005. NBER Working Papers 14833, National Bureau of Economic Research, Inc.

Ortega, F. and Peri, G. (2013). The role of income and immigration policies in attracting international migrants. *Migration Sudies*, 1(1):1–28.

Ortega, F. and Peri, G. (2014). Openness and income: The roles of trade and migration. *Journal of International Economics*, 92(2):231–251.

Ottaviano, G. I. and Peri, G. (2006). The economic value of cultural diversity: Evidence from US cities. *Journal of Economic Geography*, 6(1):9–44.

Ottaviano, G. I. and Peri, G. (2012). Rethinking the effect of immigration on wages. *Journal of the European Economic Association*, 10(1):152–197.

Parrotta, P., Pozzoli, D., and Pytlikova, M. (2014). The nexus between labor diversity and firms innovation. *Journal of Population Economics*, 27(2):303–364.

Peri, G., Shih, K., and Sparber, C. (2015). STEM workers, H-1B visas and productivity in US cities. *Journal of Labor Economics*, 33(S1):225–255.

Razin, A. and Wahba, J. (2015). Welfare magnet hypothesis, Fiscal burden, and immigration skill selectivity. *Scandinavian Journal of Economics*, 117(2):369–402.

Sala-i Martin, X. (2006). The world distribution of income: Falling poverty and convergence,... period. *Quarterly Journal of Economics*, 121(2):351–397.

Salas, V. B. (2014). International remittances and human capital formation. *World Development*, 59(C):224–237.

Shrestha, S. A. (2017). No man left behind: Effects of emigration prospects on educational and labour outcomes of non-migrants. *The Economic Journal*, 127(600):495–521.

Spilimbergo, A. (2009). Foreign students and democracy. *American Economic Review*, 99(1):528–43.

Stark, O., Helmenstein, C., and Prskawetz, A. (1997). A brain gain with a brain drain. *Economics Letters*, 55(2):227–234.

Stephen, E. H. and Bean, F. D. (1992). Assimilation, disruption and the fertility of Mexican-origin women in the United States. *International Migration Review*, 26(1):67–88.

Tanaka, R., Farr, L., and Ortega, F. (2014). Immigration, naturalization, and the future of public education. IZA Discussion Papers 8342, Institute for the Study of Labor (IZA).

United Nations (2011). World Population Prospects - The 2010 Revision: Highlights and Advance Tables. Working Paper No. ESA/P/WP.220, United Nations, Department of Economic and Social Affairs, Population Division.

Walmsley, T. L. and Winters, L. A. (2005). Relaxing the restrictions on the temporary movement of natural persons: A simulation analysis. *Journal of Economic Integration*, 20(4):688–726.

Weil, D. N. and Galor, O. (2000). Population, technology, and growth: From Malthusian stagnation to the demographic transition and beyond. *American Economic Review*, 90(4):806–828.

Winters, L. A. (2001). Assessing the efficiency gain from further liberalization: A comment. In Suave, P. and Subramanian, A., editors, *Efficiency, Equity and Legitimacy: The Multilateral Trading System at the Millennium*, pages 106–113. Brookings Institution Press.

World Bank (2010). World Development Indicators. The World Bank: Washington DC. *The World Bank: Washington DC*.

Yi, J., Zhang, J., and Ha, W. (2009). Brain drain, brain gain, and economic growth in China. Technical Report 2009/37, Human Development Research Paper.

LUXEMBOURG INSTITUTE OF
SOCIO-ECONOMIC RESEARCH

11, Porte des Sciences
Campus Belval
L-4366 Esch-sur-Alzette

T +352 58 58 55-1
F +352 58 58 55-700

www.liser.lu