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Abstract

Global migration is heavily skill-biased, with tertiary-educated workers being four times more likely to migrate than workers with a lower education. In this paper, we quantify the global impact of this skill bias in migration. Based on a quantitative multi-country model with trade, we compare the current world to a counterfactual with the same number of migrants, where all migrants are neutrally selected from their countries of origin. We find that most receiving countries benefit from the skill bias in migration, while a small number of sending countries is significantly worse off. The negative effect in many sending countries is completely eliminated — and often reversed — once we account for remittances and additional migration-related externalities. In a model with all our extensions, the average welfare effect of skill-biased migration in both OECD and non-OECD countries is positive.

Keywords: migration, skill selection, global welfare
JEL codes: F22, O15, J61

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1 Introduction

Policymakers' concerns about migration are as much about the skills of migrants — "who migrates?" — as they are about the scale of migration — "how many migrate?" Many migrant-sending countries worry that the emigration of high-skilled workers negatively affects economic development, whereas most receiving countries seek to attract high-skilled while restricting access for low-skilled immigrants. And indeed, the data point to a heavy skill bias in global migration. From most sending countries, high-skilled people are three to four times more likely to emigrate than low-skilled people, such that the skill selection from most sending countries is positive. From the perspective of the receiving countries, a similar pattern can be observed. In the UK and Canada, for example, the current share of tertiary-educated workers among immigrants is three times as large as it would be if all immigrants were drawn at random from the population of their country of origin. .

Separate literatures have emerged for the sending and receiving countries, approaching the implications of the skill bias in migration from fundamentally different angles. The literature on the sending countries — often summarized by the buzzword *Brain Drain* — takes a macro perspective, thereby analyzing the impact of the skill bias in migration on economic growth as well as the channels through which this effect operates.[1] In contrast, much of the literature on the receiving countries approaches the skill bias from a micro perspective by analyzing the self-selection of migrants from the population of the sending country. Most papers study if and why a country's immigrants have been selected from the top or bottom of the skill distribution in the sending country.[2] These literatures leave two important gaps that we aim to fill. First, despite ample evidence that migrants are self-selected from their country of origin, it is unclear whether the resulting skill bias in migration has economic consequences for the receiving countries. The key question here is whether natives would be better or worse off if immigrants were selected differently from the country of origin. Second, it is unclear whether the skill bias in migration yields global efficiency gains, i.e. whether global welfare is higher if migrants are positively self-selected from their countries of origin, and if so, how big these gains are.

In this paper, we jointly quantify the importance of the skill bias in migration for the welfare of never-migrants — people who are non-migrants today as well as in our counterfactual of skill-neutral selection — in the sending and receiving countries. We consider South-North migration from 111 countries to the OECD, as well North-North migration within OECD countries.[3] Our central contribution is to provide an order of magnitude of the extent to which the skills of migrants affect the welfare of people in 146 countries as well as globally.[4] If the skill bias

[1] For a summary of the literature as well as a quantification of the most important channels, see Docquier & Rapoport (2012).

[2] See Biavaschi & Elsner (2013) for a literature review. The skill bias in migration also feeds into the literature on the labor market effects of migration (see Kerr & Kerr, 2011 for a summary), but this literature is mostly about changes in the scale of migration.

[3] As detailed in Section 4, data limitations prevent us to consider South-South migration.

[4] We focus here on the welfare of never-migrants and deliberately leave out the welfare of migrants. To some readers, this may look like a bold undertaking — especially in light of the evidence that the main beneficiaries of migration are the migrants themselves (Clemens *et al.* , 2017) — but including the welfare of

in migration leads to global efficiency gains because high-skilled workers are going to places where they are most productive, our estimate can inform policymakers about the welfare costs of restricting high-skilled emigration from poor countries through taxes (Bhagwati & Hamada, 1974) or emigration restrictions (Collier, 2013).

To assess the global welfare implications of the skill bias in migration, we develop a quantitative model of the world economy in which countries are linked through trade in differentiated goods. Within the model, a change in the skill distribution of migrants simultaneously alters the skill composition of the workforce in the sending and receiving countries, which in turn affects the welfare of never-migrants through changes in market size, skill prices and trade flows. We calibrate the model to match key features of the global economy, namely bilateral trade flows, differences in GDP per capita across countries as well as wage premia for different skill groups within countries. We then use this model to simulate the impact of a change in the skill composition of migrants on the welfare of never-migrants in the sending and receiving countries. To obtain a first benchmark estimate, we begin with a basic trade model before gradually adding remittances as well as other channels through which the skill composition of migrants can affect welfare.

The analysis aims to answer the question '*how important is the skill bias in migration in today's world?*'. Consequently, in our simulations we construct a counterfactual that eliminates the skill bias in global migration. We isolate the impact of the skill bias by holding bilateral migrant stocks constant while changing the skill composition of migrants, thereby assuming that migrants are neutrally selected from their countries of origin. Take as an example migration from India to the US, which is heavily skill biased: the share of tertiary educated people in the Indian population is close to 10%, while among Indian migrants going to the US, this share stands at almost 80%. In our counterfactual, we assume that the number of Indians living in the US remains the same but only 10% have a tertiary education. In this scenario, a larger number of high-skilled workers stay in India and fewer high-skilled Indians live and work in the US. Such a counterfactual may not be congruent with actual migration policies — hardly any country wants to replace high-skilled with low-skilled immigrants — but it serves to estimate the magnitude by which the skill bias contributes to global welfare in the current world.

This analysis yields five main results. First, when we simulate the counterfactual in our baseline model, the skill bias in migration has a positive effect on most receiving countries, while negatively affecting a handful of sending countries. This basic analysis yields welfare gains in the receiving countries that range between 0 and 2%. In some sending countries, the losses amount to over 5%, although in most sending countries — importantly China and India, which jointly represent one third of the world population — the effect is virtually zero.

Second, the global welfare impact of the skill bias in migration is positive but small. While in the most parsimonious model the sign of the effect for each country is largely determined by the direction of the self-selection (positive or negative) and the model assumptions, it is

migrants would not allow for a clean research design. Yet, by focusing on never-migrants, our model makes predictions for 97% of the population of the 146 countries included in this study. More on that in Section 5.

unclear whether the global effect is positive or negative. The global effect can turn negative if, for example, the emigration of a high-skilled worker has a larger negative effect on the welfare of never-migrants in the sending country than in the receiving country. We find, however, a small positive effect, which means that the gains from the skill bias in migration in the receiving countries outweigh the losses in the sending countries.

Third, the skill bias in migration has a different effect on high- versus low-skilled workers. In today's world, high-skilled workers are more abundant in the receiving and more scarce in the sending countries compared to a world without a skill bias in migration. In the receiving countries, this leads to lower wages for high-skilled and higher wages for low-skilled workers, while the opposite is true in the sending countries.

Fourth, when comparing the effect of the skill bias in migration to the total welfare effect of migration — that is, the difference between a world with the current migration stocks and one without any migration — we find that the skill bias is much more important in the sending than in the receiving countries. In most sending countries, the skill bias accounts for one third of the total effect of migration, whereas in most receiving countries, the overall effect of migration is mainly explained by the scale rather than the skill composition.

Fifth, by including five additional adjustment channels, we show that the benchmark model delivers conservative estimates of the global welfare effect of the skill bias in migration. In a series of extensions, we include remittances, a Lucas (1988)-type human capital externality, a *brain gain* externality, a network externality in trade as well as skill depreciation of migrants in the receiving countries. The inclusion of the first four channels — all of which have been highlighted in the literature — leads to considerably higher estimates. The global impact of each channel operates through their effects on different country groups. For example, remittances amplify the global welfare gain by dampening the losses in the sending countries while having no effect on the receiving countries. On the other hand the Lucas (1988)-externality increases both the losses in the sending and the gains in the receiving countries, although the gains exceed the losses. The only channel that leads to lower estimates is the skill depreciation of migrants in the receiving country. However, once we include all five channels at the same time — which represents our most plausible scenario — the global effect doubles compared to the benchmark. Most importantly, the welfare effect in both OECD and non-OECD countries is now positive.

With this paper, we contribute to two large strands of literature. First, by focusing on the skill composition of global migration, the paper complements prior research seeking to estimate the global welfare effects of migration. The main margin analyzed in this literature is a change in the number of migrants. Some studies estimate the contribution of current migration to global welfare by simulating a counterfactual world in autarky, i.e. without any migration (di Giovanni *et al.* , 2015, Aubry *et al.* , 2016), while others take the current number and skill composition of migrants as benchmark and estimate the welfare effect of having more migrants, a scenario that would occur if some or all migration restrictions were lifted.[5] These quantitative studies

[5] See, for example, Hamilton & Whalley (1984), Felbermayr & Kohler (2007), Klein & Ventura (2007, 2009), Iranzo & Peri (2009), Docquier *et al.* (2015), Kennan (2013), Battisti *et al.* (2017), Delogu *et al.* (2018),

have highlighted the importance of migration for global welfare and the global distribution of income. The central contribution of this paper is to explicitly isolate the global impact of the skill bias in migration, i.e. isolating "*who migrates*" from "*how many migrate*". Given that many policymakers are concerned with the skills of migrants, we believe it is important to provide an estimate of the quantitative importance of the skills alone, and to assess under what conditions they matter and under which they do not.

A second strand of literature this paper contributes to is the self-selection of migrants. Beginning with the theoretical work of Borjas (1987), many economists have been interested in the determinants of who migrates and why.[6] The fact that some immigrant groups are selected from the lower part of the skill distribution of their country of origin while other groups are selected from the upper part has been put forward as a main explanation why some immigrant groups fare so much better than others. However, to assess whether the self-selection is economically important for the receiving country, it is crucial to estimate its impact on never-migrants. If it turns out that never-migrants are unaffected by the skill composition of their fellow migrants, then the economic impact of migrant self-selection would be limited. In this paper, we provide a quantitative assessment of migrant self-selection on a global scale. Our findings show that migrant self-selection — which is positive for most bilateral migration stocks and flows — has small positive effects on never-migrants in the receiving countries. At the same time, consistent with the literature on the welfare effects of high-skilled emigration, we find small negative effects of migrant self-selection on a number of sending countries.

The remainder of the paper unfolds as follows. Section 2 establishes the stylized facts about skill-biased migration from the perspective of the sending and receiving countries. Section 3 presents the main features of the theoretical model and explains the channels through which skill-biased migration affects welfare. The calibration of the model is explained in Section 4. Section 5 presents the main simulation results of the welfare impact of skill-biased migration. In Section 6, we describe a series of extensions and sensitivity checks, for which details can be found in the appendix. Section 7 concludes.

2 The skill bias in global migration: stylized facts

Before quantifying its welfare impact, we present some stylized facts about the skill bias in global migration. We speak of a skill bias if the skill distribution of emigrants differs from that of the total population in the sending country.[7] In most sending countries, the skill distribution of emigrants is heavily skewed towards high-skilled workers, i.e. the share of high-skilled workers among emigrants is often a multiple of the share of high-skilled workers in the total population.

Docquier & Machado (2015), Clemens & Pritchett (2016).

6 The most frequently studied flow is Mexican migration to the US, for which Chiquiar & Hanson (2005) find a neutral selection on education levels, whereas Fernández-Huertas Moraga (2011, 2013) and Ambrosini & Peri (2012) find negative selection based on pre-migration wages. For many other migration flows in the world, the selection seems to be positive. See Biavaschi & Elsner (2013) for a literature review.

7 The total population comprises every person born in a given country, i.e. both non-migrants and emigrants.

In the descriptive analysis that follows, we define high-skilled workers as those with at least some tertiary education.

In the sending countries, we measure the skill bias in emigration as the share of high-skilled workers among emigrants divided by the share of high-skilled workers in the total population,

$$\text{skill bias}=\frac{\text{Share of high-skilled among emigrants}}{\text{Share of high-skilled in the total population}}.$$

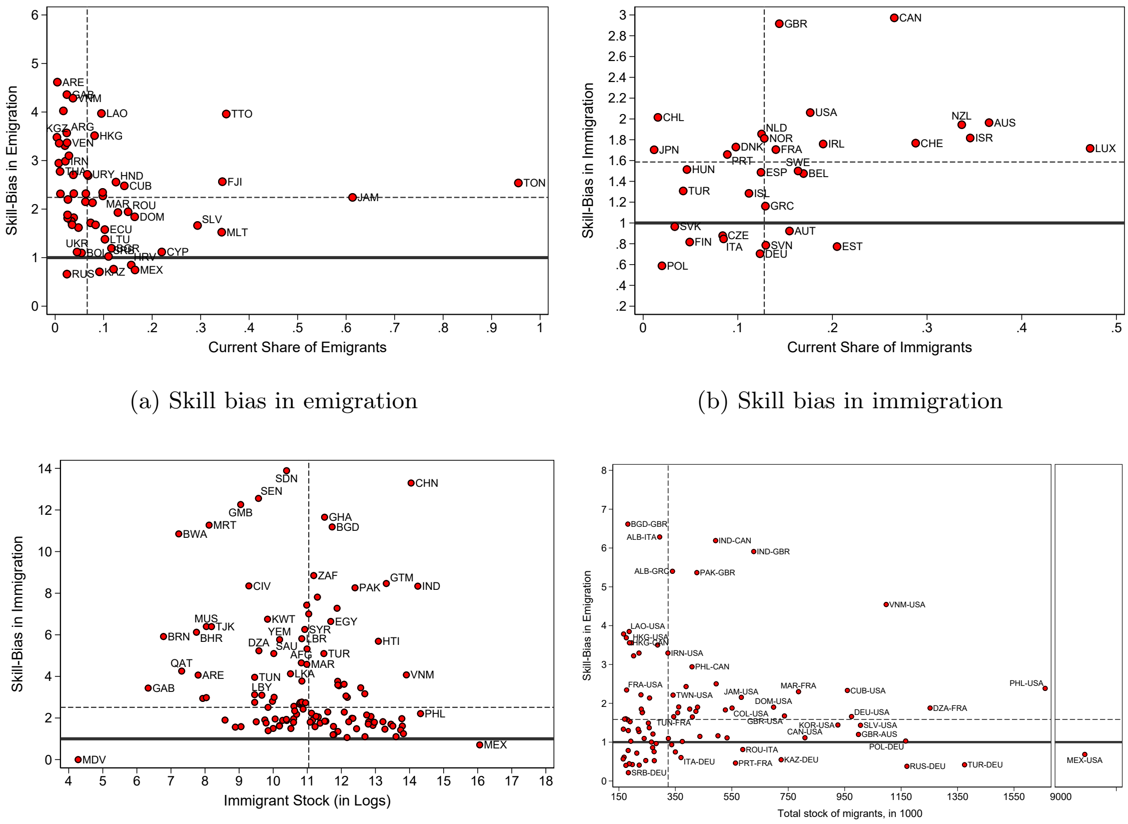
If this ratio equals 2, then the share of high-skilled workers is twice as high among emigrants compared to the total population. Figure 1(a) illustrates the extent of the skill bias for selected non-OECD countries plus Mexico in 2010.[8] The vertical axis displays the skill bias, while the horizontal axis displays the share of emigrants in the total population. The dashed lines represent the median of each axis. At a value of one on the vertical axis, indicated by the thick line, the selection of emigrants from a particular country would be skill-neutral, whereby the share of high-skilled workers among emigrants equals the share of high-skilled persons in the total population.

For the vast majority of sending countries, the skill bias in emigration is positive. At the median of the countries displayed here, the skill bias is 2. For expositional reasons, we only display here countries with a maximum skill bias of 5. However, some countries in the sample — for example, Mali — have a skill bias greater than 30.[9]

In Figure 1(b), we consider the perspective of the OECD countries. Here, the skill bias is calculated differently. The numerator is the share of high-skilled workers among immigrants in the current world with skill bias. The denominator is the share of high-skilled workers among immigrants under neutral selection, i.e. in the counterfactual world in which every migrant is randomly drawn from his/her respective country of origin. For instance, if the skill bias in a receiving country is 2, then the share of high-skilled workers among immigrants is currently twice as large as it would be in a world in which all migrants are neutrally selected from their home countries. The higher the skill bias, the more positive the selection of migrants hosted in a particular OECD country. As shown in Figure 1(b), most OECD countries attract a positive selection of immigrants. The skill bias is particularly large in countries with selective migration policies, such as Canada, the UK, the US, New Zealand and Australia. For instance, in Canada, the share of high-skilled immigrants is three times as large as it would be under skill-neutral migration. In some prominent immigration destinations — notably Germany, Italy and Austria — migrants are negatively selected, whereby their migrant stock would have higher skills under

[8] Both figures are based on the 2010 OECD-DIOC database. See Appendix G for the list of abbreviations. Despite being an OECD country, we list Mexico among the non-OECD countries because it is a major sending country and its GDP per capita is more alike with several non-OECD countries.

[9] These differences in the skill compositions of migrants can be explained by supply and demand factors. On the supply side, they reflect individual self-selection in the migration decision, i.e. the degree to which immigration is an attractive option for tertiary-educated workers and the varying level of attractiveness of different destinations for different groups. On the demand side, receiving countries apply different degrees of skill-based migration policies, which determine the characteristics of the immigrant population. The canonical model of migrant self-selection is provided by Borjas (1987). For a discussion of the empirical evidence, see Biavaschi & Elsner (2013).



(a) Skill bias in emigration

(b) Skill bias in immigration

(c) Skill bias in immigration, US

(d) Skill bias in emigration, Top 100 Corridors

Figure 1: The skill bias in immigration and emigration

Source:. Own calculations from DIOC.

Notes: These graphs plot the skill bias in migration (vertical axis) against the share of emigrants and immigrants, respectively (horizontal axis), for the main sending countries (Panel (b)) and the OECD countries (Panel (a)). Panel (c) shows the skill-bias among immigrants to the US against the total number of immigrants (in logs). Panel (d) illustrates the skill bias in the 100 largest bilateral corridors in the world against the stock of immigrants (in 1,000). A value of 1 on the vertical axis indicates the absence of a skill bias. The dashed lines represent the median of both axes. See text for the calculation of the skill bias.

neutral selection from the country of origin.

While Panel (a) and (b) show the average skill bias in a given sending or receiving country, Figure 1(c) provides an example for the skill bias among immigrants to a single receiving country, namely the US. It shows that the average skill bias of 2 seen in panel (b) masks substantial variation by country of origin: the share of high-skilled among migrants from China to the US is 13 times larger than it would be with neutral selection, while the same share among the Mexican migrants stands at 0.7.[10]

In the analysis to follow, we will quantify the welfare impact of the skill bias in migration by comparing the current world — in which migration is heavily skill-biased — to a world in

[10] For mere expositional reasons we only display here countries with a skill-bias smaller than 14.

which all migrants are neutrally selected from their country of origin. In our counterfactual, the number of migrants remains the same within each migration *corridor*, although the skill distribution of migrants is now the same as the one of the population in the sending country. Figure 1(d) illustrates the skill bias in migration for the 100 largest bilateral corridors.[11] In our counterfactual, we will keep every corridor at the same value on the horizontal axis, but change the skill distribution such that the skill bias equals one and all points lie on the solid horizontal line. For few of the corridors, this means that the receiving country gets a higher share of high skilled migrants while the sending country gets a lower share of high skilled emigrants (e.g. Mexico-USA, or Turkey-Germany). For the vast majority of the corridors, the opposite will be true.

We expect the skill bias to have the largest impact in countries in the northeastern corner of Figures 1(a) - (d), namely those with both a high skill bias and a high share of migrants. The size of the effect will depend on many factors, such as the stage of a country's economic development, the skill structure of the labor market and trade flows.

3 Theoretical framework

To quantify the global welfare impact of the skill bias in migration, we develop an integrated multi-country general equilibrium model that allows us to perform counterfactual simulations whereby we exogenously change the skill composition of migrants. The baseline model is static, although in an extension we will include human capital externalities as a dynamic adjustment mechanism.[12]

The basic setup of the model is in the spirit of Krugman (1980).[13] We consider a world with J countries, indexed by $i = 1, \ldots, J$ and differentiated goods. In each country, the economy comprises two broad sectors: a traditional sector producing a homogeneous good T, and a horizontally differentiated manufacturing sector. The manufacturing sector comprises two sub-sectors, one producing a tradable differentiated good X, and one producing a non-tradable differentiated good Y. The market for manufactured goods X and Y is monopolistically competitive. Firms can freely enter the market, although they pay a sunk entry cost. Good T is consumed domestically and not traded across countries, while the markets for the tradable differentiated good X are separated by asymmetric iceberg trade costs. The real wage of workers is expressed in US dollars adjusted for cross-country purchasing power parities, which serve as the numeraire. Countries differ in terms of worker productivity. The workforce in each country

[11] For expositional reasons we display here corridors with a skill bias smaller than 7.

[12] The recent literature — for example Delogu *et al.* (2018) — has highlighted the importance of population growth and education dynamics in evaluating the impact of migration in the long run. These dynamical channels are absent in our baseline model, which aims to quantify the effects of selection for a given population size and under exogenous migration stocks.

[13] In line with Aubry *et al.* (2016) and Iranzo & Peri (2009) , we abstract here from firm-heterogeneity within sectors in spirit of Melitz (2003) and in contrast to the approach applied to migration by di Giovanni *et al.* (2015). As argued by di Giovanni *et al.* (2015), the main source of the market size effect is the change in the number of firms, rather than the changes in the distribution of technology within sectors due to the entry-and-exit process at the margin of the productivity distribution.

comprises three education levels (low-, medium- and high-skilled workers), the maximum number of skill groups for which consistent data is available. Moreover, in the receiving countries, immigrants and natives are imperfect substitutes in production.

As one key innovation, our model includes non-homothetic preferences over basic goods versus differentiated goods. This is in contrast to most standard trade models, which assume that the share of expenditure on food and other goods remains constant irrespective of income. We choose this alternative preference structure to account for shifts in spending patterns as people's income changes, which is particularly relevant in a pooled sample of developed and developing countries, given the vast shifts in spending patterns as income grows in developing countries. Our baseline model includes trade in differentiated goods, which ensures that an expansion in market size in one country is passed on to its trading partners. In a series of extensions in Section 6, we incorporate several adjustment channels that have been highlighted in the literature, such as remittances, incentives to invest in education or trade creation through ethnic networks.

In the remainder of this section, we provide a description of the main building blocks of the baseline model as well as a critical discussion of its main mechanisms. Further details about the model can be found in Appendix A. Later in the analysis, we assess the sensitivity of the results to most modeling assumptions, both in terms of functional form as well as parameter values.

3.1 Preferences and welfare

Consumers have non-homothetic preferences; they always demand a certain amount of the traditional good T independent of income. We think of the traditional good as a basket of goods necessary for survival, such as food and drinks. With non-homothetic preferences, an increase in average income translates into an over-proportional shift in consumption away from the traditional good and towards manufactured goods. Most individuals for whom we simulate the welfare effects live in low- to medium-income countries, where consumers spend a high fraction of their income on agricultural goods. It appears unrealistic, however, that these individuals spend the same income share on food as their income increases. Rather, they will spend an increasing part of their resources on goods other than basic necessities, a shift taken into account by the non-homothetic preferences. As we will show in the quantitative part of the paper, these shifts induced by non-homothetic preferences are non-trivial in developing countries.

A consumer in country $i = 1, \dots, I$ with income w_i maximizes utility

$$\begin{aligned} &\max_{\{T_i, x_{ij}(k), y_i(k)\}} \beta^T (T_i)^{\mu} + \left(1 - \beta^T\right) \left[(1-\beta)(Y_i)^{\frac{\theta-1}{\theta}} + \beta(X_i)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \\ &\text{subject to: } P_i^T T_i + P_i^Y Y_i + P_i^X X_i = w_i, \end{aligned} \tag{1}$$

where β is the relative preference for the tradable differentiated goods, β^T is a preference parameter for the traditional good, and θ is the elasticity of substitution between tradable and non-tradable goods X and Y. The consumption of traditional goods is subject to decreasing marginal utility, such that $\mu < 1$. Y_i and X_i are CES composites of different varieties k produced in the manufacturing sector,

$$X_i = \left[\sum_{j=1}^{J} \int_0^{N_j^X} (x_{ij}(k))^{\frac{\varepsilon-1}{\varepsilon}} dk \right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad Y_i = \left[\int_0^{N_i^Y} (y_i(k))^{\frac{\varepsilon-1}{\varepsilon}} dk \right]^{\frac{\varepsilon}{\varepsilon-1}}. \tag{2}$$

N_i^X and N_i^Y are the numbers of varieties of goods X_i and Y_i available in country i. Varieties of the composite tradable good X_i are either domestically produced, $x_{ii}(k)$, or imported from other countries $x_{ij}(k), j \neq i$, while all varieties of Y_i, $y_i(k)$, are domestically produced. The parameter ε is the elasticity of substitution between any two varieties within a sub-sector, with $\varepsilon > \theta > 1$. Therefore, consumer preferences exhibit love of variety, which means that consumers gain utility when the number of available varieties increases. This translates into a 'market size effect' similar to the one obtained by Iranzo & Peri (2009) and di Giovanni *et al.* (2015) in a two-sector model and Aubry *et al.* (2016) in a one-sector model.

We measure the welfare of a country's population or sub-population as the average indirect utility, which is derived from the base consumption of good T_i, and the utility-maximizing consumption of varieties of the differentiated goods X_i and Y_i. Thus, indirect utility equals the weighted average of the utility from consuming the traditional good, and the utility from consuming manufactured goods divided by the price index in country i,

$$U_i = \beta^T \left(\frac{\beta^T \mu}{1-\beta^T} \frac{P_i}{P_i^T} \right)^{\frac{\mu}{1-\mu}} + (1-\beta^T) \frac{w_i - T_i}{P_i}. \tag{3}$$

where P_i is the ideal price index in country i,

$$\begin{aligned} P_i &= \left[(1-\beta)^\theta \left(P_i^Y\right)^{1-\theta} + \beta^\theta \left(P_i^X\right)^{1-\theta} \right]^{\frac{1}{1-\theta}}, \\ \text{with: } P_i^X &= \left[\sum_{j=1}^{J} \int_0^{N_j^X} (p_{ij}(k))^{1-\varepsilon} dk \right]^{\frac{1}{1-\varepsilon}}, \text{ and } P_i^Y = \left[\int_0^{N_i^Y} (p_i(k))^{1-\varepsilon} dk \right]^{\frac{1}{1-\varepsilon}}. \end{aligned} \tag{4}$$

A change in the selection of migrants affects welfare through incomes w_i as well as the overall price level P_i. Both can be affected directly, for example through competition on the labor market, and indirectly through changes in market size, complementarities between workers of different skill levels or changes in trade patterns.

3.2 Labor force composition and production

In the model, labor is the only production factor. For the purpose of assessing the impact of a change in the skill composition of migrants, it is important that the model includes a heterogeneous workforce with as many skill levels as possible. However, given that education and migration data are only available for three skill levels (low, medium, high), our model comprises three skill groups.

Countries have different levels of total factor productivity (TFP) in the traditional and manufacturing sector. Labor markets are assumed to be perfectly competitive. Workers sort into whichever sector pays the highest wage given their skill level. The traditional sector only produces with low-skilled workers,[14]

$$Q_i^T = A_i^T L_i^T, \tag{5}$$

where L_i^T is the supply of low-skilled labor employed in the traditional sector, and A_i^T is the productivity residual, which equals the price-adjusted wage of low-skilled workers: $A_i^T = W_i^L / P_i^T$.[15]

The manufacturing sector employs workers from all three skill levels and produces with a constant-elasticity-of-substitution (CES) technology. Workers with different skills are imperfect substitutes in production. The production function of the manufacturing sector is given by

$$Q_i^M = A_i^M L_i^M = A_i^M \left[\alpha_i^L \left(L_i\right)^{\frac{\sigma_s - 1}{\sigma_s}} + (1 - \alpha_i^L - \alpha_i^H) \left(M_i\right)^{\frac{\sigma_s - 1}{\sigma_s}} + \alpha_i^H \left(H_i\right)^{\frac{\sigma_s - 1}{\sigma_s}} \right]^{\frac{\sigma_s}{\sigma_s - 1}}. \tag{6}$$

In Equation (6), L_i, M_i and H_i represent the supplies of low-, medium- and high-skilled workers. L_i is the number of low-skilled workers not working in the traditional sector. α_i^L and α_i^H are the country-specific efficiency weights of low- and high-skilled workers. This production function assumes that all three skill levels are equally substitutable. In Appendix F.3, we allow for differential substitutability between skill groups by adding an additional nest to the production function.

In the receiving countries, each skill group comprises natives (labeled with superscript N) and immigrants (with superscript F), which are imperfect substitutes with a constant elasticity of substitution $\sigma_n > 1$. For example, the CES aggregate for high-skilled workers is given by

$$H_i = \left[(1 - \alpha_i^F)(H_i^N)^{\frac{\sigma_n - 1}{\sigma_n}} + \alpha_i^F (H_i^F)^{\frac{\sigma_n - 1}{\sigma_n}} \right]^{\frac{\sigma_n}{\sigma_n - 1}}, \tag{7}$$

and likewise for medium- and low-skilled workers. The parameter α_i^F denotes the relative efficiency of foreigners versus natives of a given skill level. We allow α_i^F to vary across countries, but assume that it is the same across skill groups within a country.

The manufacturing sector is monopolistically competitive, such that firms have some price-setting power. Each firm produces one variety of a differentiated good. Firms can freely enter the manufacturing sector, but incur a sunk entry cost of f_i^Y and f_i^X units of efficient labor in the respective sector. Sub-sectors Y and X both use identical production technologies. Firms within a country are homogeneous and set prices as a constant mark-up over the marginal cost

[14] We exclude medium and high-skilled workers from section T, as this is a low-productivity sector; in addition, wage equalization across sectors would imply that only a very small number of medium- and high-skilled workers could actually work in this sector. However, both migrants and natives are employed in this sector.

[15] This condition results from the profit maximization problem of firms operating on a perfectly competitive traditional sector. They set prices equal to the marginal cost of production, such that: $P_i^T = W_i^L / A_i^T$. Furthermore, wages of low-skilled workers are equal across sectors. Therefore, any low-skilled worker in sector T has no incentive to move to sectors X and Y. Note that the linear production function implies that the marginal productivity of low-skilled workers is constant in the traditional sector. In a set of sensitivity checks, we confirm that using a non-linear production function of the form $Y_T = A_T L_T^{\alpha}$ with α=0.5 or 0.8 has no impact on the results. These results are available on request.

of production,

$$p_i(k) = p_i = \frac{\varepsilon}{\varepsilon - 1} c_i, \tag{8}$$

where the $c_i = \frac{W_i}{A_i^M}$ is the marginal cost of production, and W_i is the overall wage index of the manufacturing sector, given by

$$W_i = \left[(\alpha_i^L)^{\sigma_s} (W_i^L)^{1-\sigma_s} + (1 - \alpha_i^L - \alpha_i^H)^{\sigma_s} (W_i^M)^{1-\sigma_s} + (\alpha_i^H)^{\sigma_s} (W_i^H)^{1-\sigma_s} \right]^{\frac{1}{1-\sigma_s}}. \tag{9}$$

3.3 Market size and International Trade

Each firm produces a single variety of a differentiated good. In equilibrium, firms make zero profits and all goods markets clear.[16] These conditions — together with the optimal pricing rule (8) — pin down the optimal number of varieties, N_i^X and N_i^Y:

$$N_i^X = \frac{sh_i^X L_i^M}{\varepsilon f_i^X}, \quad N_i^Y = \frac{sh_i^Y L_i^M}{\varepsilon f_i^Y}. \tag{10}$$

The optimal market size in sectors X and Y, operating in country i is proportional to the efficient labor supplies employed in these sectors and inversely proportional to the fixed costs of entry.[17]

Varieties of the manufactured good X are traded between countries such that an expansion in market size in one country is passed on to its trading partners. The volume of trade depends on trade costs, as well as differences in consumer demand and price levels. Exports from country i to country j, denoted by $Trade_{ji}$, are subject to iceberg trade costs $\tau_{ji} > 1$. Trade costs are asymmetric, such that $\tau_{ji} \neq \tau_{ij}$, for different i and j. $Trade_{ji}$ is given by

$$Trade_{ji} = \int_{k \in N_i^X} x_{ji} p_{ji} dk = N_i^X GDP_j^X \left[\frac{P_j^X}{\tau_{ji} p_i} \right]^{\varepsilon - 1}. \tag{11}$$

where p_{ji} and x_{ji} are the price and quantity of a variety produced in country i, consumed in country j. Given that $\varepsilon > 1$, trade negatively depends on import prices and trade costs, $\tau_{ji} p_i$, and positively on the domestic price level. The total value-added in sector X in country i is computed as the sum of all trade flows to country i, including domestic consumption $Trade_{ii}$.

In Equilibrium, trade is balanced within each country, such that the value of imports equals the value of exports, $\sum_{j=1}^{J} Trade_{ij} = \sum_{j=1}^{J} Trade_{ji}$. Below we provide a detailed definition of the equilibrium.

16 Full derivations are provided in Appendix A.5.

17 Thus, the sector-specific barriers to enter production (captured by the fixed cost of entry) are the main driving forces of the market size effect. Calibrating different entry costs for tradable and non-tradable sectors separately allows us to introduce both the selection mechanism in firms' trade choices (represented by uneven market size effects in tradable/non-tradable sectors) as well as changing terms of trade (the movement of relative prices of traded and non-traded bundles of varieties) within a Krugman (1980)-type model. A change in the skill distribution affects the number of varieties produced and consumed in the destination countries, and, consequently, has an indirect impact on the welfare of native citizens.

3.4 Definition of equilibrium

Definition 1 *For a set* $\{\beta, \beta^T, \theta, \mu, \varepsilon, \sigma_s, \sigma_n, \}$ *of structural parameters, a set* $\{A_i^T, A_i^M, \alpha_i^F, \alpha_i^H, \alpha_i^L, L_i^{T,N}, L_i^{T,F}, L_i^N, L_i^F, M_i^N, M_i^F, H_i^N, H_i^F, f_i^X, f_i^Y\}_{\forall i}$ *of exogenous country-specific institutional, demographic and technological characteristics, a set* $\{\tau_{ji}\}_{\forall i,j}$ *of bilateral trade costs*

- *consumption of the three types of goods* $\left\{x_{ij}^s, y_i^s, T_i^s\right\}$ *maximizes an agent's utility subject to the budget constraint,*
- *assuming full employment and cost-minimizing behavior of firms, the labor market clearing conditions equalize the wage rates to marginal productivities, and determine the nominal wages for all types of workers:* $\{w_i^{LN}, w_i^{LF}, w_i^{MN}, w_i^{MF}, w_i^{HN}, w_i^{HF}\}$
- *the price of one variety,* $p_i(k)$*, maximizes firm's profits given the demand that it faces,*
- *the price of a unit of traditional good,* P_i^T*, equals the marginal productivity of a low-skilled worker,*
- *the number of varieties in sector* X *and* Y*,* N_i^X *and* N_i^Y*, is such that the zero-profit conditions hold,*
- *the value-added equals the aggregated value of production and trade in* X *is balanced.*[18]

3.5 Mechanisms

Within the model, a change in the skill distribution of migrants affects welfare through several channels. Here we highlight the most important mechanisms, using as an example a receiving country that switches to a more highly-skilled migrant population, such that the number of low-skilled migrants L_i^M decreases while the number of high-skilled migrants H_i^M increases by the same amount, $-\Delta L_i^M = \Delta H_i^M$, while assuming for simplicity that the number of medium-skilled migrants M_i^M remains constant.

The change in the skill distribution of workers directly affects the nominal wage structure through demand and supply. Nominal wages of high-skilled workers decrease, while those of low-skilled workers increase. This affects the average nominal wage level, and especially affects the wages of never-migrants. However, the change in the nominal wage structure affects wage inequality more than it affects welfare. A more important channel for welfare is market size, i.e. the number of available varieties.[19] A workforce with a higher skill level is more productive, such that any good can be produced at a lower cost. Lower unit costs, in turn, induce more firms to enter the market and increase the number of varieties. As shown in Equation (4), a higher number of varieties reduces the price index, thus increasing welfare. This reflects consumers' love of variety, whereby their utility increases in the number of available varieties even if their

[18] A more comprehensive definition, with references to model equations, can be found in Appendix A.7.

[19] The importance of market size for the global welfare contribution of migration has also been highlighted by Aubry *et al.* (2016), di Giovanni *et al.* (2015) and Iranzo & Peri (2009).

income remains constant. The market size effect is propagated to other countries through trade linkages, which dampen the positive welfare effect at home, while increasing the welfare of all trading partners.

3.6 Discussion of the Model Assumptions

The set-up introduced in the previous sections is the result of several modelling choices. Two of these, namely having three skill groups and allowing for a market size effect through preferences for love of variety, differ from the modelling choices in the previous literature, which is why we discuss both in greater depth.

Number and nesting of skill groups The choice of three skill groups may seem arbitrary at first, but it results from a trade-off between the ideal number of groups to measure selection and the availability of education and migration data by skill level. Ideally, the model would include a continuum of worker types, that is, an infinite number of skill groups. In that case, we could precisely measure migrant selection along the entire skill distribution. As shown by Dustmann *et al.* (2013), the labor market impact of immigration unfolds in different parts of the skill distribution, such that a model with a handful of skill groups would underestimate the true effect. In our case, with a finite number of skill groups — in particular with the commonly used two skill levels — the measurement of selection becomes less precise. With two groups, it is only possible to measure selection between high- and low-skilled workers, but not selection within these groups. Therefore, the higher the number of skill groups, the more accurate is the measurement of selection.

On the other hand, our choice is constrained by the data. While it is possible in theory to have a continuum of worker types in the model (see for example Iranzo & Peri, 2009), the corresponding data are only available for very few migration corridors, notably Mexico-US (Biavaschi & Elsner, 2013). At the global level, the maximum number of skill groups for which education and migration data are available is three. Consequently, a production function with three skill groups is our preferred choice.

To keep the model parsimonious, we combine all three skill levels in a single CES aggregate, which assumes that high- and low-skilled workers are equally substitutable as medium- and low-skilled workers. This assumption may seem restrictive in light of the works of Goldin & Katz (2007), Card (2009) and Ottaviano & Peri (2012), who show that US labor market data reject equal substitutability. The data rather support a production function with two nests, whereby low- and medium-skilled workers are closer substitutes than any of these groups with high-skilled workers. In Appendix F.3, we incorporate such a nesting in the model and show that the results are robust to the choice of production function.

Market size effect In the model, an important adjustment channel is market size. If migration increases a country's productivity, more varieties of goods can be produced and are available to consumers, which in turn increases their indirect utility. While market size has played a minor role in the literature on migration so far, it has been a central ingredient of general equilibrium trade models since Krugman (1980) (for recent discussions see Melitz & Ottaviano, 2008, Arkolakis *et al.* , 2012, Melitz, 2018). Estimates by Broda & Weinstein (2006) underline the quantitative importance of the market size effect. For US consumers, the utility gain from the increase in the number of imported varieties between 1972 and 2001 is equivalent to 2.6% of GDP per capita.

In recent years, the works of Iranzo & Peri (2009), di Giovanni *et al.* (2015) and Aubry *et al.* (2016) provide evidence that, for the welfare effect of migration, market size is as important as other adjustment channels such as remittances. Our choice of incorporating preferences with love of variety follows from these results. Ultimately, the strength of the market size effect depends on the parameterization. To ensure that our model produces realistic market size effects, we perform several sensitivity checks and compare our results to those of the aforementioned studies.

4 Data and Calibration

We calibrate our model such that it replicates the most important features of the world economy in 2010, namely bilateral migrant stocks, bilateral trade flows, GDP per capita and wage differentials within countries. In terms of migration flows, we consider South-North migration from 111 countries to the OECD, as well as migration among the 34 OECD countries, thereby accounting for the majority of global migration.[20] For South-South migration, we assume that all bilateral stocks remain constant in terms of scale and skill composition in both the baseline and counterfactual.

4.1 Data

The calibration requires several types of country-specific and country-pair-specific macro variables for the reference year 2010. The sample consists of 34 OECD countries and 111 non-OECD countries. Non-OECD countries for which data is not available are lumped together in the Rest of the World (ROW). The list of countries and their abbreviations are available in Appendix G.

Migration and population data. Calibration requires data on the size and skill distribution of the migrant and never-migrant population of each country. The 2010 DIOC database provides data on bilateral stocks by education level of migrants who went from 111 sending countries to the OECD and migrants who moved between all 34 OECD countries, as well as the population size and skill distribution of natives in the 34 OECD countries. The definition of the three education levels is as follows: low-skilled individuals are those who achieved up to lower secondary education or second stage of basic education; medium-skilled individuals obtained up to some post-secondary non-tertiary education; while high-skilled individuals have at least

[20] This means that most OECD countries are both sending and receiving countries at the same time. As of December 2017, South-North and North-North migration accounted for 60% of all international migrants. Source: Population Facts No. 2017/5, December 2017, United Nations. Retrieved on March 24, 2018.

some tertiary education. To obtain the number and skill distribution of never-migrants for the non-OECD countries, we use data from Barro & Lee (2010).[21] For the Rest of the World, we apply the average skill distribution of the available non-OECD countries.

GDP, trade and fixed costs of entry. GDP per capita — in current international dollars — is taken from the World Development Indicators (WDI) database of the World Bank. The WDI database also provides the share of workers employed in agriculture and the shares in total GDP of traded and non-traded manufacturing goods. To compute the trade costs, we require a bilateral matrix of trade in value-added, which we construct by combining gross trade flows in 2010 from the UN Comtrade database and the share of value-added in trade from the OECD TiVA database. We impute missing trade flows based on an estimated gravity equation, details of which can be found in Appendix B.2. To obtain the fixed cost of entry in the tradable sector, f_i^X, we follow di Giovanni *et al.* (2015) and use a component of the World Bank Ease-of-Doing-Business indicator, which measures the number of days necessary to open a business. The longer it takes to open a business, the more difficult it is to enter a market and the higher the fixed costs of entering. We normalize the fixed costs for the US to 1 and compute the fixed costs relative to the US for all other countries.

Wage ratios. To calibrate the efficiency parameters for high- and low-skilled workers (α_H and α_L), we require country-specific wage ratios for high- vs. medium-skill, W_i^H/W_i^M, and medium- to low-skill workers, W_i^M/W_i^L. For the OECD countries, we compute these ratios from the "Education at a Glance" report 2010 (OECD, 2010). For the non-OECD countries, we take data from the Wageindicator Foundation, which runs online-based surveys about wages in 80 countries. For the non-OECD countries, Wageindicator provides information on 38 high- vs. medium-skill, and 27 medium- vs. low-skill wage ratios.[22] For the remaining countries, we impute the wage ratios based on the returns to education in similar countries. A more detailed description of the imputation procedure can be found in Appendix B.3.

4.2 Calibration of key parameters

We calibrate the model such that the generated data matches country-specific (i.e. GDP, population and wage structure) and bilateral (i.e. migration and trade) moments for the 146 countries in our sample (145 countries and ROW).

Through the parameterization of the aggregate production function, we take into account four important differences in the economic structure between all 146 countries in our sample. First, countries differ in their productivity and consequently in their GDP per capita. The GDP per capita in Luxembourg — the OECD's richest country — is five times larger than in Mexico, the OECD's poorest country. Moreover, in poorer countries the agricultural sector contributes a larger share to aggregate production. The productivity parameters A_i^T and A_i^M account

[21] For more details on the aggregation of skill groups in both datasets, see Appendix B.1.

[22] See wageindicator.org for more information. A table with all wage ratios is available upon request.

for the differences in aggregate productivity across — as well as differences in — the sectoral productivity within countries. Second, as shown by Trefler (1993), countries considerably differ in their endowment of effective labor. For instance, the same high-skilled worker is more productive in the US than in Mexico. We account for these differences through country-specific efficiency parameters for high- and low-skilled workers, α_i^L, α_i^H. Third, within a country, workers with similar skills are closer substitutes in production than workers with different skills (Card & Lemieux, 2001). We account for this imperfect substitutability by modeling the production function of the manufacturing sector with a CES structure. Fourth, as shown by Ottaviano & Peri (2012) and Peri & Sparber (2009), migrants and natives are imperfect substitutes even when they have the same level of education, which we account for in Equation (7) with an elasticity of substitution between immigrants and natives $\sigma_n < \infty$ and country-specific efficiency parameters α_i^F.[23]

To calibrate the most important structural parameters — preference parameters and elasticities of substitution between segments of the workforce — we use estimates from empirical studies where available, and set the values of the remaining parameters similar to those found in other quantitative studies. To ensure that the choice of parameters does not fundamentally change the results, we conduct a series of sensitivity checks that are presented in the appendix. Table 1 summarizes the calibrated parameters.

Table 1: Values of structural parameters

Parameter	Value	Source
Preference parameters		
β	0.5	exogenous
β^T	0.139	calibrated (match consumption to production)
θ	3	exogenous
μ	0.5	exogenous
ε	4	Simonovska & Waugh (2014)
σ_s	5	Docquier *et al.* (2014)
σ_n	20	Ottaviano & Peri (2012)
Worker efficiency parameters		
a_i^F	0.478	calibrated to match OECD average
a_i^L	0.12-0.40	calibrated from FOC of cost minimization
a_i^H	0.24-0.60	calibrated from FOC of cost minimization

Note: This table summarizes the calibration of the structural parameters in the model. A more detailed description of the procedures can be found in the text of Section 4.2 and in Appendix B.

The non-homothetic utility function ensures that the expenditure share of the traditional good decreases with income. This allows us to account for the higher fraction of income spent on traditional (i.e. agricultural) goods in developing countries, a standard observation in household

[23] Note that we will change the nesting structure of the CES in Appendix 6.3.

datasets.[24] Setting $\mu = 0.5$ implies that the expenditure share on the traditional good decreases with income and increases with the price level P_i.[25]

We set the relative preference for the tradable differentiated good, β, to 0.5, such that individuals have the same preference for the traded and non-traded manufacturing goods.[26] For the elasticity of substitution between tradable and non-tradable goods, θ, we choose a value of 3.[27] Following Simonovska & Waugh (2014), the elasticity between any two varieties within a sector, ε, has the value of 4.[28]

The share of output produced by foreign workers (a_i^F) is calibrated to match the education-specific wage premia for natives over immigrants, which is 5% in OECD countries. For non-OECD countries, we use the average value obtained in OECD countries ($a_i^F = 0.478$) as we cannot assess country-specific values due to the lack of immigration data. The production function includes three types of workers.[29] To calibrate its structural parameters, we use parameter values obtained by Ottaviano & Peri (2012). To account for imperfect substitution between the three education groups, the elasticity of substitution, σ_s, is set to 5. We further allow for imperfect substitution between immigrant and native workers within each skill group. The value of the elasticity of substitution, σ_n, is set to 20, and is identical among the three skill groups.[30]

We subsequently calibrate the country-specific efficiency parameters for high- and low-skilled workers, a_i^H and a_i^L, to perfectly match the high- vs. medium- and high- vs. low-skilled wage ratios within countries. We first use the market clearing condition for the manufacturing sector with data on GDP and the number of domestic and foreign workers per skill group to obtain the wage index for the manufacturing sector, W_i. The efficiency parameters are then obtained by inserting this information into the first-order conditions of a manufacturing firm's cost-minimization problem. With these parameters and the efficiency parameter of foreign workers, α_i^F, we compute the skill-specific wage aggregates, W_i^L, W_i^M, and W_i^H. Based on the wage aggregates and α_i^F, we compute the wages for all six types of workers.

Finally, we calibrate trade costs and TFP, such that the trade flows and cross-country TFP differences closely match their counterparts in the data. Based on these, we are able to compute

[24] As shown by the US Department of Agriculture, consumers in the US spent 6.8% of their total expenditure on food in 2011, whereas the expenditure shares in developing countries are considerably higher, for example 36.2% in Vietnam and 57.1% in Nigeria. http://www.ers.usda.gov/data-products/food-expenditures.aspx (viewed 19 Feb 2016).

[25] Our model imposes that $0 < \mu < 1$ to ensure a negative impact of the price level on the expenditure for the traditional good. The results prove robust to a wide range of values for this parameter.

[26] Note that real demand will also depend on prices, such that the quantities demanded for each good are not necessarily equal. A robustness analysis on this parameter shows that the results are not affected by this choice.

[27] As we show in Appendix F, the simulation results are robust to a wide range of parameters, ranging from $\theta = 0.5$ to $\theta = 3.9$.

[28] A value slightly higher is obtained by Parro (2013), who uses a tariff-based approach to estimate an aggregate trade elasticity for traded goods. Estimation of the shape parameter of the productivity distribution based on firm-level sales data provides values in the range of 3.6 to 4.8 (Bernard *et al.* , 2003, Eaton *et al.* , 2011). As we show in Appendix F, the simulation results are robust to changing the parameter values to $\varepsilon = 3$ and $\varepsilon = 5$.

[29] In an extension, we will additionally account for skill discounting, i.e. the fact that some high-skilled immigrants work in low-skilled jobs.

[30] All results are robust to changes in these parameters, as shown in Appendix F.

all equilibrium prices and quantities, as well as the equilibrium number of firms. In Appendix B.4, we provide a more detailed description of the calibration procedure.

5 The importance of the skill bias in global migration - baseline results

We now use the calibrated model to run counterfactual simulations based on which we estimate the welfare contribution of the skill bias in migration in the current world. The central question we aim to answer here is '*how quantitatively important is the skill bias in migration?*'.

In this section, we first describe the counterfactual that allows us to answer this question and define the population whose welfare we are analyzing. We then present the three results related to this research question. In Section 5.3, we assess the welfare impact of the skill bias in migration in the sending and receiving countries in our calibrated baseline model. In Section 5.4, we put these effects into perspective by showing how they compare to the total welfare contribution of migration. In Section 5.5, we assess the impact of the skill bias in migration on the income distribution *within* countries.

5.1 Defining the counterfactual

To assess the welfare contribution of the skill bias in migration in the current world, we construct a counterfactual that eliminates the skill bias while holding all other aspects of the global economy constant. Specifically, we hold the bilateral stocks of migrants constant, but assume that all migrants have been neutrally selected from the population of the sending country. This is the case if the shares of high-, medium- and low-skilled workers among emigrants are the same as in the total population, whereby the total population is defined as all people born in a sending country — current non-migrants as well as emigrants. In other words, our counterfactual is a world in which a receiving country 'imports' migrants that are randomly drawn from the skill distribution of all people born in a given country of origin, rather than being positively or negatively selected.[31] For people who are emigrants under the baseline but not in the counterfactual, we assume that they work in the country of origin in a job that is adequate for their education level.

In this analysis, we remain agnostic as to why the observed selection pattern came about in the first place. The literature offers several explanations: differences in returns to skill make migration more beneficial for some groups than for others (Borjas, 1987); if migration costs are the same for all workers, migration is more beneficial for high-skilled workers (Chiswick, 1999); moreover, receiving countries may actively seek to attract high-skilled while restricting access for low-skilled migrants. In our counterfactual, we undo the selection pattern that was created

[31] Given data limitations, we focus here on selection on observable characteristics. It is possible that migrants are differently selected on unobservable characteristics. However, detecting selection on unobservable characteristics would require data on wages before migration. See, for example, Fernández-Huertas Moraga (2013) or Borjas *et al.* (2018).

by these forces, and exogenously change the skill composition of migrants.[32]

5.2 Measuring welfare

Before turning to the welfare effects, we need to define the population whose welfare we analyze. In our preferred analysis, our population of interest are never-migrants, i.e. people who are neither migrants under the baseline nor would they be migrants under the counterfactual.

An alternative would be welfare per capita, i.e. the average indirect utility of all individuals living in a particular sending or receiving country. However, while this measure is easy to understand and compute, it holds limited value because the skill composition of the underlying population differs between the baseline and the counterfactual. In the language of program evaluation, the difference in welfare per capita is a combination of a *treatment effect* — the causal impact of a change in migrant selectivity on the welfare of never-migrants — and a *composition effect*, namely the result of replacing high-earning with low-earning migrants. We are interested in the treatment effect, i.e. the impact of the skill bias in migration on the welfare of people who live in a given sending country under both the baseline and the counterfactual.

To isolate the pure treatment effect of the skill bias, we base our welfare calculation on the population of *never-migrants*. Constructing the skill distribution of this group is challenging because some people who are migrants in the current world would live in their country of origin under the counterfactual, and vice versa. This difference in the composition of the population would mechanically lead to a difference in welfare between the baseline and the counterfactual. We avoid this problem by considering only the welfare of groups that are never-migrants in both scenarios. We construct these as the minimum number of workers in a given skill group between the baseline and the counterfactual. For instance, the number of high-skilled never-migrants is $H_{NM} = \min(H_{baseline}, H_{counterfactual})$. In Appendix C, we provide graphical intuition for the construction of the population of never-migrants.

5.3 Baseline results

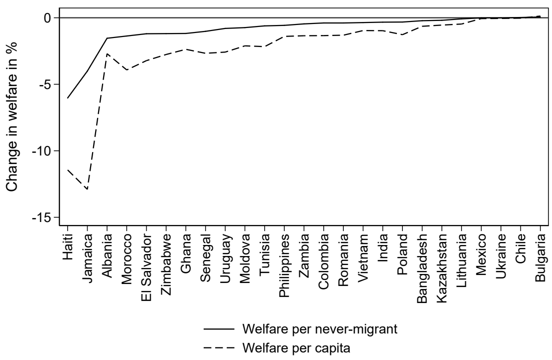
We begin by analyzing the impact of skill-biased migration on the average individual's welfare. We measure the change in welfare as the percentage difference in indirect utility,

$$\frac{\Delta U}{U} = \frac{U_{skill-bias} - U_{skill-neutral}}{U_{skill-neutral}}.$$

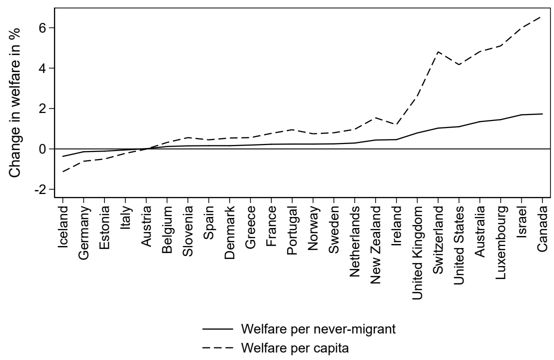
Figure 2 displays the simulation results for selected receiving and sending countries, while Appendix G reports the full set of results. The countries are ordered from left to right by welfare effect per never-migrant, from smallest to highest. All effects represent the difference in welfare under skill-biased versus skill-neutral migration. A positive effect means that the average person

[32] Critical readers might be concerned that our counterfactual is not the result of optimal migration decisions of all potential migrants in the sending countries. Nonetheless, the goal here is to provide a positive analysis and assess the quantitative importance of the skill bias in migration for the welfare of never-migrants. If one wanted to extend the model to study alternative migration policies, a microfoundation of the migration decisions would be necessary.

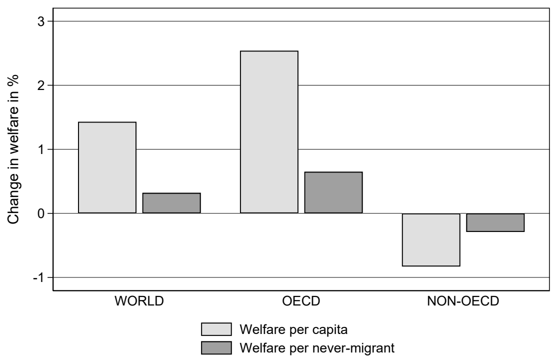
is better off under skill-biased migration. The dotted line represents the effect on welfare per capita, while the solid line represents the effect on welfare per never-migrant.



(a) Welfare Effects in the sending countries



(b) Welfare Effects in the receiving countries



(c) Welfare Effects in OECD and non-OECD countries, and in the world

Figure 2: Baseline Welfare Effects

Source: Own calculations.

Notes: This graph displays the impact of the skill bias in migration on welfare in selected countries. The dashed line represents the effect on welfare per capita, while the solid line represents the effect on welfare per never-migrant. The countries on the horizontal axis are ordered by welfare impact per never-migrant. The vertical axis shows welfare changes in percent. Panel 2(a) focuses on selected sending countries, while panel 2(b) focuses on selected receiving countries. Panel 2(c) shows the average effect in all non-OECD and OECD countries as well as across the whole world.

Figure 2(a) shows the effects for selected sending countries. These correspond to the welfare effects of high-skilled emigration that have been estimated in the previous literature (Beine *et al.* , 2008). The effects are negative for all sending countries, and are particularly large for Jamaica and Haiti, both of which have large shares of emigrants who are predominantly high-skilled. Depending on the welfare measure, the brain drain lowers the welfare in these two countries by 4-13%, while in most other countries the welfare effects are smaller, and lie between 0 and 3%. The difference in the effect under both welfare measures highlights the importance of choosing the right base population. The effects are considerably larger when we consider welfare per capita, whereas the effect on welfare per never-migrant is smaller. In contrast to Beine *et al.*

(2008), we do not find positive welfare effects for high-skilled emigration, mainly because our baseline model does not include human capital externalities. As we show in several extensions, once these externalities are included, some countries with low shares of emigrants experience small positive effects.

In Figure 2(b), we turn to the receiving countries. As shown in Section 2, the skill bias in migration is positive for most receiving countries, i.e. they receive more high-skilled immigrants than they would if all migrants were neutrally selected from their countries of origin. With the exceptions of a handful of countries, the impact of the skill bias in migration is positive in most countries. The effects are particularly large in Canada, Australia, Israel, the US and Luxembourg, all of which combine high immigration rates with a high degree of selectivity. In the receiving countries, the difference in the effect on both welfare measures is more pronounced than in the sending countries. The impact on welfare per never-migrant is considerably smaller than the impact on welfare per capita. Nonetheless, the effect on welfare per never-migrant is positive for most countries, and lies between 0 and 2%. As shown in Figure 2(c), across the OECD as a whole, welfare is about 0.7% higher due to the skill bias in migration.

Relative importance of channels The welfare effect presented above results from the interplay of several economic forces. To assess the importance of these forces, in Table 2 we decompose the total effect into the market size effect, the wage channel, the trade channel and a residual that mainly reflects the change in consumption patterns due to consumers' non-homothetic preferences.

We find market size to be the dominant force behind the total welfare effect in OECD and non-OECD countries. This result is consistent with results in Iranzo & Peri (2009), di Giovanni *et al.* (2015), Aubry *et al.* (2016), and is consistent with the large welfare gains obtained with the introduction of new varieties through international trade (Broda & Weinstein, 2006). On the contrary, the wage effect for the average never-migrant is quantitatively less important. While wages are affected by the skill bias in migration, its impact is redistributive; some workers gain and others lose, while the average effect remains small. For the OECD countries it represents 13%, and for the non-OECD countries 5% of the total effect. In our model, all countries are linked through trade in differentiated goods, which propagates changes in a country's market size across all trading partners, thereby mitigating the domestic welfare effect. However, trade only explains a small part of welfare changes: in OECD countries less than 4% of the total effect and in non-OECD countries less than 2% of the total effect. This reinforces the finding that the welfare impact of the skill bias in migration occurs because of changes in other channels rather than trade.

Finally, the importance of the residual considerably differs between regions. In the OECD it only accounts for less than 1%, whereas in non-OECD countries it accounts for 45% of the total effect. The contribution of the residual underlines the importance of non-homothetic preferences for assessing the impact of migration, in particular in poor countries where people spend most of their income on subsistence goods. Non-homothetic preferences lead to asymmetric effects on utility for increases vs. decreases in income. An increase in income shifts consumption further towards the differentiated goods, over-proportionally increasing people's utility from consumption. On the other hand, a decrease in income does not affect the consumption of the traditional good, leading to an under-proportional decrease in utility. This is reflected in the positive sign of the residual in Table 2. Intuitively, while skill biased migration lowers market size in poor countries, the resulting loss in utility is dampened by consumers shifting away from expensive manufactured goods and towards the cheaper traditional good.

Table 2: Relative importance of channels

	Market size	Wage	Trade	Residual
OECD	82.36%	13.12%	3.90%	0.62%
NON-OECD	50.98%	4.78%	1.70%	44.54%

Note: own calculations based on a decomposition of the total welfare effects in the regions listed on the left.

5.4 Who vs. how many: how important is the skill bias?

Thus far, we have found effects of the skill bias in migration on the welfare of never-migrants ranging between 0 and 2% in the receiving and between -9% and 0 in the sending countries. Once the effects are weighted by population and we look at the net effect in the world, we find a welfare gain of 0.3%. Upon first glance, this appears to be a small effect. However, to assess the magnitude of this effect, the results have to be put in perspective.

A first point of comparison is the share of migrants relative to the share of never-migrants. In 2010, never-migrants accounted for over 97% of the world population. The welfare effects from the skill bias in migration, while affecting most of the world population, are the result of less than 3% of the world population being positively selected from their country of origin. If the share of migrants was higher or the skill bias was more pronounced or both, the global welfare contribution of the skill bias in migration would be much larger.

Another important point of comparison is the welfare contribution of the skill bias in migration relative to the overall welfare contribution of migration. To obtain the overall welfare effect of migration, we simulate a counterfactual with zero migration, whereby all migrants are being repatriated to their country of origin. As shown in Figure 3, in non-OECD countries the skill bias accounts for one-third of the overall welfare effect of migration. By contrast, in the receiving countries the skill bias in migration only plays a minor role in explaining the overall welfare effect.

This no-migration counterfactual also allows us to compare the predictions of our model to those in di Giovanni *et al.* (2015) and Aubry *et al.* (2016).[33] Our estimate for the total welfare contribution of migration in the OECD countries is similar to that found in those two

[33] di Giovanni *et al.* (2015) develop a Melitz (2003)-type model with remittances to assess the global welfare contribution of migration. Aubry *et al.* (2016) apply a Krugman (1980)-type model to assess the welfare contribution of migration in the OECD countries.

studies. In contrast, our estimates for the sending countries have the opposite sign compared to di Giovanni *et al.* (2015), because our model does not include remittances. We discuss the role of remittances in Section 6.

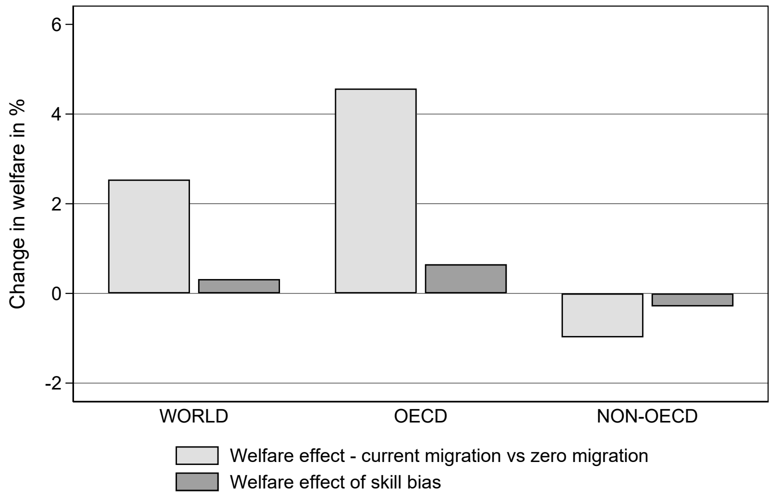


Figure 3: Selection vs. scale effects

Source:. Own calculations.
Notes: In this graph, we compare the welfare effect of the skill bias in migration to the welfare impact of migration *per se*, namely the welfare difference between the status quo and a world without migration. The vertical axis shows changes in welfare per never-migrant in percent.

5.5 The skill bias and wages

Besides having an impact on aggregate welfare, the skill bias in migration differs by skill level. A change in the skill composition of migrants alters the relative supply of high- vs. low-skilled workers, which in turn affects the nominal wage structure. Nominal wages are affected through direct competition on the labor market, as well as through complementarities between high-, medium- and low-skilled workers, and between immigrants and natives.

Figure 4 displays the impact of the skill bias in migration on the real wages for different education levels. As in the previous section, a positive value means that the respective groups have higher real wages in a world with skill-biased migration. Figure 4(a) shows the different effects in the sending countries for workers with different skill levels. In all sending countries, high-skilled workers gain and low-skilled workers lose, while the impact for medium-skilled workers hovers around zero. The gains in real wages are particularly pronounced for high-skilled workers in Albania (+24%), Haiti (+25%) and Zimbabwe (+19%), while in most other countries the effects are close to zero. In most countries, the gains for high-skilled workers are larger than the losses for the low-skilled workers. The sign of the effects can be explained by a simple supply-and-demand mechanism. Most sending countries experience a severe outflow of high-skilled workers, such that high-skilled workers who stay behind become a scarcer resource in the labor market, thereby leading to wage increases. The opposite holds true for low-skilled workers. The magnitude of these effects depends on the skill distribution of the never-migrant population, as well as the direction and magnitude of the general equilibrium effects. Overall, the skill bias in migration increases the wage gap between high- and low-skilled workers in sending countries.

As Figure 4(b) shows, the skill bias has the opposite effect in the receiving countries: low-skilled workers gain, while high-skilled workers lose. The gains for low-skilled workers have two sources: first, with skill-biased migration, they face less competition on the labor market, leading to higher nominal wages; and second, they benefit from the market size effect due to a larger number of available varieties and lower prices. For high-skilled workers, the effects are less clear. In most countries, high-skilled workers lose by a small margin, while they gain in others. High-skilled workers benefit from the same positive market size effect as low-skilled workers, although they face more competition on the labor market. If these effects balance out, the net effect may be zero. Overall, the skill bias in migration reduces the wage gap between high- and low-skilled workers in the receiving countries.

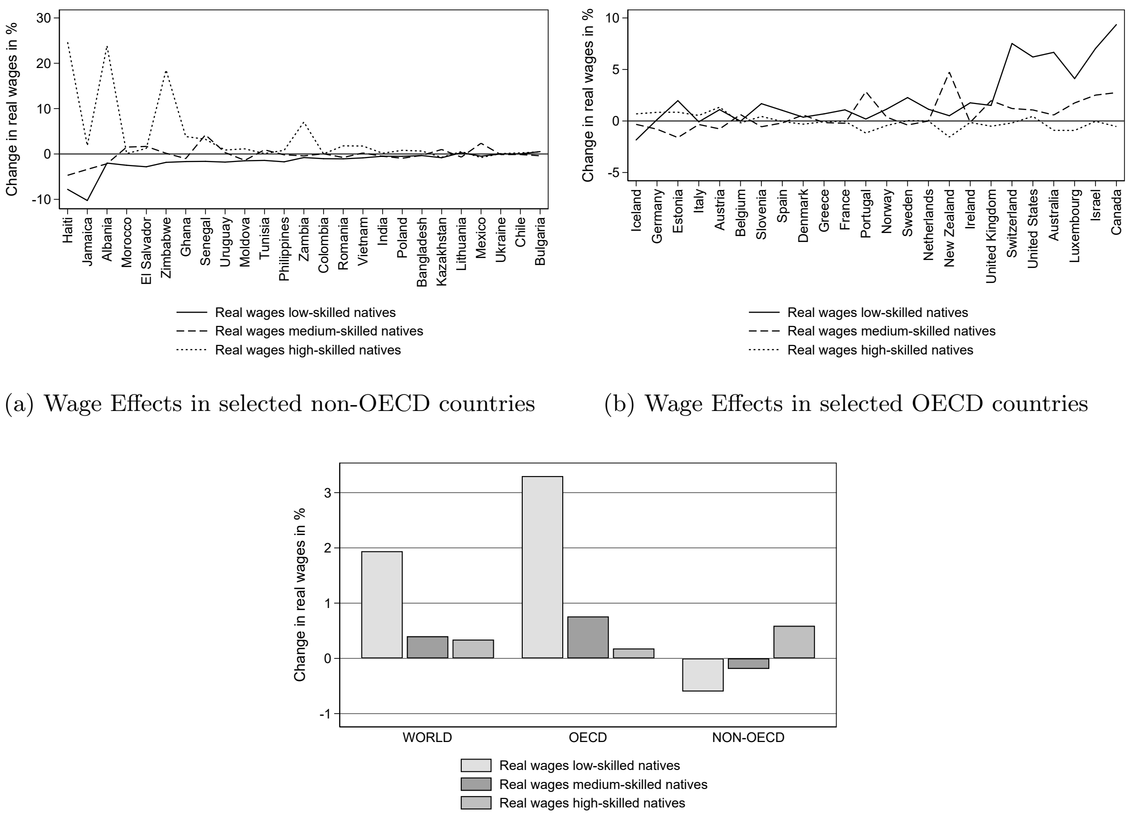
Upon first glance, the gains for low-skilled workers in the receiving countries may seem puzzling in light of the evidence that migration reduces the wages of low-skilled natives (Borjas, 2003, Dustmann *et al.* , 2013). The main difference between these studies and ours is the choice of counterfactual. Most studies explore the impact of having *more* immigrants, whereas our interest lies in the impact of having *different* immigrants. Given that under skill-biased migration the receiving countries have fewer low-skilled immigrants than under the counterfactual, low-skilled never-migrants are better off under skill-biased migration.[34]

We also report the real wage changes for the OECD and the world as a whole, as shown in Panel (c). Low-skilled never-migrant workers in the OECD gain about 3%, and low-skilled workers in the world gain around 2%, while the effects for high-skilled workers are close to zero. Taken together, the results from Section 5.3 and this section suggest that skill-biased migration leads to a more efficient allocation of labor and greater productivity in the world, although it also changes relative wages, making some groups better and others worse off.

6 Towards the Most Plausible Scenario

Our baseline model incorporates some of the most important adjustment channels through which a change in the migrant skill distribution affects welfare, namely market size, trade flows and changes in the nominal wage structure. However, the literature has highlighted several additional mechanisms through which migration has global welfare implications, such as human capital

[34] To bring further credibility to our results, we show in Appendix D that the negative effects on the low-skilled workers highlighted by the empirical literature, for example Borjas (2003) or Dustmann *et al.* (2013) can be reproduced in our model with a counterfactual similar to the one used in these study. We show the distributional consequences of increasing the number of migrants (from zero to the current world), while at the same time allowing for perfect substitutability between migrants and never-migrants within skill group and excluding the market size effect. Such counterfactual is similar to that of a reduced-form estimation where similarly educated workers compete in a national labor market and a partial equilibrium approach is adopted (e.g. Borjas, 2003). We show that in such scenario the wages of low-skilled workers are about 3% lower in the OECD countries due to migration. See Appendix D for details.



(a) Wage Effects in selected non-OECD countries

(b) Wage Effects in selected OECD countries

(c) Wage Effects in OECD and non-OECD countries, and in the world

Figure 4: Distributional effects

Source:. Own calculations.

Notes: This graph shows the impact of the skill bias in migration on the real wages of low-, medium- and high-skilled workers. The countries on the horizontal axis are ordered by welfare impact per never-migrant. The vertical axis shows real wage changes, in percent, for high-, medium- and low-skilled workers.

externalities, remittances, or trade creation through ethnic networks.[35] In this section, we first incorporate these mechanisms one-by-one in the model and analyse their welfare implications. In a second step, we present the most plausible scenario, whereby we include all these mechanisms in the model. Finally, we perform sensitivity checks to assess the robustness of our results to changes in the structural parameters and the model structure.

We provide here a brief description of the analysis and the results. A more detailed description with additional results can be found in Appendix E. The results of the sensitivity checks can be found in Appendix F.

[35] In light of the literature showing that technological progress has a heterogenous effect on individuals with different education levels (Acemoglu, 2002, Autor *et al.* , 2003), one could also model the relative productivity of high-skilled workers as a function of the skill ratio of high-skilled to low-skilled workers. The drawback of doing so is the lack of credible estimates of these effects outside the US context. We run simulations that include skill-biased technical change, calibrated based on estimates from Moretti (2004b) and Diamond (2016). These results show that global welfare gains remain positive. The results are available upon request.

6.1 Additional adjustment mechanisms

Remittances. Remittances are an important source of income in developing countries that could potentially offset the negative market size effect of the skill bias in migration in the sending countries. The extent to which this occurs depends on the remittance behavior of migrants. If migrants remit a fixed amount regardless of their income, this will have different welfare implications than if migrants remit a share of their income. In the former case, remittances have virtually no welfare effect because the number of migrants and, therefore, the amount of remittances does not change. However, if migrants remit a share of their income, the global amount of remittances is higher in a world with skill bias in migration, because more high-skilled, high-earning people are migrants. The literature provides mixed evidence regarding remittance behavior, although some studies suggest that high- and low-skilled migrants have different propensities to remit (Bollard *et al.* , 2011, Faini, 2007, Niimi *et al.* , 2008). To incorporate different remittance behaviors, we simulate several scenarios.

To account for differences in the share of income remitted across sending and receiving countries, we compute country-pair-specific shares based on remittance data from the World Bank.[36] In the origin countries, we assume that remittances are equally distributed across the population as a lump-sum transfer.

The welfare effects in a model with and without remittances are presented in Appendix E.1. Across all scenarios, remittances dampen the negative welfare effect in the non-OECD countries. This result is consistent with other studies showing that remittances play an important role in explaining the overall impact of migration on welfare (for example, di Giovanni *et al.* , 2015). In the OECD countries, in contrast remittances do not contribute to the overall welfare effect.[37] Consequently, global welfare always increases once remittances are accounted for, albeit the magnitude of such increase depends on the elasticity of remittances with respect to income.

Human capital externalities in TFP. A further important adjustment channel is human capital externalities. As shown by Lucas (1988), higher human capital might lead to a more efficient use of all production factors and, in turn, to higher output. In our context, this type of externality should amplify the losses in sending countries if migrants are positively selected. Similarly, the gains in receiving countries will be larger than in the baseline model. Our simulations, shown in Figure E.4 and further explained in Appendix E.2, confirm this intuition, but also show that global gains remain positive. The stronger the response of TFP to changes in human capital is, the larger are the global gains.

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36 We obtain country-pair-specific remittances based on the methodology developed by Ratha and Shaw, 2007, "South-South Migration and Remittances," Development Prospects Group, World Bank (`www.worldbank.org/prospects/migrationandremittances`). The remittance data cover 2010, and are disaggregated using host country and origin country incomes from 2010, as well as estimated migrant stocks from 2010. The share of remittances in income is calculated as the total amount of remittances sent from a given destination country divided by the total immigrant wage bill in that country.

37 The small increase in welfare in OECD countries primarily derives from the increase in remittances to OECD countries from OECD emigrants.

Network effects in trade. There is ample evidence that immigrants foster trade with their home countries by reducing trade costs and demanding home-country-specific goods (Gould, 1994, Rauch & Trindade, 2002, Felbermayr & Toubal, 2012, Egger *et al.* , 2012, Parsons & Vézina, 2018). The strength of these network effects may vary depending on the skill level of the immigrants. We extend our baseline model by including network effects in trade. In one scenario, we model trade costs as a decreasing function in the number of high-skilled and in another as a decreasing function in the number of low-skilled workers. The details of the analysis are provided in Appendix E.3. As shown in Figure E.5, we find that the global welfare gains are larger once we include network effects in trade.

Down-skilling of immigrants. Finally, we incorporate the down-skilling of migrant, that is, the fact that not every high-skilled migrant also works in a high-skill intensive occupation. As shown by Mattoo *et al.* (2008), the degree of down-skilling can be significant due to an initial skill mismatch as well as costly investment in location-specific human capital. We account for down-skilling in Appendix E.4. As shown in Figure E.6, this reduces the welfare effects of skill-biased migration in the receiving countries, while leaving the effect in the sending countries unchanged. The global effect is now smaller but remains positive at around 0.15%.

Incentives to invest in education *(Brain Gain)*. A further channel highlighted in the literature is human capital externalities. The opportunity to migrate raises the incentives to invest in education, which may lift the level of human capital in the sending countries and may dampen the negative welfare effects of high-skilled emigration. While initially this mechanism was shown as a theoretical possibility (Mountford, 1997, Stark *et al.* , 1997, Beine *et al.* , 2001, 2008), the recent empirical literature provides evidence of the existence and importance of this mechanism (Chand & Clemens, 2008, Batista *et al.* , 2011, Shrestha, 2015, Dinkelman & Mariotti, 2016).

In Appendix E.5, we incorporate this so-called *brain gain* mechanism into the model by endogenizing the share of high skilled stayers in sending countries. As shown in Figure E.7, including this channel reduces the negative welfare effects for the sending countries, with negligible effects on the receiving countries. Overall, even at modest levels of brain gain and across all possible scenarios, global welfare is larger than in our baseline simulation.

6.2 The most plausible scenario

The results discussed above suggest that our baseline simulations yield a lower bound to the global welfare effect of the skill bias in migration. Once we include adjustment mechanisms, one at a time, the global welfare effect is larger, typically because these mechanisms dampen the effect of the skill bias in the sending countries. The exception here is down-skilling, which reduces the welfare gains in the receiving countries as well as the global gain.

In reality, however, multiple adjustments are at play at the same time. In this Section, we perform our simulations including all adjustment channels introduced in the previous section. To bound the effects, we choose three sets of structural parameters, namely *optimistic* — parameter values that yield large welfare effects —, *pessimistic* — those yielding small welfare effects —, and *intermediate*, which lie in between. The parameter values are reported below in Table 3.

Table 3: Values of parameters in different scenarios

Externality	Parameter	Pessimistic	Intermediate	Optimistic
Remittances	γ	0	0.5	1
Brain gain	σ_b	0	0.025	0.04
TFP	σ_a	0	0.1	0.2
Network effects	σ_t	0	0.02	0.04
Downskilling	-	yes	no	no

Note: This table summarizes the calibration of the structural parameters in the extensions to the model. A more detailed description of the procedures can be found in Appendix E.

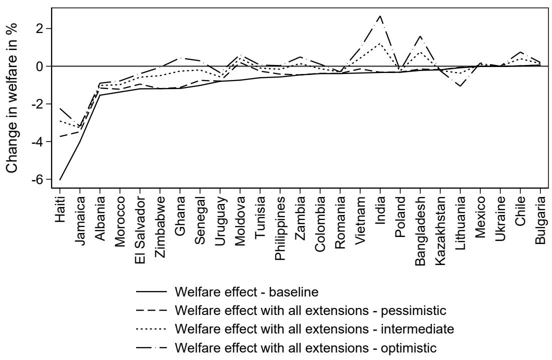
Figure 5 displays the results. In the sending countries, shown in Figure 5(a), the welfare effects are negative in some countries while being close to zero in others. But even in the pessimistic scenario, the effects are lower than in our baseline simulations, suggesting that these adjustment mechanisms dampen the welfare effect in the sending countries. In the receiving countries, shown in Figure 5(b), the opposite holds true. The welfare effects are — if only slightly — larger than in our baseline.

Figure 5(c) summarizes the effects by region. On average, across all scenarios, we observe global gains from the skill bias in migration. In the most pessimistic scenario, these gains amount to 0.34%, compared to 0.32% in our baseline model. In the most optimistic scenario, gains are as large as 0.84%. These larger effects derive from the lower losses in the sending countries and the slightly higher gains in the receiving countries. At intermediate parameter values, the global gain amounts to 0.6%. Remarkably, once all adjustment channels are included and parameters are at intermediate levels, the effect of the skill bias is positive in both OECD and non-OECD countries. In this case, the general equilibrium effects are strong enough to exceed the negative first-order effect of skill-biased emigration on welfare.

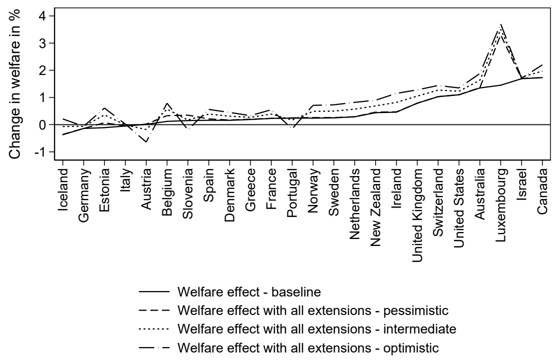
Overall, our most plausible scenario — including all extensions and with parameters set to their intermediate levels — provides an optimistic picture of the global impact of the skill bias in migration. While never-migrants in a number of sending countries — those shown in Figure 5(a) — undoubtedly lose, the average never-migrant in both the sending and receiving countries gains, resulting in strictly positive global effects.

6.3 Sensitivity checks

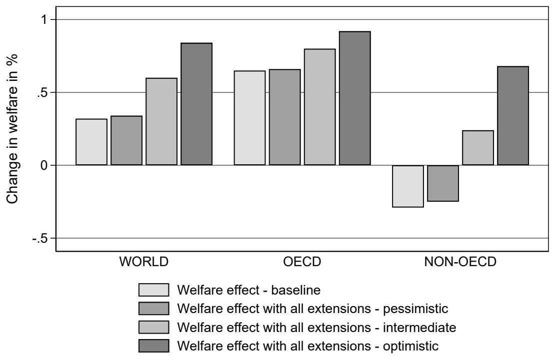
The results so far have shown that the baseline results are conservative estimates of the global welfare effect of skill-biased migration. Once we account for remittances, network effects in trade or human capital externalities, the global welfare effect is higher, even using the most



(a) Sending countries



(b) Receiving countries



(c) Aggregate results

Figure 5: Welfare effects under the most plausible scenario

Source: Own calculations.

Notes: This graph displays the impact of the skill bias in migration on welfare in selected countries. The countries on the horizontal axis are ordered by welfare impact per never-migrant. The solid line represents the effect on welfare per never-migrant under the baseline. The other lines represent the welfare effects when all the mechanisms detailed in Appendix E are accounted for. The pessimistic scenario sets all key parameters in the extensions to their lowest values, the intermediate scenario sets all key parameters in the extensions to their intermediate values and the optimistic scenario sets all key parameters in the extensions to their highest values. See Appendix E for details.

conservative set of parameters.

Sensitivity to changes structural parameters. In Appendix F.1, we assess the sensitivity of the baseline results to changes in all exogenous parameters of the model, one by one. The qualitative result of positive effects in the receiving countries, negative effects in the sending countries and a positive global welfare effect remains, and the magnitudes are similar.[38]

A nested CES technology. In our baseline model, we chose a parsimonious production function that combines the inputs of low-, medium- and high-skilled workers in one CES

[38] We discuss there also the sensitivity of the "most plausible scenario" to changes in all exogenous structural parameters.

aggregate. This choice may seem restrictive, as it implies that the three skill types are equally substitutable. However, labor market data in the US do not support equal substitutability but rather suggest that low- and medium-skilled workers are much closer substitutes than each of these groups is with high-skilled workers. To account for such a possibility, we incorporate an additional nest in the CES production function that combines low- and medium-skilled workers. At the higher nest of the CES function, this composite is combined with high-skilled workers. The results, presented in Appendix F.3, suggest that our conclusions are robust to the structure of the production function, although the global welfare effect is larger when we allow for differential substitutability between workers.

7 Conclusion

The question of "who migrates" remains at the forefront of the policy debate on migration. Receiving countries are concerned whether they attract migrants with the right skills, whereas many sending countries worry about losing high-skilled workers. Despite the evident skill bias in global migration, we know little about its impact on global welfare. The existing literature mainly quantifies the welfare impact of changes in the scale of migration — having more or fewer migrants — rather than the skill composition of the migrants. This paper fills this gap by quantifying the relevance of the skill bias in migration for the welfare of never-migrants in receiving countries and sending countries. For this purpose, we develop a multi-country general equilibrium model based on which we compare the welfare in today's world to a counterfactual with the same number of migrants but without skill bias in migration.

Our analysis delivers three central findings. First, receiving countries gain from the positive selection of immigrants. In our benchmark scenario, the welfare of never-migrants in OECD countries range between 0 and 2% larger because the immigrants in their country are positively rather than neutrally selected from the sending countries. Second, we find welfare gains at the global level, which result from the gains from the skill bias in the receiving countries exceeding the losses in the sending countries. Therefore a world with a skill bias in migration is one where talent is more efficiently allocated, that is, a larger number of high-skilled workers live and work in countries where they are most productive. However, the skill bias in migration creates winners and losers within a country. It raises the wage differential between high- and low-skilled workers in most sending countries while reducing it in most receiving countries. Third, these global welfare gains even arise in a model without remittances or any other mechanisms that could offset the negative effect in the sending countries. Once these mechanisms are included, the welfare gains are significantly higher.

This paper opens up several avenues for future research. Our paper simulates a counterfactual that eliminates the skill bias in global migration. While answering our main research question, namely the quantification of the global effects of skill-biased migration, this counterfactual is incongruent with actual migration policies. Future research could evaluate instead policy proposals related to the skill bias in migration. In addition, our baseline analysis shows that while more selective migration leads to global welfare gains, it also exhacerbates income inequality between rich and poor countries. Given that some countries win and others lose while the global gains are positive, it should be possible to design a migration policy that increases the global welfare by encouraging more skill-biased migration, in combination with a scheme in which the winners compensate the losers. Finally, the impact of migration on global inequality becomes less clear once we consider the welfare of migrants themselves, which have been left out in this paper. We are comfortable calling the welfare effect global because it covers more than 97% of the world population, namely all never-migrants. But the simulations show that migrants seem to gain considerably. Quantifying the impact of selectivity on the migrants themselves therefore deserves further attention.

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Online Appendices

(For Online Publication)

A Theoretical model - components

This section provides a detailed description of the theoretical model that has been summarized in Section 3.

A.1 Consumer's decision

A consumer in country i with income w_i maximizes utility

$$\begin{aligned} &\max_{\{T_i, x_{ij}(k), y_i(k)\}} \beta^T (T_i)^\mu + \left(1-\beta^T\right) \left[(1-\beta)(Y_i)^{\frac{\theta-1}{\theta}} + \beta(X_i)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \\ &\text{subject to: } P_i^T T_i + P_i^Y Y_i + P_i^X X_i = w_i, \end{aligned} \tag{A.1}$$

where β is the relative preference for the tradable differentiated goods, β^T is a preference parameter for the traditional good, and θ is the elasticity of substitution between tradable and non-tradable goods X and Y. The consumption of traditional goods is subject to decreasing marginal utility, such that $\mu < 1$. Y_i and X_i are CES composites of different varieties k produced in the manufacturing sector,

$$X_i = \left[\sum_{j=1}^{J} \int_0^{N_j^X} (x_{ij}(k))^{\frac{\varepsilon-1}{\varepsilon}} \, dk\right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad Y_i = \left[\int_0^{N_i^Y} (y_i(k))^{\frac{\varepsilon-1}{\varepsilon}} \, dk\right]^{\frac{\varepsilon}{\varepsilon-1}}. \tag{A.2}$$

N_i^X and N_i^Y are the numbers of varieties of goods X_i and Y_i available in country i. Varieties of the composite tradable good X_i are either domestically produced, $x_{ii}(k)$, or imported from other countries $x_{ij}(k), j \neq i$, while all varieties of Y_i, $y_i(k)$, are domestically produced. The parameter ε is the elasticity of substitution between any two varieties within a sub-sector, with $\varepsilon > \theta > 1$. Therefore, consumer preferences exhibit love of variety, which means that consumers gain utility when the number of available varieties increases. This translates in a 'market size effect' similar to the one obtained by Iranzo & Peri (2009) and di Giovanni *et al.* (2015) in a two-sector model and Aubry *et al.* (2016) in a one-sector model.

After maximizing utility subject to the budget constraint in Equation (A.1), the individual demands for all types of consumption goods are as follows:

$$\begin{aligned} T_i^s &= \left(\frac{\beta^T \mu}{1-\beta^T} \frac{P_i}{P_i^T}\right)^{\frac{1}{1-\mu}}, \\ Y_i^s &= (w_i^s - T_i^s)(1-\beta)^\theta (P_i)^{\theta-1} (P_i^Y)^{-\theta}, \\ X_i^s &= (w_i^s - T_i^s)\beta^\theta (P_i)^{\theta-1} (P_i^X)^{-\theta}, \\ x_{ij}^s &= (w_i^s - T_i^s)\beta^\theta (P_i)^{\theta-1} (P_i^X)^{\varepsilon-\theta} (p_{ij})^{-\varepsilon}, \\ y_i^s &= (w_i^s - T_i^s)(1-\beta)^\theta (P_i)^{\theta-1} (P_i^Y)^{\varepsilon-\theta} (p_i)^{-\varepsilon}. \end{aligned} \tag{A.3}$$

The demand for the traditional good is the same for all individuals in country i, and is independent of their real wage. This follows from the assumption of non-homothetic preferences. Consumption of these goods can be seen as expenditure that is necessary for survival. Once consumers have more income, they spend a greater share of their income on differentiated goods. Thus, the relative demand for the goods X and Y increases with income.
Inserting the demands (A.3) into the utility function (A.1), we obtain an agent's indirect utility,

$$U_i^s = \beta^T \left(\frac{\beta^T \mu}{1-\beta^T} \frac{P_i}{P_i^T} \right)^{\frac{\mu}{1-\mu}} + (1-\beta^T) \frac{w_i^s - T_i^s}{P_i}. \tag{A.4}$$

where P_i is the ideal price index in country i,

$$\begin{aligned} P_i &= \left[(1-\beta)^\theta \left(P_i^Y\right)^{1-\theta} + \beta^\theta \left(P_i^X\right)^{1-\theta} \right]^{\frac{1}{1-\theta}}, \\ \text{with: } P_i^X &= \left[\sum_{j=1}^{J} \int_0^{N_j^X} (p_{ij}(k))^{1-\varepsilon} dk \right]^{\frac{1}{1-\varepsilon}}, \text{ and } P_i^Y = \left[\int_0^{N_i^Y} (p_i(k))^{1-\varepsilon} dk \right]^{\frac{1}{1-\varepsilon}}. \end{aligned} \tag{A.5}$$

A.2 Labor demand and wages

The production functions of the traditional and the manufacturing sector are

$$\begin{aligned} Q_i^T &= A_i^T L_i^T, \\ Q_i^M = A_i^M L_i^M &= A_i^M \left[\alpha_i^L (L_i)^{\frac{\sigma_s - 1}{\sigma_s}} + (1-\alpha_i^L - \alpha_i^H)(M_i)^{\frac{\sigma_s - 1}{\sigma_s}} + \alpha_i^H (H_i)^{\frac{\sigma_s - 1}{\sigma_s}} \right]^{\frac{\sigma_s}{\sigma_s - 1}}. \end{aligned}$$

where L_i^T is the supply of low-skilled labor employed in the traditional sector, and A_i^T is the productivity residual, which equals the wage rate of the low-skilled workers over the price level in T:[39]

$$A_i^T = W_i^L / P_i^T. \tag{A.6}$$

L_i, M_i and H_i represent the supplies of low-, medium- and high-skilled workers in the manufacturing sector. This production function assumes that all three skill levels are equally substitutable. In Appendix F.3, we allow for differential substitutability between skill groups by adding an additional nest to the production function. The parameters α_i^L and α_i^H indicate, respectively, the efficiency of low- and high-skilled workers in production. Each skill group consists of natives (labeled by superscripts N) and foreigners (with superscripts F). All domestic and foreign workers are assumed to be imperfect substitutes with a constant elasticity of substitution equal to σ_n. We define the efficient labor supplies for each sector and education group as

$$\begin{aligned} L_i^T &= \left[(1-\alpha_i^F)(L_i^{T,N})^{\frac{\sigma_n - 1}{\sigma_n}} + \alpha_i^F (L_i^{T,F})^{\frac{\sigma_n - 1}{\sigma_n}} \right]^{\frac{\sigma_n}{\sigma_n - 1}}, \\ L_i &= \left[(1-\alpha_i^F)(L_i^N)^{\frac{\sigma_n - 1}{\sigma_n}} + \alpha_i^F (L_i^F)^{\frac{\sigma_n - 1}{\sigma_n}} \right]^{\frac{\sigma_n}{\sigma_n - 1}}, \\ M_i &= \left[(1-\alpha_i^F)(M_i^N)^{\frac{\sigma_n - 1}{\sigma_n}} + \alpha_i^F (M_i^F)^{\frac{\sigma_n - 1}{\sigma_n}} \right]^{\frac{\sigma_n}{\sigma_n - 1}}, \\ H_i &= \left[(1-\alpha_i^F)(H_i^N)^{\frac{\sigma_n - 1}{\sigma_n}} + \alpha_i^F (H_i^F)^{\frac{\sigma_n - 1}{\sigma_n}} \right]^{\frac{\sigma_n}{\sigma_n - 1}}. \end{aligned} \tag{A.7}$$

We assume a fixed, country-specific share of outputs of natives and foreigners ($(1-\alpha_F)$ and α_F respectively).

Firms solve their cost-minimization problem, taking wages as given. Demand for each type

[39] This wage is equal across sectors and across workers' origin. Therefore, any low-skilled worker from sector T has no incentives to move to sectors X and Y. In addition, the linear production function implies that the marginal productivity of low-skilled workers is constant in the traditional sector. In a set of results available upon request we confirm that using a non-linear production function of the form $Y_T = A_T L_T^\alpha$ with α=0.5 or 0.8 has no impact on the results.

of labor is then set as

$$
\begin{aligned}
L_i^N &= \frac{Q_i^M}{A_i^M}\left[\frac{(1-\alpha_i^F)W_i^L}{w_i^{LN}}\right]^{\sigma_n}\left[\frac{\alpha_i^L W_i}{W_i^L}\right]^{\sigma_s}, & L_i^{T,N} &= \frac{Q_i^T}{A_i^T}\left[\frac{(1-\alpha_i^F)W_i^L}{w_i^{LN}}\right]^{\sigma_n}, \\
L_i^F &= \frac{Q_i^M}{A_i^M}\left[\frac{\alpha_i^F W_i^L}{w_i^{LF}}\right]^{\sigma_n}\left[\frac{\alpha_i^L W_i}{W_i^L}\right]^{\sigma_s}, & L_i^{T,F} &= \frac{Q_i^T}{A_i^T}\left[\frac{\alpha_i^F W_i^L}{w_i^{LF}}\right]^{\sigma_n}, \\
M_i^N &= \frac{Q_i^M}{A_i^M}\left[\frac{(1-\alpha_i^F)W_i^M}{w_i^{MN}}\right]^{\sigma_n}\left[\frac{(1-\alpha_i^H-\alpha_i^L)W_i}{W_i^M}\right]^{\sigma_s}, & H_i^N &= \frac{Q_i^M}{A_i^M}\left[\frac{(1-\alpha_i^F)W_i^H}{w_i^{HN}}\right]^{\sigma_n}\left[\frac{\alpha_i^H W_i}{W_i^H}\right]^{\sigma_s}, \\
M_i^F &= \frac{Q_i^M}{A_i^M}\left[\frac{\alpha_i^F W_i^M}{w_i^{MF}}\right]^{\sigma_n}\left[\frac{(1-\alpha_i^H-\alpha_i^L)W_i}{W_i^M}\right]^{\sigma_s}, & H_i^F &= \frac{Q_i^M}{A_i^M}\left[\frac{\alpha_i^F W_i^H}{w_i^{HF}}\right]^{\sigma_n}\left[\frac{\alpha_i^H W_i}{W_i^H}\right]^{\sigma_s},
\end{aligned}
\tag{A.8}
$$

where the wage indices for the low-, medium- and high-skilled workers are equal to:

$$
\begin{aligned}
W_i^L &= \left[(1-\alpha_i^F)^{\sigma_n}(w_i^{LN})^{1-\sigma_n} + (\alpha_i^F)^{\sigma_n}(w_i^{LF})^{1-\sigma_n}\right]^{\frac{1}{1-\sigma_n}}, \\
W_i^M &= \left[(1-\alpha_i^F)^{\sigma_n}(w_i^{MN})^{1-\sigma_n} + (\alpha_i^F)^{\sigma_n}(w_i^{MF})^{1-\sigma_n}\right]^{\frac{1}{1-\sigma_n}}, \\
W_i^H &= \left[(1-\alpha_i^F)^{\sigma_n}(w_i^{HN})^{1-\sigma_n} + (\alpha_i^F)^{\sigma_n}(w_i^{HF})^{1-\sigma_n}\right]^{\frac{1}{1-\sigma_n}},
\end{aligned}
\tag{A.9}
$$

and the overall wage index in the manufacturing sector is given by:

$$
W_i = \left[(\alpha_i^L)^{\sigma_s}(W_i^L)^{1-\sigma_s} + (1-\alpha_i^L-\alpha_i^H)^{\sigma_s}(W_i^M)^{1-\sigma_s} + (\alpha_i^H)^{\sigma_s}(W_i^H)^{1-\sigma_s}\right]^{\frac{1}{1-\sigma_s}}. \tag{A.10}
$$

A.3 Firm's decision

Firms within a country are homogeneous. The manufacturing sector is monopolistically competitive, such that firms have some price-setting power. Each firm produces one variety of a differentiated good. Firms can freely enter the manufacturing sector, but incur a sunk entry cost of f_i^Y and f_i^X units of efficient labor in the respective sector. Sub-sectors Y and X both use identical production technologies.

Each firm k in sector X (the same applies to firms in sector Y) maximizes its profit

$$
\max_{p_i(k)} \; (p_i(k) - c_i(k))x_i(k) - f_i^X W_i, \tag{A.11}
$$

where $x_i(k)$ is the total demand faced by firm k. This leads to a price which is a constant mark-up over the marginal cost of production,

$$
p_i(k) = p_i = \frac{\varepsilon}{\varepsilon - 1} c_i, \tag{A.12}
$$

where the $c_i = \frac{W_i}{A_i^M}$ is the marginal cost of production, and W_i is the overall wage index of the manufacturing sector given by Equation (A.10).

A.4 Market clearing conditions

Since all firms earn zero profits, the total wage bill must equal the value added produced in all sectors:

$$\begin{aligned} GDP_i^T &= W_i^L L_i^T = w_i^{LN} L_i^{T,N} + w_i^{LF} L_i^{T,F}, \\ GDP_i^X + GDP_i^Y &= W_i L_i^M = \\ &= w_i^L \left(L_i^N + L_i^F\right) + w_i^{MN} M_i^N + w_i^{MF} M_i^F + w_i^{HN} H_i^N + w_i^{HF} H_i^F. \end{aligned} \tag{A.13}$$

In equilibrium, when demand equals the value of production, the total value-added in the traditional sector equals the expenditures: $GDP_i^T = P_i^T A_i^T L_i^T$. Furthermore, in the tradable and non-tradable manufacturing sectors the value-added equals the aggregated value of production of all N_i^X and N_i^Y firms:

$$\begin{aligned} GDP_i^X &= N_i^X \sum_{j=1}^{J} p_{ji} x_{ji} = N_i^X p_i x_i, \\ GDP_i^Y &= N_i^Y p_i y_i. \end{aligned} \tag{A.14}$$

where x_{ji} is the demand in country j for a product of any firm operating in sector X in country i. For simplicity, we aggregate this quantity into one number, namely the total demand for the products of one firm in country i: $x_i = \sum_{j=1}^{J} \tau_{ji} x_{ji}$. Due to the iceberg trade costs, in order to sell x_{ji} units in country j, the firm from country i has to ship $\tau_{ji} x_{ji}$ units of this good (with $\tau_{ji} \geq 1$).

The aggregation of the values of agents' individual demands gives the level of nominal GDP in country i (equivalent to the sum of all expenditure):

$$GDP_i = GDP_i^T + GDP_i^X + GDP_i^Y = P_i^T T_i + P_i^Y Y_i + P_i^X X_i. \tag{A.15}$$

Consequently, the share of value-added produced in the traditional sector is equal to:

$$sh_i^T \equiv \frac{GDP_i^T}{GDP_i} = \frac{POP_i}{GDP_i} \left(\frac{\beta^T \mu}{1-\beta^T} \frac{P_i}{P_i^T} \right)^{\frac{1}{1-\mu}}, \tag{A.16}$$

where POP_i stands for the number of people living in country i (since every person consumes the same amount of good T).[40] The remainder of GDP is spent on the differentiated good. We provide expressions for the shares of goods X and Y in Appendix A.5. Based on sh_i^Y and sh_i^X, we derive the optimal number of varieties in equilibrium using the zero-profit and free-entry conditions.

A.5 Market size

Each firm produces a single variety of a differentiated good. In equilibrium, firms make zero profits and all goods markets clear. These conditions — together with the optimal pricing rule (A.12) — pin down the optimal number of varieties, N_i^X and N_i^Y. To derive an expression for the optimal number of firms in sub-sectors X and Y, we first derive the shares of value-added

[40] Total population has the following structure: $POP_i = L_i^{T,N} + L_i^{T,F} + L_i^N + L_i^F + M_i^N + M_i^F + H_i^N + H_i^F$. The low-skilled natives and foreigners are divided into those who work in the traditional sector and those who are employed in the differentiated good sector. The medium- and high-skilled workers are only employed sectors X and Y.

in the manufacturing sector, which are given by

$$sh_i^X \equiv \frac{P_i^X X_i}{GDP_i^X + GDP_i^Y} = \beta^\theta \left(\frac{P_i^X}{P_i}\right)^{1-\theta}, \text{ and } sh_i^Y = (1-\beta)^\theta \left(\frac{P_i^Y}{P_i}\right)^{1-\theta}, \tag{A.17}$$

where GDP_i^X and GDP_i^Y are the sums of the wage bills of all workers in the respective sector.[41] Combining Equation (A.17) and the optimal pricing rule (A.12) yields the resource constraints of the economy:

$$sh_i^X A_i^M L_i^M = \frac{\varepsilon}{\varepsilon-1} N_i^X x_i, \quad sh_i^Y A_i^M L_i^M = \frac{\varepsilon}{\varepsilon-1} N_i^Y y_i. \tag{A.18}$$

The resource constraints state that the effective labor supply in a given sector (left-hand side) has to equal labor demand by firms in this sector (right-hand side). The zero-profit condition implies that $p_i x_i = \varepsilon W_i f_i^X$ and $p_i y_i = \varepsilon W_i f_i^Y$, which yields the number of units produced by each firm,

$$x_i = A_i^M f_i^X (\varepsilon - 1), \quad y_i = A_i^M f_i^Y (\varepsilon - 1). \tag{A.19}$$

Combining (A.18) and (A.19), we obtain the optimal market size

$$N_i^X = \frac{sh_i^X L_i^M}{\varepsilon f_i^X}, \quad N_i^Y = \frac{sh_i^Y L_i^M}{\varepsilon f_i^Y}, \tag{A.20}$$

which states that the number of firms in sectors X and Y, operating in country i, are proportional to the efficient labor supplies employed in these sectors and inversely proportional to the fixed costs of entry.[42]

A.6 International trade

Varieties of the manufactured good X are traded between countries such that an expansion in market size in one country is passed on to its trading partners. The volume of trade depends on trade costs, as well as differences in consumer demand and price levels. Exports from country i to country j, denoted by $Trade_{ji}$, are subject to iceberg trade costs $\tau_{ji} > 1$. Trade costs are asymmetric, such that $\tau_{ji} \neq \tau_{ij}$. $Trade_{ji}$ is given by

$$Trade_{ji} = \int_{k \in N_i^X} x_{ji} p_{ji} dk = N_i^X GDP_j^X \left[\frac{P_j^X}{\tau_{ji} p_i}\right]^{\varepsilon - 1}. \tag{A.21}$$

where p_{ji} and x_{ji} are the price and quantity of a variety produced in country i, consumed in country j. Given that $\varepsilon > 1$, trade negatively depends on import prices and trade costs, $\tau_{ji} p_i$, and positively on the domestic price level. The total value-added in sector X in country i is computed as the sum of all trade flows to country i, including domestic consumption $Trade_{ii}$,

---

[41] Note that, by construction, $sh_i^X + sh_i^Y = 1$, following from Equations (A.5) and (A.17).

[42] Thus, the sector-specific barriers to enter production (captured by the fixed cost of entry) are the main driving forces of the market size effect. Calibrating different entry costs for tradable and non-tradable sectors separately allows us to introduce both the selection mechanism in firms' trade choices (represented by uneven market size effects in tradable/non-tradable sectors) as well as changing terms of trade (the movement of relative prices of traded and non-traded bundles of varieties) within a Krugman (1980)-type model. A change in the skill distribution affects the number of varieties produced and consumed in the destination countries, and, therefore, has an indirect impact on the welfare of native citizens.

and is given by

$$GDP_i^X = N_i^X \sum_{j=1}^{J} GDP_j^X \left(\frac{P_j^X}{\tau_{ji} p_i} \right)^{\varepsilon - 1}. \tag{A.22}$$

Solving Equation (A.22) for N_i^X and substituting into (A.21), we can express the share of exports as a total share of production in sector X as

$$\frac{Trade_{ji}}{GDP_i^X} = \frac{GDP_j^X \left(P_j^X / \tau_{ji} \right)^{\varepsilon - 1}}{\sum_{h=1}^{J} GDP_h^X \left(P_h^X / \tau_{hi} \right)^{\varepsilon - 1}}. \tag{A.23}$$

Equation (A.23) can be interpreted as a gravity equation. The share of exports from country i to country j in GDP of country i increases with GDP in the foreign country. This ratio grows when the foreign price level increases and shrinks when bilateral trade costs increase. In equilibrium, trade is balanced within each country, such that the value of imports equals the value of exports, $\sum_{j=1}^{J} Trade_{ij} = \sum_{j=1}^{J} Trade_{ji}$. Below we provide a detailed definition of the equilibrium.

A.7 Definition of equilibrium

Definition 2 *For a set* $\{\beta, \beta^T, \theta, \mu, \varepsilon, \sigma_s, \sigma_n, \}$ *of structural parameters, a set* $\{A_i^T, A_i^M, \alpha_i^F, \alpha_i^H, \alpha_i^L, L_i^{T,N}, L_i^{T,F}, L_i^N, L_i^F, M_i^N, M_i^F, H_i^N, H_i^F, f_i^X, f_i^Y\}_{\forall i}$ *of exogenous country-specific institutional, demographic and technological characteristics, a set* $\{\tau_{ji}\}_{\forall i,j}$ *of bilateral trade costs*

- *consumption of the three types of goods* $\left\{x_{ij}^s, y_i^s, T_i^s\right\}$ *maximizes an agent's utility (A.1) subject to the budget constraint,*
- *assuming full employment and cost-minimizing behavior of firms, the labor market clearing conditions (A.8) equalize the wage rates to marginal productivities, and determine the nominal wages for all types of workers:* $\{w_i^{LN}, w_i^{LF}, w_i^{MN}, w_i^{MF}, w_i^{HN}, w_i^{HF}\}$
- *the price of one variety,* $p_i(k)$*, maximizes firm's profits given the demand that it faces (A.12),*
- *the price of a unit of traditional good,* P_i^T*, equals the marginal productivity of a low-skilled worker in (A.6),*
- *the number of varieties in sector* X *and* Y*,* N_i^X *and* N_i^Y*, is such that the zero-profit conditions hold in (A.20),*
- *the value-added equals the aggregated value of production and trade in* X *is balanced as follows from (A.22).*

B Calibration and simulation

B.1 Classification of skill groups

Table B.1 provides some details about the aggregation of skill groups in both datasets.

Table B.1: Classification of skill groups

	DIOC	Barro and Lee (2010)
Low-skilled	No schooling	No schooling
	Some primary education	Some primary education
	Completed primary education	Completed primary education
	Lower secondary education	Non-completed secondary education
Medium-skilled	(Upper) secondary education	Completed secondary education
	Post-secondary non-tertiary education	
High-skilled	First stage of tertiary education	Tertiary education
	Second stage of tertiary education	(Non-completed and completed)

Note: This table details the classification of skill groups in Barro & Lee (2010) and DIOC.

B.2 Imputation of trade flows

To compute the bilateral trade costs, we require a (146×146) matrix of gross trade flows between all countries in the sample (145 countries plus the Rest of the World). The UN Comtrade database provides information to fill 66.5% of all entries of this matrix, whereas the remaining trade flows are missing. Because we require every trade flow to be non-negative for computational purposes, we impute the missing trade flows based on a gravity equation. We first fit the following linear fixed-effect regression on all observed trade flows:

$$\ln(trade)_{od} = \boldsymbol{X'_{od}}\boldsymbol{\Gamma} + \delta_o + \delta_d + \varepsilon_{od}, \tag{B.24}$$

where index o denotes the origin and d the destination of a trade flow. $\boldsymbol{X_{od}}$ is a vector of dyad-specific determinants of trade flows, and includes: a common border dummy, a dummy for a common official language, the log distance between the capital cities, a dummy for a common colonial past. These data are taken from the CEPII Gravity dataset (Mayer *et al.* , 2010, Head & Mayer, 2015). ε_{od} is an i.i.d error term. δ_o and δ_d are origin and destination fixed effects. Based on the fitted values, we then predict the trade flows for all remaining dyads.

B.3 Imputation of missing wage ratios

The two country-specific wage ratios (high-skilled to medium-skilled and medium-skilled to low-skilled) are obtained as follows. For the 34 OECD countries, the wage ratios are provided by the "OECD Education at a Glance" report 2010 (OECD, 2010). The WageIndicator Foundation provides information on 38 additional high-skill to medium-skill and 27 medium-skill to low-skill wage ratios. For the remaining countries, we construct wage ratios as a function of the average return of one additional year of schooling[43] (λ) and the difference in years of schooling (d) between two education levels (k,m)

$$w_i^k / w_i^m = (1 + \lambda_{km})^d, \tag{B.25}$$

using data from Barro & Lee (2010).

[43] These are assessed based on the countries for which wage ratios and average years of education are available.

B.4 Equilibrium prices and quantities

In this section, we explain how we calibrate the free parameters of the model and compute equilibrium prices and quantities. The calibration of bilateral trade flows depends on goods prices in each country, which are a function of TFP levels and bilateral trade costs. For a given matrix of bilateral trade costs, the combination of the zero-profit condition and the expression of units produced per firm in Equation (A.19) yield the level of country-specific TFP in the manufacturing sector. Based on the TFP level, we can assess the marginal cost of production and recover all prices and price aggregates from Equations (A.5) and (A.12). Combining these with trade costs allows us to assess the value of bilateral trade flows. For this purpose, we use the gravity equation (A.23) to iterate over TFP and trade costs until the trade flows in the model match the trade flows in the data as closely as possible.

The iterative procedure is carried out in two steps. We first define an outer loop in which the trade cost matrix $[\tau_{ji}]_{j,i \in J}$ is determined iteratively, based on the gravity equation (A.23). In each iteration, a new matrix of τ's is computed from the gravity equation. A new general equilibrium is then obtained by iterating on A_i^M (i.e. the inner loop) until the distance between the trade matrix from the data and the trade matrix in the model is minimized. The inner loop takes trade costs as given, and iterates on the TFP in the manufacturing sector, A_i^M, such that the zero-profit conditions are fulfilled for firms in all the countries at the same time (and hence the general equilibrium is guaranteed). The iteration uses the whole vector of country-specific TFP in the manufacturing sector, A_i^M, because profits in country i are dependent on the prices of goods in all other countries (P_i in Equation (A.5) is a weighted sum of prices of all imported goods, and hence depends on the trade costs defined in the previous step of the outer loop). Once we obtained the vector of TFP, we use the trade costs along with the equilibrium conditions (A.18) and (A.19) to compute the vectors of unit prices p_i, and the price indexes, Pi^X and Pi^Y, for both sectors.

To compute the fixed cost of entry for the non-tradable manufacturing sector, we first compute the equilibrium number of varieties produced in sector Y, N_i^Y, given the price level Pi^Y. We then back out the fixed cost f_i^Y from Equation (A.20) to match the number of varieties. The last parameter to be calibrated is the preference towards goods produced in the traditional sector, β^T. Its value of 0.139 is such that we match consumption of the traditional good to its production.

B.5 Simulation algorithm

To simulate the counterfactual scenario, we impose an exogenous shock (on the skill structure of migrants) to the general equilibrium of the system of J economies. We then need to compute new wages, price indices and values of production in all sectors. The first equilibrium to compute is in the market for the traditional good. Equalizing its demand and supply in all countries, we can compute first guesses of the number of people who work in agriculture, and the wage levels of low-skilled workers. Then, taking the first guess on the GDP levels in manufacturing sector, we compute the wage indices (using the system of J zero-profit equations in sectors X and Y). However, we have no information about the shares of GDP^X and GDP^Y in manufacturing (which are driven by peoples' preferences towards different varieties of products and prices). Thus, we make an initial guess of the variable sh^X — on which we iterate — to meet the definitions of price indices and numbers of varieties (Equations (A.5), and (A.20)). Additionally, according to the current value of sh^X, we calculate the price indices, numbers of varieties and GDPs in X and Y. With a new guess for sh^X we return to the outer loop and re-compute the equilibrium wage for the low-skilled workers and GDP^T, using the T market clearing condition.

Having pinned down the nominal wage of low-skilled workers and the values of GDPs in all sectors, we can calculate the exact wage index in the manufacturing sector and the wages of all types of workers (using the system of labor demand equations, (A.8)). Now, unlike in the calibration procedure, the wage premium between high-/medium-skilled and medium-/low-skilled workers is endogenous and determined by the skill composition of the workforce.

Once again, the final step is to compute the endogenously determined trade matrix for the given levels of GDP^X, price indexes and trade costs (taken as given). Using the system of gravity equations (A.23), we are able to determine all the bilateral trade flows across J countries.

C Construction of the population of never-migrants

Figure C.1 provides further intuition for the construction of the population of never-migrants in the sending countries. The population of never-migrants are those residing in the country in both cases, as indicated by the dashed line. For simplicity, in this figure the numbers of high- and low-skilled never-migrants are equal, although this need not be the case in the actual exercise. The figure shows the skill composition of stayers in a migrant sending country in a scenario when over-proportionally many high-skilled workers have left the country (Panel A), and when the skill selection of migrants is neutral (Panel B), such that the number of high-skilled workers at home is higher and the number of low-skilled workers is lower. Welfare per capita would be mechanically higher under the baseline than under the counterfactual. As we show in the paper, isolating the treatment effect from this mechanical composition effect is very important, as the welfare effects are considerably higher per capita than per never-migrant.

D Immigration and wages: further simulations

As discussed in the paper, the skill bias in migration affects workers of different skill levels by altering the relative supply of high- vs. low-skilled workers. The results, shown in Figure 4 reveal that, in the sending countries, high-skilled workers gain from the skill bias in migration, while in the receiving countries low-skilled workers gain. These results differ from those in studies on the labor market effects of migration. The crucial difference is that labor market studies typically measure the impact of more migration, whereas our analysis measures the impact of *different* migration.

To verify the credibility of our model and calibration, we show that our model reproduces the effects found in studies on the labor market effects of immigration, for example Borjas (2003) or Dustmann *et al.* (2013). We simulate two counterfactual scenarios. First, we compare our baseline findings with the distributional impact of turning from a world without migration to the current world with migration. Next, we simulate a change from zero migration to today's levels and skill composition of migration, while at the same time assuming that migrants and natives with the same skills are perfect substitutes and setting the market size effect to zero.

The results are shown in Figure D.2. In the second scenario, which is conceptually close to the framework of analysis in Borjas (2003), we find effects similar to those in well-cited partial equilibrium studies on the labor market effects of immigration.

E Extensions to the model

In Section 6, we summarized the results from several extensions to the model. For the sake of brevity, we verbally described the theoretical underpinnings of each extension and briefly

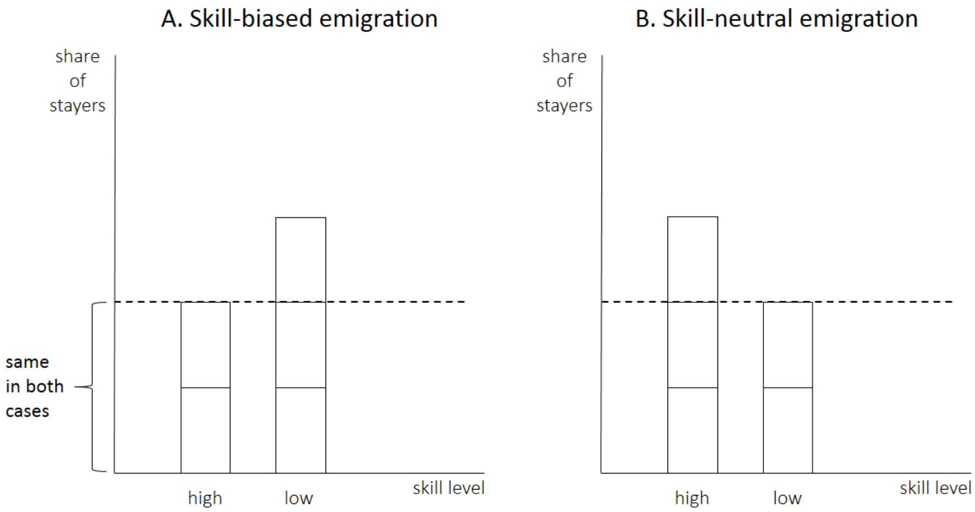


Figure C.1: Skill distribution of stayers under the baseline and counterfactual.

Note: See text for explanation. This figure shows the skill composition of stayers in a migrant sending country in a scenario when over-proportionally many high-skilled workers have left the country (Panel A), and when the skill selection of migrants is neutral (Panel B), such that the number of high-skilled workers at home is higher and the number of low-skilled workers is lower. The population of never-migrants is those residing in the country in both cases, as indicated by the dashed line. For simplicity, in this figure the numbers of high- and low-skilled never-migrants are equal, although this need not be the case in the actual exercise.

discussed the results. In this appendix, we provide more detail in both respects. For each extension, we explain our modeling choices and discuss how the results compare to the baseline results.

E.1 Remittances

To include remittances in the model, we assume that the fraction of income remitted by the emigrants is exogenous, and is country-pair-specific. To measure remittances, we use bilateral data on the volume of remittances from the World Bank (2015). Formally, the amount of remittances per emigrant of skill type s is given by

$$R_{ij}^s = \eta_{ij}^s (w_{ij}^s)^\gamma \tag{E.26}$$

and the income after remittances ($\hat{w}_{ij}^s$) of an emigrant of skill type s from country i in destination country j becomes

$$\hat{w}_{ij}^s = w_{ij}^s - \eta_{ij} \left(w_{ij}^s\right)^\gamma , \tag{E.27}$$

where (w_{ij}^s) is the wage income before remittances and the second term indicates residual remittances. These range from a fixed amount of income η_{ij}, when $\gamma = 0$, to a share η_{ij} of wages remitted when $\gamma = 1$. Intermediate values of γ imply a positive elasticity of remittances with respect to wages and thus allow to account for intermediate scenarios between constant amount and constant wage share for the remittances sent from country j to country i. For a given γ, the propensity to remit η_{ij} is assessed using data on the volume of bilateral remittances flowing

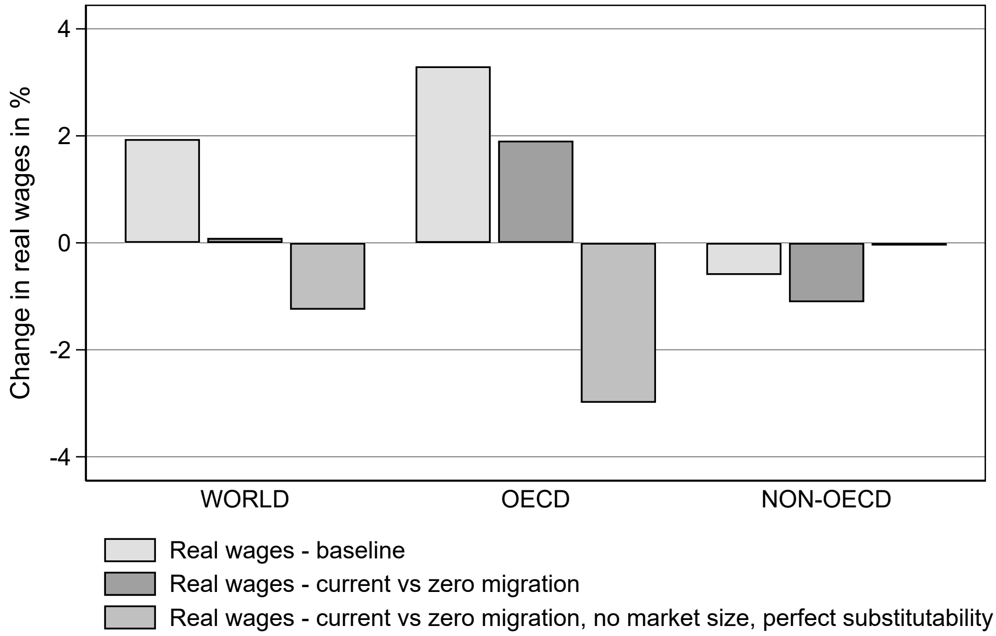


Figure D.2: Changes in real wages of low-skilled never-migrants, different scenarios

Source: Own calculations.
Notes: This graph displays the impact of migration on the real wages of low-skilled workers. Results are reported for three different scenarios: our baseline, a scenario of current vs zero migration, a scenario of current vs zero migration without market size effects and with perfect substitutability between migrants and never-migrants. The vertical axis shows changes in real wages, in percent.

from country j to country i, denoted $REMIT_{ji}$. Thus,

$$REMIT_{ji} = \sum_{s=L,M,H} N_{ij}^s \eta_{ij} \left(w_{ij}^s\right)^\gamma, \tag{E.28}$$

where N_{ij}^s is the number of emigrants with skill s from country i living in j. The propensity to remit (η_{ij}) can then be recovered using Equation (E.28) with data on $REMIT_{ji}$, the emigration matrix (N_{ij}^s) and the calibrated values for the wages (w_{ij}^s). Next, the total volume of remittances received by natives living in the origin country i is assessed by summing the remittance flows across all destination countries:

$$REMIT_i = \sum_j REMIT_{ji}. \tag{E.29}$$

In the origin countries, the total amount of remittances received is then split equally among the never-migrating nationals, independent of their skill level. The per worker amount, rem_i, is then defined as:

$$rem_i = \frac{REMIT_i}{\sum_{s=L,M,H} N_{jj}^s}. \tag{E.30}$$

Thus, the total income after remittances of a never-migrant in country i of type s is given by:

$$\hat{w}_{ii}^{s} = w_{ii}^{s} + rem_i, \tag{E.31}$$

where w_{ii}^{s} is the skill-specific wage rate.[44]

Figure E.3 displays the welfare effects under different assumptions about the propensity to remit. We start from a scenario in which $\gamma = 0$ so each immigrant remits the same amount. We label this as pessimistic scenario as in this case skill-biased migration will not change the amount of remittances sent. We then include an intermediate scenario with $\gamma = 0.5$ and finally an optimistic scenario in which the amount remitted is a constant fraction of the wage ($\gamma = 1$). In these latter two cases, the amount of remittances sent will less than proportionally and proportionally change with skill-biased migration, as the income received by the migrants will be higher in the current world than in the one with skill neutrality.

As shown in the figures, the higher is the elasticity of remittances to income (i.e. the more remittances are proportional to income), the lower are the losses for the sending countries, while the impact in the receiving countries is virtually unchanged.

E.2 Human capital externalities in TFP

A further human capital externality could work through total factor productivity (TFP). As shown by Lucas (1988), an economy with a higher average level of human capital may use its production factors more efficiently, leading to an additional positive impact of human capital on output. We incorporate a Lucas-type externality in the model, with TFP being a concave function of the average level of human capital. Consequently, a marginal change in the level of human capital has a larger effect in poorer countries, which start from a lower level of human capital.[45] We parameterize total factor productivity as

$$A_i = a_i \left(\frac{H_i}{H_i + M_i + L_i} \right)^{\sigma_a}. \tag{E.32}$$

The elasticity σ_a governs the strength of the response of TFP to changes in the share of high-skilled workers in the population. We run separate simulations for $\sigma_a \in \{0.1, 0.3, 0.5\}$.[46] The parameter a_i is a country-specific scaling factor implicitly computed from Equation (E.32), using data on calibrated values of TFP (A_i) and the information on the workforce composition.

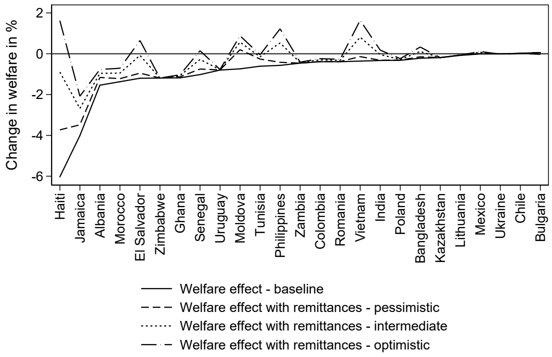
As shown in Figure E.4, the welfare effects of skill-biased migration are larger once the TFP externality is accounted for, and considerably so at high levels of σ_a. The overall effect on world welfare is of similar size as the effect without the externality, whereas the gap between OECD and non-OECD countries is larger.[47] These results suggest that the baseline simulation results

[44] We have also adapted Equation (E.28) to account for skill-specific remitting behavior among emigrants. To this end, we experimented with two scenarios: one in which the low-skilled remit more, and one in which the highly skilled remit more. Results are qualitatively the same as the ones reported. The results are available upon request.

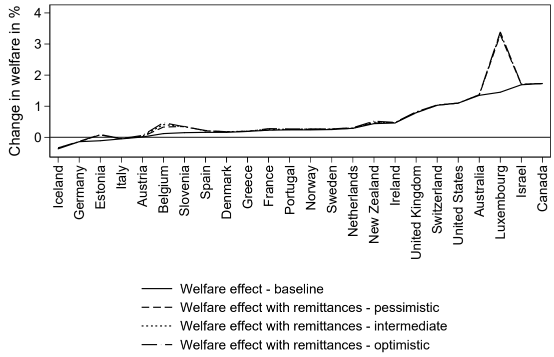
[45] An alternative interpretation of this externality could be that high-skilled emigration in one generation reduces the productivity of the next generation if it reduces the opportunity of the next generation to get educated, or if it leads to less innovation. While our model does not include multiple generations, one could interpret this externality as a reduced-form representation of a multigenerational feedback mechanism between human capital and productivity.

[46] The parameters estimated in the empirical literature widely vary. While Acemoglu & Angrist (2000) find an elasticity close to zero, Iranzo & Peri (2009) find a value close to 0.44. Moretti (2004c,a) finds values between 0.75 and 1.00. de la Croix & Docquier (2011) use a value of 0.277.

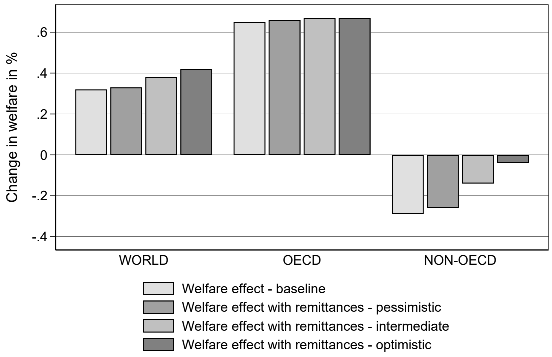
[47] A further — negative — externality through which migration affects TFP in the receiving countries is institutions. As highlighted by Collier (2013) and Borjas (2015), migrants from countries with poor institutions



(a) In the sending countries



(b) In the receiving countries



(c) In OECD and non-OECD countries, and in the world

Figure E.3: Welfare Effects adding Remittances

Source: Own calculations.

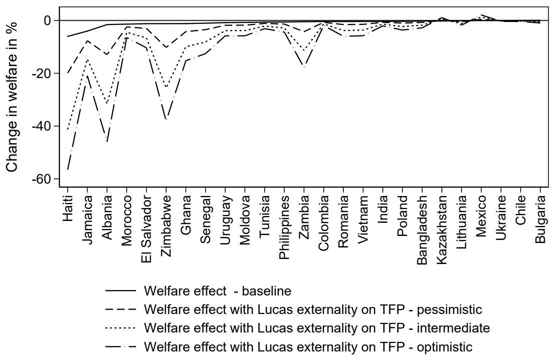
Notes: This graph displays the impact of the skill bias in migration with remittances. The solid line represents the effect on welfare per never-migrant under the baseline. The dashed lines represent the effect on welfare per never-migrant when remittances are included in the model. The pessimistic scenario sets $\gamma = 0$, the intermediate scenario sets $\gamma = 0.5$ and the optimistic scenario sets $\gamma = 1$. The countries on the horizontal axis are ordered by welfare impact per never-migrant. The vertical axis shows welfare changes, in percent. Panel (a) focuses on selected sending countries, while panel (b) focuses on selected receiving countries. Panel (c) shows the average effect in all non-OECD and OECD countries as well as across the whole world.

presented in Figure 2 represent a lower bound and that they could be larger in the presence of externalities.

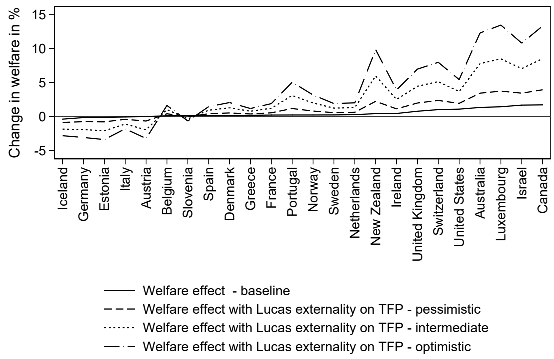
E.3 Network effects in trade

A growing body of literature shows that immigrants foster trade with their home countries by reducing trade costs and demanding home-country-specific goods (Gould, 1994, Rauch &

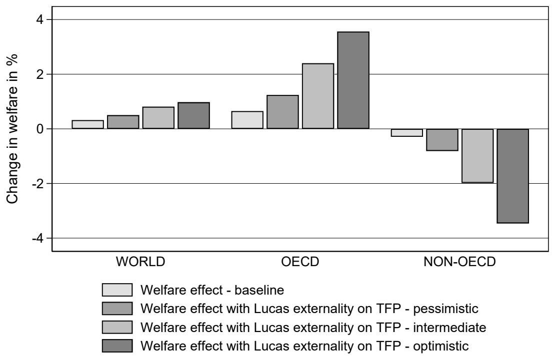
may import these institutions in the receiving country. However, recent work by Clemens & Pritchett (2016) suggests that large negative effects only unfold under fairly extreme conditions. Moreover, in the receiving countries, the diversity of high-skilled migrants could have an additional effect on TFP. Alesina *et al.* (2016) find an inverse U-shaped relationship between birthplace diversity and GDP per capita.



(a) In the sending countries



(b) In the receiving countries



(c) In OECD and non-OECD countries, and in the world

Figure E.4: Including Lucas externality on TFP

Source:. Own calculations.

Notes: This graph displays the welfare effects of the skill bias in migration with a Lucas-type externality on TFP. The solid line represents the effect on welfare per never-migrant under the baseline. The dashed lines represent the effect on welfare per never-migrant with a Lucas-type externality on TFP. We vary the elasticity parameter σ_a. The pessimistic scenario sets $\sigma_a = 0.1$, the intermediate scenario sets $\sigma_a = 0.3$ and the optimistic scenario sets $\sigma_a = 0.5$. The countries on the horizontal axis are ordered by welfare impact per never-migrant. The vertical axis shows changes in welfare per never-migrant in percent. Panel (a) focuses on selected sending countries, while panel (b) focuses on selected receiving countries. Panel (c) shows the average effect in all non-OECD and OECD countries as well as across the whole world.

Trindade, 2002, Felbermayr & Toubal, 2012, Egger *et al.* , 2012, Parsons & Vézina, 2018). For our analysis, this channel is important if trade flows respond to changes in the skill composition; for example, because high-skilled migrants establish better business links. In this case, network effects could add to the overall welfare effect. To assess the importance of skill-biased migration for trade, we simulate two scenarios: one in which trade costs are reduced by both medium- and high-skilled migrants ("intermediate scenario") and one in which they are reduced by high-skilled migrants ("optimistic scenario"). We compute trade costs as

$$\tau_{ij} = \bar{\tau}_{ij} \left(\frac{H_{ij}}{H_{ij} + M_{ij} + L_{ij}} \right)^{\sigma_t}, \tag{E.33}$$

where H_{ij}, M_{ij} and L_{ij} are the skill-specific stocks of immigrants and $\bar{\tau}_{ij}$ are the bilateral trade costs at baseline. In an alternative simulation, which we label "intermediate scenario", we consider trade costs as a function of the share of both high- and medium-skilled workers, i.e.

$$\tau_{ij} = \bar{\tau}_{ij} \left(\frac{H_{ij} + M_{ij}}{H_{ij} + M_{ij} + L_{ij}} \right)^{\sigma_t} . \tag{E.34}$$

The parameter σ_t is the elasticity of trade costs with respect to the skill share of immigrants. To calibrate this elasticity, we use $\sigma_t = -0.04$, as estimated by Parsons & Vézina (2018). Given that this externality is based on immigration, it directly affects the receiving countries. The sending countries — having no immigrants by assumption — can only be indirectly affected through general equilibrium effects.

Figure E.5 displays the welfare effects of skill-biased migration without network effects in trade (baseline), with trade costs being reduced by medium and high skilled migrants (intermediate scenario) and with trade costs being reduced by high skilled migrants only (optimistic scenario). The overall welfare effect in the world is larger when we allow for network effects.

E.4 Down-skilling of immigrants

As a further sensitivity check, we account for the skill depreciation of migrants in the receiving country. It is common that immigrants — especially those from developing countries — work in jobs for which they are over-qualified (Mattoo *et al.* , 2008). This qualification mismatch might imply that we over-estimate the welfare effects of skill-biased migration in the receiving countries, because replacing a high-skilled with a low-skilled worker may not lead to a change in productivity if both were working in low-skilled jobs to begin with.

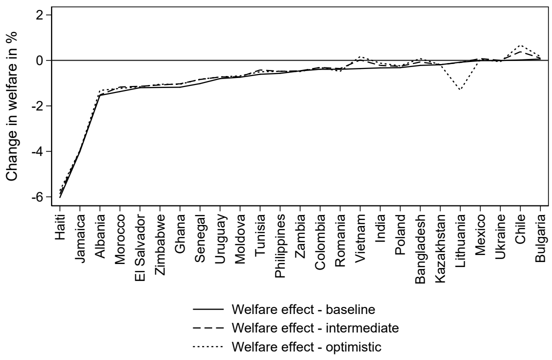
To account for the skill depreciation of immigrants, we compute origin-country-specific down-skilling rates, which measure — for example — the likelihood that a high-skilled Senegalese migrant works in France in a job in which most French workers are low-skilled. Across all sending countries, 29% of all high-skilled emigrants are working in the OECD in medium-skilled occupations, 10% in low-skilled occupations and 24% of all medium-skilled emigrants are working in low-skilled jobs.

To compute the down-skilling rates for a given sending country, we use the OECD-DIOC data, which has information on the skill requirement for occupations at the ISCO one-digit level, as well as the skill distribution of immigrants within each occupation by sending country. For instance, we know how many high-skilled Senegalese are working in low-skilled occupations in France, Canada, the UK and all other OECD countries. Based on this information, we can compute the three down-skilling rates for every country pair, for example, $d^H_{M,ij}$. To compute the sending-country-specific down-skilling rates, we compute a weighted average over all receiving countries (index d),

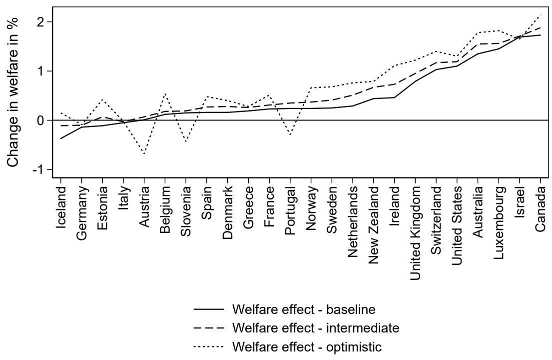
$$d^H_{M,i} = \sum_j \left(\frac{H^{emig}_{ij}}{H^{emig}_i} \right) d^H_{M,ij},$$

with the weights $\frac{H^{emig}_{ij}}{H^{emig}_i}$ being the share of high-skilled emigrants in receiving country j among all high-skilled emigrants from sending country i. The remaining down-skilling rates are computed analogously.

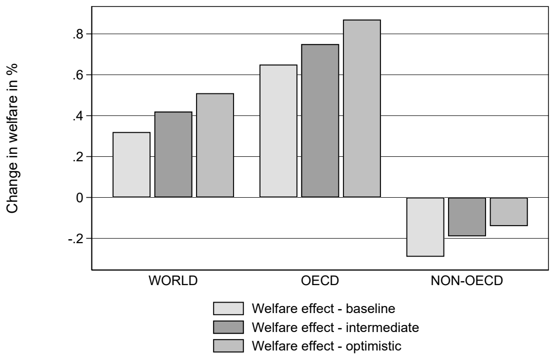
As shown in Figure E.6, down-skilling reduces the welfare effects of skill-biased migration in the receiving countries, while leaving the effect in the sending countries unchanged. The global effect is smaller but remains positive at around 0.15%.



(a) In the sending countries



(b) In the receiving countries



(c) In OECD and non-OECD countries, and in the world

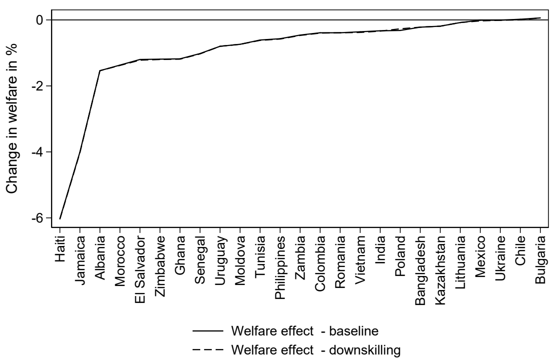
Figure E.5: Including network effects of migration on trade

Source:. Own calculations.

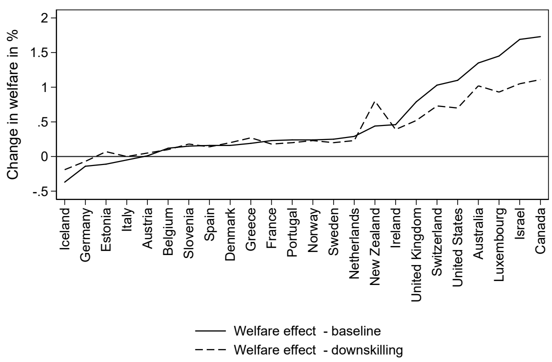
Notes: This graph displays the welfare effects of the skill bias in migration with network effects of migration on trade. The solid line represents the effect on welfare per never-migrant under the baseline. The dashed lines represents the effect on welfare per never-migrant when network effects are included in the model. In the intermediate scenario trade costs are reduced by medium and high skilled migrants. In the optimistic scenario trade costs are reduced by high skilled migrants. The countries on the horizontal axis are ordered by welfare impact per never-migrant. The vertical axis shows changes in welfare per never-migrant in percent. Panel (a) focuses on selected sending countries, while panel (b) focuses on selected receiving countries. Panel (c) shows the average effect in all non-OECD and OECD countries as well as across the whole world.

E.5 Brain gain - investment in education

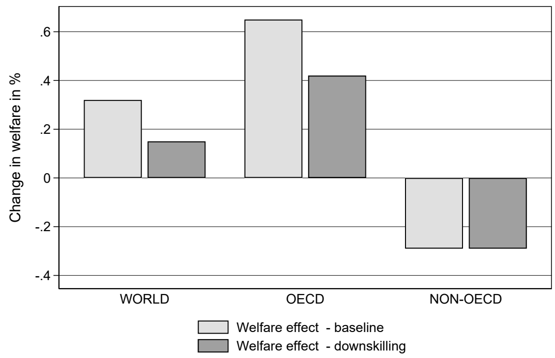
While the traditional literature on the brain drain predicted severe negative welfare effects for the sending countries, the more recent literature has highlighted that human capital externalities may partially offset the losses in the sending countries, even leading to a 'brain gain' in a more optimistic scenario. As shown in theoretical works by Mountford (1997), Stark *et al.* (1997) and Beine *et al.* (2001), the opportunity to emigrate increases the returns to education, leading to higher investment in education. This can have a positive welfare effect if not everyone who invested in education leaves the country. Several micro-studies provide evidence of a substantial response of investment in education to improvements in the possibility to migrate (Chand &



(a) In the sending countries



(b) In the receiving countries



(c) In OECD and non-OECD countries, and in the world

Figure E.6: Allowing for down-skilling in the receiving country

Source:. Own calculations.

Notes: This graph displays the average welfare effects of the skill bias in migration with down-skilling of migrants. The solid line represents the effect on welfare per never-migrant under the baseline. The dashed lines represent the effect on welfare per never-migrant with downskilling. The countries on the horizontal axis are ordered by welfare impact per never-migrant. The vertical axis shows changes in welfare per never-migrant in percent. Panel (a) focuses on selected sending countries, while panel (b) focuses on selected receiving countries. Panel (c) shows the average effect in all non-OECD and OECD countries as well as across the whole world.

Clemens, 2008, Batista *et al.* , 2011, Shrestha, 2015, Dinkelman & Mariotti, 2016). Moreover, at the macro level, Beine *et al.* (2008) find that the brain gain offsets the negative brain drain effect in sending countries with low emigration rates, while in countries with high emigration rates the negative effect dominates.

To incorporate a brain gain mechanism into the model, we endogenize the share of high-skilled stayers in the sending countries.[48] Define $sh_S = \frac{H_n}{H_n+M_n+L_n}$ and $sh_E = \frac{H_e}{H_e+M_e+L_e}$, respectively, as the observed share of high-skilled stayers and emigrants under the baseline scenario, and $\widehat{sh_S}$ and $\widehat{sh_E}$ as the equivalent shares under the counterfactual. We compute the new counterfactual share of high-skilled stayers as

[48] This represents a reduced-form relationship. The underlying microfoundations have been described in Mountford (1997) and Stark *et al.* (1997).

$$\widehat{sh_S} = sh_S\left(1 + \sigma_b \frac{\widehat{sh_E} - sh_E}{sh_E}\right). \tag{E.35}$$

The elasticity σ_b describes the strength of the brain gain mechanism. If $\sigma_b = 0$, there is no additional investment in education, whereas if σ_b is positive, the share of high-skilled stayers becomes an increasing function in the share of high-skilled emigrants. We calibrate the model using elasticities between 0 (no brain gain effect), and 0.05, the brain gain effect estimated in Beine *et al.* (2008). To compute the counterfactual skill distribution in the sending countries, we implement an iterative procedure that simultaneously solves for $\widehat{sh_S}$ and $\widehat{sh_E}$, and computes the shares of low- and medium-skilled stayers as residuals.

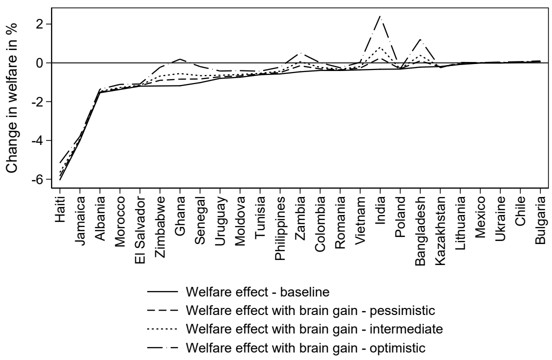
Counterfactual share of high-skilled workers The precise procedure for finding the share of high-skilled workers in the counterfactual works as follows. Define $sh_S = \frac{H_n}{H_n+M_n+L_n}$ and $sh_E = \frac{H_e}{H_e+M_e+L_e}$, respectively, as the observed share of high-skilled stayers and emigrants under the baseline scenario, and $\widehat{sh_S}$ and $\widehat{sh_E}$ as the equivalent shares under the counterfactual. We compute the new counterfactual share of high-skilled stayers as

$$\widehat{sh_S} = sh_S\left(1 + \sigma_b \frac{\widehat{sh_E} - sh_E}{sh_E}\right). \tag{E.36}$$

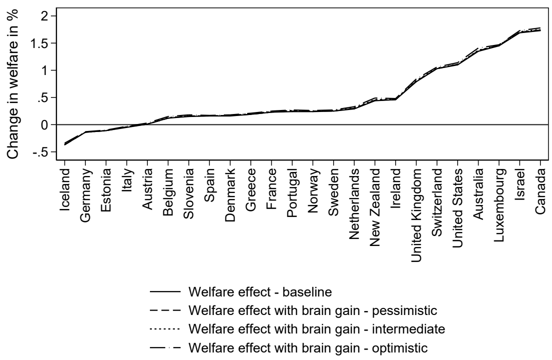
Further, define the total number of stayers and emigrants in the counterfactual world as $\widehat{Stay} = \widehat{H_n} + \widehat{M_n} + \widehat{L_n}$ and $\widehat{Emig} = \widehat{H_e} + \widehat{M_e} + \widehat{L_e}$. The new share of high-skilled workers in the total population ($\widehat{sh_N}$) is then:

$$\widehat{sh_N} = \frac{\widehat{sh_S}\widehat{Stay} + \widehat{sh_E}\widehat{Emig}}{\widehat{Stay} + \widehat{Emig}}. \tag{E.37}$$

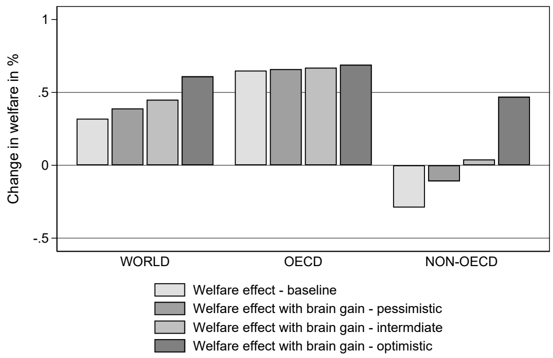
In the neutrally-selected world, the share of skilled workers among the emigrants, the stayers and the total population is equal. However, the skilled emigrants in the neutrally-selected world will induce a brain gain mechanism as the new share of skilled among emigrants becomes $\widehat{sh_E} = \widehat{sh_N}$. We therefore need to iterate on $\widehat{sh_E}$ until $\widehat{sh_E} = sh_E$. Thus, we first compute the share of skilled stayers using Equation $(E.36)$. We save the value of the share of skilled emigrants used in the computation in order to replace it in the next iteration ($sh_E = \widehat{sh_E}$). Based on this, we assess the new share of skilled natives $\widehat{sh_N}$ using Equation $(E.37)$. Given that in a neutrally-selected world $\widehat{sh_E} = \widehat{sh_N}$, we use this value in the next iteration, by inserting it jointly with the value of sh_E previously saved into Equation $(E.36)$. Hence, we iterate on sh_E until the new equilibrium share of skilled natives (and emigrants) is obtained (i.e. $sh_S = \widehat{sh_S}$ in Equation $(E.36)$). We can then assess the new skill distribution of the population. The total population and the number of emigrants does not change (by assumption) and the initial share of tertiary-educated workers allows us to recover the number of educated workers in each population group (emigrants and stayers). The remaining workers are distributed between the medium- and low-skilled groups using the relative weight of the groups in our baseline counterfactual exercise, namely $sh_{Med} = \frac{Med}{Med+Low}$ for the medium-skilled and $sh_{Low} = \frac{Low}{Med+Low}$ for the low-skilled. Hence, the new shares of medium- and low-skilled workers become $\widehat{sh_{Med}} = sh_{Med}(1-\widehat{sh_N})$ and $\widehat{sh_{Low}} = sh_{Low}(1-\widehat{sh_N})$, respectively. Multiplying the total number of stayers and emigrants by these respective shares allows us to recover the full distribution of workers.



(a) In the sending countries



(b) In the receiving countries



(c) In OECD and non-OECD countries, and in the world

Figure E.7: Allowing for brain gain

Source:. Own calculations.

Notes: This graph displays the welfare effects of the skill bias in migration allowing for incentives to invest in education in the sending countries. The solid line represents the effect on welfare per never-migrant under the baseline. The dashed lines represent the effect on welfare per never-migrant when brain gain is allowed. We vary the elasticity parameter σ_b. The pessimistic scenario sets $\sigma_b = 0.01$, the intermediate scenario sets $\sigma_b = 0.02$ and the optimistic scenario sets $\sigma_b = 0.05$. The countries on the horizontal axis are ordered by welfare impact per never-migrant. The vertical axis shows changes in welfare per never-migrant in percent. Panel (a) focuses on selected sending countries, while panel (b) focuses on selected receiving countries. Panel (c) shows the average effect in all non-OECD and OECD countries as well as across the whole world.

Results The simulation results are displayed in Figure E.7. Results are reported for three different scenarios: a pessimistic one, with a low brain gain elasticity, set to 0.01, an intermediate scenario, with elasticity at 0.02 and an optimistic scenario, with elasticity at 0.05. The brain gain channel dampens the welfare losses from skill-biased migration in the sending countries, even leading to an overall welfare gain in some cases. The receiving countries are only mildly affected due to general equilibrium effects. In the optimistic scenario, with a brain gain elasticity of $\sigma_b = 0.05$, the impact of the skill bias in migration on world welfare is twice as large as without a brain gain mechanism. However, one should be cautious when interpreting the difference in results with and without brain gain because they do not represent marginal effects. In some countries, the share of high-skilled emigrants under the baseline is a multiple of the share of high-skilled emigrants under the counterfactual. Thus, an elasticity of $\sigma_b = 0.05$ is probably too high to account for these substantial differences in high-skilled emigration rates. However, even at a modest brain gain elasticity of $\sigma_b = 0.01$, the welfare losses in the sending countries are considerably lower than in a world without brain gain.

F Sensitivity checks

In this section we report sensitivity checks of: 1) the benchmark model to changes in structural parameters, 2) the most plausible scenario to changes in all structural parameters, from pessimistic to optimistic values, 3) the benchmark model, where production now follows a three-level CES. Table F.2 summarizes the parameter values used in the sensitivity checks.

Table F.2: Sensitivity checks to structural parameters

Parameters	Pessimistic	Intermediate/Baseline	Optimistic
ε	3	4	5
θ	0.5	3	3.9
σ_s	2	5	8
σ_n	100	20	10
μ	0.1	0.5	0.6
β	0.1	0.5	0.9
f_x	-	$f_x \times 1$	$f_x \times 10$

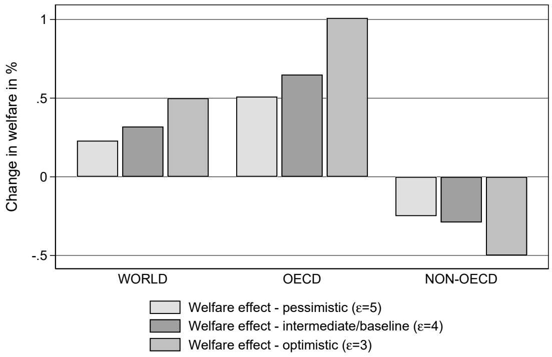
Note: This table summarizes the calibration of the structural parameters in the sensitivity checks reported in Section F.1.

F.1 Sensitivity of the benchmark model to structural parameters

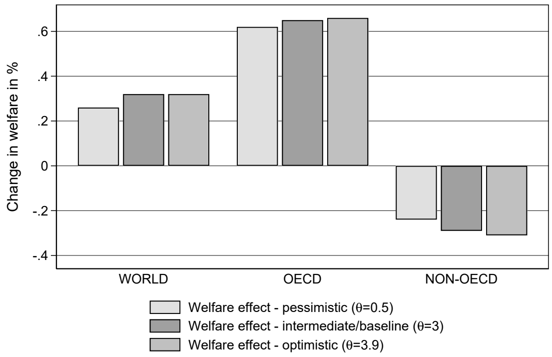
In Figure F.7 panels (a)-(g), we perform a series of sensitivity checks with respect to the structural parameters. Overall, the results are both quantitatively and qualitatively robust to changes in parameters, although some parameters have a greater influence than others. The details are as follows:

- In panel (a), we vary the elasticity of substitution between varieties of X and Y. A higher elasticity of substitution translates into a more pronounced market size effect, which leads to higher gains in the receiving and higher losses in the sending countries.
- In panel (b), we vary the elasticity of substitution between tradable and non-tradable goods. The results are very similar to the baseline results. A higher elasticity of substitution leads to a greater response in trade flows, and dampens the overall effect.
- In panel (c), we vary the elasticity of substitution between different education levels, σ_s. A low substitutability between high- and low-skilled workers has a particularly strong impact on the sending countries, because it becomes more difficult for low-skilled workers to replace high-skilled emigrants.

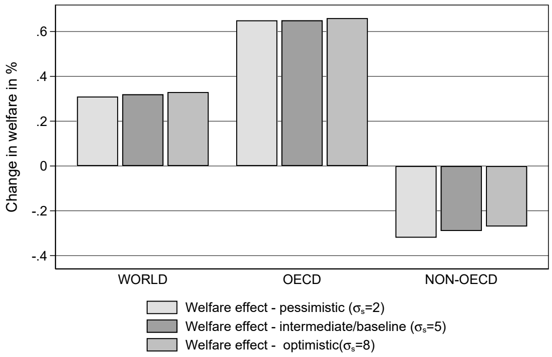
- In panel (d), we vary the elasticity of substitution between migrants and natives, σ_n. In the sending countries, this parameter only affects the overall welfare effect through trade, but the results hardly respond to changes in σ_n. In the receiving countries, the effects are larger when migrants and natives are closer substitutes, but the overall results do not change by a large amount.
- In panel (e), we vary the preference parameter for the output from the traditional sector, μ. If this parameter is very low, the effects are smaller because a given change in consumption of T has a smaller impact on utility.
- In panel (f), when we vary β, the relative preference for the tradable manufactured good, it turns out that the largest effect in the sending countries occurs if both goods receive equal weight, and the increase in market size is spread across both sectors, X and Y. In the receiving countries, the welfare effect is almost unaffected by changes in β.
- In panel (g), we increase the fixed costs of entry by multiplying the original fixed costs with a factor 10. The effects in the sending countries are stronger, because even fewer varieties are produced in the baseline compared to the counterfactual.



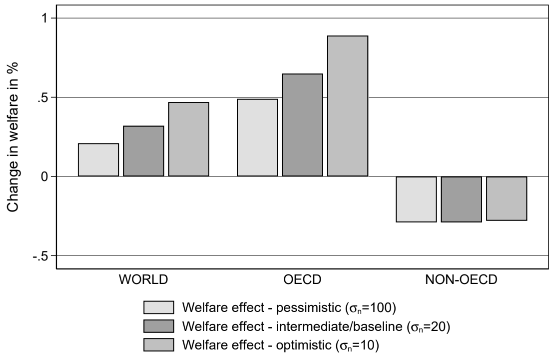
(a) Varying ε



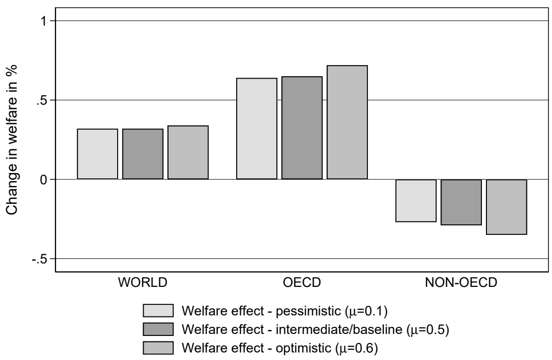
(b) Varying θ



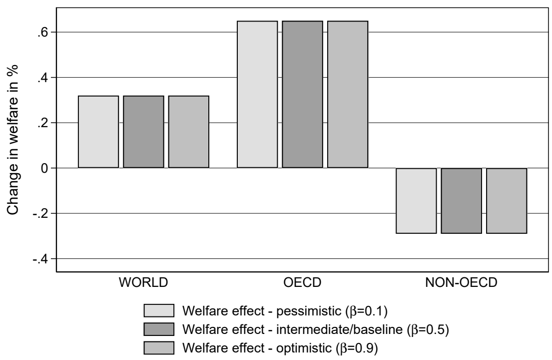
(c) Varying σ_s



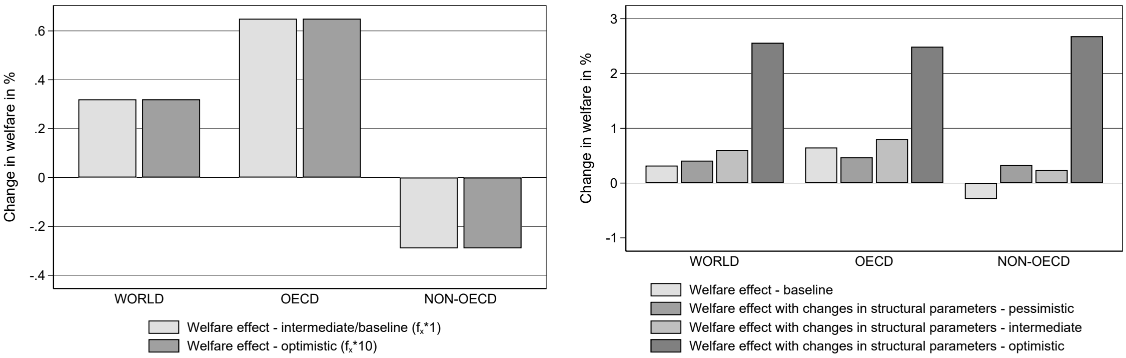
(d) Varying σ_n



(e) Varying μ



(f) Varying β



(g) Varying f_x

(h) Varying all structural parameters with all migration channels

Figure F.7: Sensitivity Checks

Source:. Own calculations.

Notes: Panel (a) displays the welfare effects of the skill bias in migration with varying elasticity of substitution between differentiated goods, $\varepsilon \in \{3, 4, 5\}$. Panel (b) displays the welfare effects of the skill bias in migration with varying elasticity of substitution between tradable and non-tradable goods, $\theta \in \{0.5, 3, 3.9\}$. Panel (c) displays the welfare effects of the skill bias in migration with varying elasticity of substitution between education groups, $\sigma_s \in \{2, 5, 8\}$. Panel (d) displays the welfare effects of the skill bias in migration with varying elasticity of substitution between immigrants and natives, $\sigma_n \in \{10, 20, 100\}$. Panel (e) displays the welfare effects of the skill bias in migration with a varying preference parameter for the traditional good, $\mu \in \{0.1, 0.5, 0.6\}$. Panel (f) displays the welfare effects of the skill bias in migration with varying relative preference for the tradable good, $\beta \in \{0.1, 0.5, 0.9\}$. Panel (g) displays the welfare effects of the skill bias in migration with varying fixed costs of entry (baseline vs. fixed cost under baseline multiplied by 10). Panel (h) displays the welfare effects in a model with remittances ($\gamma = 0$), brain gain ($\sigma_b = 0.02$), human capital externalities ($\sigma_a = 0.3$), network effects (trade costs reduced by medium and high skilled migrants) and downskilling. We then set the structural parameters to the following levels: in the pessimistic scenario to all pessimistic levels reported above, in the intermediate scenario to all intermediate levels and in the optimistic scenario to all optimistic levels. In all panels, the vertical axis shows changes in welfare per never-migrant in percent.

F.2 Sensitivity of the "most plausible scenario" to changes in structural parameters

In Section 6.2 we kept our technology and the preference parameters to their baseline, intermediate, level (reported again in Table F.2) and included all the additional adjustment mechanisms stemming from migration.[49] We discussed there the relevance of these mechanisms and varied their strength. We also discussed a most plausible scenario, in which structural parameters and parameters for migration-driven mechanisms were all at an intermediate level.

One might wonder if our conclusions would be affected by varying instead the structural parameters of the model. Figure F.7(h) carries out the following simulations. We consider the most plausible scenario, whereby all migration mechanisms and preference parameters were set at their intermediate value, as listed in Table 3. This corresponds to the intermediate scenario of Section 6.2. Next, we set all structural parameters to their lower bound (pessimistic scenario) and the upper bound (optimistic scenario), as listed in Table F.2, and quantify the welfare implication of skill-biased migration.

Figure F.7(h) shows that the results from the most plausible scenario of 0.6% global gains are lower if we use a more conservative set of structural parameters and reach about 0.41%. This number is still above our baseline result, which, once again, proves to be a lower bound of global welfare gains. By using more optimistic values of the structural parameters, welfare gains increase further and distributional concerns across country regions are dampened.

To summarize, while the magnitude of the effects is affected by changes in the parameters, the qualitative result of a positive global welfare effect remains.

F.3 Sensitivity checks to different nesting of the CES

To further check the sensitivity of our model, we model production using the nested CES structure for the labor-composite suggested by Ottaviano & Peri (2012). L_i, M_i and H_i represent the supplies of low-, medium- and high-skilled workers in the manufacturing sector. The parameter α_i^a indicates the efficiency of the low-skill labor composite in production. The low-skill labor-composite consists of less-educated and medium-educated workers

$$Q_i^{M,l} = \left[\alpha_i^b \, (L_i)^{\frac{\sigma_2 - 1}{\sigma_2}} + (1 - \alpha_i^b) \, (M_i)^{\frac{\sigma_2 - 1}{\sigma_2}}\right]^{\frac{\sigma_2}{\sigma_2 - 1}}, \tag{F.38}$$

where α_i^b is the efficiency of the less-educated workers. Each skill-group (L_i, M_i and H_i) consists of natives (labeled by superscripts N) and foreigners (with superscripts F). All domestic and foreign workers are assumed to be imperfect substitutes with a constant elasticity of substitution

[49] Technology parameters are the elasticity of substitution between varieties ϵ, tradable and non-tradable θ, education levels σ_s, migrants and natives σ_n and the level of fixed costs f_x. Preference parameters are: the one for output μ and the relative preference for the tradable manufactured good β.

equal to σ_3. We define the efficient labor supplies for each sector and education group as

$$\begin{aligned}
L_i^T &= \left[(1-\alpha_i^c)(L_i^{T,N})^{\frac{\sigma_3-1}{\sigma_3}} + \alpha_i^c(L_i^{T,F})^{\frac{\sigma_3-1}{\sigma_3}}\right]^{\frac{\sigma_3}{\sigma_3-1}}, \\
L_i &= \left[(1-\alpha_i^c)(L_i^{N})^{\frac{\sigma_3-1}{\sigma_3}} + \alpha_i^c(L_i^{F})^{\frac{\sigma_3-1}{\sigma_3}}\right]^{\frac{\sigma_3}{\sigma_3-1}}, \\
M_i &= \left[(1-\alpha_i^c)(M_i^{N})^{\frac{\sigma_3-1}{\sigma_3}} + \alpha_i^c(M_i^{F})^{\frac{\sigma_3-1}{\sigma_3}}\right]^{\frac{\sigma_3}{\sigma_3-1}}, \\
H_i &= \left[(1-\alpha_i^c)(H_i^{N})^{\frac{\sigma_3-1}{\sigma_3}} + \alpha_i^c(H_i^{F})^{\frac{\sigma_3-1}{\sigma_3}}\right]^{\frac{\sigma_3}{\sigma_3-1}}.
\end{aligned} \tag{F.39}$$

We assume a fixed, country-specific share of outputs of natives and foreigners ($(1-\alpha_i^c)$ and α_i^c respectively).

Firms solve their cost-minimization problem, taking wages as given. Demand for each type of labor is then set as

$$\begin{aligned}
L_i^N &= \frac{Z_i^M}{A_i^M}\left[\frac{(1-\alpha_i^c)W_i^L}{w_i^{LN}}\right]^{\sigma_3}\left[\frac{\alpha_i^b W_i^c}{W_i^L}\right]^{\sigma_2}\left[\frac{\alpha_i^a W_i}{W_i^c}\right]^{\sigma_1}, & L_i^{T,N} &= \frac{Z_i^T}{A_i^T}\left[\frac{(1-\alpha_i^c)W_i^L}{w_i^{LN}}\right]^{\sigma_3}, \\
L_i^F &= \frac{Z_i^M}{A_i^M}\left[\frac{\alpha_i^c W_i^L}{w_i^{LF}}\right]^{\sigma_3}\left[\frac{\alpha_i^b W_i^c}{W_i^L}\right]^{\sigma_2}\left[\frac{\alpha_i^a W_i}{W_i^c}\right]^{\sigma_1}, & L_i^{T,F} &= \frac{Z_i^T}{A_i^T}\left[\frac{\alpha_i^c W_i^L}{w_i^{LF}}\right]^{\sigma_3}, \\
M_i^N &= \frac{Z_i^M}{A_i^M}\left[\frac{(1-\alpha_i^c)W_i^M}{w_i^{MN}}\right]^{\sigma_3}\left[\frac{(1-\alpha_i^b)W_i^c}{W_i^M}\right]^{\sigma_2}\left[\frac{\alpha_i^a W_i}{W_i^c}\right]^{\sigma_1}, & H_i^N &= \frac{Z_i^M}{A_i^M}\left[\frac{(1-\alpha_i^c)W_i^H}{w_i^{HN}}\right]^{\sigma_3}\left[\frac{(1-\alpha_i^a)W_i}{W_i^H}\right]^{\sigma_1}, \\
M_i^F &= \frac{Z_i^M}{A_i^M}\left[\frac{\alpha_i^c W_i^M}{w_i^{MF}}\right]^{\sigma_3}\left[\frac{(1-\alpha_i^b)W_i^c}{W_i^M}\right]^{\sigma_2}\left[\frac{\alpha_i^a W_i}{W_i^c}\right]^{\sigma_1}, & H_i^F &= \frac{Z_i^M}{A_i^M}\left[\frac{\alpha_i^c W_i^H}{w_i^{HF}}\right]^{\sigma_3}\left[\frac{(1-\alpha_i^a)W_i}{W_i^H}\right]^{\sigma_1},
\end{aligned} \tag{F.40}$$

where the wage indices for the medium- and high-skilled workers are equal to:

$$\begin{aligned}
W_i^L &= \left[(1-\alpha_i^c)^{\sigma_3}(w_i^{LN})^{1-\sigma_3} + (\alpha_i^c)^{\sigma_3}(w_i^{LF})^{1-\sigma_3}\right]^{\frac{1}{1-\sigma_3}}, \\
W_i^M &= \left[(1-\alpha_i^c)^{\sigma_3}(w_i^{MN})^{1-\sigma_3} + (\alpha_i^c)^{\sigma_3}(w_i^{MF})^{1-\sigma_3}\right]^{\frac{1}{1-\sigma_3}}, \\
W_i^H &= \left[(1-\alpha_i^c)^{\sigma_3}(w_i^{HN})^{1-\sigma_3} + (\alpha_i^c)^{\sigma_3}(w_i^{HF})^{1-\sigma_3}\right]^{\frac{1}{1-\sigma_3}},
\end{aligned} \tag{F.41}$$

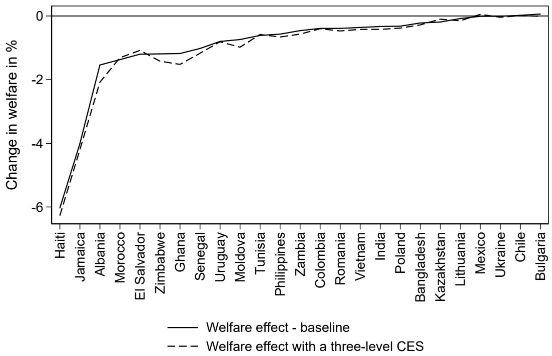
the wage index of the less- and medium-educated workers is given by:

$$W_i^c = \left[(\alpha_i^b)^{\sigma_2}(W_i^L)^{1-\sigma_2} + (1-\alpha_i^b)^{\sigma_2}(W_i^M)^{1-\sigma_2}\right]^{\frac{1}{1-\sigma_2}}, \tag{F.42}$$

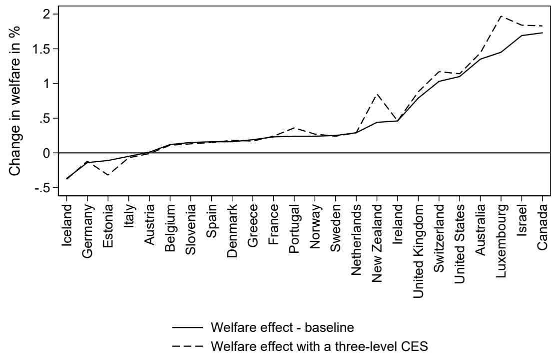
and the overall wage index in the manufacturing sector is given by:

$$W_i = \left[(\alpha_i^a)^{\sigma_1}(W_i^c)^{1-\sigma_1} + (1-\alpha_i^a)^{\sigma_1}(W_i^H)^{1-\sigma_1}\right]^{\frac{1}{1-\sigma_1}}. \tag{F.43}$$

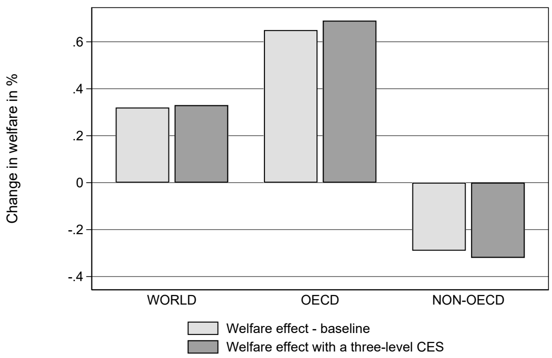
Following Ottaviano & Peri (2012) we set $\sigma_1 = 2, \sigma_2 = 30, \sigma_3 = 20$. Results using this different production function are shown in Figure F.8. The consequences are very minimal and, if anything, our baseline results are once again slightly more conservative: global welfare gains are 0.33% with a three-level CES vs 0.32% in our baseline.



(a) In the sending countries



(b) In the receiving countries



(c) In OECD and non-OECD countries, and in the world

Figure F.8: Changing nesting in the CES

Source:. Own calculations.

Notes: This graph displays the welfare effects of the skill bias in migration with a nested CES production function. We set $\sigma_1 = 2, \sigma_2 = 30, \sigma_3 = 20$. The solid line represents the effect on welfare per never-migrant under the baseline. The dashed lines represent the effect on welfare per never-migrant with a nested CES production function. The countries on the horizontal axis are ordered by welfare impact per never-migrant. The vertical axis shows changes in welfare per never-migrant in percent. Panel (a) focuses on selected sending countries, while panel (b) focuses on selected receiving countries. Panel (c) shows the average effect in all non-OECD and OECD countries as well as across the whole world.

G List of abbreviations and full baseline results

Table G.3: List of Country Abbreviations and Baseline Results

Abbreviation	Country	Welfare per capita	Welfare per never-migrant
Overall Average Effects			
WORLD	World average	1.43%	0.32%
OECD	OECD average	2.54%	0.65%
NON-OECD	non-OECD average	-0.83%	-0.29%
OECD countries			
AUS	Australia	4.82%	1.35%
AUT	Austria	-0.01%	0.01%
BEL	Belgium	0.32%	0.12%
CAN	Canada	6.58%	1.73%
CHE	Switzerland	4.81%	1.03%
CHL	Chile	-0.03%	0.02%
CZE	Czech Republic	-0.46%	-0.08%
DEU	Germany	-0.61%	-0.14%
DNK	Denmark	0.45%	0.16%
ESP	Spain	0.54%	0.16%
EST	Estonia	-0.50%	-0.11%
FIN	Finland	-0.06%	-0.02%
FRA	France	0.77%	0.23%
GBR	United Kingdom	2.62%	0.79%
GRC	Greece	0.56%	0.19%
HUN	Hungary	-0.39%	-0.06%
IRL	Ireland	1.20%	0.46%
ISL	Iceland	-1.13%	-0.37%
ISR	Israel	5.99%	1.69%
ITA	Italy	-0.22%	-0.05%
JPN	Japan	0.11%	0.05%
KOR	Korea, Rep.	-0.40%	-0.09%
LUX	Luxembourg	5.10%	1.45%
MEX	Mexico	-0.06%	-0.01%
NLD	Netherlands	0.97%	0.29%
NOR	Norway	0.75%	0.24%
NZL	New Zealand	1.54%	0.44%
POL	Poland	-1.27%	-0.32%
PRT	Portugal	0.95%	0.24%
SVK	Slovak Republic	-1.49%	-0.39%
SVN	Slovenia	0.56%	0.15%
SWE	Sweden	0.80%	0.25%
TUR	Turkey	-0.10%	-0.05%
USA	United States	4.17%	1.10%

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Table G.3 – continued from previous page

Abbreviation	Country	Welfare per capita	Welfare per never-migrant
	NON-OECD countries		
AFG	Afghanistan	-1.43%	-0.68%
ALB	Albania	-2.70%	-1.54%
ARE	United Arab Emirates	-0.33%	-0.08%
ARG	Argentina	-1.40%	-0.42%
ARM	Armenia	-2.37%	-1.02%
BDI	Burundi	-1.72%	-1.04%
BEN	Benin	-0.78%	-0.42%
BGD	Bangladesh	-0.64%	-0.22%
BGR	Bulgaria	0.13%	0.06%
BHR	Bahrain	-1.26%	-0.28%
BLZ	Belize	-10.68%	-4.06%
BOL	Bolivia	-0.91%	-0.35%
BRA	Brazil	-0.36%	-0.10%
BRB	Barbados	-12.71%	-5.24%
BRN	Brunei Darussalam	-1.46%	-0.37%
BWA	Botswana	-0.73%	-0.20%
CAF	Central African Republic	-2.64%	-1.83%
CHN	China	-0.09%	-0.02%
CIV	Cote d'Ivoire	-1.55%	-0.61%
CMR	Cameroon	-2.84%	-1.19%
COD	Democratic Republic of the Congo	-1.32%	-0.59%
COG	Congo	-1.89%	-0.47%
COL	Colombia	-1.34%	-0.39%
CRI	Costa Rica	-0.85%	-0.25%
CUB	Cuba	-4.71%	-1.39%
CYP	Cyprus	-0.01%	0.02%
DOM	Dominican Republic	-3.42%	-1.04%
DZA	Algeria	-2.50%	-0.70%
ECU	Ecuador	-2.58%	-0.80%
EGY	Egypt	-0.76%	-0.26%
FJI	Fiji	-4.32%	-1.77%
GAB	Gabon	-2.40%	-0.66%
GHA	Ghana	-2.37%	-1.18%
GMB	Gambia, The	-4.03%	-2.04%
GTM	Guatemala	-2.58%	-1.23%
GUY	Guyana	-13.59%	-8.93%
HKG	Hong Kong SAR, China	-2.10%	-0.44%
HND	Honduras	-7.37%	-2.25%
HRV	Croatia	0.68%	0.21%
HTI	Haiti	-11.44%	-6.03%
IDN	Indonesia	-0.07%	-0.02%
IND	India	-0.97%	-0.33%

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Table G.3 – continued from previous page

Abbreviation	Country	Welfare per capita	Welfare per never-migrant
IRN	Iran	-1.41%	-0.46%
IRQ	Iraq	-1.63%	-0.52%
JAM	Jamaica	-12.90%	-4.01%
JOR	Jordan	-1.35%	-0.34%
KAZ	Kazakhstan	-0.55%	-0.19%
KEN	Kenya	-3.93%	-1.67%
KGZ	Kyrgyz Republic	-0.25%	-0.10%
KHM	Cambodia	-1.48%	-0.88%
KWT	Kuwait	-2.23%	-0.58%
LAO	Lao PDR	-2.86%	-1.96%
LBR	Liberia	-7.22%	-4.03%
LBY	Libya	-0.67%	-0.14%
LKA	Sri Lanka	-2.19%	-0.73%
LSO	Lesotho	-0.39%	-0.17%
LTU	Lithuania	-0.47%	-0.08%
LVA	Latvia	-1.87%	-0.50%
MAC	Macao SAR, China	-0.01%	-0.01%
MAR	Morocco	-3.92%	-1.37%
MDA	Moldova	-2.11%	-0.74%
MDV	Maldives	-0.53%	-0.15%
MLI	Mali	-1.07%	-0.65%
MLT	Malta	-6.82%	-1.71%
MMR	Myanmar	-0.37%	-0.28%
MNG	Mongolia	-0.29%	-0.11%
MOZ	Mozambique	-1.09%	-0.54%
MRT	Mauritania	-1.02%	-0.34%
MUS	Mauritius	-6.53%	-2.06%
MWI	Malawi	-0.68%	-0.34%
MYS	Malaysia	-0.54%	-0.14%
NAM	Namibia	-1.05%	-0.34%
NER	Niger	-0.15%	-0.09%
NIC	Nicaragua	-6.52%	-2.36%
NPL	Nepal	-1.72%	-0.93%
PAK	Pakistan	-1.53%	-0.62%
PAN	Panama	-2.91%	-0.80%
PER	Peru	-1.35%	-0.39%
PHL	Philippines	-1.40%	-0.57%
PNG	Papua New Guinea	-0.87%	-0.55%
PRY	Paraguay	-0.91%	-0.36%
QAT	Qatar	-0.48%	-0.08%
ROU	Romania	-1.31%	-0.39%
RUS	Russian Federation	0.34%	0.10%
RWA	Rwanda	-1.51%	-0.79%

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Table G.3 – continued from previous page

Abbreviation	Country	Welfare per capita	Welfare per never-migrant
SAU	Saudi Arabia	-0.33%	-0.05%
SDN	Sudan	-0.76%	-0.34%
SEN	Senegal	-2.67%	-1.02%
SGP	Singapore	-0.49%	-0.07%
SLE	Sierra Leone	-8.31%	-6.04%
SLV	El Salvador	-3.22%	-1.20%
SRB	Serbia	0.22%	0.10%
SWZ	Swaziland	-1.24%	-0.45%
SYR	Syrian Arab Republic	-1.15%	-0.42%
TGO	Togo	-1.10%	-0.57%
THA	Thailand	-0.24%	-0.06%
TJK	Tajikistan	-0.19%	-0.08%
TON	Tonga	-3.56%	-1.93%
TTO	Trinidad and Tobago	-10.03%	-2.68%
TUN	Tunisia	-2.17%	-0.61%
TWN	Taiwan	-0.58%	-0.19%
TZA	Tanzania	-1.10%	-0.56%
UGA	Uganda	-1.47%	-0.67%
UKR	Ukraine	-0.05%	-0.01%
URY	Uruguay	-2.58%	-0.80%
VEN	Venezuela	-1.31%	-0.39%
VNM	Vietnam	-0.96%	-0.36%
YEM	Yemen	-0.37%	-0.12%
ZAF	South Africa	-2.48%	-0.64%
ZMB	Zambia	-1.35%	-0.46%
ZWE	Zimbabwe	-2.76%	-1.19%
ROW	Rest of World	-1.38%	-0.59%