

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

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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

This paper benefited from the helpful suggestions from four anonymous referees. We are grateful to Michel Beine, Simone Bertoli, Bastien Chabé-Ferret, Giuseppe 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 (September 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). Joël Machado acknowledges funding by the Luxembourg National Research Fund (9037210).

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s10887-017-9153-z>) contains supplementary material, which is available to authorized users.

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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

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 50–150% 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 price 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-

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.

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), 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 also changes the incentives to educate before emigration occurs. This link between

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).

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.

emigration prospects and human capital formation has been identified in the macro and micro literatures.⁸

Furthermore, exposed to a new environment and to 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 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 micro-founded 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 twenty-first 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

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 Brouckerhoff 1995). Convergence is also obtained in studies of international migration, including Stephen and Bean (1992), Lindstrom and Saucedo (2002) for women of Mexican origin living in the US (see also Chiswick and Miller 2012; Fernández and Fogli 2009).

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

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).

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% of the world GDP in the short run. However, in the absence of a rapid convergence in income of less developed countries, the long-run effects are always 4 to 5 times greater than the short-run ones.

The rest of this paper is organized as follows. In Sect. 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 Sect. 3. Our benchmark results are presented in Sect. 4. A large set of extensions and robustness checks are discussed in Sect. 5. Finally, Sect. 6 concludes.

2 Theory

In this section, we develop a 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 Sect. 4.4.

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

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 Sect. 2.1. Fertility and basic education decisions are modeled in Sect. 2.2. Human capital and population dynamics are characterized in Sect. 2.3. Section 2.4 describes the production technology. The intertemporal equilibrium is defined in Sect. 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:

$$U_{ki,t}^s = \ln v_{i,t}^s + \ln (1 - x_{ki,t}^s) + \ln (1 - z_k^s) + \varepsilon_{ki,t}^s, \tag{1}$$

where $\ln v_{i,t}^s \in \mathfrak{R}$ is the deterministic level of utility that can be reached in location i at period t (explained in Sect. 2.2)¹¹; this term depends on the adult's level of consumption, and on the number and (basic) education of children. The second term, $\ln (1 - x_{ki,t}^s)$, captures the net disutility implied by migration, and $x_{ki,t}^s \leq 1$ 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 $x_{kk,t}^s = 0$). Hence, the higher are the migration costs $x_{ki,t}^s$, the higher

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.

is the disutility of migrating. Migration costs $x_{ki,t}^s$ vary across country pairs and education levels. We distinguish between visa costs and private costs. Private costs, denoted by $\bar{x}_{ki,t}^s$, 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 $(x_{ki,t}^s - \bar{x}_{ki,t}^s)$.

Individuals are heterogeneous in their ability to acquire higher education and in their preference for alternative locations: ε_{ki}^s and z_k^h are individual-specific. Basic education is a prerequisite 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 $\tau_k^h \equiv (1 - z_k^h)^{-1} \in [0, \infty]$, a monotonic and increasing function of z_k^h , follows a Pareto distribution with a country-specific lower bound $\bar{\tau}_k > 0$ and a common shape parameter $\alpha > 0$. The individual-specific random taste shock for moving from country k to i is denoted by $\varepsilon_{ki}^s \in \mathfrak{R}$ 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 $(\varepsilon_{ki,t}^s)$ 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 Sect. 2.2.

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:

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

An individual chooses to educate if the expected benefits from college education exceed the training effort, i.e., when $E(U_{k,t}^h) > E(U_{k,t}^l)$. 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 $\tau_k^h \equiv (1 - z_k^h)^{-1}$ 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 (3), 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 (3) 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:

$$H_{k,t} = q_{k,t-1} \left[1 - \left(\frac{\bar{\tau}_k \left((v_{k,t}^l)^{1/\mu} + (V_{k,t}^l)^{1/\mu} \right)^\alpha}{(v_{k,t}^h)^{1/\mu} + (V_{k,t}^h)^{1/\mu}} \right) \right], \tag{4}$$

where $\bar{\tau}_k$, 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 ($\bar{\tau}_k$).

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 ($\bar{\tau}_k$). 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 $\ln v_{i,t}^s + \ln (1 - x_{ki,t}^s) + \varepsilon_{ki}^s$ 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 multinomial logit expression. The emigration rate is given by:

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.

$$\frac{N_{ki,t}^s}{N_{k,t}^s} = \frac{\exp\left(\frac{\ln v_{i,t}^s + \ln(1-x_{ki,t}^s)}{\mu}\right)}{\sum_{j=1}^I \exp\left(\frac{\ln v_{j,t}^s + \ln(1-x_{kj,t}^s)}{\mu}\right)} = \frac{(v_{i,t}^s)^{1/\mu} (1-x_{ki,t}^s)^{1/\mu}}{\sum_{j=1}^I (v_{j,t}^s)^{1/\mu} (1-x_{kj,t}^s)^{1/\mu}}. \tag{5}$$

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

$$\frac{N_{ki,t}^s}{N_{kk,t}^s} = \left(\frac{v_{i,t}^s}{v_{k,t}^s}\right)^{1/\mu} (1-x_{ki,t}^s)^{1/\mu}. \tag{6}$$

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 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. Equation (6) 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 $x_{ki,t}^s$. Heterogeneity in migration tastes implies that emigrants select all destinations for which $x_{ki,t}^s < 1$ (if $x_{ki,t}^s = 1$, the corridor is empty). Additionally, all corridors for which $x_{ik,t}^s, x_{ki,t}^s < 1$ exhibit bidirectional migration flows.

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

$$p_{k,t}^s \equiv \frac{\sum_{i \neq k} N_{ki,t}^s}{N_{k,t}^s} = \frac{(V_{k,t}^s)^{1/\mu}}{(v_{k,t}^s)^{1/\mu} + (V_{k,t}^s)^{1/\mu}},$$

$$\rho_{k,t} \equiv \frac{p_{k,t}^h}{p_{k,t}^l} = \frac{(V_{k,t}^h)^{1/\mu}}{(V_{k,t}^l)^{1/\mu}} \left[\frac{(v_{k,t}^h)^{1/\mu} + (V_{k,t}^h)^{1/\mu}}{(v_{k,t}^l)^{1/\mu} + (V_{k,t}^l)^{1/\mu}} \right]^{-1}. \tag{7}$$

The skill ratio of emigration rates increases with $V_{k,t}^h$ and decreases with $V_{k,t}^l$. From (4) and (7), we have $sgn\left(\frac{\partial H_{k,t}}{\partial v_{k,t}^s}\right) = sgn\left(\frac{\partial \rho_{k,t}}{\partial v_{k,t}^s}\right)$ and $sgn\left(\frac{\partial H_{k,t}}{\partial v_{k,t}^s}\right) \neq sgn\left(\frac{\partial \rho_{k,t}}{\partial v_{k,t}^s}\right)$. The implication is that emigration-driven expected utility shocks $(\Delta V_{k,t}^s)$ induce a positive association between human capital formation $(H_{k,t})$ and the ratio of emigration rates $(\rho_{k,t})$. Local expected utility shocks $(\Delta v_{k,t}^s)$ 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 $(p_{k,t}^s)$ 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 $\ln v_{k,t}^s$ 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 $(c_{k,t}^s)$, fertility $(n_{k,t}^s)$ and the proportion of children receiving basic (primary and secondary) education $(q_{k,t}^s)$ 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), Galor (2011), our *inner utility function* $v_{k,t}^s$ is a logarithmic function of $c_{k,t}^s$, $n_{k,t}^s$ and $q_{k,t}^s$:

$$\ln v_{k,t}^s = (1 - \theta) \ln c_{k,t}^s + \theta \ln n_{k,t}^s + \theta \lambda \ln q_{k,t}^s, \tag{8}$$

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 $w_{k,t}^s$ 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 $e_{k,t}^s$. We allow non-educated children to work and earn a wage $w_{k,t}^c$ 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:

$$c_{k,t}^s + n_{k,t}^s q_{k,t}^s e_{k,t}^s = w_{k,t}^s (1 - \phi n_{k,t}^s) + n_{k,t}^s (1 - q_{k,t}^s) w_{k,t}^c. \tag{9}$$

Each adult maximizes utility (8) subject to $q_{k,t}^s \leq 1$ 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 $q_{k,t}^s < 1$, the optimal fertility rate and investment in basic education are given by:

$$n_{k,t}^s = \frac{\theta(1 - \lambda)w_{k,t}^s}{\phi w_{k,t}^s - w_{k,t}^c}, \tag{10}$$

$$q_{k,t}^s = \frac{\lambda}{1 - \lambda} \frac{\phi w_{k,t}^s - w_{k,t}^c}{e_{k,t}^s + w_{k,t}^c}. \tag{11}$$

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.

In line with intuition, the fertility rate decreases with the adult’s wage rate ($w_{k,t}^s$) but increases with the child’s wage rate ($w_{k,t}^c$). Children’s basic education increases with the adult’s wage rate ($w_{k,t}^s$) but decreases with the education cost ($e_{k,t}^s$) and the child’s wage rate ($w_{k,t}^c$).

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

$$n_{k,t}^s = \frac{\theta w_{k,t}^s}{\phi w_{k,t}^s + e_{k,t}^s}. \tag{12}$$

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

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

and

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

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 $\omega_{k,t}$:

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

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

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 Eq. (4). Clearly, $N_{k,t}$ 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:

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

$$Q_{k,t} = \left(\eta_k \ell_{k,t}^h \frac{\sigma_s - 1}{\sigma_s} + (1 - \eta_k) \ell_{k,t}^l \frac{\sigma_s - 1}{\sigma_s} \right)^{\frac{\sigma_s}{\sigma_s - 1}}, \tag{22}$$

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:

$$w_{k,t}^h = \eta_k A_{k,t} \left(\frac{Q_{k,t}}{\ell_{k,t}^h} \right)^{\frac{1}{\sigma_s}}, \tag{23}$$

$$w_{k,t}^l = (1 - \eta_k) A_{k,t} \left(\frac{Q_{k,t}}{\ell_{k,t}^l} \right)^{\frac{1}{\sigma_s}}, \tag{24}$$

$$w_{k,t}^c = \omega_{k,t} w_{k,t}^l. \tag{25}$$

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

$$\sigma_{k,t} \equiv \frac{w_{k,t}^h}{w_{k,t}^l} = \frac{\eta_k}{1 - \eta_k} \left(\frac{\ell_{k,t}^h}{\ell_{k,t}^l} \right)^{\frac{-1}{\sigma_s}}, \tag{26}$$

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 1 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.

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, $A_{k,t}(\cdot)$ 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 ($L_{k,t}^h + L_{k,t}^l$).

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:

Definition 1 For a set $\{\theta, \lambda, \phi, \mu, \alpha, \sigma_s\}$ of structural parameters, a set $\{\omega_{k,t}, \xi_{k,t}^s, \bar{\tau}_{k,t}, A_{k,t}, \eta_k\}_{\forall k,s,t}$ of exogenous country-specific institutional, educational and technological characteristics, a set $\{x_{ki,t}^s\}_{\forall k,i,t,s}$ 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 $\{w_{k,t}^s, \sigma_{k,t}, H_{k,t}, n_{k,t}^s, q_{k,t}^s, N_{ki,t}^s, L_{k,t}^s, h_{k,t}, \ell_{k,t}^s\}_{\forall k,i,t,s}$ such that (i) wages $w_{k,t}^s$ 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 (4), (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 (6), (v) aggregation constraints $L_{k,t}^s \equiv \sum_i N_{ik,t}^s$, $h_{k,t} \equiv L_{k,t}^h / (L_{k,t}^h + L_{k,t}^l)$, (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 Sect. 3 we parameterize the baseline (pre-liberalization) trajectory for the world economy. We then simulate the effects of liberalization shocks in Sect. 4. More specifically, in our benchmark scenario, a complete removal of legal migration barriers means that $x_{ki,t}^s$ decrease to $\bar{x}_{ki,t}^s$ 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 Sect. 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: $A_{k,2000} = Y_{k,2000}/Q_{k,2000}$. 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 Sect. 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), 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 ($w_{i,t}^s/w_{k,t}^s$) between 0.6 and 0.7. Given the values of the preference parameters and plugging the solution of the maximization problem in (15) into (6), 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 (4). We iterated on α (and the vector of $\bar{\tau}_{k,t}$, 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.

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

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

For subsequent periods, $n_{k,t}^l$ and q_k^l 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 $n_{k,t}^l \forall k, t$. 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 $\xi_{k,t}^s = \xi_{k,1975}^s \forall k, s, t$. Note that the evolution of these country characteristics determines the trajectory of $\ln \Omega_{k,t}^s$ in (15) and the trajectory of the supply of labor $(\ell_{k,t}^s)$ 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 $\bar{\tau}_{k,t}$, is allowed to vary across countries. For a given α , $\bar{\tau}_{k,2000}$ 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 $\bar{\tau}_{k,t} = \bar{\tau}_{k,2000}$ 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 $(x_{ki,t}^s)$ as residuals from the migration technology in Eq. (6). We use the data set described in Artuç et al. (2015), which documents bilateral migration stocks for all pairs of countries $(N_{ki,2000}^s)$ and the stocks of native stayers $(N_{kk,2000}^s)$ by education level in 2000. Because the level of $v_{k,2000}^s$ is governed by preference and institutional characteristics, bilateral migration costs $(1 - x_{ki,2000}^s)$ can be recovered for each pair of countries as residuals of (6).

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, $A_{ki,t}^s$, that would be observed if migration barriers were lifted. The skill-specific potential migration stocks $\bar{N}_{ki,t}^s$ (also referred to as desiring migrants) are then denoted:

$$\bar{N}_{ki,t}^s = N_{ki,t}^s + A_{ki,t}^s, \tag{27}$$

where $N_{ki,t}^s$ denotes the observed migrant stocks of skill s between country k and country i and $A_{ki,t}^s$ 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 $(1 - \bar{x}_{ki,2000}^s)$ as a residual of (6) using the number of uncorrected desiring migrants (i.e., observed and additional immigrants), $\bar{N}_{ki,2000}^s$.

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 Ruysen 2016), though the size of the actual flows is smaller.

The interpretation of our calibrated migration costs should not be pushed too far because $x_{ki,2000}^s$ 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

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

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

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 given origin 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 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, $A_{ki,t}^s$, is the sum of constrained individuals, $A_{ki,t}^{s,visa}$, and individuals who are not constrained by policies but have not realized their migration aspiration for other reasons, $A_{ki,t}^{s,unc}$:

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

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 $A_{ki,t}^{s,visa}$ should be accounted for in our simulations and thus the stock of desiring immigrants, $\hat{N}_{ki,t}^s$, should be:

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

In our benchmark counterfactual scenario, denoted $\bar{N}_{ki,t}^s$, we assume that $A_{ki,t}^{s,unc} = 0$ and thus $A_{ki,t}^s = A_{ki,t}^{s,visa}$. In the alternative counterfactual, denoted $\hat{N}_{ki,t}^s$, we relax the assumption that $A_{ki,t}^{s,unc} = 0$ and proxy the number of unconstrained migrants in the data. From Eq. (29), we have that:

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

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

$$= (N_{ki,t}^s + A_{ki,t}^s) (1 - \eta_{ki,t}^s), \tag{32}$$

where $(1 - \eta_{ki,t}^s)$ 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, $A_{ki,t}^s = A_{ki,t}^{s,unc}$ (and $A_{ki,t}^{s,visa} = 0$) when $k, i \in Schengen$:

$$\eta_{Sch}^s = \frac{\sum_{k,i \in Schengen} A_{ki,t}^{s,unc}}{\sum_{k,i \in Schengen} (N_{ki,t}^s + A_{ki,t}^{s,unc})} = \frac{\sum_{k,i \in Schengen} A_{ki,t}^s}{\sum_{k,i \in Schengen} (N_{ki,t}^s + A_{ki,t}^s)}. \tag{33}$$

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:

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

$$A_{ki,t}^{s,visa} = \max(0; A_{ki,t}^s (1 - \eta_{Sch}^s) - \eta_{Sch}^s N_{ki,t}^s) \text{ if } k, i \notin Schengen, \tag{35}$$

whereas, as before:

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

The skill-specific fraction of unrealized migration aspirations for intra-Schengen area movements are $\eta_{Sch}^l = 0.3226$ and $\eta_{Sch}^h = 0.3339$. Applying these values to corridors outside the Schengen area in Eq. (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 $(1 - \hat{x}_{ki,2000}^s)$ are obtained using the Schengen-adjusted desiring migrants stocks, $\hat{N}_{ki,2000}^s$. 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 $x_{ki,t}^s = x_{ki,2000}^s$, $\bar{x}_{ki,t}^s = \bar{x}_{ki,2000}^s$ and $\hat{x}_{ki,t}^s = \hat{x}_{ki,2000}^s$ 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 Sect. 4.2 discusses the impact of a liberalization using the Schengen-adjusted visa costs. Alternative interpretations of the Gallup data are presented in Sect. 4.3. Section 4.4 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:

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

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 Fig. 1a–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 1a 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

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 Sect. 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”.

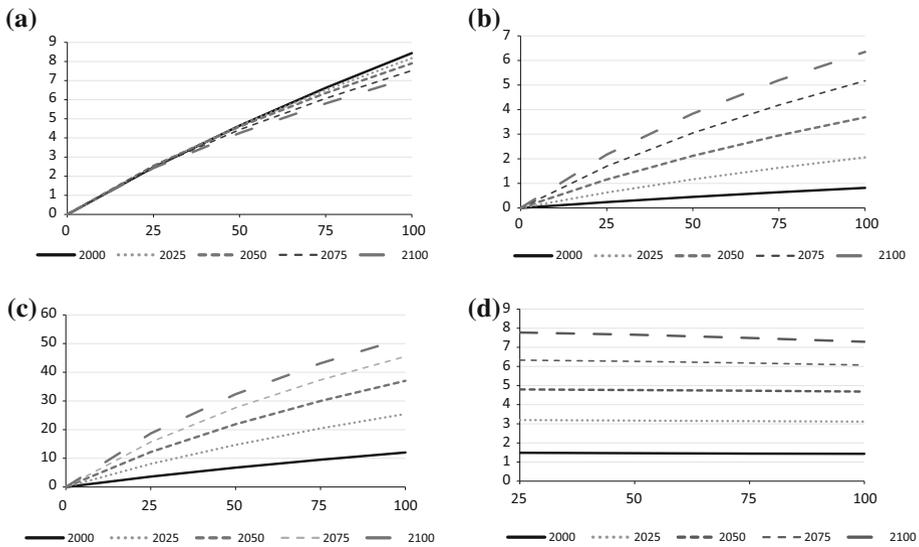


Fig. 1 World economy response to liberalization under the benchmark model. **a** Prop. of migrants (Dev.), **b** prop. of college-educated (Dev.), **c** GDP per worker (Perc. of dev.), **d** GDP-migration semi-elasticity

2000 onwards. Overall, this *brain gain* effect is somewhat small, as shown in Fig. 1b: 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, Fig. 1c 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 1d 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, Table 1 presents 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

The effects by region are much smaller than the worldwide gains discussed above. The reason is that the region-specific changes in GDP per worker do not reflect the income gain that migrants are experiencing when moving from poor to rich countries. These migrants are the main beneficiaries from the abolition of migration restrictions. Ideally, their income should be compared with that of the population at origin.²² Theoretically speaking, liberalizing migration can increase the worldwide level of GDP per worker while, at the same time, decrease the level of GDP per worker in all regions. This is typically the case if migrants are more educated than those left behind and less educated than the host-country population. However, this does not happen in our dynamic framework due to the rise in education levels. Hence, the worldwide effect accounts for the migrants' gains, and the region-specific effects are provided to illustrate the distributive implications of the liberalization, in line with other studies.

In the short term, the GDP per worker decreases in all developed regions (see Table 1). 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). This increase is generated by the greater incentives of individuals to acquire

²⁰ As shown in Sect. 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".

²² See Biavaschi et al. (2016) for a discussion on the population composition effects in the measurement of the skill selection of migrants (relative to non-migrants).

Table 1 Regional effects of a complete liberalization

	Baseline (in USD)					Liberalization (Perc. of dev.)				
	2000	2025	2050	2075	2100	2000	2025	2050	2075	2100
<i>(a) GDP per adult worker</i>										
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	5752	7599	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	7397	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	9536	13,664	20,247	30,303	44,346	+0.6	+1.6	+2.6	+3.6	+4.7
	Baseline (as percent)					Liberalization (dev. in pp)				
	2000	2025	2050	2075	2100	2000	2025	2050	2075	2100
<i>(b) Proportion of college graduates in the labor force</i>										
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

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)

higher education, which increases the proportion of tertiary educated after the liberalization (see the discussion in Sect. 5.1 and the results for selected countries in “Appendix C.4”). However, the positive income responses provided in Table 1 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.

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:

$$x_{ki,t}^s \longrightarrow \hat{x}_{ki,t}^s \quad \forall s, k, i, t. \quad (38)$$

Given the lower number of additional migrants in the alternative counterfactual scenario (described in Sect. 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.

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*”.

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

- 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:

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

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

This scenario is labeled “Network”.

The results of the potential migration variants are depicted in Fig. 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

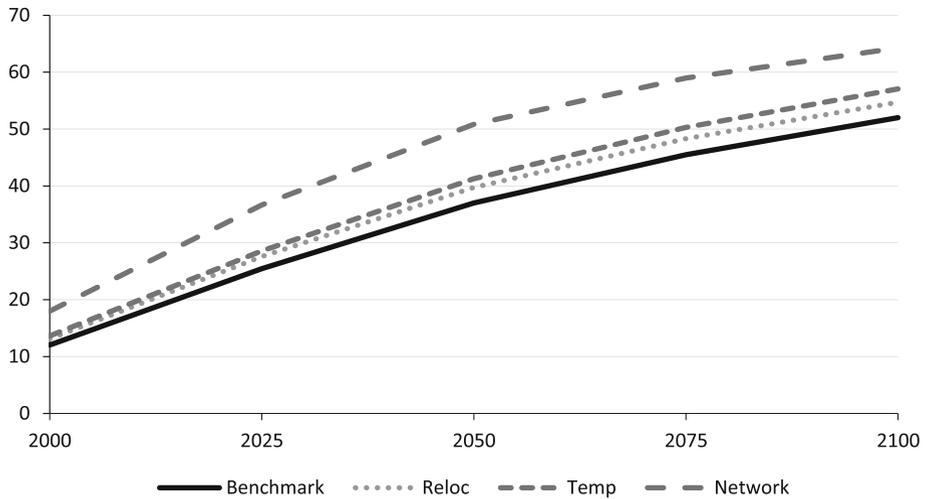


Fig. 2 Robustness to potential migration: impact on GDP per worker

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 Fig. 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).

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).²³ In “Appendix C.3”, we estimate the size of these redistributive effects. They are large if 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.²⁴

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

²³ 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 of varieties produced at origin by the repatriated individuals).

²⁴ 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).

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 Sect. 5.1. We then assess the sensitivity to technological non-linearities (associated with human capital, congestion and cultural diversity) in Sects. 5.2 and 5.3. Finally, we consider scenarios with faster growth rates for developing countries, African countries and the BRIC countries in Sect. 5.4. For these robustness checks, we use the benchmark level of visa costs ($\bar{x}_{k,i,t}^s$). We focus on the complete liberalization scenario ($\vartheta = 100\%$) and provide results for the worldwide level of GDP per worker only.²⁵

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.²⁶ 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. (4) 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 Fig. 3a. 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 work-

²⁵ “Appendix 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”.

²⁶ 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 Eqs. 13 and 14).

ers 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 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 Fig. 3b. 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.²⁷

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, 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

²⁷ 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.

(2014), 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 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*”.²⁸
- To embrace the view of Collier (2013), 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.²⁹ This scenario is labeled “*DivTot cost*”.

The results of the cultural diversity variants are depicted in Fig. 3c. 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 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.

²⁸ 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.

²⁹ 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 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:

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

where b represents the speed of convergence of TFP in country k towards the TFP level of the United States.³⁰ 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 and 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 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 Fig. 3d. 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.

³⁰ Log-linearizing this expression implies: $\ln(A_{k,t+1}/A_{k,t}) = 25 \ln(1.015) + b \ln(A_{US,t}/A_{k,t})$.

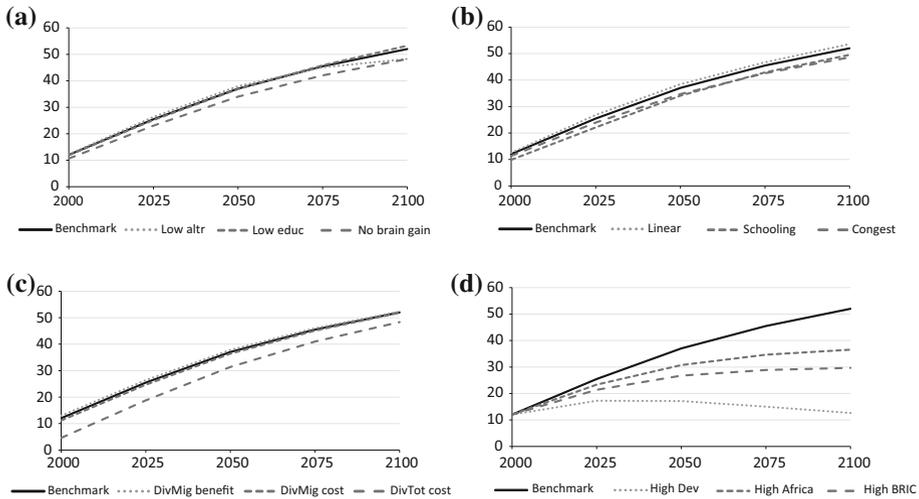


Fig. 3 Robustness checks for the world GDP per worker. **a** Human capital, **b** technological. non linearities, **c** cultural diversity, **d** convergence in TFP

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%.

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.

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