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Doctoral Thesis

The Macroeconomics of Immigration, Search and Income Inequality

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Declaration of Autorship

I, Bright Isaac Ikhenaode, declare that this thesis titled, "The Macroeconomics of Immigration, Search and Income Inequality" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- Where I have clearly indicated any work carried out jointly by myself and any other person.
- I have acknowledged all main sources of help.

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Date:

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Summary

This thesis comprises three chapters that analyze the impact of migration on welfare, inequality and macroeconomic stability in the presence of labor market frictions.

Chapter 1 presents a dynamic two-country model with search frictions and endogenous labor migration to study the long-run implications of labor factor mobility on the economic performance and welfare of both source and host countries. In the model, the two countries differ in productivity, so that the high-TFP country (North) acts as the destination country for migration, while the low-TFP country (South) acts as the origin country. In this chapter, we prove that there always exists a unique steady-state equilibrium for the world economy, and find that a permanent increase in migration effort causes per capita income to rise in North and to fall in South. However, our simulations also show the existence of a job displacement effect in the host country that makes domestic employment fall in the longrun. In an extension of the baseline model, we test the long-run effects of a pro-employment protectionist policy of the destination country consisting in imposing a distortionary tax on the domestic firms hiring migrant workers. Our analysis shows that a positive tax rate on foreign employment can increase natives welfare, but only at the expense of losses in national production and employment. These results are robust across different degrees of substituability between migrant and native workers.

Chapter 2 addresses the importance of the labor market structure when assessing the welfare and inequality effects of immigration. In particular, in this chapter we build and parameterize a general equilibrium model that allows to compare seven labor market specifications. These variants combine different assumptions concerning labor supply decisions, unemployment rates and wage levels, as well as different calibration strategies. Quantitatively, we find that the labor market specification matters. Modelling unemployment is instrumental to assessing the average welfare effects from immigration, while modelling labor force participation is instrumental to assessing its inequality effects. The specification choice is usually more important than the calibration of labor market elasticities, except for the choice of the elasticity of substitution between immigrants and natives.

Chapter 3 analyzes the effects of immigration on natives welfare, labor market outcomes and fiscal redistribution in a selected group of 19 OECD countries. To this end, we build and simulate a search and matching model that allows for endogenous natives skill acquisition and intergenerational transfers. The obtained results are then compared with different variations of our benchmark model, allowing us to assess to what extent natives skill adjustment and age composition affect the impact of immigration. Our comparative statics analysis suggests that when natives adjust their skill in response to immigration, they successfully avoid, under most scenarios, any potential displacement effect in the labor market. Moreover, taking into account age composition plays a key role in assessing the fiscal impact of immigration, which turns out to be positive when we include retired workers that receive intergenerational transfers. Finally, we find that, under any scenario, our model yields more optimistic welfare effects than a standard search model that abstracts from skill decision and intergenerational redistribution. These welfare effects are found to be overall particularly positive when the migration flows comprise high-skilled workers.

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Chapter 1

Endogenous Migration in a Two-Country Model with Labor Market Frictions*

1.1 Introduction

This study develops a two-country Neoclassical model with labor market frictions and endogenous migration to analyze the long-run effects of international labor migration on macroeconomic performance and social welfare. The literature on international macroeconomics has so far paid a limited attention to the general-equilibrium implications of labor mobility. Studies that have analyzed the dynamic effects of migration by means of open economy frameworks include Galor (1986), Miyagiwa (1991), Reichlin and Rustichini (1998), Lundborg and Segerstrom (2000), Larramona and Sanso (2006), Klein and Ventura (2009), Kim et al. (2010), Levine et al. (2010), Mandelman and Zlate (2012), Khraiche (2015) and Parello (2017). These studies do not consider employment/unemployment issues that may arise as a result in the host country labor market. This study tries to bridge the gap of the literature and investigates how migration affects capital accumulation, labor market conditions and employment in both the origin and the destination economy. To this end, we extend the dynamic framework with labor market frictions developed by Hashimoto and Im (2016) to the case of a two-country model with international labor migration.

In order to build a model as tractable as possible, we focus on an asymmetric scenario in which the two-country economy is composed of a low-TFP economy (henceforth referred as "South") and a high-TFP economy (henceforth referred as "North"). Labor markets are characterized by frictional unemployment and, because of the difference in countries productivity, only workers in South find it profitable to look for a job abroad.

The choice of a frictional labor market allows us to (i) get a better grasp of the underlying interdependence between labor market conditions and migration dynamics; (ii) have a better comprehension of the main dynamic implications of migration on national saving, physical capital

*This work is jointly written with Carmelo Pierpaolo Parello.

accumulation and social welfare. Indeed, in contrast to the bulk of the literature, in our model migrants never cut their ties with their original households, and optimally determine the amount of personal consumption, saving and remittances to be sent to the country of origin.[1]

Though most of the theoretical contributions on migration and growth consider domestic and immigrant workers as perfect substitutes in production, in this chapter we follow Parello (2017) and use a two-level production technology in which natives and immigrants enter production as imperfect substitutes. As the issue is controversial and the empirical literature has so far given no clear-cut results on this issue (see, e.g., Cortes, 2008; Card, 2009; Ottaviano and Peri, 2012), in order to account for the contribution of immigrants to the production process in North, we use a CES aggregator of domestic and migrant workers able to capture all degrees of substitutability between the two types of workers.

The model is solved for the steady-state equilibrium and then used to explore, through the use of several simulation exercises, the long-run effects of an increase in migration intensity on per capita consumption, employment, remittances and physical capital accumulation. Here, our ultimate goal is to investigate to what extent changes in labor market conditions, induced by labor mobility, represent a boon or a bane for both the origin and the destination country.

The main results of the study are the following. First, despite the analytical complexities of the model, we analytically prove that there always exists a unique steady-state equilibrium for the world economy. Second, we find that a permanent increase in migration flows causes per capita consumption to increase worldwide in the post-increase equilibrium. Third, higher migration intensity spurs job competition in the host labor market and generates a sort of "displacement effect" that hurts native employment. However, despite native displacement, increased migration causes overall employment to increase in the destination country, which in turn induces firms to increase capital accumulation. Fourth, increases in migration flows are found not to affect the equilibrium wage rate in South, while they are found to asymmetrically affect the equilibrium wage rates in North. Specifically, our simulations show that whilst immigrant employment suffers a loss in wages because of the competition coming from new immigrants, the equilibrium wage rate paid to native workers is positively affected by migration due to the imperfect substitutability hypothesis incorporated in the CES aggregator of labor types.

We also simulate the welfare effect of migration and find that, though emigration leads to a permanent increase in output per inhabitant in the host country and to a permanent fall in the source country, households welfare is found to increase in both countries, with Southern households gaining relatively more than the Northern ones. This result is due to the increase in

[1] According to World Bank (2018), the estimated remittances to low- and middle-income countries amount to $466 billions in 2017. India ($ 69 billions), China ($ 64 billions), Philippines ($ 33 billions) and Mexico ($ 31 billions) are the largest recipient countries, as well as the top countries from which U.S. immigrant workers come from. See Rapoport and Docquier (2006) for an in-depth review of remittances behavior and their potential effects on developing countries growth.

the overall flow of remittances that prevents per capita consumption from falling because of the reduction in final output. Even though the final effect of increasing labor migration is a reduced flow of per capita remittances, the increased share of immigrant employment characterizing the post-shock equilibrium causes the overall flow of remittances to rise, thereby allowing households in South to compensate for the loss of income due to emigration.

In the last part of the chapter, we also consider an extension of the benchmark model to the case of a "protectionist" policy consisting in imposing a (distortionary) tax on firms hiring immigrant workers. In her 2017 French presidential campaign, right-wing candidate Marine Le Pen proposed to impose an extra tax on the employment of non-French workers with the aim of protecting national employment. We use Marine Le Pen's proposed policy as an example to assess up to what extent protectionist policies can be effective in slowing down migration and support national employment and welfare. We find that raising a 10 percent tax on immigrant employment is far from being employment enhancing for the receiving country. Specifically, we find that, though the imposition of a tax on foreign labor is able to increase native welfare, it fails to turn down the native displacement effect and leads to a permanent fall in per capita output and equilibrium employment of the receiving country.

Our study relates to the literature on migration and growth. In particular, our study closely relates to Mandelman and Zlate (2012) and Parello (2017). Mandelman and Zlate (2012) analyze the effects of a border enforcement between U.S. and Mexico through a two-country business cycle model of labor migration and remittances. In line with our findings, they show that when foreign labor becomes relatively scarce, immigrants earn higher wages and increase remittances to their countries of origin. At the same time, a lower share of migrant workers reduces capital accumulation and dampens labor productivity in the destination economy. However, the authors completely abstract from employment issues, so that the presence of potential displacement effects in the host economy are not considered in their model.

Similarly to us, Parello (2017) relies on a CES aggregator to aggregate across native and immigrant labor. However, in contrast to our study, Parello's analysis focuses on a full-employment small open economy with frictionless migration and finds that both local and global indeterminacy can emerge in the equilibrium. Our study improves upon Parello's in at least two respects. First, our model adopts a North-South approach rather than a small open economy approach to study the macroeconomic implications of migration. Second, in our model migration is not governed by a frictionless Harris-Todaro migration function as they are in Parello's, but rather it is the result of a utility-maximizing decision made by decentralized agents.

Our study also relates to the recent stream of the macroeconomic literature that studies the macroeconomic implications of migration (both legal and illegal) through search and matching models. Far from being vast, this literature includes papers by Ortega (2000), Liu (2010), Chassamboulli and Palivos (2014), Chassamboulli and Peri (2015), and Battisti et al. (2018). In particular, a paper closely related to our analysis is Liu (2010), who employs a dynamic general equilibrium model with labor market frictions to explore the economic consequences of illegal migration. In his model, increased job competition in the host labor market lowers the job finding rate of native unemployed workers, and therefore generates a displacement effect that harms the level of welfare of the natives permanently. However, Liu's closed economy framework migration is exogenous, while in our two-country approach it is endogenously determined by market forces.

analysis focuses on a closed economy framework with exogenous migration.

The outline of the chapter is the following. Section 1.2 introduces the baseline version of our North-South model with migration and characterizes the search equilibrium. Section 1.3 describes the calibration procedure used to simulate the model and discusses the main macroeconomic implications of a permanent increase in Southern workers looking for a job in North. Section 1.4 presents an extension of the model in which a protectionist policy is introduced by the Northern government. The extended model is then used to analyze the long-run effects on the global economy of imposing a tax on the Northern firms that hire immigrant workers. Section 1.5 provides a sensitivity analysis on the elasticity of substitution between immigrant and native workers. Finally, Section 1.6 offers some concluding remarks.

1.2 The model

We consider a global economy consisting of two countries: a high-TFP North (denoted by N) and a low-TFP South (denoted by S). Each country produces a non-tradable aggregate good which can be interchangeably consumed or accumulated as physical capital.

In each country, the population consists of a unit continuum of infinitely-lived households, each of which comprises a continuum of identical individuals of measure one. Individuals are endowed with one unit of time, which they can spend either working for wages or searching for jobs. The countries are assumed to be symmetric in all respects but two. First, North is supposed to be more productive in terms of TFP than South. Second, only workers from South are supposed to migrate in search for better job opportunities and higher wages.

Time is set in continuous time, but for ease of exposition we will suppress the time variable t where no confusion arises. We begin by presenting a benchmark version of the model in which firms can freely hire foreign workers without incurring in any sort of restriction. In Section 1.4 we will relax this assumption by focusing on the special case in which the Northern government imposes a tax on firms hiring migrants in order to prioritize natives welfare.

1.2.1 Labor markets and matching

In this section, we describe how labor markets work in both North and South. The way unemployed workers and job vacancies meet follows a matching process similar to that developed by

Pissarides (2000) and then extended by Shi and Wen (1997) and Hashimoto and Im (2016).

The Southern labor market

In South, the total population can be divided into job searchers (denoted by s_M), employed workers in North (denoted by m) and employed workers in South (denoted by n_S), such that the following resource constraint for labor applies at every moment in time

$$1 = n_S + s_M + m. \tag{1.1}$$

Among all job searchers, we assume that a fraction ϕs_M - with $\phi \in (0,1)$ - resides and looks for jobs in North, while the complement fraction $(1-\phi)\, s_M$ resides and looks for jobs in South.[2] As in Shi and Wen (1997), in this chapter the notion of job searchers conforms to the notion of unemployment, so that at each moment of time $L_S \equiv n_S + (1-\phi)s_M$ is the size of the workforce of South and $(1-\phi)s_M/[n_S + (1-\phi)s_M]$ is its unemployment rate.

To create a productive job, vacancies and workers must match with each other. We assume that the process of matching is summarized by a matching function

$$z_S = \bar{z}_S \left[(1-\phi)\, s_M\right]^{1-\epsilon} v_S^{\epsilon}, \quad \bar{z}_S > 0, \quad \epsilon \in (0,1), \tag{1.2}$$

where z_S is the number of job matches in South, $\bar{z}_S$ is a constant capturing the Southern efficiency of matching, v_S is the number of vacancies posted by Southern firms, and ϵ is a given parameter capturing the elasticity of the matching function with respect to vacancies.

Equation (1.2) determines the flow of workers who find a job and who exit the unemployment pool within a time interval of length dt. Dividing both sides of (1.2) by $(1-\phi)\, s_M$ and v_S we obtain, respectively, the instantaneous probability that a Southern worker finds a job in her home country, and the instantaneous probability that a Southern vacancy is filled. Thus, denoting with $\theta_S \equiv v_S/\,(1-\phi)\, s_M$ the vacancy-unemployment ratio, which we take as a measure of tightness of the labor market in South, these two probabilities can be written as

$$\frac{z_S}{(1-\phi)\, s_M} = \bar{z}_S \theta_S^{\epsilon} \equiv p\left(\theta_S\right) \tag{1.3}$$

$$\frac{z_S}{v_S} = \bar{z}_S \theta_S^{-(1-\epsilon)} \equiv q\left(\theta_S\right). \tag{1.4}$$

As it is easy to check, $p'\left(\theta_S\right) > 0$ and $q'\left(\theta_S\right) < 0$, so that market tightness makes it easier to find a job for a worker, but harder to fill a vacancy for a firm.

[2] The exogenous parameter ϕ determines the share of Southern-born workers that look for a job in North and can be interpreted as the share of effort on looking for a job abroad.

The Northern labor market

In North, the fraction of the population in work can be split into job searchers (denoted by s_N), and employed workers (denoted by n_N), such that, at each time t, it must be that

$$1 = n_N + s_M. \tag{1.5}$$

However, because a fraction of m individuals from South are currently working as employed workers for Northern firms and a fraction ϕs_M are residing in North as unemployed workers, the size of the labor force differs from that of the native population and is equal to $L_N = 1+m+\phi s_M$. Moreover, the size of the unemployment pool of North is also inclusive of immigrants workers and it equates $(s_N + \phi s_M)/(m + \phi s_M + s_N + n_N)$.

Denoting the number of vacancies posted by Northern firms as v_N, the matching function of North can be written as

$$z_N = \bar{z}_N \left(s_N + \phi s_M\right)^{1-\epsilon} v_N^{\epsilon}, \quad \bar{z}_N > 0, \tag{1.6}$$

where z_N is the number of job matches in South and $\bar{z}_N$ is the efficiency parameter of matching in North.

From (1.6), it follows that the Northern labor market tightness depends on both types of unemployed workers, i.e. native unemployed workers s_N and immigrant unemployment workers, ϕs_M. Hence, by defining the labor market tightness of North as $\theta_N \equiv v_N/(s_N + \phi s_M)$, it is easy to verify that an increase in immigration might worsen the conditions of the labor market of North through the term ϕs_M. Indeed, dividing both sides of (1.6) by $s_N + \phi s_M$ and v_N, we obtain the following pair of expressions for the job finding rate and vacancy filling rate

$$\frac{z_N}{s_N + \phi s_M} = \bar{z}_N \theta_N^{\epsilon} \equiv p\left(\theta_N\right) \tag{1.7}$$

$$\frac{z_N}{v_N} = \bar{z}_N \theta_N^{-(1-\epsilon)} \equiv q\left(\theta_N\right). \tag{1.8}$$

According to (1.7) and (1.8), the size of immigrant unemployment affects the probability that a firm or a worker (both native and immigrant) will meet a partner, implying that migration can exacerbate the negative search externality on native job searchers and firms.

1.2.2 Households

In each country $i = \{S, N\}$, households derive utility from consumption, c_i, and hold assets in the form of ownership claims on capital, k_i. We suppose that preferences are identical in the two countries and given by the life-time utility

$$U_i(t) = \int_0^{\infty} e^{-\rho t} \log\left(c_i\right) \mathrm{d}t, \quad \rho > 0, \quad i = \{S, N\}, \tag{1.9}$$

where ρ is the subjective discount rate of households.

Given an initial value for assets holding $k_i(0)$, the objective of the representative household of country i at time $t > 0$ is to choose a path for c_i to maximize (1.9) subject to a country-specific flow budget constraint. Following mainstream search literature, we assume that all household members completely insure each other against variations in labor income (see, e.g., Merz, 1995; Andolfatto, 1996). Since Southern households comprise migrants among their members, such an assumption implies that all migrant workers care about the welfare of their own household, and send home remittances, below denoted by R, in order to completely smooth risks in consumption within the household of origin.[3] As a consequence, the flow budget constraint of the representative household of South can be written as

$$\dot{k}_S = r_S k_S + w_S n_S + b_S(1-\phi)s_M + \pi_S + R - (c_S + \tau_S)(1 - m - \phi s_M), \tag{1.10}$$

where r_S the rate of return on Southern capital k_S, w_S is the wage rate received by each of the n_S household's member employed in South, b_S is the unemployment benefit paid to each of the $(1-\phi)s_M$ household's members who are currently unemployed, π_S is the instantaneous stream of profits paid by Southern firms and τ_S is the lump-sum tax of South paid by the $1 - m - \phi s_M$ members who reside in South at time t.

Similarly, the flow budget constraint of the representative household is given by

$$\dot{k}_N = r_N k_N + \pi_N + w_N n_N + b_N s_N - (\tau_N + c_N), \tag{1.11}$$

where r_N is the rate of return on Northern capital k_N, w_N is the wage rate received by each employed member of the household, b_N is the unemployment benefit paid to each of the s_N unemployed members, π_N is the instantaneous stream of profits paid by Northern firms and τ_N is the lump-sum tax paid by the household overall at time t.

According to (1.10) and (1.11), in each country i the stock of domestic capital k_i changes over time if and only if disposable income turns out to be either larger or smaller than consumption expenditure. When this happens, the rates at which each domestic economy accumulates capital equates its current income less the sum of consumption and taxation, and the dynamics of k_S and k_N are given by (1.10) and (1.11).

Standard maximization techniques yield the familiar Euler conditions

$$\dot{c}_S = c_S (r_S - \rho) \tag{1.12}$$

$$\dot{c}_N = c_N (r_N - \rho). \tag{1.13}$$

[3]Mandelman and Zlate (2012) make use of a similar risk sharing mechanism of remittances in their model.

1.2.3 Producers

In each country $i = \{S, N\}$, there is a continuum of perfectly-competitive firms producing the non-tradable good y_i by combining capital, k_i, and labor, ℓ_i, according to the Cobb-Douglas technology

$$y_i = A_i k_i^{\alpha} \ell_i^{1-\alpha}, \quad A_i > 0, \quad \alpha \in (0,1),$$

where A_i (with $A_N > A_S$) is a given parameter capturing the level of TFP in country i at time $t > 0$, and α is the Cobb-Douglas parameter.

In South, labor input, ℓ_S, consists of only native Southern workers, n_S, while in North it is given by a mix of native Northern workers, n_N, and immigrant workers, m. Following Ottaviano and Peri (2012), we assume that the contribution of each labor input type to Northern production is captured by the CES aggregator, $\ell_N \equiv \left[(1-\lambda)n_N^{\eta} + \lambda m^{\eta}\right]^{1/\eta}$, where $\lambda \in (0,1)$ is the share parameter and $\eta < 1$ is the CES parameter. This implies that the production technology of South takes the form of the standard Cobb-Douglas

$$y_S = A_S k_S^{\alpha} n_S^{1-\alpha}, \tag{1.14}$$

while the production technology of North takes the form of a nested Cobb-Douglas production function with the CES-nest for the labour input

$$y_N = A_N k_N^{\alpha} \left[(1-\lambda)n_N^{\eta} + \lambda m^{\eta}\right]^{(1-\alpha)/\eta}, \tag{1.15}$$

where the elasticity of substitution between the two types of labor inputs, i.e. migrant and native workers, is equal to $\sigma \equiv 1/(1-\eta)$.

Southern firms

In South, firms rent capital from the local households and hire workers on a frictional labor market. In doing so, they open vacancies in response to expected profits. Each vacancy costs the firm $\gamma_S > 0$ and matches with a worker at the rate $q(\theta_S)$, where θ_S is taken as given by the firm. Consequently, denoting the separation rate of Southern employment by δ_S, the time evolution of employment in South can be described by the following

$$\dot{n}_S = q(\theta_S) v_S - \delta_S n_S, \tag{1.16}$$

Given an initial level of local employment $n_S(0)$, Southern firms' objective is to choose paths for n_S and k_S to maximize the present value of expected future cash-flows

$$V_S(0) = \int_0^{\infty} e^{-\int_0^t r_S(\omega)\mathrm{d}\omega} \pi_S \mathrm{d}t, \tag{1.17}$$

subject to the dynamic equation (1.16) and

$$\pi_S = A_S k_S^{\alpha} n_S^{1-\alpha} - r_S k_S - w_S n_S - \gamma_S v_S. \tag{1.18}$$

Denoting the costate variable for n_S by ξ_S, the necessary and sufficient conditions for an optimum are given by

$$\xi_S = \frac{\gamma_S}{q\left(\theta_S\right)} \tag{1.19a}$$

$$r_S = A_S \alpha \left(\frac{k_S}{n_S}\right)^{-(1-\alpha)} \tag{1.19b}$$

$$\dot{\xi}_S = \left(r_S + \delta_S\right) \xi_S - \left[A_S\left(1-\alpha\right)\left(\frac{k_S}{n_S}\right)^{\alpha} - w_S\right], \tag{1.19c}$$

where (1.19a) and (1.19b) are the optimality conditions for posting vacancies and renting capital, and (1.19c) is a dynamic equation governing the time evolution of the shadow price ξ_S. The term in square brackets on the right-hand side of (1.19c) is particularly important for the development of the remaining parts of the model because it captures the firm's share of the quasi-rent generated by a job match. Consequently, in the remainder of the chapter we will denote it as

$$\triangle_S^f \equiv A_S\left(1-\alpha\right)\left(k_S/n_S\right)^{\alpha} - w_S. \tag{1.20}$$

Equations (1.19a) and (1.19c) can be used to obtain a dynamic law governing the conditions of the labor market. Indeed, combining (1.19a) and (1.19c), and then using (1.4) to substitute for $q\left(\theta_S\right)$, we get

$$\dot{\theta}_S = \left(\frac{\theta_S}{1-\epsilon}\right)\left[r_S + \delta_S - \frac{\triangle_S^f}{\gamma_S}\bar{z}_S \theta_S^{-(1-\epsilon)}\right], \tag{1.21}$$

Dynamic equation (1.21) is one of key equations of the model. It governs the dynamics of labor market tightness, θ_S, and characterizes the labor market conditions of South.

Northern firms

Similarly to South, Northern firms rent capital from households and hire workers on a frictional labor market. In doing so, they open vacancies in response to expected profits, each of which costs the firm $\gamma_N > 0$ and matches with a worker at the rate $q\left(\theta_N\right)$. Since all job searchers - i.e. native and immigrant unemployed workers - compete for the same vacancies v_N, the probability that a vacancy is matched with a worker of either the type "N" or "M" depends on the relative abundance of each labor type in the economy.

Let $\psi \equiv s_N / (\phi s_M + s_N)$ denote the relative abundance of native workers in the unemployment pool. For any given ψ, the probability that the vacancy is filled with a native worker is given by $q(\theta)\psi$, so that, at each moment of time, the motion of native employment in North is governed by

$$\dot{n}_N = q(\theta_N)\psi v_N - \delta_N n_N, \tag{1.22}$$

where δ_N is the separation rate of Northern employment.

Likewise, the probability that the vacancy is matched with an immigrant worker is given by $q(\theta_S)(1-\psi)$, while the time evolution of the immigrant employment is driven by

$$\dot{m} = q(\theta_N)(1-\psi)v_N - \delta_N m, \tag{1.23}$$

where $1 - \psi = \phi s_M / (\phi s_M + s_N)$ captures the relative abundance of native workers in the unemployment pool of North.

Given a pair of initial conditions for native and immigrant employment, $n_N(0)$ and $m(0)$, the objective of the representative firm of North is to choose paths for n_N, k_N and m to maximize

$$V_N(0) = \int_t^\infty e^{-\int_t^h r_N(\omega)\mathrm{d}\omega} \pi_N \mathrm{d}h, \tag{1.24}$$

subject to (1.22), (1.23), and

$$\pi_N = A_N k_N^\alpha \left[(1-\lambda)n_N^\eta + \lambda m^\eta\right]^{(1-\alpha)/\eta} - r_N k_N - w_N n_N - w_M m - \gamma_N v_N. \tag{1.25}$$

Denoting the shadow prices of n_N and m by, respectively, ξ_N and ξ_M, the maximization entails the following set of first-order conditions

$$\xi_M + \psi(\xi_N - \xi_M) = \frac{\gamma_N}{q(\theta_N)} \tag{1.26a}$$

$$r_N = \alpha A_N k_N^{\alpha-1}[(1-\lambda)n_N^\eta + \lambda m^\eta]^{(1-\alpha)/\eta} \tag{1.26b}$$

$$\dot{\xi}_N = (r_N + \delta_N)\xi_N - \left\{(1-\alpha)(1-\lambda)A_N k_N^\alpha[(1-\lambda)n_N^\eta + \lambda m^\eta]^{\frac{1-\alpha-\eta}{\eta}} n_N^{\eta-1} - w_N\right\} \tag{1.26c}$$

$$\dot{\xi}_M = (r_N + \delta_N)\xi_M - \left\{(1-\alpha)\lambda A_N k_N^\alpha[(1-\lambda)n_N^\eta + \lambda m^\eta]^{\frac{1-\alpha-\eta}{\eta}} m^{\eta-1} - w_M\right\}, \tag{1.26d}$$

where the first two equations (1.26a) and (1.26b) are the optimality conditions for posting vacancies and renting capital, and the two differential equations (1.26c) and (1.26d) are the two dynamic laws governing the time evolution of the shadow prices ξ_N and ξ_M. The two terms in curly brackets on the right-hand sides of (1.26c) and (1.26d) indicate the Northern firm's shares of the quasi-rent generated by the hiring of, respectively, a native and an immigrant worker, and are henceforth denoted by

$$\triangle_N^f \equiv (1-\alpha)A_N k_N^{\alpha}\left[(1-\lambda)n_N^{\eta}+\lambda m^{\eta}\right]^{(1-\alpha-\eta)/\eta}(1-\lambda)n_N^{\eta-1}-w_N \tag{1.27}$$

$$\triangle_M^f \equiv (1-\alpha)A_N k_N^{\alpha}\left[(1-\lambda)n_N^{\eta}+\lambda m^{\eta}\right]^{(1-\alpha-\eta)/\eta}\lambda m^{\eta-1}-w_M. \tag{1.28}$$

To obtain the dynamic equation governing the time path of θ_N, we proceed as follows. First, we define $\Omega \equiv \xi_N - \xi_M$, such that $\dot{\Omega} \equiv \dot{\xi}_N - \dot{\xi}_M$, and thus - via (1.26c) and (1.26d)

$$\dot{\Omega} \equiv (r_N+\delta_N)\,\Omega + \triangle_M^f - \triangle_N^f. \tag{1.29}$$

The variable Ω is a new endogenous variable to be determined in the equilibrium. It is equal the spread between the shadow price of native and immigrant employment and is thought to capture the relative convenience to hire an immigrant worker rather than a native worker.

Given Ω and its dynamic law (1.29), the next step consists in determining the dynamic law of θ_N. To do that, we time-differentiate (1.26a), and then use (1.8), (1.26c) and (1.26d) to substitute for $q(\theta_N)$, $\dot{\xi}_N$ and $\dot{\xi}_M$. This gives the following dynamic equation for θ_N

$$\dot{\theta}_N = \left(\frac{\theta_N}{1-\epsilon}\right)\left\{r_N+\delta_N-\left[\frac{\dot{\psi}\Omega-\psi\triangle_N^f+(1-\psi)\,\triangle_M^f}{\gamma_N}\right]\bar{z}_N\theta_N^{-(1-\epsilon)}\right\}, \tag{1.30}$$

Equations (1.29) and (1.30) are other two key equations of the model.

1.2.4 Remittances

In this chapter, both employed and unemployed immigrants remit part of their disposable income to their countries of origin.

Consider first the case of an employed immigrant worker that works at the current wage rate w_M and pays the lump-sum tax τ_N. At each moment of time, the worker saves a fraction of her income equal to the difference between the current disposable income, $w_M-\tau_N$, and consumption expenditure c_S. Hence, since the number of employed immigrants is equal to m, the aggregate flow of remittances coming from this type of immigrant worker is $R_E = (w_M-\tau_N-c_S)\,m$.

Consider now the case of an unemployed immigrant worker receiving the unemployment benefit b_M and paying the lump-sum tax τ_N. Similarly to the case of the Southern worker, her flow of remittances equates forgone consumption and can thus be written as the difference between disposable income, $b_M-\tau_N$, and consumption expenditure c_S. Because only ϕs_M units of Southern individuals reside in North as unemployed workers, the aggregate flow of remittances coming from this other type of immigrant worker is $R_U = (b_M-\tau_N-c_S)\,\phi s_M$.

Thus, by summing R_E and R_U, the overall flow of remittances moving from North to South at any moment of time is given by

$$R \equiv R_E + R_U = w_M m + b_M\phi s_M - (\tau_N + c_S)\,(m+\phi s_M)\,. \tag{1.31}$$

1.2.5 Wage determination

In both countries, job matches generate economic quasi-rents and wages are set to share these quasi-rents through a wage Nash bargaining process. We assume that, in each country i, the bargained wage is the solution of the following maximization problem

$$w_i = \arg\max \left(\triangle_i^h\right)^{\chi} \left(\triangle_i^f\right)^{1-\chi}, \quad \chi \in (0,1),$$

where χ is the bargaining strength of workers, and $\triangle_i^h$ and $\triangle_i^f$ are the share of the match quasi-rent that go, respectively, to workers and firms.

In South, the joint value of the match is equal to the difference between the marginal productivity of labor, $\partial y_S/\partial n_S$, and the outside option of the Southern workers b_S. The share of the quasi-rent of firms, $\triangle_S^f$, is given by (1.20), while the share of workers can be obtained from the distribution rule $\triangle_S^h + \triangle_S^f = \partial y_S/\partial n_S - b_S$, and reads

$$\triangle_S^h = w_S - b_S. \tag{1.32}$$

Thus, using (1.20) and (1.32) to substitute for $\triangle_S^h$ and $\triangle_S^f$ in the above Nash bargaining program, and then solving the maximization for the bargained wage yields

$$w_S = \frac{\chi A_S (1-\alpha) \left(\frac{k_S}{n_S}\right)^{\alpha}}{1-(1-\chi)\mu_S}, \tag{1.33}$$

where $\mu_S \in (0,1)$ denotes the replacement rate in South, so that $b_S \equiv \mu_S w_S$.

In North, the total value of the quasi-rent generated by a match depends on the type of the matched workers. In the case of a native worker, it is given by the difference between the marginal productivity of native labor, $\partial y_N/\partial n_N$, and the outside option of native workers b_N, while in the case of an immigrant worker, it is given by the difference between the marginal productivity of immigrant labor, $\partial y_N/\partial m$, and the outside option of immigrant workers b_M. Similarly to the case of the Southern economy, the shares of the quasi-rents that go to Northern firms are given by (1.27) and (1.28), while those that go to native and immigrant workers are determined from the two distribution rules $\triangle_N^h + \triangle_N^f = \partial y_N/\partial n_N - b_N$ and $\triangle_M^h + \triangle_M^f = \partial y_N/\partial m - b_M$. Indeed, solving these two equations for $\triangle_N^h$ and $\triangle_M^h$ and then substituting for $\triangle_N^f$ and $\triangle_M^f$ from (1.27) and (1.28), we obtain the following expressions

$$\triangle_N^h = w_N - b_N, \quad \triangle_M^h = w_M - b_M. \tag{1.34}$$

Plugging (1.27), (1.28) and (1.34), and then solving the resulting Nash bargaining problem for the two bargained wages of Northern and immigrant workers gives the following expressions

$$w_N = \frac{\chi(1-\alpha)A_N k_N^{\alpha}[(1-\lambda)n_N^{\eta}+\lambda m^{\eta}]^{\frac{1-\alpha-\eta}{\eta}}(1-\lambda)n_N^{\eta-1}}{1-(1-\chi)\mu_N} \tag{1.35}$$

$$w_M = \frac{\chi(1-\alpha)A_N k_N^{\alpha}[(1-\lambda)n_N^{\eta}+\lambda m^{\eta}]^{\frac{1-\alpha-\eta}{\eta}}\lambda m^{\eta-1}}{1-(1-\chi)\mu_N}, \tag{1.36}$$

where $b_j \equiv \mu_N w_j$, and $\mu_N \in (0,1)$ is the replacement rate in North.

1.2.6 Governments

In this chapter, each local government is assumed to run a balanced-budget policy, in which social welfare expenditures are balanced by levying lump-sum taxes on the resident population.

From (1.1), it follows that the number of workers that currently reside in South and pay the lump-sum tax τ_S is $L_S = 1 - m - \phi s_M$, of which $(1-\phi)s_M$ of them are unemployed workers that receive the unemployment benefit $\mu_S w_S$ from the government. Accordingly, the Southern government's budget constraint can be written as

$$\tau_S(1-m-\phi s_M) = \mu_S w_S(1-\phi)s_M. \tag{1.37}$$

Similarly, from (1.1), it follows that the number of individuals, both natives and immigrants, that currently reside in North and pay the lump-sum tax τ_N is $L_N = 1 + m + \phi s_M$, of which s_N natives and ϕs_M immigrants are currently unemployed workers receiving financial support from the Northern government. Thus, government's budget constraint in North can be written as

$$\tau_N(1+m+\phi s_M) = \mu_N s_N w_N + \mu_N w_M \phi s_M. \tag{1.38}$$

Equations (1.37) and (1.38) complete the description of the model.

1.2.7 The steady-state equilibrium

In this section, we solve the model for the steady-state equilibrium. The general equilibrium of the model is characterized by a set of ten differential equations governing the long-run dynamics of the aggregate economy, and ten static equations establishing equilibrium relationships and prices.

The dynamic equations of the model are: the two Euler conditions for consumption (1.12) and (1.13); the two flow budget constraints of households, (1.10) and (1.11); the five dynamic laws for domestic employments, (1.16), (1.22) and (1.23), and labor market tightness, (1.21) and (1.30); the auxiliary costate variable capturing the relative shadow price of Northern employment, (1.29).

The ten static equations of the model are referred to: the resource constraints for all of the labor inputs, (1.1) and (1.5), the flow of remittances of immigrants (1.31), the ongoing levels of the interest rates and wages, (1.19b), (1.26b), (1.33), (1.35) and (1.36), and the balanced-budget rules of local governments (1.37) and (1.38).

In any steady-state equilibrium, consumption per capita, c_S and c_N, capital stocks, k_S and k_N, employments, n_S, n_N and m, labor market tightness, θ_S and θ_N, and the relative shadow price of Northern employment, Ω, are constant over time, as well as the flow of remittances, R, and input prices r_S, r_N, w_S, w_S and w_M. Formally, this means that, at each moment of time, it must be that $\dot{c}_S = \dot{k}_S = \dot{n}_S = \dot{m} = \dot{\theta}_S = \dot{c}_N = \dot{k}_N = \dot{n}_N = \dot{\theta}_N = \dot{\Omega} = 0$, such that the steady-state values of all of the aforementioned endogenous variables, denoted by "ˆ", are defined by a set of thirteen steady-state conditions. Below we characterize the steady state system of the model.

We begin with the Euler conditions (1.12) and (1.13). In the steady-state, the domestic interest rates equate the marginal product of capital. Thus, we plug (1.19b) and (1.26b) into (1.12) and (1.13) to yield

$$A_S \alpha \left(\frac{\hat{k}_S}{\hat{n}_S} \right)^{-(1-\alpha)} = \rho \tag{SS1}$$

$$\alpha A_N \hat{k}_N^{\alpha-1} \left[(1-\lambda) \hat{n}_N^{\eta} + \lambda \hat{m}^{\eta} \right]^{(1-\alpha)/\eta} = \rho. \tag{SS2}$$

The resource constraints of households are given by the flow budget constraints (1.10) and (1.11). Substituting for π_S and π_N from (1.18) and (1.25), and then using (1.33), (1.35) and (1.36) to substitute for w_S, w_N and w_M, we obtain

$$\begin{aligned} & A_S \hat{k}_S^{\alpha} \hat{n}_S^{1-\alpha} \left\{ 1 + \frac{\mu_S \chi (1-\alpha)(1-\phi)(1-\hat{n}_S - \hat{m})}{[1-(1-\chi)\mu_S] \hat{n}_S} \right\} + \hat{R} = \\ & = \gamma_S \hat{\theta}_S (1-\phi)(1-\hat{n}_S - \hat{m}) + (\hat{c}_S + \tau_S) [1 - \hat{m} - \phi (1 - \hat{n}_S - \hat{m})] \end{aligned} \tag{SS3}$$

$$\begin{aligned} & \gamma_N \hat{\theta}_N [1 - \hat{n}_N + \phi (1 - \hat{n}_N - \hat{m})] + (\hat{c}_N + \hat{\tau}_N) = A_N \hat{k}_N^{\alpha} \left[(1-\lambda) \hat{n}_N^{\eta} + \lambda \hat{m}^{\eta} \right]^{\frac{1-\alpha}{\eta}} \times \\ & \times \left\{ 1 + \frac{\chi (1-\alpha) \left[\mu_N (1-\lambda) \hat{n}_N^{\eta-1} (1 - \hat{n}_N - \hat{m}) - \lambda \hat{m}^{\eta} \right]}{[1-(1-\chi)\mu_N] \left[(1-\lambda) \hat{n}_N^{\eta} + \lambda \hat{m}^{\eta} \right]} \right\}, \end{aligned} \tag{SS4}$$

where, in order to obtain (SS3) and (SS4), the relationships $b_S = \mu_S w_S$, $b_N = \mu_N w_N$, $v_S = \theta_S (1-\phi)(1 - n_S - m)$ and $v_N = \theta_N [1 - n_N + \phi (1 - n_N - m)]$ have been used.

The equilibrium flows of remittances, $\hat{R}$, and lump-sum taxes $\hat{\tau}_S$ and $\hat{\tau}_N$ appearing in (SS3) and (SS4) are determined by (1.31), (1.37) and (1.38). Using (1.1), (1.5), (1.33), (1.35) and (1.36) to substitute for s_N, s_M, w_S, w_N and w_M in (1.31), (1.37) and (1.38) and recalling that in this model $b_M = \mu_N w_M$, yields

$$\hat{R} = [\hat{m} + \mu_N \phi (1 - \hat{n}_S - \hat{m})] \frac{\chi (1-\alpha) A_N \hat{k}_N^{\alpha} [(1-\lambda)\hat{n}_N^{\eta} + \lambda \hat{m}^{\eta}]^{\frac{1-\alpha-\eta}{\eta}} \lambda \hat{m}^{\eta-1}}{1-(1-\chi)\mu_N} - $$
$$- (\hat{\tau}_N + \hat{c}_S) [\hat{m} + \phi (1 - \hat{n}_S - \hat{m})] \tag{SS5}$$

$$\hat{\tau}_S [1 - \hat{m} - \phi (1 - \hat{n}_S - \hat{m})] = \mu_S \frac{\chi A_S (1-\alpha)(1-\phi)(1-\hat{n}_S - \hat{m})}{1-(1-\chi)\mu_S} \left(\frac{\hat{k}_S}{\hat{n}_S} \right)^{\alpha} \tag{SS6}$$

$$\hat{\tau}_N [1 + \hat{m} + \phi (1 - \hat{n}_S - \hat{m})] = \mu_N \chi (1-\alpha) A_N \hat{k}_N^{\alpha} [(1-\lambda)\hat{n}_N^{\eta} + \lambda \hat{m}^{\eta}]^{\frac{1-\alpha-\eta}{\eta}} \times$$
$$\times \left\{ \frac{(1-\hat{n}_N)(1-\lambda)\hat{n}_N^{\eta-1} + \phi(1-\hat{n}_S-\hat{m})\lambda \hat{m}^{\eta-1}}{1-(1-\chi)\mu_N} \right\}. \tag{SS7}$$

The time evolution of domestic employments is given by the dynamic equations (1.16), (1.22) and (1.23), while the conditions of the local labor markets are determined by (1.21) and (1.30). We begin by focusing on the steady-state conditions determining the values of domestic employments: $\hat{n}_S$, $\hat{n}_N$ and $\hat{m}$.

Using (1.4) and (1.8) to substitute for the job finding rates $q(\theta_S)$ and $q(\theta_N)$ from the right-hand sides of (1.16), (1.22) and (1.23), and recalling that $\psi = (1-n_N)/[1-n_N+\phi(1-n_N-m)]$, $v_S = \theta_S (1-\phi)(1-n_S-m)$ and $v_N = \theta_N [1-n_N+\phi(1-n_N-m)]$, we obtain the following triplet of steady-state conditions for native and migrant employments

$$(1-\phi)(1-\hat{n}_S-\hat{m}) \bar{z}_S \hat{\theta}_S^{\epsilon} = \delta_S \hat{n}_S \tag{SS8}$$

$$(1-\hat{n}_N) \bar{z}_N \hat{\theta}_N^{\epsilon} = \delta_N \hat{n}_N \tag{SS9}$$

$$\phi (1-\hat{n}_N-\hat{m}) \bar{z}_N \hat{\theta}_N^{\epsilon} = \delta_N \hat{m}. \tag{SS10}$$

Next, we turn to the labor-market tightness relationships (1.21) and (1.30). Recall that in the steady-state $\dot{\psi} = 0$. Thus, to obtain the steady-state conditions associated to (1.21) and (1.30) we proceed as follows. Firstly, we plug (1.33), (1.35) and (1.36) into the shares of quasi-rents of firms (1.20),(1.27) and (1.28). Then, we use the resulting expressions to substitutes for Δ_S^f, Δ_N^f and Δ_M^f in (1.21) and (1.30). Finally, we substitute for r_S and r_N from the right-hand sides of (1.21) and (1.30) by using first-order conditions (1.19b) and (1.26b). The result is

$$\alpha A_S \left(\frac{\hat{k}_S}{\hat{n}_S} \right)^{-(1-\alpha)} + \delta_S = (1-\alpha) A_S \left(\frac{\hat{k}_S}{\hat{n}_S} \right)^{\alpha} \frac{1-(1-\chi)\mu_S - \chi}{\gamma_S [1-(1-\chi)\mu_S]} \bar{z}_S \hat{\theta}_S^{-(1-\epsilon)} \tag{SS11}$$

$$\alpha A_N \hat{k}_N^{\alpha-1} \left[(1-\lambda)\hat{n}_N^{\eta} + \lambda \hat{m}^{\eta}\right]^{(1-\alpha)/\eta} + \delta_N = (1-\alpha) A_N \hat{k}_N^{\alpha} \left[(1-\lambda)\hat{n}_N^{\eta} + \lambda \hat{m}^{\eta}\right]^{\frac{1-\alpha-\eta}{\eta}} \times$$
$$\times \left\{ \frac{(1-\chi)(1-\mu_N)\left[(1-\hat{n}_N)(1-\lambda)\hat{n}_N^{\eta-1} + \phi(1-\hat{n}_N-\hat{m})\lambda\hat{m}^{\eta-1}\right]}{\gamma_N [1-(1-\chi)\mu_N][1-\hat{n}_N+\phi(1-\hat{n}_N-\hat{m})]} \right\} \bar{z}_N \hat{\theta}_N^{\epsilon-1}, \tag{SS12}$$

where, to obtain (SS11) and (SS12), we used $\psi = (1-n_N)/[1-n_N+\phi(1-n_N-m)]$.

Finally, setting the steady-state condition $\dot{\Omega} = 0$ to the auxiliary costate variable in equation (1.29), then using (1.26b) to substitute for the Northern interest rate, and equations (1.20), (1.27), (1.28), (1.33), (1.35) and (1.36) to substitute for all of firms' quasi-rent shares, Δ_S^f, Δ_N^f and Δ_M^f, and wage rates, w_S, w_N and w_M, we obtain the following steady-state condition for the auxiliary costate variable

$$\hat{\Omega} = \frac{(1-\alpha)A_N \hat{k}_N^{\alpha} \left[(1-\lambda)\hat{n}_N^{\eta} + \lambda \hat{m}^{\eta}\right]^{\frac{1-\alpha-\eta}{\eta}}}{\left\{\alpha A_N \hat{k}_N^{\alpha-1} \left[(1-\lambda)\hat{n}_N^{\eta} + \lambda \hat{m}^{\eta}\right]^{(1-\alpha)/\eta} + \delta_N\right\}} \times \\ \times \left\{ \frac{(1-\chi)(1-\mu_N)\left[(1-\lambda)\hat{n}_N^{\eta-1} - \lambda \hat{m}^{\eta-1}\right]}{\gamma_N \left[1-(1-\chi)\mu_N\right]} \right\}. \tag{SS13}$$

Equations (SS1)-(SS13) form a system of thirteen equations in thirteen unknowns: $\hat{c}_S$, $\hat{c}_N$, $\hat{k}_S$, $\hat{k}_N$, $\hat{R}$, $\hat{\tau}_S$, $\hat{\tau}_N$, $\hat{n}_S$, $\hat{n}_N$, $\hat{m}$, $\hat{\theta}_S$, $\hat{\theta}_N$, and $\hat{\Omega}$.

Proposition 1 *The model always predicts a unique, economically meaningful steady-state equilibrium with positive migration.*

Proof. See Appendix 1.A. ■

Armed with this result, in the next section we will calibrate our model for the case of the U.S. economy and analyze the steady-state effects of a permanent increase in Southern workers looking for a job in North.

1.3 Rising migration effort in South

In the previous section, we have solved the model for the steady-state equilibrium and have demonstrated that the equilibrium with positive labor migration always exists and is unique. In what follows we explore the impact of an increase in migration flows by shocking the share of Southern unemployed members looking for a job in North, ϕ.[4] Due to the complexity of the model, we will perform this analysis through a simulation exercise. In doing so, we will take the period of the model to correspond to one quarter and calibrate all the exogenous parameters in order to match (*i*) the key statistics for the U.S. economy during the period 2007–2017; (*ii*) the recent empirical findings in the fields of international macroeconomics and international labor mobility.

1.3.1 Parametrization

Table 1.1 shows the benchmark values for all the calibrated parameters. Following Siegel (2002), we set the subjective discount rate ρ to 0.01, so that the annual interest rate is roughly 4%.

[4] Several determinants may induce an increase in search effort for a job abroad – even exogenous ones, such as the erosion of political order recently experienced by a number of sending countries.

Parameter	Description	Value
ρ	Subjective discount rate	0.01
A_S	TFP of South	1
A_N	TFP of North	3
α	Capital share	0.33
σ	Substitution elasticity	20
λ	Productivity share	0.4206
ϕ	Share of Southern unemployed in North	0.2087
ϵ	Matching elasticity	0.5
χ	Worker bargaining power	0.5
δ_S	Southern separation rate	0.0475
δ_N	Northern separation rate	0.0488
γ_S	Southern vacancy cost	26.634
γ_N	Northern vacancy cost	74.235
$\bar{z}_S$	Southern matching efficiency	1
$\bar{z}_N$	Northern matching efficiency	1
μ_S	Southern replacement rate	0.31
μ_N	Northern replacement rate	0.62

TABLE 1.1: Benchmark parametrization of the model.

Further, we choose the capital share parameter $\alpha = 0.33$ to match the empirical evidence of Gollin (2002). Hendricks (2002) finds – using data on immigrants earnings – that TFP contributes for a factor of 3 in explaining output per worker disparities between U.S. and low-income countries. For this reason, in the simulations we set $A_S = 1$ and $A_N = 3$.

The choice of η is consistent with Ottaviano and Peri (2012), who find an elasticity of substitution between U.S. natives and immigrants with similar education and experience levels of 20. The share parameter $\lambda = 0.4206$ is thus chosen to match the wage ratio between native and migrant workers of 1.253 over the decade 2007-2017.[5]

As top sender countries are characterized by a lower unemployment rate than the U.S. during the considered period, we set the separation rates $\delta_S = 0.0475$ and $\delta_N = 0.0488$ so to match, respectively, the Mexico and U.S. unemployment rates of about 4.5% and 6.7%.[6] The share of Southern workers looking for a job abroad, ϕ, is instead set to match the equilibrium share of immigrant workers out of the total workforce in North close to the 13% of immigrant workers residing in U.S. over the period 2007-2017.[7] As far as the fiscal component is concerned, the Northern replacement rate μ_N is set to 0.62, so as to match the short-term unemployment benefits that single workers in the U.S. receive after loosing a job.[8] Because sending countries

[5] Source: Current Population Survey (CPS) data.

[6] We take Mexico unemployment rate for reference as top sender country. The other top sender countries, namely China, India, and Philippines, have a similarly low unemployment rate of 4.4%, 3.6% and 3.4%, respectively. Source: International Labour Organization, ILOSTAT database.

[7] Source: America Community Survey (ACS) data.

[8] Source: OECD, Tax-Benefit Models

tend to have a far lower unemployment benefit coverage, we set the Southern replacement rate μ_S to 0.31, so that μ_N is twice as high as μ_S.[9]

Following the bulk of the literature on search and matching, we set the matching function parameter ϵ to 0.5 so as to allow it to fall within the range of estimates reported by Petrongolo and Pissarides (2001) and Mortensen and Nagypal (2007), and the worker bargaining power χ to 0.5, so as to meet the so-called Hosios condition (see Hosios, 1990). Further, we set the Southern vacancy cost to 26.634 so to obtain a Southern market tightness equal to one (i.e., as in Shimer, 2005, the worker finding rate is equal to the job finding rate), while the Northern vacancy cost is set to 74.235, coherently with U.S. market tightness of about 0.45.[10] Finally, we normalize the matching parameters $\bar{z}_S$ and $\bar{z}_N$ to one for simplicity.

Armed with the parametrization displayed in Table 1.1, in the next two sections we will evaluate the long-run effects of a 10% permanent increase in the share of Southern searchers looking for a job in North. We begin by assessing the macroeconomic effects of rising migration worldwide. Next, we turn to analyze the long-run impact on national welfare in both North and South.

1.3.2 The macroeconomic effects

Suppose both economies are in their own steady-state and suppose that at $t = 0$ an exogenous shock causes the share of search effort abroad ϕ to raise permanently by 10%. Table 1.2 shows the results of the comparative statics analysis.[11]

	South			North		
Variable	Initial	Final	Variation	Initial	Final	Variation
c_i	4.3919	4.4144	0.51%	13.567	13.64	0.54%
k_i	149.85	147.04	-1.87%	562.84	569.118	1.11 %
n_i	0.8114	0.7962	-1.87%	0.9323	0.9322	-0.02%
m	n.a.	n.a.	n.a.	0.134	0.1548	10.59%
θ_i	1	1	0%	0.452	0.4498	-0.5%
y_i	4.5408	4.4558	-1.87%	17.056	17.246	1.11%
w_i	2.2188	2.2188	0%	7.9316	7.9361	0.06%
w_m	n.a	n.a.	n.a.	6.329	6.3011	-0.45%
Π_i	0.2161	0.2121	-1.87%	0.5352	0.5411	1.11%
R	0.2178	0.2325	6.76%	n.a.	n.a.	n.a.

TABLE 1.2: The steady-state effects of a 10% raising in migration effort – Comparative statics results.

[9] In Appendix 1.B we show a sensitivity analysis for different values of μ_S.

[10] Source: Federal Reserve Economic Data (FRED).

[11] As described in Section 1.2, in the model there are ten endogenous variables. Five of those are predetermined variables, and five are control variables. The Jacobian matrix of the linearized system evaluated around the steady-state possess five stable eigenvalues and five unstable ones, thus the Blanchard-Kahn conditions are met and the unique steady-state equilibrium is saddle-path stable (see Blanchard and Kahn, 1980).

We begin from the Northern economy. In North, a permanent increase in the share of Southern searchers abroad, ϕ, makes immigrant employment in North, m, increase. This affects the economy in three different ways. Firstly, the rise in m increases the supply for labor in North and causes the marginal product of capital to deviate temporarily from its steady-state level, ρ. That causes firms to respond positively to the consequent increase in the marginal product of capital by spurring investment and capital accumulation until the marginal productivity equates the interest rate in the new steady state. Eventually, the increase in capital input (+1.11%), along with the increase in labor input, lead to a higher level of per capita output (+1.11%) and profits (+1.11%), and thus to higher per capita consumption in North (+0.54%).

Secondly, the rise in ϕ generates a slight displacement effect in the Northern labor market that hurts native employment. As both migrants and natives compete for the same vacancies, the increase in migration flows eventually lowers the amount of the employed natives (-0.02%), and increases that of the employed migrants (+10.59%). However, since competition between workers intensifies due to the increase in the search effort coming from South, market tightness in North decreases in the post-shock equilibrium (-0.5%), implying a lower job-finding rate, $p(\theta_N)$, and a higher unemployment rate (+0.23%) for all Northern workers.

Lastly, a positive migration shock has asymmetric impacts on wages. Since migrants and natives are imperfect substitutes in production, the rise in the inflow of migrant workers increases competition among foreign-born workers, and decreases that among native workers. For this reason, the wage paid to migrant workers decreases (-0.45%), whereas the wage rate paid to domestic workers slightly increases (+0.06%). This completes the description of the macroeconomic effects in North of rising migration effort in South.

Consider now the Southern economy. Differently from North, in South the ultimate effect of a permanent rise in ϕ is to slim the local workforce and employment because of emigration. Southern firms respond to the fall in labor supply by reducing investment and shrinking the steady-state level of capital per worker (-1.87%). Consequently, in the post-shock steady-state equilibrium, per capita output, y_S, and profits, π_S, decrease permanently.

Interestingly, the fall in per capita income is not accompanied by a fall in consumption. As shown by Table 1.2, even though all the main macroeconomic variables of South experience a contraction, per capita consumption, c_S, shows a slight increase (+0.51%) because of the increase in remittances (+6.76% overall) due to the increase in emigration rate. In fact, since southern workers pool their income together regardless of their location, the increase in migration translates into a higher consumption for all Southern household's members around the world.

Curiously enough, despite the fall in labor supply due to emigration, in the long run the equilibrium wage rate of South does not change because of the shock. Such a finding is due to the interplay between the upward pressure coming from the reduced labor supply, and the downward pressure coming from lower capital accumulation. Eventually, the two effects compensate one another, thereby leading to no change in Southern wages in the post-shock equilibrium.

1.3.3 Welfare analysis

Once assessed the steady-state effects of migration on the main macroeconomic variables of the model, it is now time to restrict our attention to analyzing the long-run effects on consumer welfare. In doing so, we keep assuming that the global economy is in its own steady-state equilibrium and that, at $t = 0$, a shock causes the shock parameter ϕ to raise permanently by 10%.

Life-time utility (1.9) provides a natural metric for measuring social welfare. Indeed, evaluated at the steady-state equilibrium, equation (1.9) gives the following indirect utility function we use as the welfare index of the model

$$\mathcal{W}_i = \frac{\log(\hat{c}_i)}{\rho}.$$

Since the steady-state consumption $\hat{c}_i$ depends on all the other steady-state variables of our model, an increase in ϕ generates an ambiguous impact on the households welfare that cannot be determined without a quantitative analysis. However, our simulations show that the Southern welfare gain is around 0.34%, while the Northern welfare gain is about 0.2% (cf. Table 1.3).

	South			North		
Variable	Initial	Final	Variation	Initial	Final	Variation
c_i	4.3919	4.4144	0.51%	13.567	13.64	0.54%
W_i	147.98	148.49	0.35%	260.77	261.3	0.2 %

TABLE 1.3: Steady-state impact of migration on welfare.

This means that both households experience a welfare gain from an increased Southern search effort in North, though the Southern household gains relatively more than the Northern one.

1.4 Extension

In the baseline model of Section 1.2, central governments played no role in governing the process of labor migration. In this section, we extend the baseline model by assuming the existence of a protectionist government in North that wants to discourage domestic firms from hiring migrant workers through the imposing of a positive tax rate on immigrant employment. The main objective of the section is thus to study to what extent protectionist policies can be useful in improving employment opportunity for natives and rise national welfare.

We start by plugging the interventionist policy into the formal framework developed in Section 1.2. Then, we characterize the search equilibrium of the extended model and perform some comparative statics exercises for the case in which the Northern government introduces a 10 percent distortionary tax rate on domestic firms.

1.4.1 The search equilibrium with a protectionist government in North

Formally, the model is identical to that presented in the previous section except for the presence of a tax on foreign employment. Let $\tau_F \in [0,1)$ denote the tax rate on foreign employment in North. The new Northern government balance reads

$$\tau_N(1 + m + \phi s_M) + \tau_F w_M m = \mu_N \left(s_N w_N + \phi s_M w_M\right), \tag{1.39}$$

where the left-hand side, i.e. (the government revenues), also includes the new term $\tau_F w_M m$, which indicates the amount of profits drained out from Northern firms that employ immigrant workers.

Households' preferences and firms' technologies are identical to those presented in Section 1.2. Consequently, no changes take places in the utility maximization problems of the Southern and Northern representative household, as well as in the profit maximization problem of the representative firm in South. However, the profit maximization of Northern producers changes to include the positive tax rate on foreign employment. In particular, because of the tax rate, the labor cost associated to each immigrant worker rises to $(1 + \tau_F)\, w_M$, so the cash flow of the representative firm becomes

$$V_N\left(0\right) = \int_t^{\infty} e^{-\int_t^h r_N(\omega)\mathrm{d}\omega} \left[y_N - r_N k_N - w_N n_N - (1 + \tau_F)\, w_M m - \gamma v_N\right] \mathrm{d}h. \tag{1.40}$$

The firm chooses quantities of v_N, k_N, m and n_N to maximize the (1.40) subject to the production technology (1.15) and the dynamic equations governing native and immigrant employment, (1.22) and (1.23). Using the same optimization methods employed to solve the dynamic problem of Section 1.2.3, we obtain the same first-orders conditions for v_N, k_N and n_N, but a different one for m, which reads

$$\dot{\xi}_M = \left(r_N + \delta_N\right) \xi_M - \Delta_M^f, \tag{1.41}$$

where the quasi-rent going to the representative Northern producer, Δ_M^f, in the presence of the distortionary tax is given by

$$\Delta_M^f \equiv \left(1 - \alpha\right) \lambda A_N k_N^{\alpha} [(1 - \lambda) n_N^{\eta} + \lambda m^{\eta}]^{\frac{1-\alpha-\eta}{\eta}} m^{\eta - 1} - (1 + \tau_F) w_M, \tag{1.42}$$

Using (1.42) to substitute for Δ_M^f in the Nash bargaining problem of Section 1.2.5, we obtain the following expression for the bargained wage rate of the immigrant workers

$$w_M = \frac{\chi(1-\alpha)\lambda A_N k_N^{\alpha}[(1-\lambda)n_N^{\eta}+\lambda m^{\eta}]^{\frac{1-\alpha-\eta}{\eta}} m^{\eta-1}}{\chi\tau_F + 1 - (1-\chi)\mu_N}, \tag{1.43}$$

which is decreasing in the new distortionary tax, τ_F, imposed by the government.

The dynamic and static equations of the extended model only differ from the benchmark model for the Northern firm surplus of hiring a migrant worker, which is now determined by equation (1.42), and by the new equation that determines the wage rate of immigrants (1.36). Overall, compared with the steady-state system of the baseline model of 1.2, the stationary conditions for variables $\hat{k}_S$, $\hat{k}_N$, $\hat{\tau}_S$, $\hat{n}_S$, $\hat{n}_N$, $\hat{m}$ and $\hat{\theta}_S$ do not change because of the protectionist government of North,[12] while the stationary conditions for the remaining endogenous variables $\hat{c}_S$, $\hat{c}_N$, $\hat{R}$, $\hat{\tau}_N$, $\hat{\theta}_N$ and $\hat{\Omega}$ do change considerably and have to be determined accordingly.

In fact, by making use of the same proceeding described in Section 1.2.7, it can be shown that the following steady-state equations hold for, respectively, households consumption, $\hat{c}_S$ and $\hat{c}_N$,

$$A_S\hat{k}_S^{\alpha}\hat{n}_S^{1-\alpha}\left\{1+\frac{\mu_S\chi(1-\alpha)(1-\phi)(1-\hat{n}_S-\hat{m})}{[1-(1-\chi)\mu_S]\hat{n}_S}\right\}+\hat{R}=$$
$$=\gamma_S\hat{\theta}_S(1-\phi)(1-\hat{n}_S-\hat{m})+(\hat{c}_S+\hat{\tau}_S)[1-\hat{m}-\phi(1-\hat{n}_S-\hat{m})] \tag{SS3.1}$$
$$\gamma_N\hat{\theta}_N[1-\hat{n}_N+\phi(1-\hat{n}_N-\hat{m})]+(\hat{c}_N+\hat{\tau}_N)=A_N\hat{k}_N^{\alpha}\left[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}\right]^{\frac{1-\alpha}{\eta}}\{1+$$
$$+\frac{\chi(1-\alpha)}{(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}}\left[\frac{\mu_N(1-\lambda)\hat{n}_N^{\eta-1}(1-\hat{n}_N-\hat{m})}{1-(1-\chi)\mu_N}-\frac{\lambda\hat{m}^{\eta}}{\chi\tau_F+1-(1-\chi)\mu_N}\right]\Bigg\}, \tag{SS4.1}$$

remittances, $\hat{R}$, and Northern lump-sum tax, $\hat{\tau}_N$

$$\hat{R}=[\hat{m}+\mu_N\phi(1-\hat{n}_S-\hat{m})]\frac{\chi(1-\alpha)A_N\hat{k}_N^{\alpha}[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}]^{\frac{1-\alpha-\eta}{\eta}}\lambda\hat{m}^{\eta-1}}{\chi\tau_F+1-(1-\chi)\mu_N}-$$
$$-(\hat{\tau}_N+\hat{c}_S)[\hat{m}+\phi(1-\hat{n}_S-\hat{m})] \tag{SS5.1}$$
$$\tau_N[1+\hat{m}+\phi(1-\hat{n}_S-\hat{m})]=\mu_N\chi(1-\alpha)A_N\hat{k}_N^{\alpha}[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}]^{\frac{1-\alpha-\eta}{\eta}}\times$$
$$\times\left\{\frac{(1-\hat{n}_N)(1-\lambda)\hat{n}_N^{\eta-1}}{1-(1-\chi)\mu_N}+\frac{\phi(1-\hat{n}_S-\hat{m})\lambda\hat{m}^{\eta-1}}{\chi\tau_F+1-(1-\chi)\mu_N}\right\}. \tag{SS7.1}$$

Similarly, the steady-state equation for the labor market tightness of North changes, as the profitability of firms from migrant employment is affected by the distortionary tax τ_F. The

[12] Namely, these conditions are (SS1), (SS2), (SS6), (SS8), (SS9), (SS10) and (SS11).

result is

$$\alpha A_N \hat{k}_N^{\alpha-1}\left[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}\right]^{(1-\alpha)/\eta}+\delta_N=(1-\alpha)A_N\hat{k}_N^{\alpha}\left[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}\right]^{\frac{1-\alpha-\eta}{\eta}}\times$$
$$\left\{\frac{(1-\chi)(1-\mu_N)(1-\hat{n}_N)(1-\lambda)\hat{n}_N^{\eta-1}}{\gamma_N\left[1-(1-\chi)\mu_N\right]\left[1-\hat{n}_N+\phi(1-\hat{n}_N-\hat{m})\right]}+\right.$$
$$\left.+\frac{\left[\chi(\tau_F-1)+1-(1-\chi)\mu_N\right]\phi(1-\hat{n}_N-\hat{m})\lambda\hat{m}^{\eta-1}}{\gamma_N\left[\chi\tau_F+1-(1-\chi)\mu_N\right]\left[1-\hat{n}_N+\phi(1-\hat{n}_N-\hat{m})\right]}\right\}\bar{z}_N\hat{\theta}_N^{-(1-\epsilon)}. \tag{SS12.1}$$

Finally, the steady-state equation for the auxiliary costate variable $\hat{\Omega}$ reads

$$\hat{\Omega}=\frac{(1-\alpha)A_N\hat{k}_N^{\alpha}\left[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}\right]^{\frac{1-\alpha-\eta}{\eta}}}{\left\{\alpha A_N\hat{k}_N^{\alpha-1}\left[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}\right]^{(1-\alpha)/\eta}+\delta_N\right\}}\times$$
$$\times\left\{\frac{(1-\chi)(1-\mu_N)(1-\lambda)\hat{n}_N^{\eta-1}}{\gamma_N\left[1-(1-\chi)\mu_N\right]}-\frac{\left[\chi(\tau_F-1)+1-(1-\chi)\mu_N\right]\lambda\hat{m}^{\eta-1}}{\gamma_N\left[\chi\tau_F+1-(1-\chi)\mu_N\right]}\right\}. \tag{SS10.1}$$

This completes the description of the steady-state equilibrium of the extended version of the model. In the next section, we will assess the steady-state effects of the immigration tax on the same endogenous variables discussed in Section 1.3.

1.4.2 Taxing immigrant employment

Suppose that both economies are in their own steady-state equilibrium, and suppose that at $t=0$ the Northern government decides to lay a tax rate of 10% on the wage rate paid by native employers to immigrant workers. Making use of the same parametrization adopted in the baseline model, Table 1.5 reports the steady-state effects of the policy on the main macroeconomic variables of the model.[13]

In North, a 10 percent tax rate on immigrant wages affects the macroeconomic equilibrium through two interlinked channels: labor market conditions and capital accumulation. First, the introduction of the tax rate τ_F lowers Northern firms profitability (-0.83%) which, in turn, open less job vacancies (i.e. the market tightness decreases by 1.41%), hurting not only migrant employment (-0.61%), but also native one (-0.05%). Second, the overall fall in employment caused by the tax on migration induces Northern firms to rent less capital (-0.11%) and reduce production (-0.11%). This further result is due to the unitary elasticity of substitution between capital and labor inputs displayed by the Cobb-Douglas type production technology (1.15) used in North.

It is worth noticing how, despite of worsened labor market conditions, both native consumption and welfare increase due to the lower lump-sum tax that Northern workers pay in

[13]As in the quantitative analysis of the baseline model, the Blanchard-Kahn conditions are met and the unique steady-state equilibrium is saddle-path stable.

	South			North		
Variable	Initial	Final	Variation	Initial	Final	Variation
c_i	4.3919	4.339	-1.2%	13.567	13.627	0.44%
k_i	149.85	150	0.1%	562.84	562.23	-0.11 %
n_i	0.8114	0.8122	0.1%	0.9323	0.9319	-0.05%
m	n.a.	n.a.	n.a.	0.134	0.1391	-0.61%
θ_i	1	1	0%	0.452	0.4456	-1.41%
y_i	4.5408	4.5453	0.1%	17.056	17.037	-0.11%
w_i	2.2188	2.2188	0%	7.9316	7.9314	-0.%
w_m	n.a	n.a.	n.a.	6.329	5.9032	-6.73%
Π_i	0.2161	0.2163	0.1%	0.5352	0.5307	-0.83%
R	0.2178	0.173	-20.11%	n.a.	n.a.	n.a.
$\mathcal{W}_i$	147.98	146.76	-0.82%	260.77	261.2	0.17%

TABLE 1.4: The steady-state effects of a 10% tax on immigrant employment – Comparative statics results.

the post-shock steady-state (+0.44% and +0.17%, respectively). Indeed, taxing immigrant employment makes government revenues increase and, as a consequence, Northern government will lower the lump-sum tax paid by all workers residing in North until the budget balances again.

In South, the imposing of a positive tax rate on foreign employment in North affects the local macroeconomic equilibrium only indirectly through changes in the equilibrium flows of migration and per capita remittances. Firstly, the cut in immigrant employment undertaken in North significantly reduces the equilibrium wage rate of immigrant workers (-6.73%), and discourages Northern firms from employing immigrants, thereby implying that in the post-policy long-run equilibrium the share of household's members participating to the Southern labor market increases, making employment in South to raise by 0.11%. Secondly, increased labor supply induces Southern firms to increase their demand for capital (+0.11%), temporary speeding up the pace of capital accumulation and thus increasing production (+0.11%).

Curiously, Southern wage rates are not affected by the protectionist policy of North. Indeed, according to Table 1.5, in the post-policy steady state wages do not experience any change in their equilibrium levels because of the tax policy. Such a surprisingly result can be explained through the interaction of two offsetting effects, in which the shift in the labor demand schedule that positively affects w_S works simultaneously together with the increase in the labor supply that negatively affects w_S for compensating with each other.

Finally, concerning remittances, Table 1.5 shows that the downward correction on migrant wages generates a dramatic fall in remittances (-20.11%). Far from being harmless, the fall in remittances heavily affects Southern welfare because of the permanent fall in per capita consumption (-1.2%), which in turn causes the welfare index to decrease by 0.82%.

1.5 Sensitivity analysis on the elasticity of substitution

Because of the empirical disagreement on the degree of substitutability between immigrant and native workers (see Borjas et al., 2012), in this section we perform a sensitivity analysis on the elasticity of substitution between immigrant and native workers, σ. In these simulations we account for parametrization of $\sigma = (20, 50, 100, 1000)$ for both the baseline and the extended model. Table 1.5 shows the results of the sensitivity analysis.

	Baseline				Extension			
Variable	$\sigma = 20$	$\sigma = 50$	$\sigma = 100$	$\sigma = 1000$	$\sigma = 20$	$\sigma = 50$	$\sigma = 100$	$\sigma = 1000$
c_N	0.54	0.49	0.47	0.46	0.44	0.42	0.41	0.41
c_S	0.51	0.49	0.48	0.47	-1.2	-1.17	-1.15	-1.14
k_N	1.11	1.06	1.04	1.02	-0.11	-0.1	-0.1	-0.1
k_S	-1.87	-1.88	-1.88	-1.88	0.1	0.09	0.09	0.09
n_N	-0.02	-0.02	-0.02	-0.02	-0.05	-0.05	-0.04	-0.04
n_S	-1.87	-1.88	-1.88	-1.88	0.1	0.09	0.09	0.09
m	10.59	10.52	10.5	10.49	-0.61	-0.58	-0.57	-0.56
θ_N	-0.5	-0.6	-0.64	-0.67	-1.41	-1.34	-1.32	-1.3
θ_S	0	0	0	0	0	0	0	0
Y_N	1.11	1.06	1.04	1.02	-0.11	-0.1	-0.1	-0.1
Y_S	-1.87	-1.88	-1.88	-1.88	0.1	0.09	0.09	-0.09
w_N	0.06	0.02	0.01	0.	-0.	-0.	-0.	-0.
w_M	-0.45	-0.18	-0.09	-0.	-6.73	-6.75	-6.75	-6.76
w_S	0	0	0	0	0	0	0	0
Π_N	1.11	1.06	1.04	1.02	-0.83	-0.79	-0.77	-0.76
Π_S	-1.87	-1.88	-1.88	-1.88	0.1	0.09	0.09	0.09
R	6.76	7.65	8.01	8.36	-20.11	-23.17	-24.24	-25.30
$\mathcal{W}_N$	0.2	0.18	0.18	0.17	0.16	0.16	0.16	0.16
$\mathcal{W}_S$	0.35	0.33	0.33	0.32	-0.82	-0.8	-0.79	-0.79

TABLE 1.5: Sensitivity analysis on σ – steady-state variations in percentage points.

Even when considering the case with the highest degree of substitutability ($\sigma = 1000$), the main results obtained in Section 1.3 and 1.4 hold unaffected, that is: (*i*) an increase in migration is able to slightly displace native employment but, at the same time, increases Northern production as well as welfare in both North and South; (*ii*) the imposition of a tax on firms hiring immigrant workers fails to promote native employment, though it is able to increase native welfare at the expense of capital accumulation and production.

This result underlines that our findings are robust to the assumption of imperfect substitutability between immigrant and native workers. Indeed, all steady-state variations preserve the same sign as in the benchmark parametrization, with differences in magnitudes being overall very modest. In particular, higher parametrizations of σ translate in slightly less optimistic post-shock variation for South and North in the benchmark version of our model. As the degree of substitutability between immigrants and natives increases, firms profitability from employing an additional immigrant decreases, so that capital accumulation and production decrease as well. In the extreme case of $\sigma \to \infty$, immigrant and native workers are perfect substitutes in production, and an increase in migration flows produce the same wage effects for both native and immigrant workers. That is why Table 1.5 shows that, as σ increases, variations on immigrant and native wages converge to the same percentage, 0, in the benchmark version of our model.

As far as the extended version of the model is concerned, higher calibration values of σ lead to less optimistic results for the North, but less pessimistic results for the South. This is because, as Northern firms find optimal to employ less immigrant workers when σ is higher, the protectionist policy turns out to benefit from a lower number of immigrants, thus generating a slightly lower welfare variations in both South and North.

1.6 Conclusions

In this chapter, we have analyzed the macroeconomic and social welfare impacts of international labor mobility through a two-country Ramsey-Cass-Koopmans model with labor market frictions and endogenous migration. In the model, workers have the opportunity to migrate from a low-TFP South towards a high-TFP North. The structure of the model enables us to (1) capture the effect of migration on the employment opportunities of native workers; (2) endogenously take into account the migration decision made by foreign workers; (3) address the role of remittances in consumption smoothing across the two economies. These aspects are largely overlooked by the general-equilibrium literature on migration and growth, which tends to abstract from employment issues and worker's decision on migration and remittances.

The analysis shows that there always exists a unique steady-state equilibrium for the world economy. In order to provide an assessment of the long-run impacts of a rise in migration effort on a global scale, we have calibrated our two-country model and performed a numerical simulation. Overall, our simulations generate three major findings. First, a permanent increase in migration causes per capita income and capital accumulation to rise in North, and to fall in South. Nonetheless, per capita consumption increases not only in the Northern country, but also in the Southern country, where a higher overall flow of received remittances is the main responsible for this result. Second, higher migration intensity spurs job competition in North, and generates a slight "displacement effect" that harms native employment. This result is consistent with what found by Card (2001) and Liu (2010), but in contrast with Ortega (2000), Moreno-Galbis and Tritah (2016), and Chassamboulli and Palivos (2014), who find that search friction may explain a positive employment effect of immigrants on natives. Third, households welfare is found to increase in both countries, with households welfare increasing relatively more in the low-TFP than in the high-TFP economy.

In the second part of this chapter, we have developed an extended version of the model in order to analyze to what extent a protectionist policy in North is able to support national employment and welfare by imposing a distortionary tax on the domestic firms who hire foreign workers in place of native ones. Our simulation shows that: on the one hand, this policy fails to promote native employment in North, damaging employers profitability who, as a consequence, post less job vacancies for both immigrants and natives, reducing capital accumulation and production as a consequence; on the other hand, the protectionist policy is able to slightly increase native consumption by redistributing the additional government revenues to unemployed workers in North.

We further perform a sensitivity analysis and find that, for both versions of the model, our results are robust across different degrees of substitutability between migrant and native workers.

Our analysis can be extended to address several issues for future research. One significant issue to be pursued in future work is to allow for endogenous growth. A number of studies have included migration flows in endogenous growth models, notably considering the role of immigrants on technological progress and their contribution to innovation (see, e.g., Lundborg and Segerstrom, 2000; Kim et al., 2010; Levine et al., 2010). However, these studies rely on the assumption of full employment labor markets, leaving potential interdependence concerns between labor market conditions and growth dynamics thus far unexplored. Another interesting issue to be considered is to extend our model for financial integration across the two economies. As empirical research suggests, migration may spur bilateral trade through a number of channels and, in turn, differently affect the relationship between migration and growth dynamics. Finally, since more selective migration policies are proliferating worldwide in order to attract highly skilled workers, it would be interesting to extend our model to allow for workers skills heterogeneity. Such framework would be able to shed some light on the effectiveness of such selective policies.

Appendices

1.A Proof of Proposition 1

This appendix provides the formal demonstration of the existence and unicity of the steady-state equilibrium of the model described in Section 1.2. To soften the notational burden, in what follows we adopt the following collection of given parameters: $\Psi_S \equiv (\alpha A_S/\rho)^{\frac{1}{1-\alpha}}$, $\Psi_N \equiv (\alpha A_N/\rho)^{\frac{1}{1-\alpha}}$, $\Phi_S \equiv (1-\phi)\,\bar{z}_S\delta_N$ and $\Phi_N \equiv \phi\bar{z}_N\delta_S$.

The system (SS1)-(SS13) used to solve the steady-state equilibrium of the model has a recursive structure. First, equations (SS1), (SS2), (SS8), (SS9) and (SS10) can be solved simultaneously for $\hat{k}_S$, $\hat{k}_N$, $\hat{n}_S$, $\hat{n}_N$ and $\hat{m}$ to get the following five steady-state conditions

$$\hat{k}_S = \frac{\Psi_S\Phi_S\hat{\theta}_S^{\epsilon}}{\delta_S\delta_N + \Phi_N\hat{\theta}_N^{\epsilon} + \Phi_S\hat{\theta}_S^{\epsilon}} \equiv \hat{k}_S(\hat{\theta}_S, \hat{\theta}_N) \tag{A1}$$

$$\hat{k}_N = \Psi_N\left[\lambda\left(\frac{\Phi_N\hat{\theta}_N^{\epsilon}}{\Phi_N\hat{\theta}_N^{\epsilon} + \delta_N\delta_S + \Phi_S\hat{\theta}_S^{\epsilon}}\right)^{\eta} + (1-\lambda)\left(\frac{\bar{z}_N\hat{\theta}_N^{\epsilon}}{\delta_N + \bar{z}_N\hat{\theta}_N^{\epsilon}}\right)^{\eta}\right]^{\frac{1}{\eta}} \equiv k_N(\hat{\theta}_S, \hat{\theta}_N) \tag{A2}$$

$$\hat{n}_S = \frac{\Phi_S\hat{\theta}_S^{\epsilon}}{\delta_S\delta_N + \Phi_N\theta_N^{\epsilon} + \Phi_S\hat{\theta}_S^{\epsilon}} \equiv \hat{n}_S(\hat{\theta}_S, \hat{\theta}_N) \tag{A3}$$

$$\hat{n}_N = \frac{\bar{z}_N\hat{\theta}_N^{\epsilon}}{\delta_N + \bar{z}_N\hat{\theta}_N^{\epsilon}} \equiv \hat{n}_N(\hat{\theta}_N) \tag{A4}$$

$$\hat{m} = \left(\frac{\Phi_N\hat{\theta}_N^{\epsilon}}{\Phi_N\hat{\theta}_N^{\epsilon} + \delta_N\delta_S + \Phi_S\hat{\theta}_S^{\epsilon}}\right) \equiv \hat{m}(\hat{\theta}_S, \hat{\theta}_N). \tag{A5}$$

Next plugging $\hat{k}_S(\hat{\theta}_S, \hat{\theta}_N)$, $\hat{k}_N(\hat{\theta}_S, \hat{\theta}_N)$, $\hat{n}_S(\hat{\theta}_S, \hat{\theta}_N)$ and $\hat{m}(\hat{\theta}_S, \hat{\theta}_N)$ into equation (SS11), after heavy simplification, we obtain the steady-state value for the Southern labor market tightness

$$\hat{\theta}_S = \left\{\frac{(1-\alpha)(1-\chi)A_S\,(1-\mu_S)\,\bar{z}_S\Psi_S^{\alpha}}{\gamma_S\,[1-\mu_S\,(1-\chi)]\left(\alpha A_S\Psi_S^{\alpha-1} + \delta_S\right)}\right\}^{\frac{1}{1-\epsilon}}. \tag{A6}$$

Based on functions (A1)-(A5), we can establish the following lemma.

Lemma 1 *$\hat{k}_S(\hat{\theta}_N)$, $\hat{k}_n(\hat{\theta}_N)$, $\hat{n}_S(\hat{\theta}_N)$, $\hat{n}_N(\hat{\theta}_N)$ and $\hat{m}(\hat{\theta}_N)$ are positive-valued functions for any $\hat{\theta}_N \in (0, \infty)$. Moreover, $k_S(\hat{\theta}_N)$ and $n_S(\hat{\theta}_N)$ are monotonically decreasing, while $k_N(\hat{\theta}_N)$, $n_n(\hat{\theta}_N)$ and $m(\hat{\theta}_N)$ are monotonically increasing and concave.*

Proof. It is easy to check that, since all parameters are positive, and the restrictions $\lambda \in (0,1)$, $\mu_S \in (0,1)$, $\alpha \in (0,1)$ and $\chi \in (0,1)$ apply, functions (A1)-(A5) and equation (A6) determine positive steady-state values for any $\hat{\theta}_N \in (0, \infty)$. Moreover, taking the partial derivative of (A1) and (A3) with respect to $\hat{\theta}_N$ yields

$$\hat{k}_S'(\hat{\theta}_N) = -\frac{\epsilon\Phi_N\Phi_S\Psi_S\hat{\theta}_N^{\epsilon-1}\theta_S^{\epsilon}}{\left(\delta_N\delta_S + \Phi_N\hat{\theta}_N^{\epsilon} + \Phi_S\hat{\theta}_S^{\epsilon}\right)^2} < 0$$

$$\hat{n}_S'(\hat{\theta}_N) = -\frac{\epsilon\Phi_N\Phi_S\hat{\theta}_N^{\epsilon-1}\hat{\theta}_S^{\epsilon}}{\left(\delta_N\delta_S + \Phi_N\hat{\theta}_N^{\epsilon} + \Phi_S\hat{\theta}_S^{\epsilon}\right)^2} < 0,$$

where $\hat{\theta}_S$ is a positive collection of parameters determined by equation (A6). Taking the first and second derivatives of (A2) and (A4), and recalling that $\epsilon \in (0, 1)$, we obtain

$$\hat{n}_N'(\hat{\theta}_N) = \frac{\epsilon\delta_N\bar{z}_N\hat{\theta}_N^{\epsilon-1}}{\left(\delta_N + \bar{z}_N\hat{\theta}_N^{\epsilon}\right)^2} > 0$$

$$\hat{n}_N''(\hat{\theta}_N) = \frac{\epsilon\delta_N\bar{z}_N\hat{\theta}_N^{\epsilon-2}\left[(\epsilon-1)\delta_N - (\epsilon+1)\bar{z}_N\hat{\theta}_N^{\epsilon}\right]}{\left(\delta_N + \bar{z}_N\hat{\theta}_N^{\epsilon}\right)^3} < 0$$

$$\hat{m}'(\hat{\theta}_N) = \frac{\epsilon\Phi_N\hat{\theta}_N^{\epsilon-1}\left(\delta_N\delta_S + \Phi_S\hat{\theta}_S^{\epsilon}\right)}{\left(\delta_N\delta_S + \Phi_N\hat{\theta}_N^{\epsilon} + \Phi_S\hat{\theta}_S^{\epsilon}\right)^2} > 0$$

$$\hat{m}''(\hat{\theta}_N) = \frac{\epsilon\Phi_N\hat{\theta}_N^{\epsilon-2}\left(\delta_N\delta_S + \Phi_S\hat{\theta}_S^{\epsilon}\right)\left[(\epsilon-1)\left(\delta_N\delta_S + \Phi_S\hat{\theta}_S^{\epsilon}\right) - (\epsilon+1)\Phi_N\hat{\theta}_N^{\epsilon}\right]}{\left(\delta_N\delta_S + \Phi_N\hat{\theta}_N^{\epsilon} + \Phi_S\hat{\theta}_S^{\epsilon}\right)^3} < 0.$$

Finally, equation (A2) can be rewritten as follows

$$k_N(\hat{\theta}_N) = \Psi_N\left[\lambda\hat{m}^{\eta}(\hat{\theta}_N) + (1-\lambda)\hat{n}_N^{\eta}(\hat{\theta}_N)\right]^{\frac{1}{\eta}}. \tag{A2.1}$$

Since the functional form of $\hat{k}_N(\hat{\theta}_N)$ depends on $\hat{n}_N(\hat{\theta}_N)$ and $\hat{m}(\hat{\theta}_N)$, which are monotonically increasing and concave, we can conclude that $\hat{k}_N'(\hat{\theta}_N) > 0$ and $\hat{k}_N''(\hat{\theta}_N) < 0$. That completes the proof of Lemma 1.■

We now turn to the steady-state value of the Northern market tightness, $\hat{\theta}_N$. Using $\hat{k}_S(\hat{\theta}_N)$, $\hat{k}_N(\hat{\theta}_N)$, $\hat{n}_S(\hat{\theta}_N)$, $\hat{n}_N(\hat{\theta}_N)$ and $\hat{m}(\hat{\theta}_N)$ to substitute into equation (SS12), we obtain the following steady-state condition for the Northern market tightness

$$\begin{aligned}&(\delta_N+\rho)\,\gamma_N\hat{\theta}_N\left[1+(\chi-1)\mu_N\right]\left(2\Phi_N\hat{\theta}_N^{\epsilon} + (1+\phi)\delta_N\delta_S + \Phi_S\hat{\theta}_S^{\epsilon}\right) = \\ &= \Psi_N^{\alpha}(1-\chi)\,(1-\mu_N)\left(\delta_N + z_N\hat{\theta}_N^{\epsilon}\right)\left(\Phi_N\hat{\theta}_N^{\epsilon} + \delta_N\delta_S + \Phi_S\hat{\theta}_S^{\epsilon}\right)\times \\ &\times(1-\alpha)A_N\left[\lambda\left(\frac{\Phi_N\hat{\theta}_N^{\epsilon}}{\Phi_N\hat{\theta}_N^{\epsilon} + \delta_N\delta_S + \Phi_S\hat{\theta}_S^{\epsilon}}\right)^{\eta} + (1-\lambda)\left(\frac{z_N\hat{\theta}_N^{\epsilon}}{\delta_N + z_N\hat{\theta}_N^{\epsilon}}\right)^{\eta}\right]^{\frac{1}{\eta}}.\end{aligned} \tag{A7}$$

Lemma 2 *(a) the function appearing on the left-hand side of* (A7) *is monotonically increasing and convex within* $\hat{\theta}_N \in (0, \infty)$*, and the function appearing on the right-hand side of* (A7) *is monotonically increasing and concave within* $\hat{\theta}_N \in (0, \infty)$*; (b) There exists only one intersecting point between the left- and right-hand side of* (A7)*.*

Proof. We begin by demonstrating the first part of the Lemma. The left- and right-hand-side of (A7) can be defined as follows

$$LHS(\hat{\theta}_N) = (\delta_N + \rho)\,\gamma_N \hat{\theta}_N\,[1 + (\chi - 1)\mu_N]\left(2\Phi_N \hat{\theta}_N^{\epsilon} + (1+\phi)\delta_N\delta_S + \Phi_S\hat{\theta}_S^{\epsilon}\right)$$

$$RHS(\hat{\theta}_N) = \Psi_N^{\alpha-1}(1-\chi)\,(1-\mu_N)\,g(\hat{\theta}_N)h(\hat{\theta}_N)(1-\alpha)A_N\hat{k}_N(\hat{\theta}_N),$$

where $g(\hat{\theta}_N) \equiv \left(\delta_N + z_N\hat{\theta}_N^{\epsilon}\right)$, $h(\hat{\theta}_N) \equiv \left(\Phi_N\hat{\theta}_N^{\epsilon} + \delta_N\delta_S + \Phi_S\hat{\theta}_S^{\epsilon}\right)$, and $\hat{k}_N(\hat{\theta}_N)$ is defined by equation (A2.1).

Function $LHS(\hat{\theta}_N)$ approaches 0 when $\hat{\theta}_N$ approaches 0, and $+\infty$ when $\hat{\theta}_N$ approaches $+\infty$. Since $\mu_N \in (0,1)$, we have that

$$LHS'(\hat{\theta}_N) = \gamma_N\,(\delta_N + \rho)\,[(\chi-1)\,\mu_N + 1]\left[2\,(\epsilon+1)\,P_N\hat{\theta}_N^{\epsilon} + (\phi+1)\,\delta_N\delta_S + P_S\theta_S^{\epsilon}\right] > 0$$

$$LHS''(\hat{\theta}_N) = 2\epsilon(\epsilon+1)\gamma_N P_N\,(\delta_N+\rho)\,((\chi-1)\mu_N + 1)\,\hat{\theta}_N^{\epsilon-1} > 0.$$

All these considerations lead us to conclude that the left-hand side of (A7) is monotonically increasing and concave for $\hat{\theta}_N > 0$.

We now turn to function $RHS(\hat{\theta}_N)$. $RHS(\hat{\theta}_N)$ approaches 0 when $\hat{\theta}_N$ approaches 0, while it approaches $+\infty$ when $\hat{\theta}_N$ approaches $+\infty$. Taking first and second derivatives of functions $g(\hat{\theta}_N)$ and $h(\hat{\theta}_N)$, it is easy to check that both functions are monotonically increasing and concave. Since all components of $RHS(\hat{\theta}_N)$ are monotonically increasing and concave for $\hat{\theta}_N \in (0,\infty)$, we can conclude that the function $RHS(\hat{\theta}_N)$ is monotonically increasing and concave as well. As a result, there exists only one intersecting point within $\hat{\theta}_N \in (0,\infty)$ such that $LHS(\hat{\theta}_N) = RHS(\hat{\theta}_N)$. That demonstrates the second part of the Lemma. ■

Figure 1 provides a graphical representation of the result obtained in Lemma 2. As $LHS(\hat{\theta}_N)$ is convex and $RHS(\hat{\theta}_N)$ is concave, and both functions approach 0 as $\hat{\theta}_N$ approaches 0, there exists only one value $\hat{\theta}_N \in (0,\infty)$ that solves equation (A7). Once $\hat{\theta}_N$ is obtained, $\hat{k}_S$, $\hat{k}_N$, $\hat{n}_S$, $\hat{n}_N$ and $\hat{m}$ can be recovered.

Finally, using equation (SS5) to substitute $\hat{R}$ in equation (SS3), and plugging $\hat{k}_S$, $\hat{k}_N$, $\hat{n}_S$, $\hat{n}_N$, $\hat{m}$, $\hat{\theta}_S$ and $\hat{\theta}_N$ into equations (SS3), (SS4), (SS6), (SS7), and (1.29), we obtain the steady-state

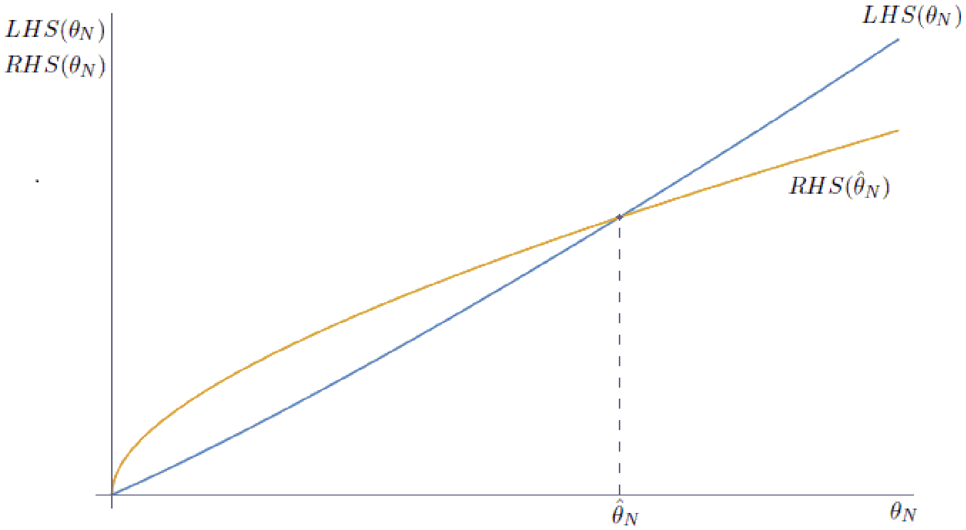

FIGURE 1: Steady-state value of the Northern labor market tightness.

values for variables $\hat{c}_S$, $\hat{c}_N$, $\hat{\tau}_S$, $\hat{\tau}_N$ and $\hat{\Omega}$

$$\hat{c}_S = A_S\hat{k}_S^{\alpha}\hat{n}_S^{1-\alpha} + \frac{\chi(1-\alpha)\lambda A_N\hat{k}_N^{\alpha}[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}]^{\frac{1-\alpha-\eta}{\eta}}\hat{m}^{\eta}}{1-(1-\chi)\mu_N} - \\ -\gamma_S\hat{\theta}_S(1-\phi)(1-\hat{n}_S-\hat{m}) - \frac{\mu_N(1-n_S)[\hat{m}+\phi(1-\hat{m}-\hat{n}_S)]}{1+\hat{m}+\phi(1-\hat{m}-\hat{n}_S)}\times \\ \times\frac{\chi(1-\alpha)(1-\lambda)A_N\hat{k}_N^{\alpha}[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}]^{\frac{(1-\alpha-\eta)}{\eta}}\hat{n}_N^{\eta-1}}{1-(1-\chi)\mu_N} + \\ +\frac{\phi\mu_N(1-\hat{m}-\hat{n}_S)\frac{\chi(1-\alpha)\lambda A_N\hat{k}_N^{\alpha}[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}]^{\frac{1-\alpha-\eta}{\eta}}\hat{m}^{\eta-1}}{1-(1-\chi)\mu_N}}{1+\hat{m}+\phi(1-\hat{m}-\hat{n}_S)}$$

$$\hat{c}_N = A_N\hat{k}_N^{\alpha}\left[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}\right]^{(1-\alpha)/\eta} - \gamma_N\hat{\theta}_N\left[\phi(1-\hat{n}_S-\hat{m}+1-\hat{n}_N)\right] + \\ +\frac{\mu_N(1-\hat{n}_S)[\hat{m}+\phi(1-\hat{n}_S-\hat{m})]\frac{\chi(1-\alpha)(1-\lambda)A_N\hat{k}_N^{\alpha}[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}]^{\frac{(1-\alpha-\eta)}{\eta}}\hat{n}_N^{\eta-1}}{1-(1-\chi)\mu_N}}{1+\hat{m}+\phi(1-\hat{m}-\hat{n}_S)} - \\ -\frac{\mu_N\phi(1-\hat{m}-\hat{n}_S)\frac{\chi(1-\alpha)\lambda A_N\hat{k}_N^{\alpha}[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}]^{\frac{1-\alpha-\eta}{\eta}}\hat{m}^{\eta-1}}{1-(1-\chi)\mu_N}}{1+\hat{m}+\phi(1-\hat{m}-\hat{n}_S)} - \\ -\frac{\chi(1-\alpha)\lambda A_N\hat{k}_N^{\alpha}[(1-\lambda)\hat{n}_N^{\eta}+\lambda\hat{m}^{\eta}]^{\frac{1-\alpha-\eta}{\eta}}\hat{m}^{\eta}}{1-(1-\chi)\mu_N}$$

$$\hat{\tau}_S = \mu_S\frac{\chi A_S(1-\alpha)(1-\phi)(1-\hat{n}_S-\hat{m})}{[1-(1-\chi)\mu_S][1-\hat{m}-\phi(1-\hat{n}_S-\hat{m})]}\left(\frac{\hat{k}_S}{\hat{n}_S}\right)^{\alpha}$$

$$\hat{\tau}_N = \mu_N \chi \left(1-\alpha\right) A_N \hat{k}_N^{\alpha} [(1-\lambda)\hat{n}_N^{\eta} + \lambda \hat{m}^{\eta}]^{\frac{1-\alpha-\eta}{\eta}} \times$$
$$\times \left\{ \frac{\left(1-\hat{n}_N\right)\left(1-\lambda\right)\hat{n}_N^{\eta-1} + \phi\left(1-\hat{n}_S-\hat{m}\right)\lambda\hat{m}^{\eta-1}}{\left[1-(1-\chi)\mu_N\right]\left[1+\hat{m}+\phi\left(1-\hat{n}_S-\hat{m}\right)\right]} \right\}$$

$$\hat{\Omega} = \frac{\left(1-\chi\right)\left(1-\mu_N\right)\left(1-\alpha\right) A_N \hat{k}_N^{\alpha} [(1-\lambda)\hat{n}_N^{\eta} + \lambda \hat{m}^{\eta}]^{\frac{1-\alpha-\eta}{\eta}}}{\left\{\alpha A_N \hat{k}_N^{-(1-\alpha)} \left[\lambda \hat{m}^{\eta} + (1-\lambda)\hat{n}_N^{\eta}\right]^{\frac{1-\alpha}{\eta}} + \delta_N\right\} \left[1-\left(1-\chi\right)\mu_S\right]} \times$$
$$\times \left[\lambda \hat{m}^{\eta-1} - \left(1-\lambda\right)\hat{n}_N^{\eta-1}\right],$$

which are always uniquely determined within $\hat{\theta}_N \in (0, \infty)$. That completes the proof of Proposition 1.■

1.B Sensitivity analysis on Southern replacement rate

This appendix provides results for the sensitivity analysis on the replacement rate in South, μ_S, for both the benchmark and extended versions of the model. In particular, we compare the benchmark parametrization ($\mu_S = 0.31$) with two extreme cases: (i) the case in which social protection for unemployed workers in South is absent ($\mu_S = 0$); (ii) the case in which the Southern government provides the same social protection scheme as in North by setting the same replacement rate ($\mu_S = 0.62$).

	Baseline			Extension		
Variable	$\mu_S = 0.31$	$\mu_S = 0$	$\mu_S = 0.62$	$\mu_S = 0.31$	$\mu_S = 0$	$\mu_S = 0.62$
c_N	0.54	0.48	0.65	0.44	0.39	0.54
c_S	0.51	0.57	0.45	-1.2	-1.12	-1.41
k_N	1.11	1	1.33	-0.11	-0.09	-0.15
k_S	-1.87	-2.5	-1.88	0.1	0.07	0.17
n_N	-0.02	-0.02	-0.02	-0.05	-0.04	-0.06
n_S	-1.87	-2.5	-1.88	0.1	0.07	0.17
m	10.59	10.93	9.82	-0.61	-0.54	-0.73
θ_N	-0.5	-0.44	-0.61	-1.41	-1.23	-1.8
θ_S	0	0	0	0	0	0
Y_N	1.11	1	1.33	-0.11	-0.09	-0.15
Y_S	-1.87	-2.5	-1.88	0.11	0.07	0.17
w_N	0.06	0.05	0.01	-0.	-0.	-0.
w_M	-0.45	-0.47	-0.4	-6.73	-6.73	-6.73
w_S	0	0	0	0	0	0
Π_N	1.11	1	1.33	-0.83	-0.71	-1.08
Π_S	-1.87	-1.5	-2.5	0.1	0.07	0.17
R	6.76	7.57	5.09	-20.11	-18.27	-24.42
$\mathcal{W}_N$	0.2	0.18	0.25	0.16	0.15	0.2
$\mathcal{W}_S$	0.35	0.4	0.29	-0.82	-0.79	-0.92

Sensitivity analysis on μ_S – steady-state variations in percentage points.

Table 6 shows that the results obtained in Section 1.3 and 1.4 hold mostly unaffected: all steady-state variations preserve the same sign as in the benchmark parametrization, with modest differences in magnitudes across the three different cases.

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Chapter 2

Immigration, Welfare and Inequality: How Much Does the Labor Market Specification Matter?*

2.1 Introduction

The rising mobility of people has triggered lively debates over the societal and economic consequences of immigration to high-income countries. Between 1960 and 2010, the number of foreign-born residents in high-income countries increased much more rapidly than the total population, shifting the average proportion of foreigners from 4.5 to 11.0 percent. In this context, the rising worries about immigration are legitimate, and it is not surprising that economists are making every effort to quantify the potential effects on native citizens in the host country.[1] In particular, general equilibrium models have been increasingly used to combine the main transmission mechanisms through which immigration affects welfare and inequality (typically, the labor market, fiscal, price, and productivity channels), and to account for interactions between them. In this literature, the concrete formalization of the labor market varies drastically across studies. Mechanisms such as labor supply, unemployment and wage formation range from completely exogenous to fully endogenous, and can be calibrated to match observed or potential levels (e.g., full employment, full participation). These assumptions governing the labor market responses not only determine the size of the wage and employment effects of immigration. They also affect the effects on taxes and transfers, on the demand for goods and services, as well as the education-driven changes in productivity. Hence, the labor market specification is likely to be a decisive ingredient governing the sign and the size of real income responses for the natives. How much does it impact the conclusion?

*This work is jointly written with Frédéric Docquier and Hendrik Scheewel.

[1]Worries about immigration are also driven by non-economic factors (adverse effects on social cohesiveness, national identity, crime, terrorism, etc.). However, individual attitudes towards inflows of foreigners are systematically correlated with economic concerns. The European Social Survey data for the year 2014 show that the disapproval of immigration is correlated with fears of adverse labor market and fiscal effects.

To address this question, we develop a quantitative model that encompasses the most frequent labor market specifications used in the literature, and we link labor market outcomes to the related fiscal, technological and price effects. Our benchmark model uses relatively consensual hypotheses to endogenize both labor market participation and unemployment rates of (native and immigrant) workers. This version of the model is calibrated on 20 selected OECD member states, so as to exactly match the actual population and labor market data by origin and skill level. For each country, the calibrated model is used to simulate the average welfare and inequality impacts of three immigration shocks of equal size but differing skill structures (low-skilled, high-skilled, current structure of the foreign-born population). Then, we simulate the same immigration shocks under alternative labor market structures (exogenous vs. endogenous participation and unemployment rates) and alternative calibration methods (observed characteristics vs. full participation or full employment).

Existing studies on the economic implications of immigration for destination countries can be classified according to three dimensions, namely the set of countries included, the modeling of transmission channels, and the granularity of population categories. Firstly, many single-country studies investigate one transmission channel in isolation, and distinguish between broad categories of people. For example, Borjas (2003), Card (1990) and Chassamboulli and Palivos (2014) focus on the wage and employment effects of immigration to the US. Auerbach and Oreopoulos (1999) and Dustmann and Frattini (2014) analyze the fiscal impact of immigration in the US and in the UK. Secondly, Bratsberg and Raaum (2012) and Dustmann et al. (2013) have opened a new strand of research by quantifying the wage effects of immigration for narrow categories of workers in Norway and in the UK, respectively. Thirdly, other authors developed general equilibrium models calibrated on broad categories of individuals for a single country; Storesletten (2000) and Chojnicki et al. (2011) incorporate interactions between transmission channels (e.g. labor market, public budget, education) into the analysis of economic responses to US immigration. Fourthly, Aubry et al. (2016), Battisti et al. (2018) and Burzyński et al. (2018) provide comparative (multi-country) studies emphasizing interactions between transmission channels (e.g. labor market, public budget, trade).

We follow the latter strategy and focus on the influence of the labor market specification on variables of interest at a more aggregate level (native average real income and income disparities) and on the interrelationship with the other channels. The structure of the labor market determines the formation of participation rates, employment rates and wages. Depending on how reactive these adjustment variables are, they will transmit their effect through further channels: the fiscal channel reacts to unemployment payments and the price level depends on the number of available varieties in the economy. Only recently studies include unemployment (Chassamboulli and Palivos, 2014; Battisti et al., 2018) or labor market participation rates (Burzyński et al., 2018) in addition to the wage channel as an adjustment variables into macroeconomic immigration models. Our benchmark model is first to combine the wage, participation and unemployment channels in one general equilibrium framework for the analysis of immigration shocks. Starting with this benchmark model, we can assess the sensitivity of the average welfare and inequality effects of immigration to the endogeneity and calibration of the key labor market indicators.

Altogether, our analysis reveals that the labor market specification matters. Qualitatively speaking, the labor market specification has little effect on the cross-country differences in the welfare and inequality responses to immigration. Quantitatvely speaking, it has important (scale) effects. Firstly, we show that modelling unemployment is instrumental to assessing the average welfare effects from immigration. In line with Chassamboulli and Palivos (2014) and Battisti et al. (2018), importing workers generates search externalities and positive employment effects. Although these labor market effects are relatively small, they induce a double dividend in terms of public finances: as unemployment decreases, tax revenues increase and public unemployment expenditures decrease. Secondly, modelling labor force participation is instrumental to assessing its inequality effects. Inequality responses are overestimated when labor force participation are exogenous or calibrated at unity. This is because the immigration-induced shocks on the labor market are further amplified when immigrants fully participate, and when previous immigrants cannot adjust their participation rates. Finally, we find that the specification choice is usually more important than the calibration of labor market elasticities, except for the choice of the elasticity of substitution between immigrants and natives.

The rest of the chapter is organized as following. Section 2.2 provides stylized facts on the labor market characteristics of immigrants in the 20 analyzed countries. The model economy and the economic equilibrium are described in Section 2.3. In Section 2.4, we discuss the calibration and present our results. Section 2.5 concludes.

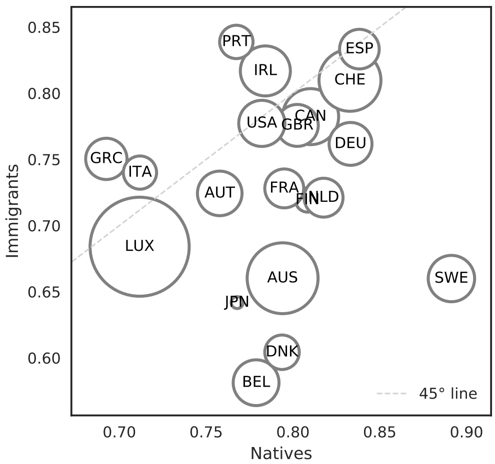
2.2 Stylized facts

The labor market characteristics of natives and immigrants are documented in the Database on Immigrants in OECD countries (DIOC) described in Arslan et al. (2014). The data are collected by country of destination and are mainly based on population censuses and administrative registers. The DIOC database provides detailed information on the country of origin, demographic characteristics, level of education, and labor market status of the population of OECD member states. Focusing on the census round 2010, we extract information about the country of origin (20 countries), age ($25-64$ and 65+), educational attainment (college graduates and less educated) and labor market status (employed, unemployed, inactive) of immigrants residing in 20 selected destinations (the 15 members of the European Union, the US, Canada, Australia, Switzerland and Japan).

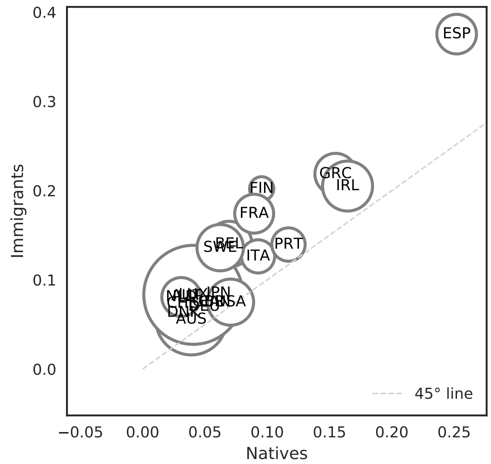
Figure 2.1 below compares the average labor market status and education level of natives and immigrants. We calculate the rates as the proportion of native/foreign-born working-age individuals that (a) participate actively in the labor market, (b) are unemployed, (c) are employed, (d) have a college degree. Countries are ranked in descending order according to the labor market status of immigrants.

FIGURE 2.1: Labor market status of immigrants and natives in 20 OECD countries

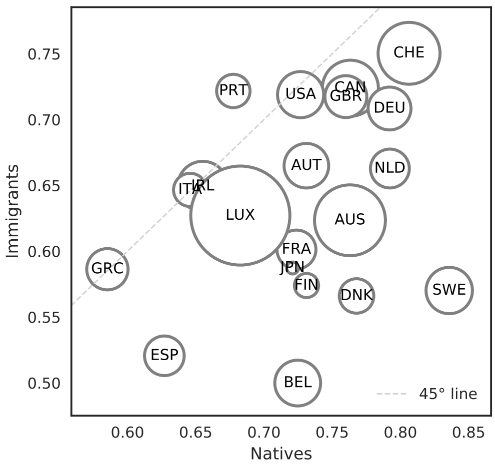
(A) Participation rate



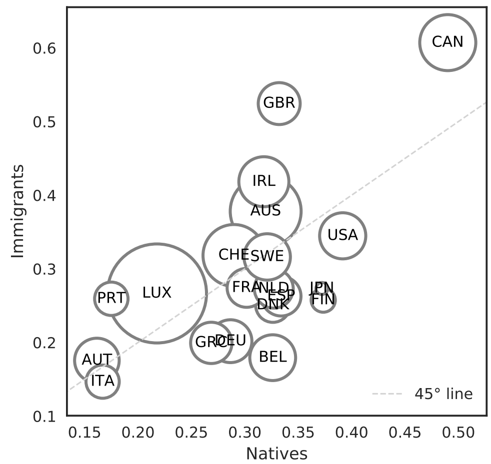
(B) Unemployment rate



(C) Employment rate



(D) Share of college graduates



Notes: Figure 2.1 shows the results for 20 selected countries: the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.

It can be seen in Figure 2.1a, that immigrants and natives differ considerably in terms of active participation in the OECD's national labor markets. There is only a low correlation between participation rates of natives and foreign-born (0.067). On average (unweighted mean), the participation rate of immigrants is 6 percentage points smaller. In Australia, Belgium, Denmark, Japan and Sweden this differential is more than twice as large. Exceptions are Greece, Ireland, Italy and Portugal where participation rates of immigrants exceed the natives' rates.

Figure 2.1b shows that, regarding unemployment rates, there is a much stronger relationship across origins: The correlation between natives' and immigrants' unemployment rates exceeds 0.942. Immigrants suffer from higher unemployment than natives in all considered countries. On average (unweighted mean), being an immigrant comes along with an unemployment rate that is 1.7 times as high as the native's rate. The disparity is particularly pronounced in Finland and Spain where the unemployment rate of foreign-born workers is more than 10 percentage points higher.

Figure 2.1c depicts origin-specific employment rates. The correlation between native and immigrant employment rates is poor (0.276). On average (unweighted mean), the employment rate of immigrants is 16 percentage points smaller. It is 20-30 percentage points smaller in Belgium, Denmark and Sweden. Exceptions are Greece, Italy and Portugal, where immigrants' employment rates are slightly higher than those of natives.

Concerning the shares of college graduates by origin, we find again a relatively high correlation between natives and foreign-born (0.645). They are illustrated in Figure 2.1d. On average (unweighted mean), the education level immigrants is almost identical to that of natives. Immigrants are more educated than natives in Canada, the United Kingdom, Australia, Ireland, Switzerland, Luxembourg, Portugal and Austria. They are less educated than natives in the other countries (especially in Belgium).

2.3 The model

We develop a general equilibrium model in order to analyze the economic impact of immigration on macroeconomic variables and on the welfare of native citizens. Four channels of influence are taken into account in the benchmark model: the employment effect, the wage effect, the market size effect, and the fiscal effect. We model the frictional labor market as in Battisti et al. (2018), the fiscal effect as in Storesletten (2000), and the market size effect as in Krugman (1980). In addition, we endogenize the labor force participation as in Burzyński et al. (2018). Empirical data show that immigrants and natives have different labor force participation rates, which might be differently affected in response to new migration flows.

In this model we formalize countries abstracting from trade linkages or capital flows between them.[2] Each country is populated by heterogeneous individuals, intermediate firms that hire workers, retailers that produce heterogeneous goods, and the government. In particular, individuals differ in skill, origin, and age. Their demographic size is exogenous and denoted by $N^a_{o,s}$, where the subscript $o = (n, m)$ refers to natives and immigrants, the subscript $s = (h, l)$ refers to college graduates and less educated, and superscript $a = (y, r)$ refers to working-age individuals and retirees. For simplicity, time and country indices are omitted. As far as firms are concerned, intermediate firms open vacancies in a frictional labor market in order to hire workers and produce intermediate goods. At the same time, retail firms buy these intermediate goods in order to produce and sell final goods in a monopolistically competitive market. The government taxes income and consumption to finance redistributive transfers, public consumption, and unemployment benefits.

In Section 2.3.1 and Section 2.3.2, we describe the preferences and technologies used to endogenize consumers' and firms' decisions. We then illustrate the frictional labor market and the monopolistically competitive retail market in Section 2.3.3 and Section 2.3.4. Finally, we define the public sector in Section 2.3.5 and characterize the steady-state equilibrium in Section 2.3.6.

2.3.1 Preferences and consumers' decisions

The preferences of a representative individual of age a, education level s and country of origin o are described by the following utility function[3]

$$\mathcal{U}^a_{o,s} = C^a_{o,s} - \frac{\Phi^a_{o,s}(1-\ell^a_{o,s})^{1+\eta}}{1+\eta}, \tag{2.1}$$

where $C^a_{o,s}$ is a composite consumption aggregate, $\ell^a_{o,s}$ is the amount of time spent outside the labor market (leisure), η is the inverse of the elasticity of labor supply to labor income, and $\Phi^a_{o,s}$ captures the disutility of participating in the labor market (i.e. working or searching for a job). $\Phi^a_{o,s}$ is allowed to vary by age group, education level and country of origin, so to match differences in participation rates deriving from cultural traits or social norms between countries.[4] Following Krugman (1980), the utility of consumption is described by a CES function over the continuum of varieties

$$C^a_{o,s} = \left[\int_0^B c^a_{o,s}(i)^{\frac{\epsilon-1}{\epsilon}} di\right]^{\frac{\epsilon}{\epsilon-1}}, \tag{2.2}$$

[2] Using a similar framework, Aubry et al. (2016) find that the welfare effect is strongly robust to the inclusion of trade. Ortega and Peri (2014) find that capital adjustments are rapid in open economies: an inflow of immigrants increases one-for-one employment and capital stocks in the short term (i.e. within one year), leaving the capital/labor ratio unchanged.

[3] Note that using a utility function that is linear in consumption allows for a measure of utility that is neither skill- nor country- specific.

[4] For all retirees we assume $\Phi^a_{o,s} = \infty$, as they do not participate in the labor market and only consume the transfers received from the government.

where B is the amount of varieties available for consumption, $\epsilon > 1$ is the constant elasticity of substitution between varieties, and $c^a_{o,s}(i)$ is the quantity of variety $i \in B$ produced in the country and consumed by an individual of type (a, o, s). This implies that individuals have a preference for variety, thus their utility from consumption does not only depend on the quantity of goods consumed, but also on the number of varieties they consume.

In each country, individuals either participate in the labor market or enjoy their leisure time. More specifically, employed individuals earn different wage rates $w_{o,s}$ according to their origin and skill,[5] whereas individuals that are looking for a job (i.e. unemployed) receive unemployment benefits, $b_{o,s}$, which are assumed to be proportional to their wage rate. Henceforth we will assume $b_{o,s} \equiv \mu w_{o,s}$, where $\mu \in (0,1)$ is the country-specific replacement rate of the national unemployment insurance scheme. Furthermore, the government taxes income and consumption at a flat rate τ and v, respectively. Hence, the individual budget constraint writes

$$\begin{aligned}\int_0^B c^a_{o,s}(i)(1+v)p(i)di =& (1-\ell^a_{o,s})\left[(1-u_{o,s})w_{o,s}(1-\tau) + u_{o,s}b_{o,s}\right] + T^a_{o,s},\\ C^a_{o,s}(1+v)P =& (1-\ell^a_{o,s})\varpi_{o,s} + T^a_{o,s},\end{aligned} \tag{2.3}$$

where $p(i)$ measures the price of variety i, P denotes the ideal price index, $u_{o,s}$ is the group-specific unemployed rate (endogenously determined in Section 2.3.3), $\varpi_{o,s} \equiv w_{o,s}\left[(1-\tau)(1-u_{o,s}) + \mu u_{o,s}\right]$ measures the nominal income per hour supplied in the labor market, and $T^a_{o,s}$ stands for redistributive transfers (that vary across origin and skill types) and public consumption (assumed identical across all individuals) provided by the government.

The individuals choose the optimal amount of hours to spend in the labor market by maximizing Eq. (2.1) subjet to (2.2) and (2.3). The solution of the problem reads

$$1 - \ell^a_{o,s} = \left(\frac{\varpi_{o,s}}{\Phi^a_{o,s}(1+v)P}\right)^{\frac{1}{\eta}}, \tag{2.4}$$

that is the labor force participation is increasing in the real income per active hour, $\varpi_{o,s}$, and decreasing in disutility of labor, $\Phi^a_{o,s}$. Moreover, as long as $\mu < 1 - \tau$, the labor force is also decreasing in the expected unemployment rate.

[5] We assume that, in each destination country, all working age immigrants in a given skill group are perfectly substitutable workers from the firm's perspective, i.e. all migrants have identical marginal productivity regardless of their origin country.

Finally, substituting Eq. (2.4) in (2.3) and (2.1), we obtain the optimal consumption and utility of each type of individual

$$C^a_{o,s} = \Phi^a_{o,s}\left(\frac{\varpi_{o,s}}{\Phi^a_{o,s}(1+v)P}\right)^{\frac{1+\eta}{\eta}} + \frac{T^a_{o,s}}{(1+v)P}, \tag{2.5}$$

$$\mathcal{U}^a_{o,s} = \frac{\eta C^a_{o,s}}{1+\eta} + \frac{T^a_{o,s}}{(1+\eta)(1+v)P}. \tag{2.6}$$

2.3.2 Technology

In each country, the final output is produced by assembling intermediate inputs in a retail sector. In turn, these intermediate inputs are produced by intermediate firms who employ young individuals of heterogeneous skill and origin country. As in Acemoglu (2001), we assume that each intermediate firm employs one worker, so that the number of intermediate goods, $Y_{o,s}$, and employed workers, $E_{o,s}$, coincide. Hence, following recent studies (such as Manacorda et al., 2012; Ottaviano and Peri, 2012), intermediate goods are taken as imperfect substitutes and the production technology adopted to produce the final output is described by the following nested CES function

$$Y = A\left[(1-\alpha)Y_h^{(\sigma_1-1)/\sigma_1} + \alpha Y_l^{(\sigma_1-1)/\sigma_1}\right]^{\sigma_1/(\sigma_1-1)}, \tag{2.7}$$

$$Y_s = \left[(1-\lambda)Y_{n,s}^{(\sigma_2-1)/\sigma_2} + \lambda Y_{m,s}^{(\sigma_2-1)/\sigma_2}\right]^{\sigma_2/(\sigma_2-1)}, \text{ for } s=(h,l),$$

where A is a given parameter capturing the country level of TFP, σ_1 and σ_2 are, respectively, the elasticity of substitution between skill groups and between origin groups, $\alpha \in (0,1)$ denotes the relative productivity of college graduates compared to less educated, and $\lambda \in (0,1)$ denotes the relative productivity of native workers compared to immigrants.

Intermediate goods are produced under perfect competition, so their price equals their marginal productivity

$$p_{m,h} = A(1-\alpha)\lambda Y^{\frac{1}{\sigma_1}} Y_h^{-\frac{1}{\sigma_1}}\left(\frac{Y_h}{Y_{m,h}}\right)^{\frac{1}{\sigma_2}} \tag{2.8}$$

$$p_{m,l} = A\alpha\lambda Y^{\frac{1}{\sigma_1}} Y_l^{-\frac{1}{\sigma_1}}\left(\frac{Y_l}{Y_{m,l}}\right)^{\frac{1}{\sigma_2}} \tag{2.9}$$

$$p_{n,h} = A(1-\alpha)(1-\lambda)Y^{\frac{1}{\sigma_1}} Y_h^{-\frac{1}{\sigma_1}}\left(\frac{Y_h}{Y_{n,h}}\right)^{\frac{1}{\sigma_2}} \tag{2.10}$$

$$p_{n,l} = A\alpha(1-\lambda)Y^{\frac{1}{\sigma_1}} Y_l^{-\frac{1}{\sigma_1}}\left(\frac{Y_l}{Y_{n,l}}\right)^{\frac{1}{\sigma_2}}. \tag{2.11}$$

Final goods are instead produced under monopolistic competition and their optimal price setting will be described in Section 2.3.4.

2.3.3 Labor market

Intermediate firms can open vacancies specific for either educated college or less educated workers. However, we assume that firms are not able to discriminate between immigrant and native workers at the vacancy posting stage.[6] Once a match has been formed, the firm and the worker (or the union that represents him) bargain the wage, which can differ between migrant and native workers.

Matching process. – The matching process is governed by the following Cobb-Douglas matching function

$$M(U_s, V_s) = \xi U_s^{\nu} V_s^{1-\nu}, \tag{2.12}$$

where M is the number of job matches, U_s and V_s are, respectively, the total amount of unemployed workers and vacancies of skill s, ξ is a constant matching efficiency parameter, and $\nu \in (0,1)$ is the elasticity parameter of the matching function.

The probabilities of finding a job and filling a vacancy depend on the labor market tightness $\theta_s \equiv \frac{V_s}{U_s}$. More specifically, the job finding rate is given by $M_s/U_s = m(\theta_s) = \xi\theta_s^{1-\nu}$, and the vacancy filling rate is given by $M_s/V_s = q(\theta_s) = \xi\theta_s^{-\nu}$. As it is easy to check, a higher market tightness makes it more difficult for firms to fill vacancies, but easier for searchers to find a job.

Asset value functions. – The steady-state discounted present values for an open vacancy, $\mathcal{J}_s^V$, and a filled vacancy, $\mathcal{J}_s^{o,F}$, are given by

$$r\mathcal{J}_s^V = -\kappa_s + q(\theta_s)\left[(1-\phi_s)\,\mathcal{J}_s^{n,F} + \phi_s\mathcal{J}_s^{m,F} - \mathcal{J}_s^V\right], \tag{2.13}$$

$$r\mathcal{J}_s^{o,F} = p_{o,s} - w_{o,s} - \delta_{o,s}\left[\mathcal{J}_s^{o,F} - \mathcal{J}_s^V\right], \tag{2.14}$$

where κ_s is the fixed cost of an open vacancy for a type s worker, $\phi_s \equiv U_s^m/U_s$ is the share of unemployed immigrants among all searching individuals of skill type s, and $\delta_{o,s}$ is the exogenous separation rate, which is allowed to differ for workers' skills and country of origin. These expressions have a straightforward interpretation. For example, the asset value of having an unfilled vacancy is given by the (negative) vacancy cost plus the expected value of filling a vacancy, which occurs at a probability $q(\theta_s)$.

For individuals supplying labor, the steady-state discounted present value of employment, $\mathcal{J}_s^{o,E}$, and unemployment, $\mathcal{J}_s^{o,U}$, are given by

$$r\mathcal{J}_s^{o,E} = (1-\tau)w_{o,s} - \delta_{o,s}\left[\mathcal{J}_s^{o,E} - \mathcal{J}_s^{o,U}\right] + T_{o,s}^y, \tag{2.15}$$

$$r\mathcal{J}_s^{o,U} = b_{o,s} + m(\theta_s)\left[\mathcal{J}_s^{o,E} - \mathcal{J}_s^{o,U}\right] + T_{o,s}^y. \tag{2.16}$$

[6] As in Battisti et al. (2018), we focus on the more interesting case in which migrants and natives share the same vacancies, so to take into account eventual effects deriving from an intensifying competition. Chassamboulli and Palivos (2014) analyzed both the case in which vacancies are shared and separated between natives and immigrants, finding positive immigration impacts on the U.S. labor market in each scenario.

Hence, the flow value of unemployment equals its return, i.e. the unemployment benefit $b_{o,s}$, plus the probability of finding a job $m(\theta_s)$, multiplied by the expected gain from such an event, and the redistributive transfer $T^y_{o,s}$. Similarly, the flow value of being employed equals the difference between the taxed wage and the expected loss from separating from the firm, plus the redistributive transfer.

Job creation condition. – Firms will find it profitable to enter the market as long as the value of posting a new vacancy is greater than zero. Hence, in steady-state the following free entry condition holds

$$\mathcal{J}^V_s = 0. \tag{2.17}$$

Combining Eqs. (2.13) and (2.14), in steady-state the job creation condition is thus given by

$$\frac{\kappa_s}{q\left(\theta_s\right)} = \left(1-\phi_s\right)\left[\frac{p^n_s - w^n_s}{r+\delta^n_s}\right] + \phi_s\left[\frac{p^m_s - w^m_s}{r+\delta^m_s}\right]. \tag{2.18}$$

Eq. (2.18) states that the expected cost of creating a vacancy, $\kappa_s/q\left(\theta_s\right)$, is equal to the expected benefit of filling a vacancy with either a native or immigrant worker, $p_{o,s} - w_{o,s}$, adjusted by the worker-type specific discount rate $r + \delta_{o,s}$. A higher market tightness would translate to higher costs of creating a vacancy, since the vacancy filling rate would decrease and firms will expect to spend more time with an unfilled vacancy.

Wage bargaining. – As hiring activity generates positive surplus for both firms and workers, we follow the mainstream search and matching literature and assume that wage rates are determined through Nash bargaining. By letting $\beta \in (0,1)$ denote the bargaining power of the worker, such a bargaining problem implies that the wage rate $w_{o,s}$ must satisfy

$$\left(1-\beta\right)\left(\mathcal{J}^{o,E}_s - \mathcal{J}^{o,U}_s\right) = \beta\left(\mathcal{J}^{o,F}_s - \mathcal{J}^V_s\right).$$

By combining the asset value Eqs. (2.13)-(2.16) and considering the free entry condition (2.17), the bargained wage rates are given by

$$w_{o,s} = \frac{\beta\left[r+\delta_{o,s}+m\left(\theta_s\right)\right]p_{o,s} + \left(1-\beta\right)\left(r+\delta_{o,s}\right)b_{o,s}}{\left(r+\delta_{o,s}\right)\left[1-\tau\left(1-\beta\right)\right]+\beta m\left(\theta_s\right)},$$

which can be seen as a weighted average between the marginal productivity $p_{o,s}$, and the outside option $b_{o,s}$. However, in this model the unemployment benefit is endogenous and proportional to the wage rate, i.e. $b_{o,s} = \mu\, w_{o,s}$. Hence, the wage rate equation writes

$$w_{o,s} = \frac{\beta\left[r+\delta_{o,s}+m\left(\theta_s\right)\right]p_{o,s}}{\left(r+\delta_{o,s}\right)\left[1-\left(1-\beta\right)\left(\tau+\mu\right)\right]+\beta m\left(\theta_s\right)}. \tag{2.19}$$

It is easy to check that a higher bargaining power of workers β leads to higher wage rates. Also note that the higher the replacement rate μ, the higher the wage rates. Intuitively, a higher μ

raises the worker's outside option, hence increasing the worker's surplus from hiring.

Unemployment rates. – The dynamic law of unemployed workers of skill s and origin o is given by the difference between amount of job separations and the number of matches formed in a given instant in time

$$\dot{U}_{o,s} = \delta_{o,s} Y_{o,s} - m\left(\theta_s\right) U_{o,s}.$$

Denoting with $Q_{o,s} \equiv (1 - l^y_{o,s}) N^y_{o,s}$ the total amount of active individuals of type (o, s), in steady-state the total amount of employed and unemployed people writes

$$E_{o,s} = \frac{m\left(\theta_s\right) Q_{o,s}}{\delta_{o,s} + m\left(\theta_s\right)}, \tag{2.20}$$

$$U_{o,s} = \frac{\delta_{o,s} Q_{o,s}}{\delta_{o,s} + m\left(\theta_s\right)}, \tag{2.21}$$

that is unemployment is increasing in the separation rate and decreasing in the market tightness. Note that, because each firm requires one worker to produce a unit of intermediate good, equation (2.20) also defines the number of intermediate goods, $Y_{o,s}$, produced in the economy. Finally, we obtain the employment and unemployment rates as follows

$$\frac{Y_{o,s}}{Q_{o,s}} \equiv e_{o,s} = \frac{m\left(\theta_s\right)}{\delta_{o,s} + m\left(\theta_s\right)}, \tag{2.22}$$

$$\frac{U_{o,s}}{Q_{o,s}} \equiv u_{o,s} = \frac{\delta_{o,s}}{\delta_{o,s} + m\left(\theta_s\right)}. \tag{2.23}$$

2.3.4 Retailers and price setting

There is a continuum of monopolistically competitive retailers with a measure B. Each monopolistic firm i buys intermediate goods and differentiates them with a technology that transforms intermediate goods into retail goods $y(i)$. Hence, the total amount of GDP in the economy can be expressed as $Y = By(i)$.

As firms use the same technology, and preferences over varieties are symmetric, the same pricing rule $p(i) = p$ holds for all i monopolistic firms and the ideal price index reads

$$P = p(i) B^{\frac{1}{1-\epsilon}}. \tag{2.24}$$

Given $\epsilon > 1$, this implies that an increase in the number of varieties available to consumers reduces the ideal price index, due to increased competition between monopolistic manufacturers.

The marginal cost that retailer firms face coincides with the price of the intermediate good $p_{o,s}$ (i.e. intermediate firms are in perfect competition). Hence, retailers maximize their profits by setting the following price

$$p = \frac{\epsilon}{\epsilon - 1}\frac{\widetilde{p}}{A}, \tag{2.25}$$

where $\epsilon/(\epsilon-1)$ is the monopoly's mark-up and $\widetilde{p}$ is an intermediate price composite related to the nested CES production function

$$\widetilde{p} = \left[(1-\alpha)\widetilde{p}_h^{(\sigma_1-1)/\sigma_1} + \alpha\widetilde{p}_l^{(\sigma_1-1)/\sigma_1}\right]^{(\sigma_1)/\sigma_1-1}, \tag{2.26}$$
$$\widetilde{p}_s = \left[(1-\lambda)\left(\widetilde{p}_{n,s}\right)^{(\sigma_2-1)/\sigma_2} + \lambda\left(\widetilde{p}_{m,s}\right)^{(\sigma_2-1)/\sigma_2}\right]^{\sigma_2/(\sigma_2-1)}, \text{ for } s=(h,l).$$

Denoting with $Z \equiv \frac{Y}{A} = \frac{By(i)}{A}$ the aggregate quantity of efficiency units of intermediate goods in the economy, i.e. the nested CES combination of the four types of intermediate goods,[7] and using Eqs. (2.24) and (2.25), it is easy to check that the retailer's profit from production, $\frac{1}{\epsilon}\left(\frac{p}{P}\right)^{1-\epsilon}\widetilde{p}Z = \frac{\widetilde{p}Z}{B\epsilon}$, is decreasing in the number of firms B. Furthermore, we assume that entering the retail sector is costly, so that each retailer faces a fixed cost ψ to produce and sell final goods in the monopolistically competitive market. This entry cost is expressed in units of efficient intermediate good composite, and can be interpreted as an investment that a firm must make to explore the market and differentiate its product. As long as gains are positive, new firms will enter the market, causing profits to fall, until they are equal to zero. Hence, the free entry condition in the retailers market is given by

$$\frac{\widetilde{p}Z}{B\epsilon} - \psi\widetilde{p} = 0,$$

that is the gain of producing another variety of good, $\frac{\widetilde{p}Z}{B\epsilon}$, must be equal to the entry cost, $\psi\widetilde{p}$. As in Krugman (1980), it follows that the mass of varieties produced in a given country is equal to

$$B = \frac{Z}{\epsilon\psi}. \tag{2.27}$$

Eq. (2.27) states that the equilibrium number of firms in a given country is increasing with the size of the intermediate goods (which can be interpreted as a measure of the economy size), and decreasing with firm's entry cost ψ.

2.3.5 Government

The government imposes a fixed tax on consumption υ and labor income τ, and uses the resulting revenues to finance unemployment benefits, $b_{o,s} \equiv \mu w_{o,s}$, and group specific transfers, $T^a_{o,s}$, that include redistributive transfers and public consumption. We assume that in steady-state the

[7] Remind that, as in the economy each intermediate firm hires one worker to produce one intermediate good, worker's origin and skill determine the intermediate good type.

government budget is balanced. Hence, the government budget constraint writes

$$(v+\tau)\,Y=\mu\sum_{o,s}U_s^o w_{o,s}+\sum_{a,o,s}N_{o,s}^a T_{o,s}^a. \tag{2.28}$$

The left-hand side of Eq. (2.28) corresponds to the government revenues, whereas the right-hand side corresponds to the government expenditures. We assume that the income tax τ endogenously adjusts to balance the government budget. This means that, for example, a temporary budget deficit generated by an increase in unemployement would make the government increase the labor income tax τ until the budget is balanced and Eq. (2.28) is satisfied again.

2.3.6 Equilibrium characterization

Definition 1. *For a set of common parameters* $\{\epsilon,\eta,\sigma_1,\sigma_2,\beta,\xi,\nu,\kappa_s\}$*, a set of destination-specific parameters* $\left\{\alpha,\lambda,A,\delta_{o,s},\psi,\mu,v,T_{o,s}^a\right\}$*, and a set of origin-specific parameters* $\left\{\Phi_{o,s}^a,N_{o,s}^a\right\}$*, the economic equilibrium is a set of endogenous variables* $\left\{w_{o,s},c_{o,s}^a,\ell_{o,s}^a,E_{o,s},U_{o,s},\theta_s,y,p_{o,s},p,P,B,\tau\right\}$ *that satisfies the following conditions*

1. *individuals maximize their utility (2.1) subject to (2.2) and (2.3),*
2. *the intermediate goods market clear, so that Eqs.* (2.8)-(2.11) *are satisfied,*
3. *the job creation condition (2.18) for each skill type s is satisfied,*
4. *the Nash bargaining optimality condition (2.19) holds for each worker type* (o,s)*,*
5. *the number of employed and unemployed workers are given by Eqs.* (2.20) *and* (2.21) *for each worker type* (o,s)*,*
6. *the retailers' free entry condition* (2.27) *holds,*
7. *the government budget (2.28) is balanced.*

2.4 Quantitative analysis

In this section, we calibrate the model on 20 selected OECD countries, and we simulate the destination-specific impact of a one-percent increase in the labor force due to immigration. Three clarifications about this numerical exercise have to be made.

Firstly, we consider two main variables of interest, (i) the average real income level of the working-age natives (a proxy for the average welfare effect of immigration),[8] and (ii) the ratio of real income between college-educated and less educated working-age natives (a proxy for the inequality effect of immigration).[9] Our proxies for average welfare and inequality are thus given

[8] Note that, because of the relationship between utility (Eq. 2.6) and consumption (Eq. 2.5), using utility as welfare index would yield analogous results.

[9] As public transfers are assumed to be exogenous, the effect on the real income of retirees is solely determined by the change in the price index ($-dP/P$).

by

$$\begin{aligned}\overline{C}_n^y &\equiv \frac{N_{n,h}^y C_{n,h}^y + N_{n,l}^y C_{n,l}^y}{N_{n,h}^y + N_{n,l}^y}, \\ I_n^y &\equiv C_{n,h}^y / C_{n,l}^y,\end{aligned}$$

where $C_{n,s}^y$ denotes the real consumption level of working-age natives of skill type s. From Eq. (3), $C_{n,s}^y$ can be rewritten as

$$C_{n,s}^y = \frac{(1-\ell_{n,s}^y) w_{n,s} (1-u_{n,s})(1-\tau)\Gamma_{n,s}^y + T_{n,s}^y}{(1+v)P}, \tag{2.29}$$

where $\Gamma_{n,s}^y \equiv 1 + \frac{\mu u_{n,s}}{(1-u_{n,s})(1-\tau)}$ is a residual multiplicative determinant of labor income.

Hence, the effects of an immigration shock on average welfare and inequality can be approximated by

$$\frac{d\overline{C}_n^y}{\overline{C}_n^y} \simeq \frac{N_{n,h}^y C_{n,h}^y}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y} \cdot \frac{dC_{n,h}^y}{C_{n,h}^y} + \frac{N_{n,l}^y C_{n,l}^y}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y} \cdot \frac{dC_{n,l}^y}{C_{n,l}^y}, \tag{2.30}$$

$$\frac{dI_n^y}{I_n^y} \simeq \frac{dC_{n,h}^y}{C_{n,h}^y} - \frac{dC_{n,l}^y}{C_{n,l}^y}. \tag{2.31}$$

Secondly, it has been abundantly shown that college-educated and low-skilled immigrants induce different effects on labor market outcomes, productivity, public finances, and market size (see Borjas, 2003; Manacorda et al., 2012; Ottaviano and Peri, 2012). This means that the welfare and inequality responses to immigration are governed by the skill structure of the immigrant population. For each country in our sample, we thus consider three education-mix variants of the immigration shock: (i) new immigrants are all low-skilled, (ii) new immigrants are all college-educated, and (iii) the skill structure of the immigration shock is identical to the actual structure of the working-age, foreign-born population living in the destination country.

Thirdly, we consider seven specifications of our model. Remember our goal is to assess whether the labor market specification is a decisive ingredient governing the sign and the size of the welfare and inequality responses to immigration. Our benchmark model is the one depicted in Section 2.3 with endogenous wages, labor force participation rates, and unemployment rates. Departing from this benchmark framework, we consider six alternative specifications combining endogenous or exogenous levels of labor force participation and unemployment (LFP_{end} vs. LFP_{exo}, and UR_{end} vs. UR_{exo}) and, in the exogenous cases, a calibration on empirically observed or full employment and participation levels (LFP_{exo} vs. $LFP = 1$, and UR_{exo} vs. $UR = 0$). This allows us to identify whether our findings are strongly influenced by some labor market features.

The rest of this section is organized in three parts. Firstly, in Section 2.4.1 we explain our calibration strategy for the benchmark model. Then, we analyze the welfare and inequality effects of immigration in Sections 2.4.2. Finally, we analyze the robustness of our findings to key elasticities in Section 2.4.3.

2.4.1 Parameterization

We parameterize our model to reflect the economic and socio-demographic features of 20 OECD countries (EU15 member states, the US, Canada, Australia, Switzerland and Japan). Our model includes a total of 40 exogenous parameters which need to be determined in order to perform a comparative statics analysis. Most of these parameters vary across countries and are set to match moments taken from the data, while some are assumed to be country-invariant and taken from the empirical literature. As in our simulation exercises we focus on analyzing steady-state variations deriving from different types of migration shocks, all scale parameters which do not affect our results – namely the TFP level A, the firm's entry cost ψ, and the matching efficiency ζ – are, for simplicity, normalized to unity in all countries. In what follows, we first describe the data sources used for the model, and then discuss our calibration strategy.

Population and labor force data. – In line with Section 2.2, we use the Database on Immigrants in OECD countries (DIOC) described in Arslan et al. (2014). For each OECD country, the database covers the census round 2010 and documents the structure of the population by country of origin, by age, by education level, by duration of stay, and by labor market status. Immigrants who did not report their origin country are distributed proportionately to observations. We first classify individuals by country of origin, and then define the college-educated group as individuals who have at least one year of college education or a bachelor degree (ISCED 5). Those with no education and with pre-primary, primary or secondary education completed are defined as the less educated. We classify individuals who did not report their education level as low-skilled. As for the age structure, we define individuals aged 25 to 64 as the working aged group, and those aged 65 and over as the retirees group. Individuals who did not report their age are assumed to belong to the working age group. The important feature of including data on labor market status allow us to also identify, for each origin country and skill group, the proportions of employed, unemployed and inactive individuals aged 25 to 64.

Labor income data. – Data on the wage ratio between college-educated and less educated workers are taken from the *Education at a Glance 2012* report of the OECD, and used as a proxy for the average return to skill w_h/w_l. Data on the wage ratio between native and immigrant workers are obtained from Büchel and Frick (2005) and from Docquier et al. (2014).

Fiscal data. – Comparable aggregate data on public finances are obtained from the *Annual National Accounts* harmonized by the OECD. In line with Burzyński et al. (2018), we use it to identify the consumption tax rate v, the redistributive transfers $T^a_{o,s}$, and the ratio of public expenditure to GDP. We also identify the amount of public consumption and treat it as a homogeneous transfer to all residents (as a part of $T^a_{o,s}$). As in Aubry et al. (2016), we also use the Social Expenditure Database (SOCX) of the OECD to decompose social protection expenditures, and the European Union Statistics on Income and Living Conditions (EU-SILC, provided by Eurostat) to disaggregate education and social protection transfers received by the natives; we identify transfers to natives by education level and by age group. We add these transfers to public consumption per capita and use it as a proxy for $T^a_{n,s}$. Finally, SOCX is also used to take data for public unemployment spending as percentage of GDP.

Calibration of common parameters. – Table 2.1 reports exogenous parameters that do not vary across countries. We set the elasticity of substitution between goods $\epsilon = 7$, so as to allow it to fall within the estimated range of 3 to 8.4 reported in Feenstra (1994), implying conservative market size effects. Following Ottaviano and Peri (2012), we assume the elasticity of substitution between skill groups and origin groups of $\sigma_1 = 2$ and $\sigma_2 = 20$, respectively. We set $\eta = 10$, so to imply an elasticity of labor supply to income of 0.1, as in Evers et al. (2008). In line with Chassamboulli and Palivos (2014) and similarly related literature, the monthly interest rate r is set to 0.4%. Following the bulk of the literature on search and matching, we set the matching elasticity parameter ν to 0.5, which is within the range of estimates reported in Petrongolo and Pissarides (2001) and Mortensen and Nagypál (2007), as well as the worker's bargaining power β to 0.5, so as to satisfy the Hosios condition (see Hosios (1990)). Finally, we normalize the low-skilled vancancy cost κ_l to the same value adopted in Chassamboulli and Palivos (2014) and Battisti et al. (2018).[10]

Table 2.1: Parameters without country variation

Parameters	Description	Value	Source
ϵ	Elast. subst. between goods	7	Feenstra (1994)
σ_1	Elast. subst. between skills	2	Ottaviano and Peri (2012)
σ_2	Elast. subst. immig/natives	20	Ottaviano and Peri (2012)
$1/\eta$	Elast. of labor supply	0.1	Evers et al. (2008)
κ_l	Low-skilled vacancy cost	0.421	Chassamboulli and Palivos (2014)
r	Interest rate (monthly)	0.004	Chassamboulli and Palivos (2014)
ν	Matching elasticity	0.5	Petrongolo and Pissarides (2001)
β	Worker bargaining power	0.5	Hosios (1990)

Calibration of country-specific parameters. – Table 2.2 lists exogenous parameters which are taken from the data and vary across countries. The firms' preferences for workers are calibrated to match the wage ratios between workers. Hence, α and λ are calibrated to match, respectively, the average return to skill w_h/w_l and the average native wage premium w_n/w_m. The separation rates $\delta_{o,s}$ are set so as to match the unemployment rates observed in the DIOC data. Specifically, separation rates are calibrated to be, on average, larger for migrants than for natives, reflecting the higher unemployment rate of immigrants (especially less-educated ones). The vacancy ratio κ_h/κ_l is parameterized to match the wage ratio w_h/w_l, implying a higher cost endured by firms

[10] In Section 2.4.3 we consider alternative levels of $\epsilon, \sigma_1, \sigma_2, \eta$ and κ_l in our robustness analysis.

with unfilled vacancies for high-skilled positions. The disutility of labor parameters $\phi^y_{o,s}$ are calibrated to match the labor force participation rates provided by the DIOC data. A larger level of $\phi^y_{m,l}$ implies a lower participation rate of less-educated immigrants compared to other cohorts.

As far as fiscal parameters are concerned, the replacement rate μ is set to match the level of public unemployment spending as percentage of GDP matches observed data.[11] Further, we calibrate the level of public transfers so to match the government expenditure to GDP as well as transfers by different cohorts taken from the OECD *Annual National Accounts* database. Using the same data source, we also calibrate the consumption tax rate v. Finally, demographic shares for all cohorts are parameterized in order to match DIOC data.[12]

2.4.2 Does the labor market specification matter?

We examine the effects of a one-percent increase in the labor force due to immigration using seven labor market variants of our model, and considering three education-mix variants of the immigration shock (low-skilled, high-skilled, actual destination-specific mix). We first describe the average welfare effects, and then discuss the inequality effects.

Average welfare effects

The average welfare effects of immigration are described in Figure 2.2. The *Benchmark* scenario assumes endogenous unemployment and labor force participation rates (what could be referred to as "UR_{end}, LFP_{end}" given the notations below), in line with the model of Section 2.3. Departing from this benchmark model, we consider six alternative labor market specifications:

- Spec. "UR_{exo}, LFP_{end}" assumes exogenous unemployment rates (calibrated at their observed levels). This scenario is used in Burzyński et al. (2018).
- Spec. "UR_{exo}, LFP_{exo}" assumes exogenous unemployment and exogenous labor force participation rates (calibrated at their observed levels).
- Spec. "$UR_{exo}, LFP = 1$" assumes exogenous unemployment rates (calibrated at their observed levels) and exogenous labor force participation (equal to unity).
- Spec. "$UR = 0, LFP = 1$" assumes exogenous unemployment rates (equal to zero) and exogenous labor force participation (equal to unity). This scenario characterizes the simplest competitive labor market model.

[11] We use public unemployment spending data (year 2013) from OECD SOCX for all countries but Denmark, which is missing in the SOCX database. Because of this, we used data on expenditure on social protection (year 2013) taken from Eurostat social protection statistics in order to calibrate Denmark's replacement rate.

[12] Note that the DIOC dataset provides data on individuals aged 65 and over (here interpreted as retirees) by skill group, but not by origin group. Hence, in order to obtain a moment to match $N^r_{o,s}$, we assume that retirees origin distribution follows the same proportion of the younger individuals, i.e. $N^r_n/N^r_m = N^y_n/N^y_m$.

TABLE 2.2: Parameters varying across countries

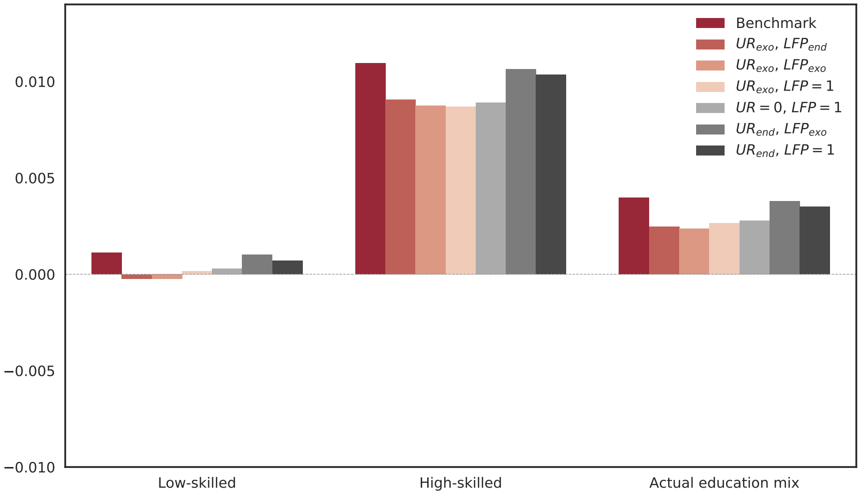
Parameters	Description	Mean	S.d.	Moment matched
Labor market parameters				
α	Firms' preference to LS	0.417	0.051	Matches avg. return to skill w_h/w_l
λ	Firms' preference to migrants	0.479	0.045	Matches avg. wage ratio w_n/w_m
$\delta_{n,h}$	Break-up rate of natives HS	0.022	0.017	Matches unempl. rate $u_{n,h}$
$\delta_{n,l}$	Break-up rate of natives LS	0.048	0.039	Matches unempl. rate $u_{n,l}$
$\delta_{m,h}$	Break-up rate of migrants HS	0.047	0.035	Matches unempl. rate $u_{m,h}$
$\delta_{m,l}$	Break-up rate of migrants LS	0.074	0.057	Matches unempl. rate $u_{m,l}$
κ_h/κ_l	Vacancy costs ratio	1.96	0.351	Matches w_h/w_l
$\Phi^y_{n,h}$	Labor disutility of natives HS	1.063	0.325	Matches LFP rate of natives HS
$\Phi^y_{n,l}$	Labor disutility of natives LS	3.509	2.088	Matches LFP rate of natives LS
$\Phi^y_{m,h}$	Labor disutility of migrants HS	2.856	1.81	Matches LFP rate of migrants HS
$\Phi^y_{m,l}$	Labor disutility of migrants LS	16.33	25.2	Matches LFP rate of migrants LS
Fiscal parameters				
μ	Replacement rate	0.201	0.128	Matches gov. exp. on unempl./GDP
v	Consumption tax rate	0.169	0.044	Matches OECD data
$T^y_{n,h}$	Transfers to natives HS	0.049	0.013	Matches gov. exp./GDP
$T^y_{n,l}/T^y_{n,h}$	Transfers ratio NL/NH	0.942	0.159	Matches OECD data
$T^y_{m,h}/T^y_{n,h}$	Transfers ratio MH/NH	1,383	0.488	Matches OECD data
$T^y_{m,l}/T^y_{n,h}$	Transfers ratio ML/NH	1.3	0.44	Matches OECD data
$T^r_{n,h}/T^y_{n,h}$	Transfers ratio ret. NH/NH	2.545	0.993	Matches OECD data
$T^r_{n,l}/T^y_{n,h}$	Transfers ratio ret. NL/NH	1.8	0.53	Matches OECD data
$T^r_{m,h}/T^y_{n,h}$	Transfers ratio ret. MH/NH	2.446	0.935	Matches OECD data
$T^r_{m,l}/T^y_{n,h}$	Transfers ratio ret. ML/NH	1.972	0.819	Matches OECD data
Demografic sizes as share of total population				
$N^y_{n,h}$	Young natives HS	0.195	0.059	Matches OECD data
$N^y_{n,l}$	Young natives LS	0.439	0.06	Matches OECD data
$N^y_{m,h}$	Young migrants HS	0.047	0.038	Matches OECD data
$N^y_{m,l}$	Young migrants LS	0.102	0.066	Matches OECD data
$N^r_{n,h}$	Retired natives HS	0.0334	0.034	Matches OECD data
$N^r_{n,l}$	Retired natives LS	0.164	0.048	Matches OECD data
$N^r_{m,h}$	Retired migrants HS	0.004	0.004	Matches OECD data
$N^r_{m,l}$	Retired migrants LS	0.015	0.01	Matches OECD data

- Spec. "UR_{end}, LFP_{exo}" assumes exogenous labor force participation rates (calibrated at their observed levels).
- Spec. "$UR_{end}, LFP = 1$" assumes exogenous labor force participation rates (equal to unity). This scenario is used in Burzyński et al. (2018).

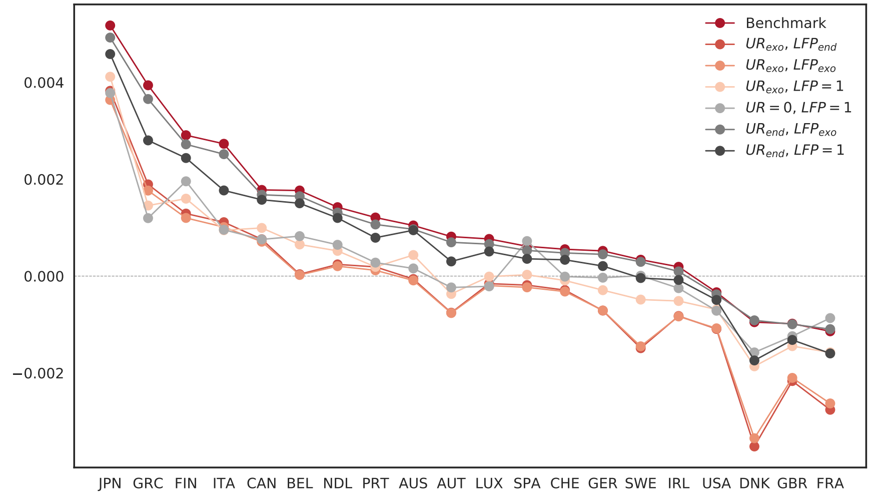
Figures 2.2b to 2.2d show the welfare effects of the three immigration shocks (low-skilled, high-skilled, and actual education mix, respectively) by country. Unsurprisingly, the greatest welfare effects are obtained when immigrants are highly educated (the average welfare gain ranges from 0.2-0.5% in Denmark to 2.1-2.5% in Japan). At the actual education mix, the welfare impact of immigration are usually beneficial regardless of the labor market structure. Negative welfare effect are obtained in France and Denmark when unemployment and labor force participation rates are treated as exogenous variables. More pessimistic results emerge when immigrants are all low-skilled. The welfare effect is always positive or nil in eight countries; it is

FIGURE 2.2: Average welfare effect of immigration (1% of the total labor force) – Sensitivity to labor market modeling

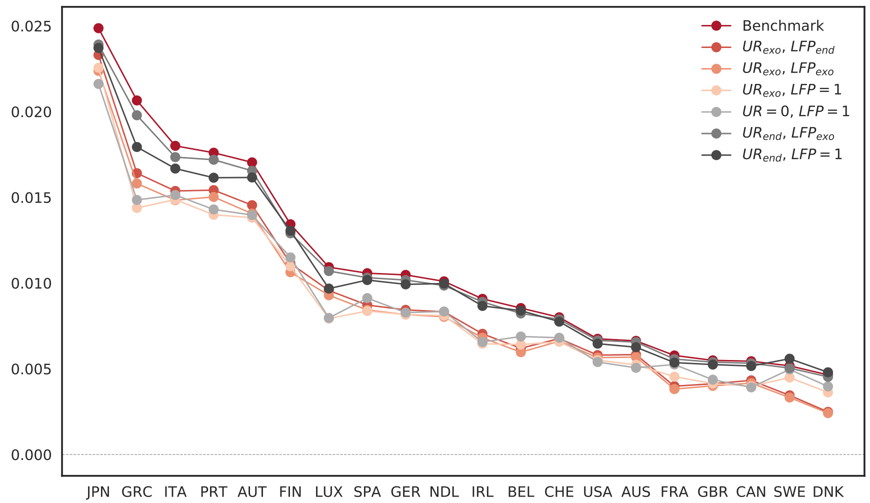
(A) Unweighted mean effect



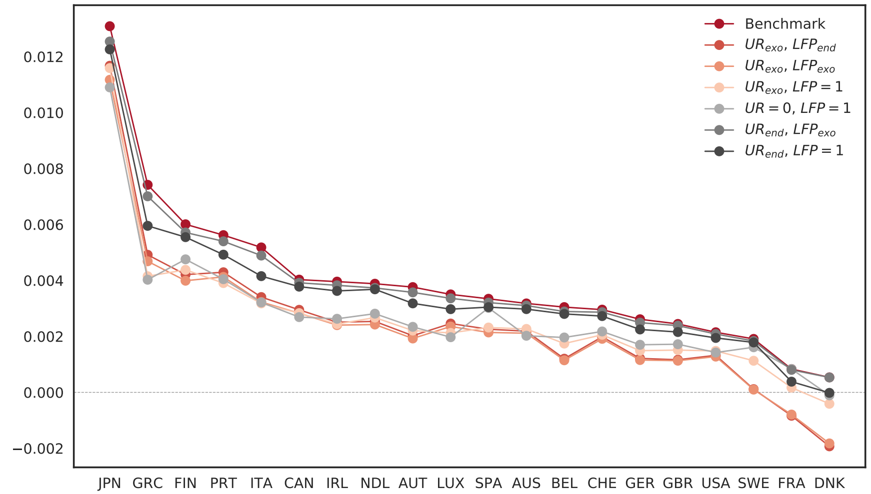
(B) Effect by country: low-skilled immigration



(C) Effect by country: high-skilled immigration

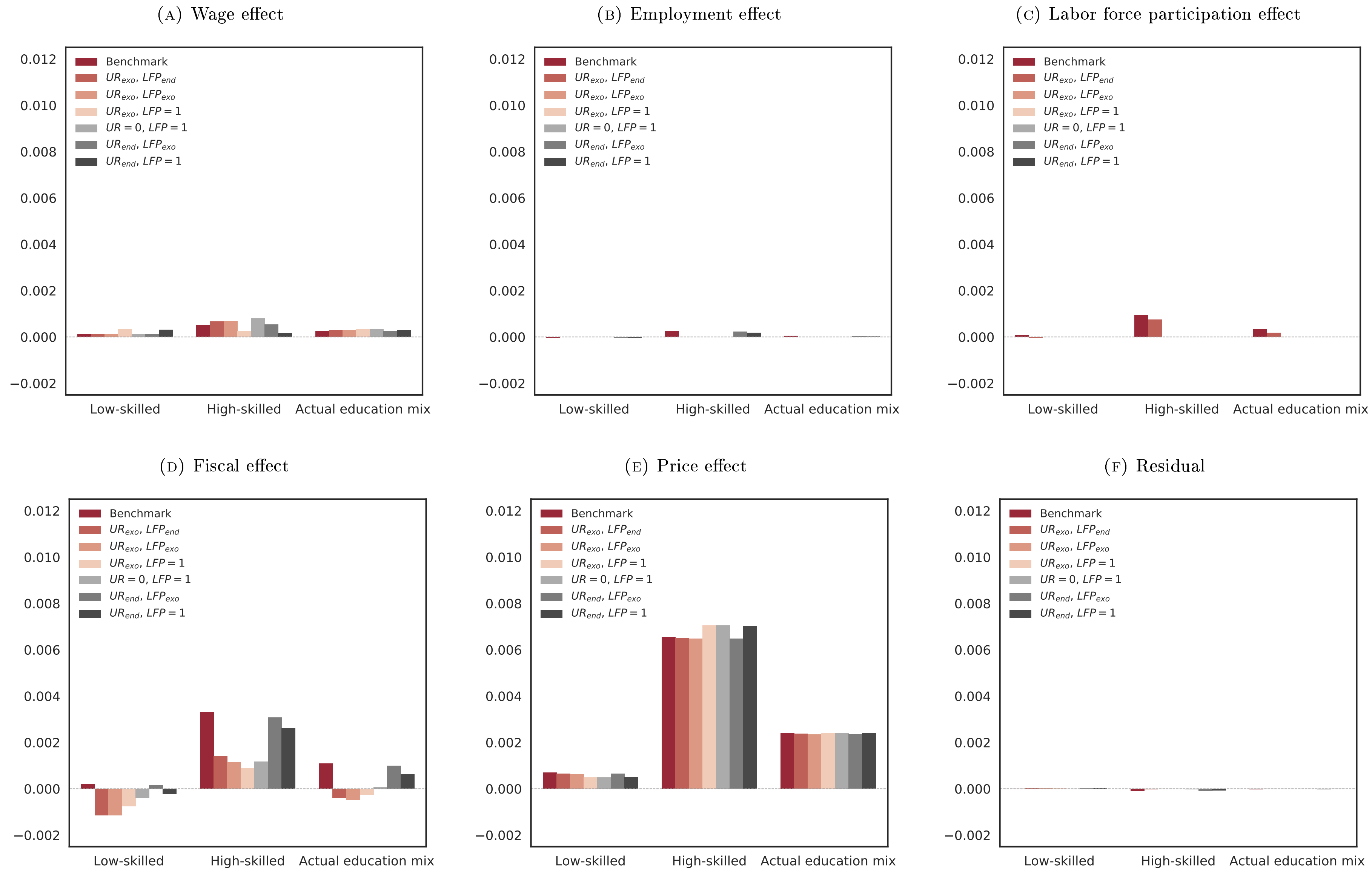


(D) Effect by country: actual education mix



Notes: Figure 2.2 shows the results for 20 selected countries: the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.

Figure 2.3: Decomposition of unweighted mean welfare effect of immigration (1% of the total labor force) – Sensitivity to labor market modeling



Notes: Figure 2.3 shows the results for 20 selected countries: the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.

always negative in four countries; in the remaining eight countries, the sign of the welfare effect depends on the labor market specification.

In Figure 2.2a, we compute the unweighted mean effects of all countries under the seven variants of the model. In line with country-specific results (see Figures 2.2b to 2.2d), it clearly appears that the most optimistic (or least pessimistic) results are obtained under the specifications with endogenous unemployment rates, whatever the skill structure of immigration. On the contrary, endogenizing labor force participation rates has smaller effects.

To shed light on the mechanisms at work, we decompose the average welfare effect into six transmission channels: the labor force participation, gross wage, employment, fiscal, residual, and price responses to immigration. Using Eq. (2.29), the welfare responses to immigration for type-s natives is the sum of these six transmission channels:

$$\frac{dC^y_{n,s}}{C^y_{n,s}} \simeq \frac{C^y_{n,s} - T^y_{n,s}}{C^y_{n,s}} \left[\frac{d(1-\ell^y_{n,s})}{(1-\ell^y_{n,s})} + \frac{dw_{n,s}}{w_{n,s}} + \frac{d(1-u_{n,s})}{(1-u_{n,s})} + \frac{d(1-\tau)}{(1-\tau)} + \frac{d\Gamma^y_{n,s}}{\Gamma^y_{n,s}} \right] - \frac{dP}{P}, \quad (2.32)$$

where the first five components are weighted by the share of labor income (net of taxes) in total income.

Substituting this expression into Eq. (2.30), the average welfare effect of immigration can be expressed as

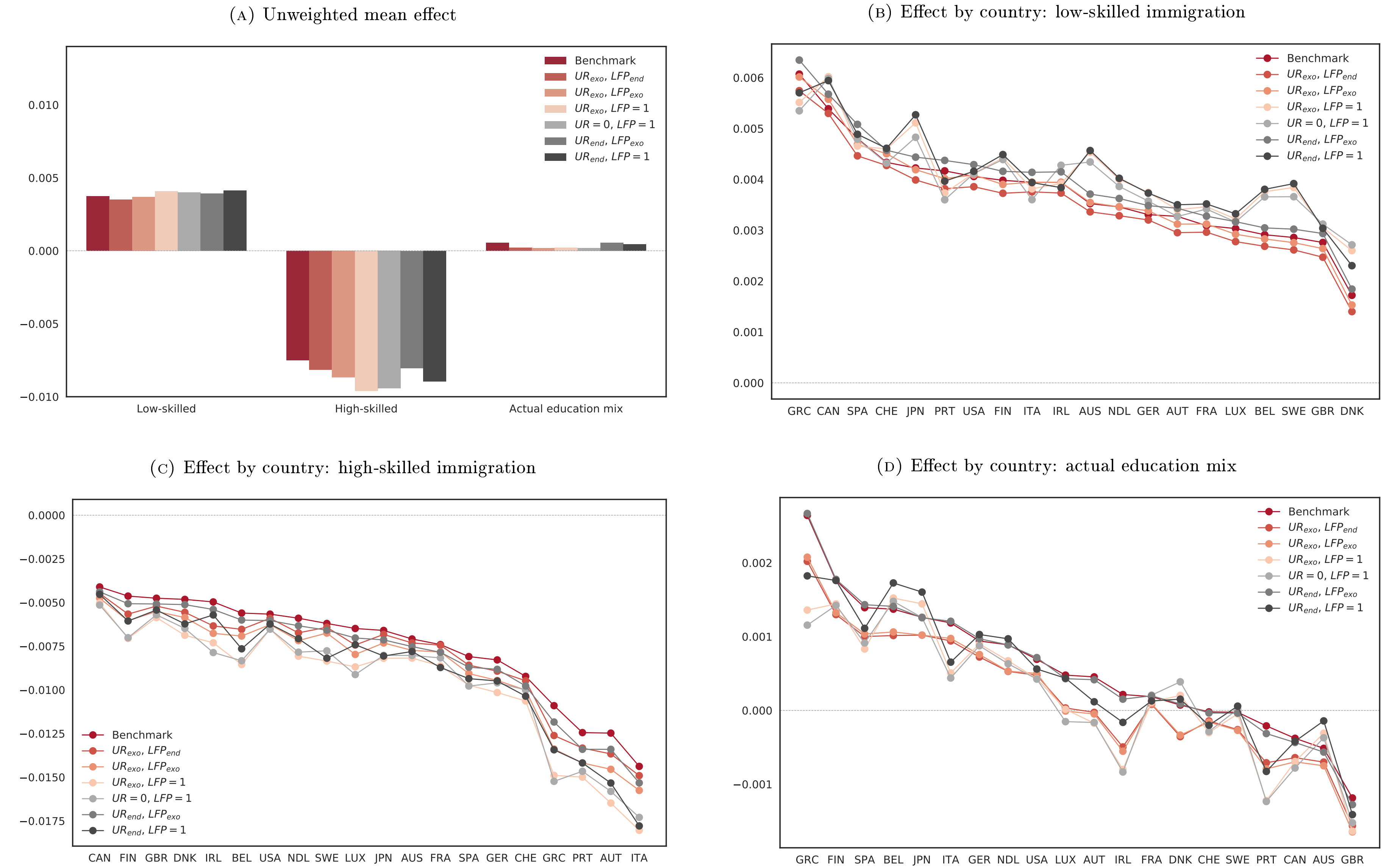
$$\frac{d\overline{C}^y_n}{\overline{C}^y_n} \simeq \left.\frac{d\overline{C}^y_n}{\overline{C}^y_n}\right|_{partic} + \left.\frac{d\overline{C}^y_n}{\overline{C}^y_n}\right|_{wage} + \left.\frac{d\overline{C}^y_n}{\overline{C}^y_n}\right|_{empl} + \left.\frac{d\overline{C}^y_n}{\overline{C}^y_n}\right|_{fiscal} + \left.\frac{d\overline{C}^y_n}{\overline{C}^y_n}\right|_{resid} + \left.\frac{d\overline{C}^y_n}{\overline{C}^y_n}\right|_{price} \quad (2.33)$$

where the six transmission channels are weighted sums of skill-specific effects.[13]

Figure 2.3 gives the unweighted mean average of these six welfare components, using the same vertical scale for the sake of comparability. The sum of these six derivatives is almost identical to the welfare effect depicted in in Figure 2.2a. We find that the average welfare responses are dominated by the fiscal and price effects of immigration, whatever the structure of immigration. These findings are very much in line with Aubry et al. (2016). Overall, the wage, labor force participation and employment responses to immigration are small, as well as the residual term. Nevertheless, the specification of the labor market matters. In our model, high-skilled immigration tends to increase the unemployment rate of the high-skilled, and to reduce the unemployment of the low-skilled of immigrants and natives. The net employment effect is small but positive. To a lesser extent, low-skilled and balanced immigration also induce small but positive net employment effects. The employment response looks negligible in Figure 2.3b but it is more visible when looking at the change in $u_{o,s}$ rather than the change in $1 - u_{o,s}$ (see Figure 2.7 in Appendix 2.B). The cause of this positive net employment effect is that firms' profits from posting a vacancy increase with the number of workers (as in Battisti et al., 2018). As unemployment decreases, tax revenues increase and public unemployment expenditures decrease. The modelling of the labor market thus affects the size of the fiscal effect of immigration, as depicted in Figure 2.3d. On the contrary, the price response to immigration varies less with labor market outcomes. In sum, modelling unemployment is instrumental to assessing the average welfare effects from immigration.

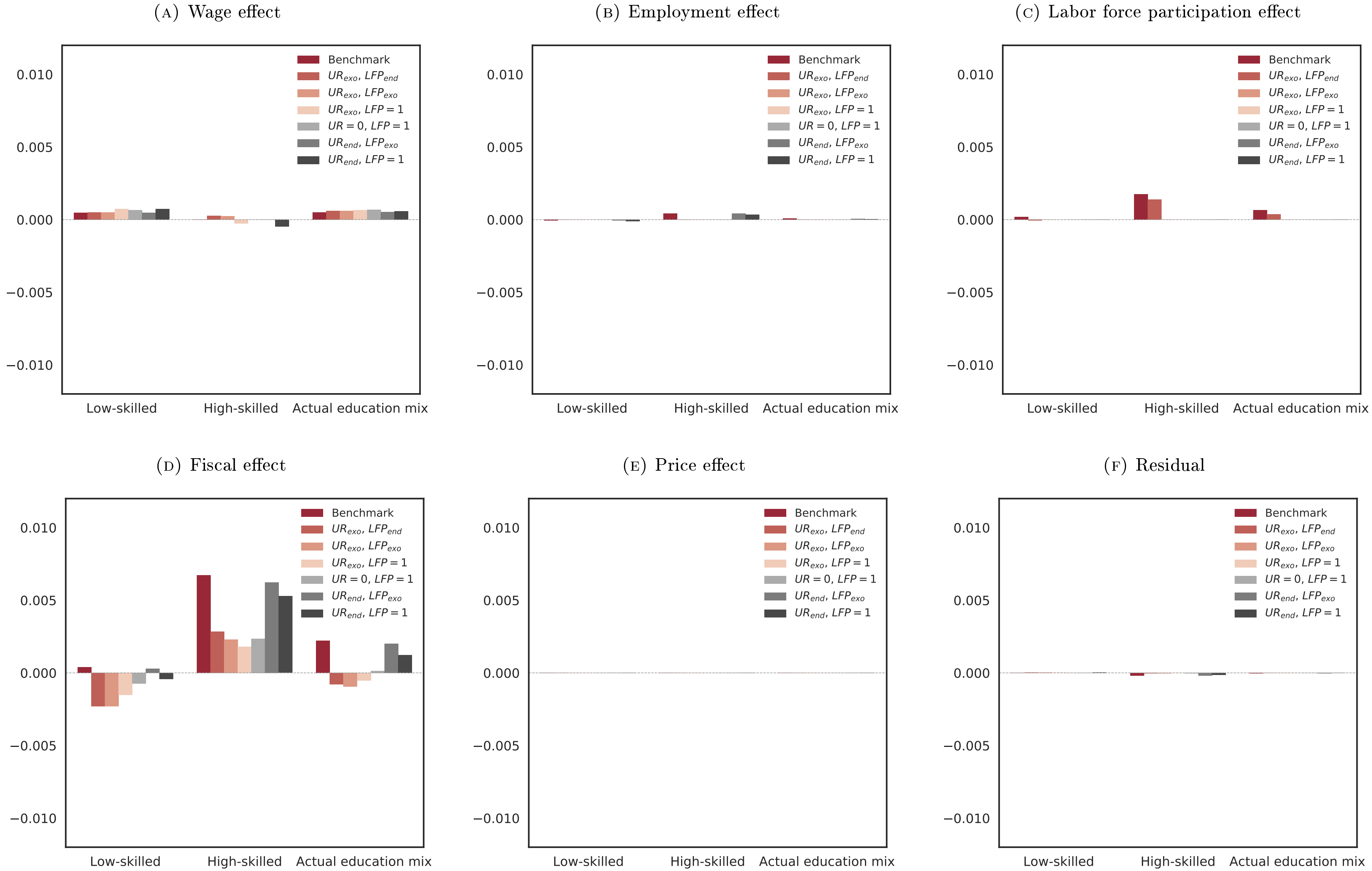
[13] See Appendix 2.A for details on the analytical decomposition of the six channels.

FIGURE 2.4: Inequality effect of immigration (1% of the total labor force) – Sensitivity to labor market modelling



Notes: Figure 2.4 shows the results for 20 selected countries: the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.

Figure 2.5: Decomposition of inequality effect of immigration (1% of the total labor force) – Sensitivity to labor market modeling



Notes: Figure 2.5 shows the results for 20 selected countries: the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.

Inequality effects

The inequality effects of immigration are described in Figure 2.4. We consider the same labor market specifications and immigration shocks as in the previous section.

Figures 2.4b to 2.4d show the inequality effects of the three immigration shocks (low-skilled, high-skilled, and actual education mix, respectively) by country. Unsurprisingly, low-skilled immigration induces in-egalitarian effects (from 0.15-0.30% in Denmark to 0.55-0.65% in Greece). On the contrary, high-skilled immigration induces egalitarian effects (from 0.45-0.50% in Canada to 1.3-1.7% in Italy). At the actual education-mix, the effect on inequality can be positive (in countries where immigrants are less educated than the natives) or negative (in selective countries).

In Figure 2.4a, we compute the unweighted mean effects of all countries under the seven variants of the model. Differences across specifications are less pronounced than in the previous section. However, the most important inequality responses are obtained when labor force participation rates are exogenous and maximal ($LFP = 1$).

Again, to shed light on the mechanisms at work, we decompose the inequality effect into six transmission channels. Plugging Eq. (2.32) into Eq. (2.31), the inequality effect of immigration can be expressed as[14]

$$\frac{dI_n^y}{I_n^y} \simeq \left.\frac{dI_n^y}{I_n^y}\right|_{partic} + \left.\frac{dI_n^y}{I_n^y}\right|_{wage} + \left.\frac{dI_n^y}{I_n^y}\right|_{empl} + \left.\frac{dI_n^y}{I_n^y}\right|_{fiscal} + \left.\frac{dI_n^y}{I_n^y}\right|_{resid} + \left.\frac{dI_n^y}{I_n^y}\right|_{price}. \tag{2.34}$$

Figure 2.5 gives the unweighted mean average of these six transmission channels, using the same vertical scale for the sake of comparability. The sum of these six derivatives is almost identical to the inequality effect depicted in In Figure 2.4a. Unsurprisingly, the inequality effect of immigration is almost insensitive to the fiscal and price channels. This is because low-skilled and high-skilled individuals face the same tax rate and price index. The inequality response to immigration is totally governed by the labor market effect in general, and by the wage effect in particular. The wage effect is larger when the labor force participation rate is exogenous and calibrated at unity. This is because the immigration-induced shock on the labor market is further amplified when immigrants fully participate, and when previous immigrants cannot reduce their participation rates (due to the fiercer competition with newcomers). In sum, modelling labor force participation is instrumental to assessing the inequality effects from immigration.

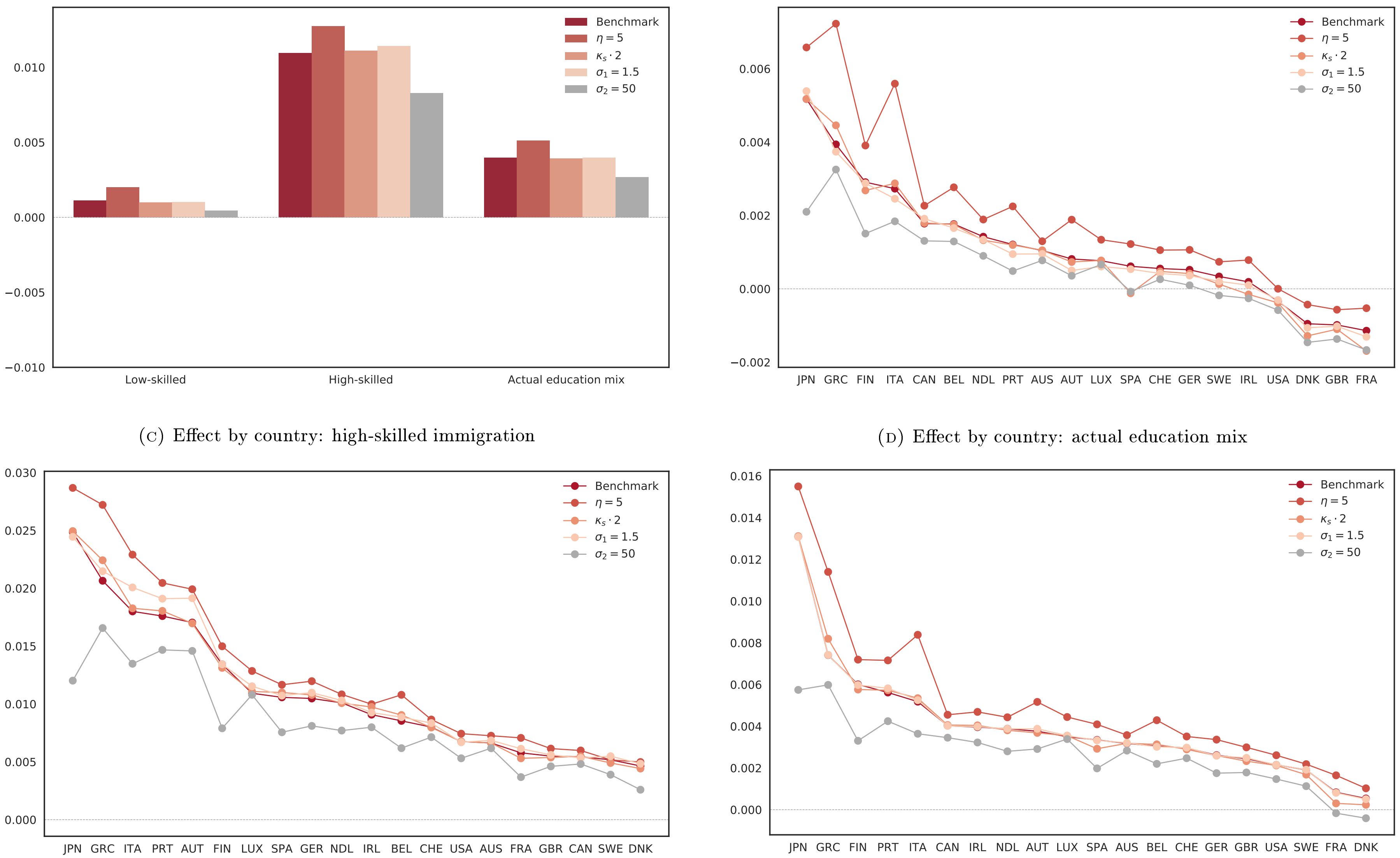
2.4.3 Do elasticities matter?

Finally, we investigate whether the labor market specification matters more or less than the calibration of elasticities. Departing from the benchmark model with endogenous labor force and unemployment rates, we change the level of four important elasticities, and we assess the sensitivity of the average welfare responses to the same immigration shocks (low-skilled, high-skilled, and actual education mix, respectively). We first reduce the inverse of the elasticity of labor supply to income (η) from 10 to 5. This means that the labor supply elasticity increases from 0.1 to 0.2.[15] Secondly, we double the country-specific costs of opening a vacancy (κ_s) in

[14] See Appendix 2.A for details on the analytical decomposition of the six channels.

[15] Figure 8 in Appendix 2.C provides further sensitivity checks with respect to the inverse labor supply elasticity. In a review of the literature, Card (1991) points to a range of [2, 20] for this parameter. We find no major changes in our results when setting η equal to these bounds.

Figure 2.6: Average welfare effect of immigration (1% of the total labor force) – Sensitivity to parameters



(a) Unweighted mean effect

(b) Effect by country: low-skilled immigration

(c) Effect by country: high-skilled immigration

(d) Effect by country: actual education mix

Notes: Figure 2.6 shows the results for 20 selected countries: the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.

all countries. Thirdly, we reduce the elasticity of substitution between different skill types (σ_1) from 2 to 1.5, thereby increasing the level of complementarity between skill groups. Fourthly, we increase the elasticity of substitution between natives and immigrants (σ_2) from 20 to 50, making immigrants and natives more substitutable.

Results for the average welfare effect after the four modifications are depicted in Figure 2.6. Qualitatively, our results are robust to the choice of elasticities. Only in six out of 60 cases (3 shocks times 20 countries), the parameter choice has an impact on the sign of the welfare change. Quantitatively, however, we find that our results are highly robust to κ_s and σ_1, but sensitive to η and σ_2. Greater welfare gains are obtained when labor supply is more elastic, although we confess that the alternative level used in Figure 2.6 can be considered as an upper bound. More importantly, results are very sensitive to the elasticity of substitution between immigrants and natives (σ_2) , which is a source of debate in the literature. Smaller welfare gains are obtained when immigrants are closer substitutes for native workers. In sum, the modelling of the labor market specification is usually more important than the calibration of labor market elasticities, except for the choice of the elasticity of substitution between immigrants and natives.

2.5 Concluding remarks

Macroeconomic models are increasingly used to quantify the welfare and inequality effects of immigration in the OECD countries. Existing studies differ in the way they formalize the labor market responses for immigrants and natives, which in turn govern the strength of the other transmission channels (e.g. public finances, price index, or total factor productivity). In this paper, we build and parameterize a general equilibrium model that allows to compare seven labor market specifications. These variants combine different assumptions concerning labor supply decisions, unemployment rates and wage levels, as well as different calibration strategies. Quantitatively, we find that the labor market specification matters for both welfare and inequality analyses. This result is due to how labor market assumptions differently affect the considered transmission channels. Firstly, modelling unemployment is instrumental to assessing the average welfare effects from immigration, as immigrant workers are found to boost firms' profits and generate a job creation effect, leading to more optimistic results when the model allows for search frictions in the labor market. Secondly, inequality effects are mostly sensible to the assumption on labor force participation. Indeed, inequality responses to immigration are found to be particularly driven by wage affects, which are further amplified when the labor force participation rate is exogenously set to unity, rather than endogenously determined. Lastly, the specification choice is usually more important than the calibration of labor market elasticities, except for the choice of the elasticity of substitution between immigrants and natives.

Appendices

2.A Transmission channels decomposition

The six transmission channels used to calculate Eq. 2.33 are weighted sums of skill-specific effects, which are given by

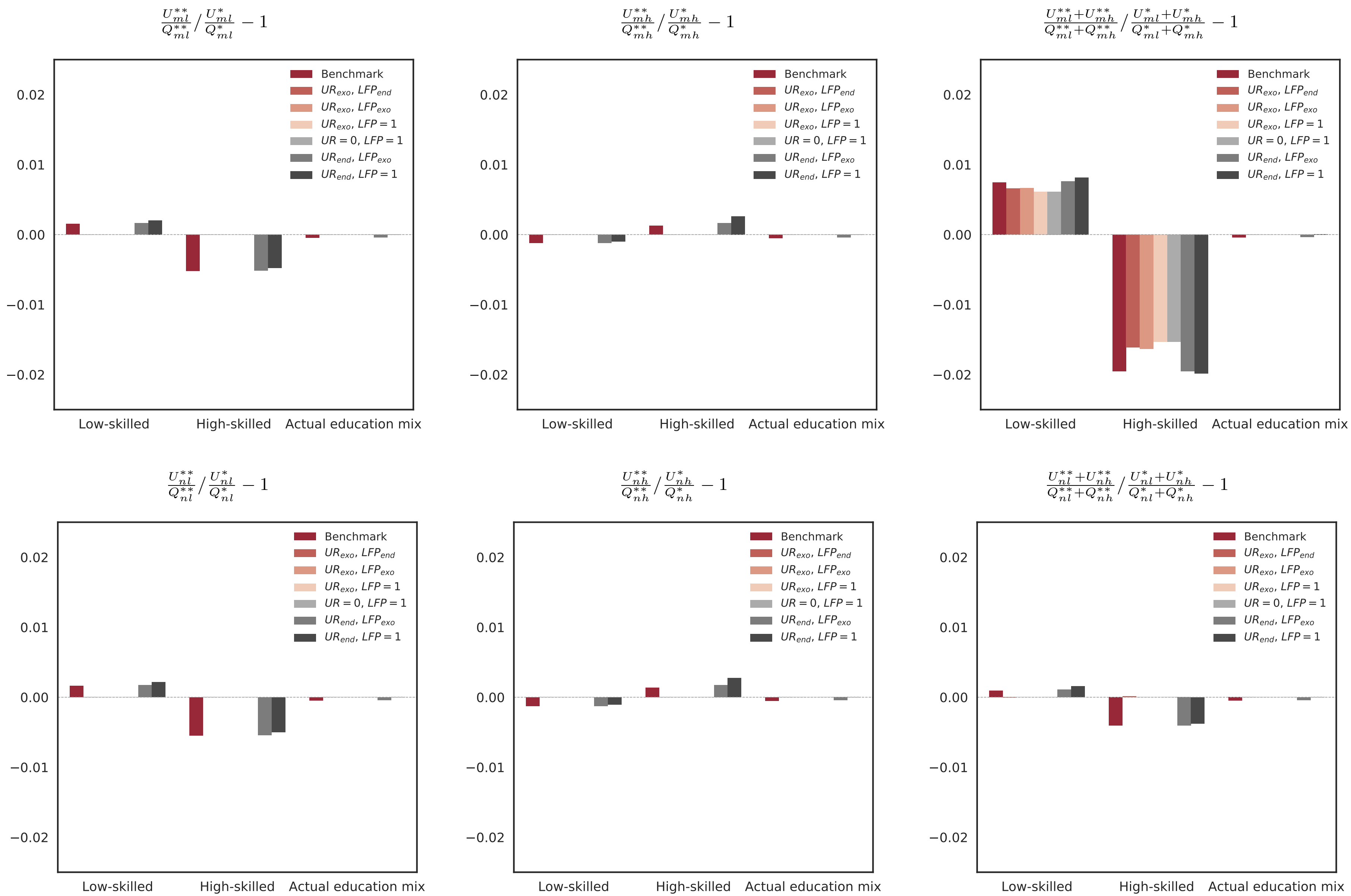
$$
\begin{aligned}
\left.\frac{d\overline{C}_n^y}{\overline{C}_n^y}\right|_{partic} &= \frac{N_{n,h}^y\left(C_{n,h}^y - T_{n,h}^y\right)}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y}\cdot\frac{d(1-\ell_{n,h}^y)}{(1-\ell_{n,h}^y)} + \frac{N_{n,l}^y\left(C_{n,l}^y - T_{n,l}^y\right)}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y}\cdot\frac{d(1-\ell_{n,l}^y)}{(1-\ell_{n,l}^y)} \\
\left.\frac{d\overline{C}_n^y}{\overline{C}_n^y}\right|_{wage} &= \frac{N_{n,h}^y\left(C_{n,h}^y - T_{n,h}^y\right)}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y}\cdot\frac{dw_{n,h}}{w_{n,h}} + \frac{N_{n,l}^y\left(C_{n,l}^y - T_{n,l}^y\right)}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y}\cdot\frac{dw_{n,l}}{w_{n,l}} \\
\left.\frac{d\overline{C}_n^y}{\overline{C}_n^y}\right|_{empl} &= \frac{N_{n,h}^y\left(C_{n,h}^y - T_{n,h}^y\right)}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y}\cdot\frac{d(1-u_{n,h})}{(1-u_{n,h})} + \frac{N_{n,l}^y\left(C_{n,l}^y - T_{n,l}^y\right)}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y}\cdot\frac{d(1-u_{n,l})}{(1-u_{n,l})} \\
\left.\frac{d\overline{C}_n^y}{\overline{C}_n^y}\right|_{fiscal} &= \frac{N_{n,h}^y\left(C_{n,h}^y - T_{n,h}^y\right)}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y}\cdot\frac{d(1-\tau)}{(1-\tau)} + \frac{N_{n,l}^y\left(C_{n,l}^y - T_{n,l}^y\right)}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y}\cdot\frac{d(1-\tau)}{(1-\tau)} \\
\left.\frac{d\overline{C}_n^y}{\overline{C}_n^y}\right|_{resid} &= \frac{N_{n,h}^y\left(C_{n,h}^y - T_{n,h}^y\right)}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y}\cdot\frac{d\Gamma_{n,h}^y}{\Gamma_{n,h}^y} + \frac{N_{n,l}^y\left(C_{n,l}^y - T_{n,l}^y\right)}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y}\cdot\frac{d\Gamma_{n,l}^y}{\Gamma_{n,l}^y} \\
\left.\frac{d\overline{C}_n^y}{\overline{C}_n^y}\right|_{price} &= -\frac{dP}{P}.
\end{aligned}
$$

Similarly, Eq. 2.34 is obtained by the sum of the following partial effects

$$
\begin{aligned}
\left.\frac{dI_n^y}{I_n^y}\right|_{partic} &= \frac{C_{n,h}^y - T_{n,h}^y}{C_{n,h}^y}\cdot\frac{d(1-\ell_{n,h}^y)}{(1-\ell_{n,h}^y)} - \frac{C_{n,l}^y - T_{n,l}^y}{C_{n,l}^y}\cdot\frac{d(1-\ell_{n,l}^y)}{(1-\ell_{n,l}^y)} \\
\left.\frac{dI_n^y}{I_n^y}\right|_{wage} &= \frac{C_{n,h}^y - T_{n,h}^y}{C_{n,h}^y}\cdot\frac{dw_{n,h}}{w_{n,h}} - \frac{C_{n,l}^y - T_{n,l}^y}{C_{n,l}^y}\cdot\frac{dw_{n,l}}{w_{n,l}} \\
\left.\frac{dI_n^y}{I_n^y}\right|_{empl} &= \frac{C_{n,h}^y - T_{n,h}^y}{C_{n,h}^y}\cdot\frac{d(1-u_{n,h})}{(1-u_{n,h})} - \frac{C_{n,l}^y - T_{n,l}^y}{C_{n,l}^y}\cdot\frac{d(1-u_{n,l})}{(1-u_{n,l})} \\
\left.\frac{dI_n^y}{I_n^y}\right|_{fiscal} &= \frac{C_{n,h}^y - T_{n,h}^y}{C_{n,h}^y}\cdot\frac{d(1-\tau)}{(1-\tau)} - \frac{C_{n,l}^y - T_{n,l}^y}{C_{n,l}^y}\cdot\frac{d(1-\tau)}{(1-\tau)} \\
\left.\frac{dI_n^y}{I_n^y}\right|_{resid} &= \frac{C_{n,h}^y - T_{n,h}^y}{C_{n,h}^y}\cdot\frac{d\Gamma_{n,h}^y}{\Gamma_{n,h}^y} - \frac{C_{n,l}^y - T_{n,l}^y}{C_{n,l}^y}\cdot\frac{d\Gamma_{n,l}^y}{\Gamma_{n,l}^y} \\
\left.\frac{dI_n^y}{I_n^y}\right|_{price} &= 0.
\end{aligned}
$$

2.B Immigration effect on unemployment rates

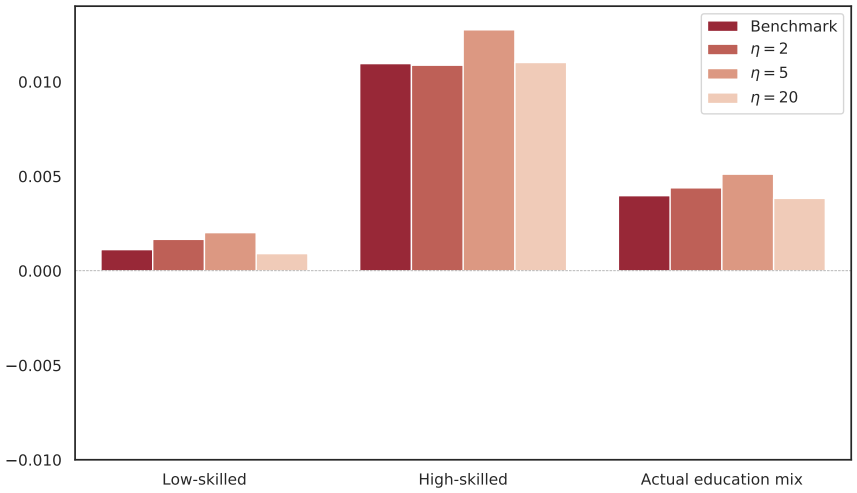
FIGURE 7: Unemployment rate changes



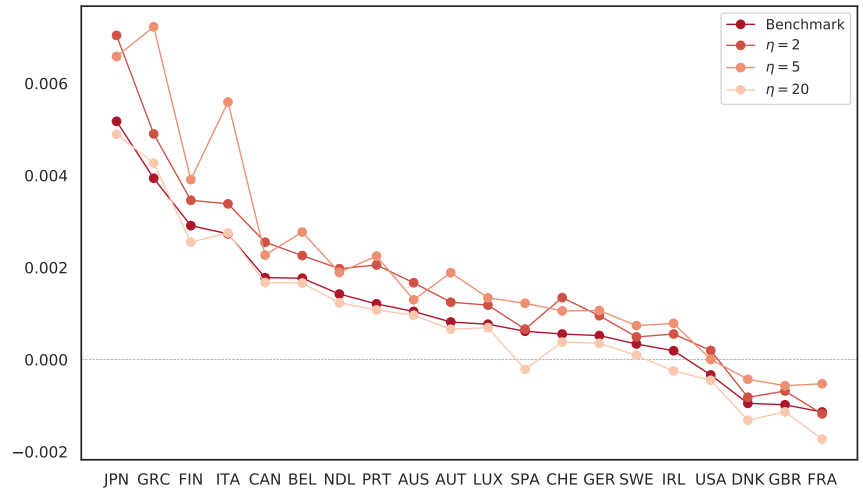
2.C Sensitivity analysis to η

FIGURE 8: Average welfare effect of immigration (1% of the total labor force) – Sensitivity to η

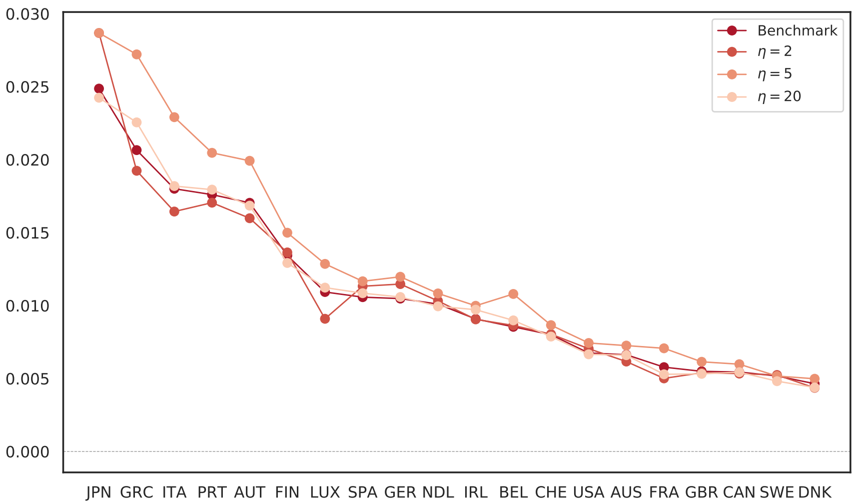
(A) Unweighted mean effect



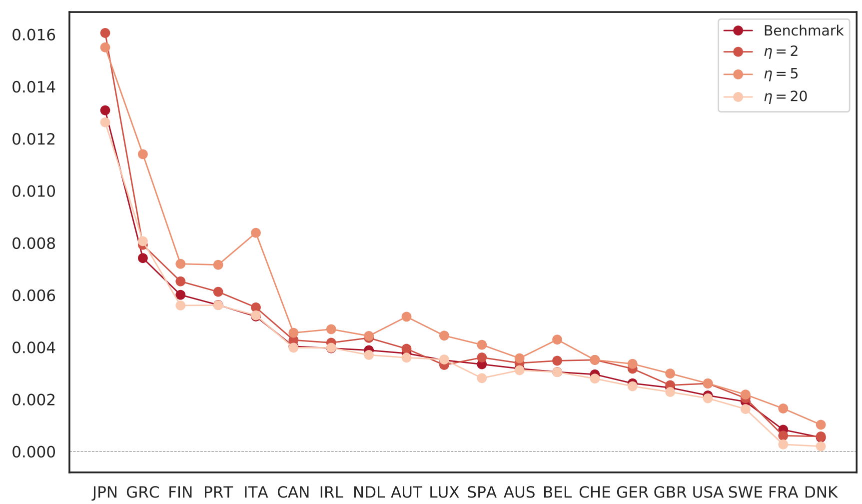
(B) Effect by country: low-skilled immigration



(C) Effect by country: high-skilled immigration



(D) Effect by country: actual education mix



Notes: Figure 8 shows the results for 20 selected countries:
the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.

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Chapter 3

Immigration, Skill Acquisition and Fiscal Redistribution in a Search-Equilibrium Model

3.1 Introduction

Over the past decade, several developed countries have begun to rise concerns over the continuous growth of international migration flows. Despite the academic literature has so far found limited effects of immigration on native citizens welfare, international migration is now at the heart of public debates and selective migration policies are proliferating worldwide in order to protect national employment and welfare.

Between 2000 and 2017, the increase in the foreign-born population accounted for almost three-quarters of the total population increase in EU/EFTA countries, and for more than one-third of the increase in the United States.[1] Such demographic changes are reshaping the host countries workforce composition and underline the importance of taking into account intergenerational aspects concerning young and older individuals when assessing for the effects of migration on the host countries. Indeed, as migration flows keep changing the host country labor force composition, in the long-run younger natives may respond to immigration by upgrading their skills and specializing in different production tasks. Further, another interesting aspect which is often debated, but rarely taken into account when evaluating the immigration surplus, is that most developed countries are aging, while migration flows are usually characterized by young workers looking for new job opportunities. Given that intergenerational transfers in high-income countries are large, immigrant workers could play a considerable role in alleviating the fiscal burden that aging populations will face in the next decades.

This study aims to contribute to the limited but growing literature regarding the impact of immigration through search and matching models, by introducing two major features that characterize the long-run equilibrium. First, we allow young natives that enter the labor market to endogenously adjust their skill in face of migration, so that the skill composition of the

[1] Source: OECD (2018).

migration flows influence the natives education decisions in the long-run. Second, we distinguish between young and retired workers, who receive different public transfers according to their age, skill and origin. This feature allows to better assess the fiscal impact of migration, as natives and immigrants are characterized by different age composition and social welfare usage. To the best of our knowledge, no previous paper has developed a theoretical model able to analyze long-run effects of migration on natives welfare by taking into account unemployment issues, endogenous skill acquirement, and fiscal redistribution among different generations.[2]

Focusing on a selected group of 19 OECD countries, we calibrate and simulate the search model under three different scenarios: (a) an increase in low-skilled migration equal to 1 percent of the total labor force; (b) an increase of the same size of high-skilled migration; (c) an increase of the same size of immigrants, keeping their skill composition constant. The obtained results are then compared to the cases in which the natives skill is exogenous and/or the retired population is not taken into account. Our quantitative analysis generates the following main results. First, when skill acquisition is endogenous, young natives are effectively able to avoid any potential displacement effect under scenarios (b) and (c), in most of the analyzed countries. When the immigration shock consists only of low-skilled workers (scenario (a)), native unemployment slightly increases in most countries, but native average wages noticeably increase in all of the 19 countries. Second, we find that taking into account the age composition of the population plays a key role in determining the fiscal impact of immigration. In particular, we find that the fiscal impact of skill-balanced and high-skilled immigration is positive for most countries when we distinguish between active and retired workers in the economy. Conversely, when abstracting from retired individuals, the fiscal impact of immigration is found to be mostly negative for all of the three analyzed scenarios. Third, in almost all of the considered countries, incorporating endogenous natives skill acquisition and age composition yields more optimistic welfare results than a standard search model that neglects both of these features. In particular, under our model, we find that skill-balanced and high-skilled migration shocks increse the average native welfare on most countries, while low-skilled immigration is found to be beneficial to natives welfare on 9 out of the 19 considered OECD countries.

This study is related to at least three strands of literature. First, it is related to the stream of literature that focuses on the effect of migration on the natives skill composition and specialization. While most of this literature is empirical and finds mixed results on the effects on natives high-school completion rate (see, e.g., Betts, 1998; Hunt, 2012), a number of papers have recently focused on the immigration effects on natives task specialization. These latter studies include Peri and Sparber (2009, 2011) and D'Amuri and Peri (2014) who, analyzing whether natives move to more complex jobs as a consequence of immigration, find that natives may

[2]Chassamboulli and Palivos (2014), in one of their extensions, analyze the case in which natives endogenously adjust their skill, but they completely abstract from the presence of a public sector.

respond to immigration by changing their specialization. Cattaneo et al. (2013) find that native Europeans are more likely to upgrade to more skilled and better paid occupations when a larger number of immigrants enter their labor market. McHenry (2015) finds that low-skilled immigration induces natives to improve their performance in school, attain more years of schooling, and take jobs that involve communication-intensive tasks, potentially mitigating the negative effects of immigration on the labor market.

Second, this chapter is related to the recent stream of the migration literature that analyzes the impacts of immigration through a framework that allows for labor market search frictions. This literature includes Ortega (2000), Liu (2010), Chassamboulli and Palivos (2014), Chassambouli and Peri (2015), Liu et al. (2017) and Battisti et al. (2018). In particular, our study is closely related to Battisti et al. (2018), who employ a setup with search and matching frictions in order to assess the welfare effects of immigration on 20 OECD countries. Their quantitative analysis suggests that immigration attenuates the effects of search frictions by boosting firms' profits and generating a job creation effect which, in turn, offsets the welfare costs of fiscal redistribution. However, as pointed out by these authors, their analysis abstracts from intergenerational transfers and population aging, so that the fiscal effect of migration could differently impact on government balance and welfare. Moreover, they assume that all workers' skill level is exogenous, so their analysis does not allow natives to update their skill in response of skill-biased migration shocks.

Last, our study also relates to that strand of the migration literature that focuses on the fiscal effects of immigration. Storesletten (2000, 2003) finds that new immigrants represent, on average, a positive gain for the fiscal balances of U.S. and Sweden. Dustmann and Frattini (2014) find a noticeable positive fiscal contribution from recent immigrants, especially those originating from EEA countries. However, aside from Battisti et al. (2018), this literature mainly focuses on an account approach without considering labor market interactions between migrant and native workers.

The remainder of this chapter is organized as follows. Section 3.2 provides stylized facts on labor market characteristics and population composition of the 19 analyzed OECD countries. Section 3.3 introduces the benchmark version of the model and characterizes the search equilibrium. Section 3.4 describes the calibration procedure used to simulate the model and discusses the results. Finally, Section 3.5 offers some concluding remarks.

3.2 Stylized facts

In OECD countries, 127 million people were foreign-born in 2017, which represents an average of 13% of the total population compared with 9.5% in 2000.[3] We use the Database on Immigrants in OECD countries (DIOC) described by Arslan et al. (2014) to account for differences in demographic characteristics, level of education, and labor market status of the population of the 19 selected OECD countries. In particular, we focus on the census round 2010, extracting information about the country of origin, age, educational attainment and labor market status of immigrants residing in 19 selected OECD countries (the 15 members of the European Union, Australia, Canada, Switzerland and US).

Figure 3.1 below compares labor market status, education level and age composition of immigrant and native residents in the analyzed countries.

Figure 3.1a displays the amount of immigrant workers of age 25–64 participating to the labor force, as a share of the total work force of the same age in the analyzed OECD countries. In 17 out of the 19 countries (all but Denmark and Finland), the share of immigrant workers is higher than 11%, with Luxembourg being the OECD country that relies the most on migrant workers (about 50% of its labor force is foreign-born). The average is 18% and the standard deviation is 10%.

Figure 3.1b shows that, on average, immigrants suffer from a higher unemployment rate (12.9% for immigrants versus 9.7% for natives). In particular, 16 out of 19 countries (all but Ireland, US and Canada) are characterized by a higher unemployment rate for immigrant workers, though the correlation between immigrant and native unemployment is extremely high (91.3%). However, it is noteworthy that in some countries the difference in unemployment rates is quite substantial. In Spain, immigrant workers suffer an unemployment rate almost 10 percent points higher than natives, while in Austria, Netherlands and Sweden the migrant unemployment rate is more than twice as high as the native one.

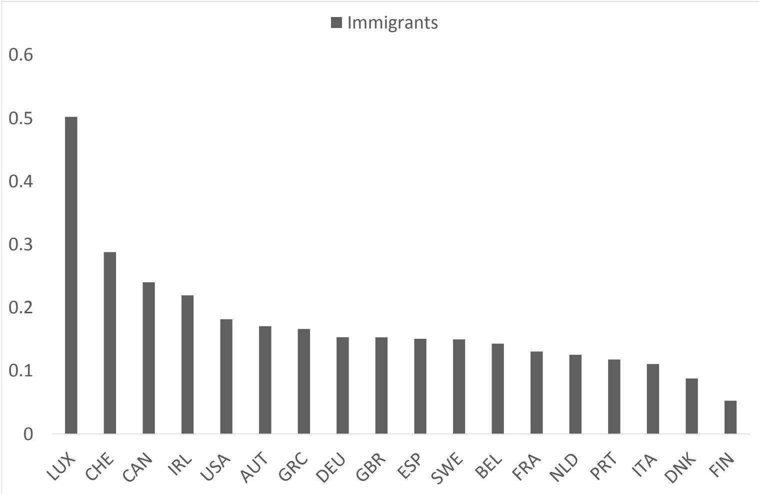
As far as skill composition is concerned, Figure 3.1c illustrates the share of immigrant and native workers with at least one year of college education or a bachelor degree (ISCED 5). Despite the correlation between native- and foreign-born is high (65.7%) and, on average, immigrants and natives have a similar share of college educated workers (33% for immigrants, 35.4% for natives), some countries still present a sharp difference in skill composition between the immigrant and native workers – particularly in Belgium, where the share of college educated natives is almost twice as high as that of college educated immigrants.

Heterogeneity in countries wage premiums are underlined in Figure 3.1d. Data on wage ratios between native and immigrant workers are obtained from Buchel and Frick (2005) and Docquier et al. (2014), while average returns to skill are taken from OECD (2012) data. In

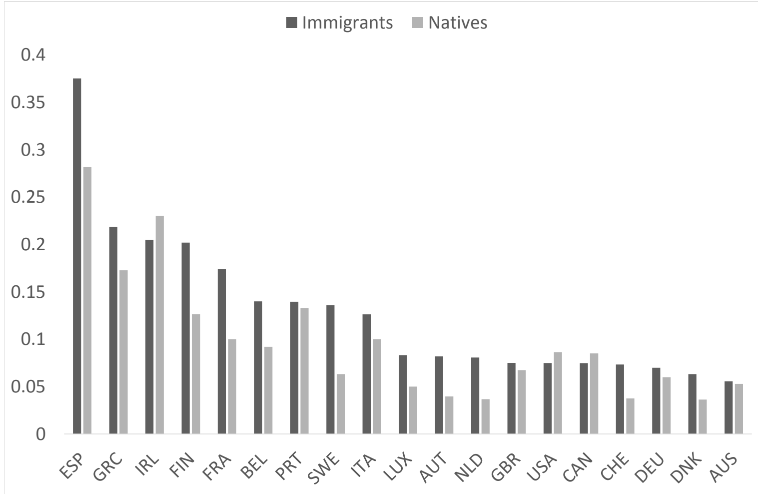
[3]Source: OECD (2018)

Figure 3.1: Labor market and population characteristics

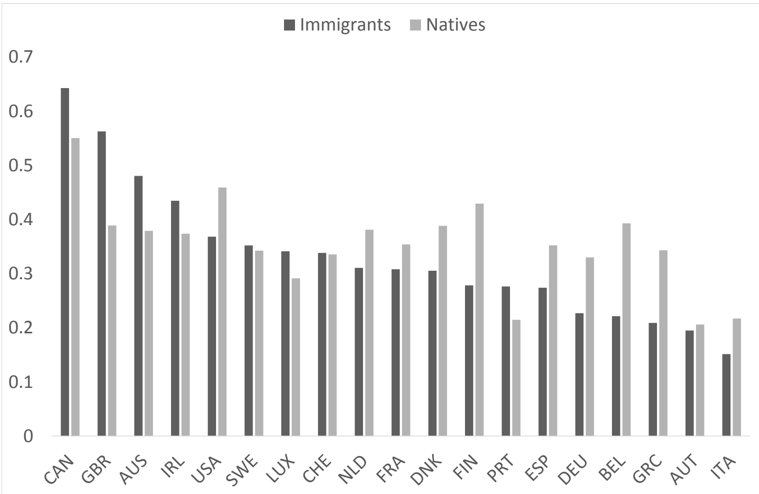
(a) Share of foreign-born labor force across countries



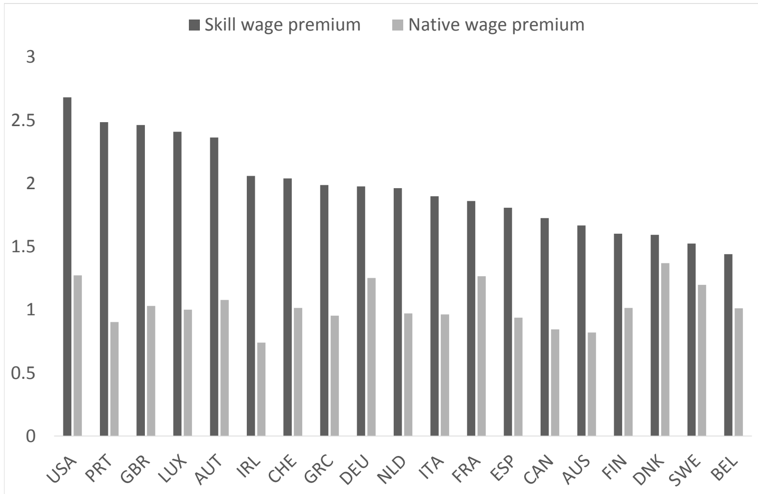
(b) Unemployment rates



(c) Shares of college-educated people



(d) Wage ratios



Note: Figure 3.1 shows population characteristics for 19 selected countries: the 15 members states of the European Union (EU15), Australia, Canada, Switzerland and US.

almost all countries, natives earn more than immigrant workers. In Section 3.3, we follow Ottaviano and Peri (2012) and interpret this stylized fact as a result of imperfect substituability in production between immigrant and native workers.[4] Finally, a consistent education wage premium is present in most countries, with college-educated workers earning more than twice as much as lesser-educated ones in 7 out of 19 countries.

3.3 The model

Consider a small open economy populated by a continuum of risk-neutral agents, who discount the future at a constant rate $r > 0$ and are heterogeneous under three respects. First, agents differ in their origin country, so that they can either be native or foreign-born individuals who immigrated in the domestic economy. Second, agents are characterized by different education attainments. Following the bulk of the literature that identifies education based-skills (e.g. Card, 2009; Docquier et al., 2014; Battisti et al., 2018), throughout the chapter we will refer to college graduates as high-skilled individuals, and to less educated as low-skilled individuals. Third, individuals of all origins are assumed to be either in their working age or retired. Young active individuals supply labor in order to be employed and earn a wage, while retirees are unable (or unwilling) to enter the labor market, so that their only income derives from government transfers and capital market. For simplicity, all agents in the economy are assumed to born and retire at the same rate ν. Moreover, in each time period t, the number of deaths equal the number of births, so that the population sizes of young and retired agents are constant over time.

As far as production is concerned, intermediate firms open vacancies in a frictional labor market in order to hire workers and produce intermediate goods. At the same time, retail firms buy these intermediate goods in order to produce and sell a homogeneous final good in a perfectly competitive market. Finally, the government taxes labor income to finance redistributive transfers, public consumption, and unemployment benefits. For easy of exposition, the time variable t is omitted where no confusion arises.

In Section 3.3.1 and Section 3.3.2, we describe the production technology and the frictional labor market that characterizes the economy. We then illustrate the skill acquisition process and the government fiscal redistribution in Section 3.3.3 and Section 3.3.4. Finally, the search equilibrium is characterized in Section 3.3.5.

3.3.1 Production

In the small open economy, retail firms employ physical capital K and a composite input good Z in order to produce a homogeneous final output Y, whose price is normalized to unity, according to the following Cobb-Douglas production function

$$Y = AK^{\alpha} Z^{1-\alpha}, \tag{3.1}$$

where $A > 0$ is a given parameter capturing the level of TFP, and $\alpha \in (0, 1)$ is the share of capital income in total output.

[4] Multiple determinants may also influence the native wage premium, such as imperfect transferability of human capital (Poutvaara, 2008), or discrimination (Bartolucci, 2014). We later perform a sensitive analysis to take into account the case in which immigrant and native workers are perfect substitutes in production.

At the same time, the composite input Z is produced by intermediate firms who employ young individuals of heterogeneous skill and origin country. Let E_{os} denote employed workers in the labor market, where the subscript $o = (n, m)$ refers to natives and immigrants, and the subscript $s = (h, l)$ refers to high- and low-skilled individuals. As standard in this strand of literature (see, e.g., Acemoglu, 2002), we assume that each intermediate firm employs at most one worker, so that the number of intermediate goods, Y_{os}, and employed workers, E_{os}, coincide in each point in time t. Hence, following recent studies (such as Manacorda et al., 2012; Ottaviano and Peri, 2012) that find imperfect substituability between native and migrant workers, the production technology used to assemble the composite input Z can be described by the following nested CES function

$$Z = \left[x Y_h^{(\sigma_1-1)/\sigma_1} + (1-x) Y_l^{(\sigma_1-1)/\sigma_1} \right]^{\sigma_1/(\sigma_1-1)} \tag{3.2}$$

$$Y_s = \left[\lambda Y_{ns}^{(\sigma_2-1)/\sigma_2} + (1-\lambda) Y_{ms}^{(\sigma_2-1)/\sigma_2} \right]^{\sigma_2/(\sigma_2-1)}, \quad s = (h, l),$$

where σ_1 and σ_2 are, respectively, the elasticity of substitution between skill groups and between origin groups, $x \in (0, 1)$ denotes the relative productivity of high-skilled compared to low-skilled, and $\lambda \in (0, 1)$ denotes the relative productivity of native workers compared to immigrants.

Because intermediate goods are produced under perfect competition, their price, p_{os}, equals their marginal productivity

$$p_{mh} = A(1-\alpha)x(1-\lambda)K^\alpha Z^{\frac{1-\alpha\sigma_1}{\sigma_1}} Y_h^{-\frac{1}{\sigma_1}} \left(\frac{Y_h}{Y_{mh}} \right)^{\frac{1}{\sigma_2}} \tag{3.3a}$$

$$p_{ml} = A(1-\alpha)(1-x)(1-\lambda)K^\alpha Z^{\frac{1-\alpha\sigma_1}{\sigma_1}} Y_l^{-\frac{1}{\sigma_1}} \left(\frac{Y_l}{Y_{ml}} \right)^{\frac{1}{\sigma_2}} \tag{3.3b}$$

$$p_{nh} = A(1-\alpha)x\lambda K^\alpha Z^{\frac{1-\alpha\sigma_1}{\sigma_1}} Y_h^{-\frac{1}{\sigma_1}} \left(\frac{Y_h}{Y_{nh}} \right)^{\frac{1}{\sigma_2}} \tag{3.3c}$$

$$p_{nl} = A(1-\alpha)(1-x)\lambda K^\alpha Z^{\frac{1-\alpha\sigma_1}{\sigma_1}} Y_l^{-\frac{1}{\sigma_1}} \left(\frac{Y_l}{Y_{nl}} \right)^{\frac{1}{\sigma_2}}. \tag{3.3d}$$

Finally, capital in the economy is free to be perfectly mobile and, because the domestic economy is assumed to be small compared to the outside world, the return on capital r is fixed by international markets. Hence, the total amount of physical capital in the economy will adjust so to satisfy the usual first order condition

$$r = A\alpha K^{\alpha-1} Z^{1-\alpha}. \tag{3.4}$$

3.3.2 Labor market

Each intermediate firm opens a vacancy for either high- or low-skilled workers. Following Chassamboulli and Palivos (2014) and Battisti et al. (2018), we assume that firms are not able to discriminate between immigrant and native workers at the vacancy posting stage, so that job vacancies V_s and unemployed individuals $U_s \equiv \sum_o U_{os}$ are randomly matched with each other according to the following Cobb-Douglas matching function

$$M(U_s, V_s) = \xi U_s^{\epsilon} V_s^{1-\epsilon}, \quad s = (h, l), \tag{3.5}$$

where M is the number of job matches, ξ is a constant matching efficiency parameter, and $\epsilon \in (0, 1)$ is the elasticity parameter of the matching function.

Let $\theta_S \equiv V_s/U_s$ denote the labor market tightness in the skill sector s. The job finding rate is given by $M_s/U_s = \xi\theta^{1-\epsilon} \equiv m(\theta_s)$, and the vacancy filling rate is given by $M_s/V_s = \xi\theta^{-\epsilon} \equiv q(\theta_s)$. As easy to verify, $m(\theta_s)$ and $q(\theta_s)$ are, respectively, increasing and decreasing in θ_s, implying that a higher market tightness makes it more difficult for firms to fill a vacancy, but easier for unemployed workers to find a job.

Asset value functions

Let $\mathcal{J}_s^{o,F}$ and $\mathcal{J}_s^V$ denote the value associated with a filled and unfilled vacancy, respectively.[5] Then, their flow value in steady-state is given by

$$r\mathcal{J}_s^{o,F} = p_{os} - w_{os} - (\delta_{os} + \nu)\left[\mathcal{J}_s^{o,F} - \mathcal{J}_s^V\right] \tag{3.6}$$

$$r\mathcal{J}_s^V = -c_s + q(\theta_s)\left[(1-\phi_s)\,\mathcal{J}_s^{n,F} + \phi_s\mathcal{J}_s^{m,F} - \mathcal{J}_s^V\right], \tag{3.7}$$

where c_s is the fixed cost of an open vacancy for a worker of skill level s, $\phi_s \equiv U_{ms}/U_s$ is the share of unemployed immigrants among all searching individuals of skill type s, and δ_{os} is the exogenous separation rate, which is allowed to differ for workers' skills and country origin. Equation (3.6) states that the asset value of a filled vacancy is given by the price at which the intermediate input is sold, minus the wage rate paid to employed workers, and the expected value of breaking up with an employed worker, multiplied by the probability that such an event occurs, $\delta_{os} + \nu$.[6] Equation (3.7) has a similar interpretation, as it states that the asset value of having an unfilled vacancy is given by the vacancy cost,$-c_s$, plus the expected value of filling a vacancy, which occurs at a probability $q(\theta_s)$.

[5] Note that the value of an open vacancy, $\mathcal{J}_s^V$, has no origin index o because firms are unable to direct their search towards different types of workers who hold the same skill level.

[6] Remind that a worker will separate from a firm at a rate $\delta_{os} + \nu$, rather than δ_{os}, because he will not supply work after retirement.

For working-age individuals who supply labor, the steady-state discounted present value of employment, $\mathcal{J}_s^{o,E}$, and unemployment, $\mathcal{J}_s^{o,U}$, are given by

$$r\mathcal{J}_s^{o,E} = (1-\tau)w_{os} + \delta_{os}\left[\mathcal{J}_s^{o,U} - \mathcal{J}_s^{o,E}\right] + \nu\left[\mathcal{J}_{os}^{R} - \mathcal{J}_{os}^{E}\right] + T_{os}^{y} + rk \tag{3.8}$$

$$r\mathcal{J}_s^{o,U} = b_{os} + m\left(\theta_s\right)\left[\mathcal{J}_s^{o,E} - \mathcal{J}_s^{o,U}\right] + \nu\left[\mathcal{J}_{os}^{R} - \mathcal{J}_{os}^{U}\right] + T_{os}^{y} + rk, \tag{3.9}$$

where τ is the labor income tax rate, T_{os}^{y} are redistributive transfers to young workers of origin o and skill s, rk is the per capita capital income, and $\mathcal{J}_{os}^{R}$ is the steady-state value of retirement which is defined later on in this chapter. According to equation (3.8), the flow value of being employed equals the difference between the after-tax wage income and the expected loss from breaking-up from the firm, plus transfers, T_{os}^{y}, capital income, rk, and the expected gain from becoming a retiree, $\nu\left[\mathcal{J}_{os}^{R} - \mathcal{J}_{os}^{E}\right]$. Likewise, equation (3.9) states that the flow value of unemployment equals its return, i.e. the unemployment benefit b_{os}, plus the probability of finding a job, multiplied by the expected gain from such event, transfers, capital income and the expected gain from retirement.

Finally, letting R_{os} denote the number of retired workers of type (o,s), the flow value of being a retired worker in steady-state, $\mathcal{J}_{os}^{R}$, can be written as

$$r\mathcal{J}_{os}^{R} = T_{os}^{R} + rk - g\mathcal{J}_{os}^{R}, \tag{3.10}$$

where T_{os}^{R} are redistributive transfers paid to retired workers and $g \equiv \nu Q_{os}/R_{os}$ is the share of retirees that die at each time period t.[7]

Job creation condition

As intermediate firms are in perfect competition and bare no costs of entry, they will find it profitable to enter the market as long as the value of posting a new vacancy is greater than zero. In steady-state, the free entry condition is thus given by

$$\mathcal{J}_s^{V} = 0. \tag{3.11}$$

Combining equations (3.6), (3.7) and (3.11), in steady-state the job creation condition reads

$$\frac{c_s}{q\left(\theta_s\right)} = \left(1-\phi_s\right)\left[\frac{p_{ns} - w_{ns}}{r+\nu+\delta_{ns}}\right] + \phi_s\left[\frac{p_{ms} - w_{ms}}{r+\nu+\delta_{ms}}\right]. \tag{3.12}$$

Equation (3.12) states that the expected cost of creating a vacancy, $c_s/q\left(\theta_s\right)$, is equal to the expected benefit of filling a vacancy with either a native or immigrant worker, $p_{os} - w_{os}$, adjusted by the worker-type specific discount rate, $r+\nu+\delta_{os}$. Note that a higher market tightness θ_s

[7] Note that, in each time period t, a mass of workers $\nu\sum_{o}\sum_{s}Q_{os}$ retire and, at the same time, the same number of retirees die. This implies that the total number of retirees is constant over time and the ratio $\nu Q_{os}/R_{os}$ is always within $(0,1)$.

translates to higher vacancy opening costs, since the waiting time for filling a vacancy is is increasing in θ_s.

Wage determination

Following mainstream search and matching literature, once a match between a worker and a vacancy has been formed, firms and workers bargain over wages. Let $\beta \in (0,1)$ denote the worker bargaining power. The solution of the bargaining problem is then given by the wage rate w_{os} that satisfies

$$(1-\beta)\left(\mathcal{J}_s^{o,E} - \mathcal{J}_s^{o,U}\right) = \beta\left(\mathcal{J}_s^{o,F} - \mathcal{J}_s^{V}\right).$$

Combining the asset value equations (3.6)-(3.9) and considering the free entry condition (3.11), the bargained wage rate paid to workers of type (o,s) is given by

$$w_{os} = \frac{\beta\left[r+\nu+\delta_{os}+m\left(\theta_s\right)\right]p_{os}}{\left(r+\nu+\delta_{os}\right)\left[1-\left(1-\beta\right)\left(\tau+\mu\right)\right]+\beta m\left(\theta_s\right)}, \tag{3.13}$$

where the unemployment benefit b_{os} has been endogenized and proportionally set to the wage rate, i.e. $b_{os} \equiv \mu w_{os}$, with $\mu \in (0,1)$ denoting the replacement rate. According to equation (3.13), higher worker bargaining power β translates to higher wage rates. It is also easy to check that the bargained wage rate w_{os} is increasing in the replacement rate μ. This is coherent with the intuition that higher values of replacement rate would increase the worker's outside option and, thus, the worker's surplus from hiring.

Employment

The dynamic law of employed workers of skill s and origin o is given by the difference between the amount of matches formed and the break-ups that take place in a given instant of time t; that is

$$\dot{E}_{os} = m\left(\theta_s\right)U_{os} - \left(\delta_{os}+\nu\right)E_{os}. \tag{3.14}$$

Denoting with $Q_{os} \equiv E_{os} + U_{os}$ the total amount of active individuals of type (o,s), the total amount of employed and unemployed people in steady-state can be written as

$$E_{os} = \frac{m\left(\theta_s\right)Q_{os}}{\delta_{os}+\nu+m\left(\theta_s\right)} \tag{3.15}$$

$$U_{os} = \frac{\left(\delta_{os}+\nu\right)Q_{os}}{\delta_{os}+\nu+m\left(\theta_s\right)}. \tag{3.16}$$

Based on equations (3.15) and (3.16), for any given size of the active population Q_{os}, employment increases in the job finding probability, $m(\theta_s)$, and decreases in the separation rate, δ_{os}.

3.3.3 Skill acquisition

Before entering the labor market, each young native individual decides whether to invest in education and become high-skilled or remain low-skilled.[8] Following Chassamboulli and Palivos (2014), agents differ in their cost of acquiring education and, in particular, older agents are assumed to face prohibitive costs that make them prevent from investing in training. Let z denote the cost of acquiring training and assume that it is distributed uniformly over the closed interval $[0, \bar{z}]$. A native young agent will invest in education if the benefit of looking for a job as high-skilled, rather than as low-skilled, exceeds the cost of acquiring training, that is

$$\mathcal{J}_{nh}^{U} - \mathcal{J}_{nl}^{U} \geq z. \tag{3.17}$$

Setting (3.17) as an equality, there exists a threshold value for the training cost

$$z^{*} = \mathcal{J}_{nh}^{U} - \mathcal{J}_{nl}^{U}, \tag{3.18}$$

such that agents will find it profitable to invest in education and become high-skilled. From equation (3.17), it follows that the fraction of native high-skilled workers, $\gamma \equiv Q_{nh}/(Q_{nh} + Q_{nl})$, is thus endogenously determined by the model and equals

$$\gamma = \frac{z^{*}}{\bar{z}}. \tag{3.19}$$

Plugging equation (3.9) into (3.17), and then using equation (3.8), the steady-state share of native high-skilled workers γ reads

$$\gamma = \frac{\mu\left(w_{nh} - w_{nl}\right) + T_{nh}^{y} - T_{nl}^{y} + m\left(\theta_h\right)\left[\frac{w_{nh}(1-\tau-\mu)}{r+\nu+\delta_{nh}+m(\theta_h)}\right] - m\left(\theta_l\right)\left[\frac{w_{nl}(1-\tau-\mu)}{r+\nu+\delta_{nl}+m(\theta_l)}\right]}{\bar{z}\left(r+\nu\right)}. \tag{3.20}$$

Equation (3.20) is coherent with the intuition that the share of educated people is positively affected by the wage gap between high- and low-skilled workers, but negatively affected by the cost of training.

It is worth noting that, since young individuals eventually age and become retired, a change in young natives skill composition implies a change in retired skill composition as well, so that, in steady-state, the ratio R_{nh}/R_{nl} always matches the ratio Q_{nh}/Q_{nl}.

3.3.4 Government

The government imposes a fixed tax rate $\tau \in (0, 1)$ on labor income in order to finance unemployment benefits μw_{os}, and group specific transfers T_{os}^{a}, where the superscript $a = (y, R)$

[8] In this model, we assume that young immigrants perform their education investment in their source country, so that they can either supply low- or high-skilled labor according to the skill level they previously acquired.

denotes young and retired individuals.[9] Assuming that the government conducts a zero profit policy, the government budget constraint writes

$$\tau \sum_o \sum_s w_{os} = \mu \sum_o \sum_s U_{os} w_{os} + \sum_o \sum_s Q_{os} T^y_{os} + \sum_o \sum_s R_{os} T^R_{os}. \tag{3.21}$$

The left-hand side of equation (3.21) corresponds to the government revenues, whereas the right-hand side corresponds to the government expenditures. The income tax τ is assumed to endogenously adjust to balance the government budget, so that when a temporary deficit (surplus) takes place, the government responses by raising (decreasing) τ.

3.3.5 Search equilibrium

Definition 1. A steady-state equilibrium is a set of equilibrium values $\{p_{os}, K, \theta_s, w_{os}, E_{os}, U_{os}, \gamma, \tau\}$, where $o = (n, m)$ and $s = (h, l)$, such that: (*i*) the intermediate inputs markets clear, so that equations (3.3a)-(3.3d) are satisfied; (*ii*) capital markets clear, so that equation (3.4) is satisfied; (*iii*) the job creation condition (3.12) for each skill type s is satisfied; (*iv*) the Nash bargaining optimality condition (3.13) holds for each origin o and skill type s; (*v*) the numbers of employed and unemployed workers are given by equations (3.15) and (3.16) for each origin o and skill type s; (*vi*) the skill acquisition condition (3.20) is satisfied; (*vii*) the government sustains a no-deficit policy and its budget (3.21) is balanced.

3.4 Quantitative analysis

In this section we assess the impact of immigration on welfare, labor market outcomes and fiscal redistribution in 19 selected OECD countries through a comparative statics analysis. More specifically, we analyze both the cases of skill-biased and -unbiased migration shocks taking place in the described economy. Throughout the analysis, we will refer to the welfare level of natives by taking into account the following welfare index[10]

$$\mathcal{W}_n \equiv \frac{\sum_s E_{ns} \mathcal{J}^E_{ns} + \sum_s U_{ns} \mathcal{J}^U_{ns} - \frac{z^*}{2} Q_{nh} + \sum_s R_{ns} \mathcal{J}^R_{ns}}{\sum_s (Q_{ns} + R_{ns})}, \tag{3.22}$$

[9] As in Burzynski et al. (2018), T^a_{os} includes redistributive transfers that vary across origin and skill types, as well as public consumption which is assumed to be identical across all individuals.

[10] Using this welfare index is equivalent of using the welfare index proposed by Battisti et al. (2018) when the skill decision is exogenous and the population size is static. For the sake of exposition, in this section we will refer to the immigration effects on welfare only for the natives group. Appendix 3.A shows the effects on immigrants welfare, as well as on specific workers groups.

where $\frac{z^*}{2}$ is the (endogenous) average cost of acquiring skill.[11] The welfare index $\mathcal{W}_n$ includes the whole flows of native labor income, capital income, unemployment benefits, transfers and cost for training.

The remainder of this Section is presented as follows. Section 3.4.1 explains the calibration strategy for the benchmark model. Section 3.4.2 shows the results obtained and compares them with different variations of the model. Finally, Section 3.4.3 provides a robustness check on the results to the parameters choice.

3.4.1 Parametrization

We parametrize the described model in order to match the economic and socio-demographic characteristics of 19 OECD countries (EU15 member states, Australia, Canada, Switzerland and USA).

The described model includes a total of 32 exogenous parameters which need to be calibrated in order to perform a quantitative analysis. Most of these parameters vary across countries and are set to match moments taken from data, while some are assumed to be country-invariant and taken from the empirical literature. Because the following analysis focuses on steady-state variations, all scale parameters which do not affect the results – namely, the TFP level A and the matching efficiency ξ – are, for simplicity, normalized to unity in all countries.

Data sources used to calibrate country specific variables. As anticipated in Section 3.2, we use the DIOC data to account for different demographic characteristics over the 19 OECD countries. These data cover the census round 2010 and document the structure of the population by country of origin, age, education level, and labor market status. As in Aubry et al. (2016), we consider the share of population aged 65 and over as retired and out of the labor force, while individuals aged 25 to 64, or that did not report their age, as the working aged group.[12] Further, individuals that have at least one year of college education or a bachelor degree are regarded as high-skilled, whereas those with no education, with pre-primary, primary or secondary education completed, or that did not report their education level, are defined as the less-educated. Following Burzynski et al. (2018), data on the wage ratio between college-educated and less educated workers are taken from the *Education at Glance 2012* report of the OECD, and used as a proxy for the average return to skill w_h/w_l. Data on the wage ratio between native and immigrant workers are instead obtained from Buchel and Frick (2005) and from Docquier et al. (2014).

[11]Recall that native workers are heterogenous with respect to their cost of training and that z in uniformly distributed. This implies that the average cost payed by natives to acquire skill is $\frac{z^*}{2}$, and the total training cost is $\frac{z^*}{2}Q_{nh}$.

[12]Note that the DIOC data do not distinguish retirees by origin country. Following Burzynski et al. (2018), we assume that retirees origin distribution follows the same proportion of the younger individuals, i.e. $R_n/R_m \equiv \sum_s Q_{ns}/\sum_s Q_{ms}$.

As far as the fiscal characteristics of the 19 OECD countries are concerned, comparable aggregate data on public finances are obtained from the *Annual National Accounts* harmonized by the OECD. In line with Burzynski et al. (2018), we use it to identify the redistributive transfers T^a_{os} and the ratio of public expenditure to GDP. We also identify the amount of public consumption and treat it as a homogeneous transfer to all residents (as a part of T^a_{os}). As in Aubry et al. (2016), we also use the Social Expenditure Database (SOCX) of the OECD to decompose social protection expenditures, and the European Union Statistics on Income and Living Conditions (EU-SILC, provided by Eurostat) to disaggregate education and social protection transfers received by the natives; transfers to natives are then identified by education level and by age group.

Calibration of common parameters. Table 3.1 reports exogenous parameters without country variation. We set the capital share parameter $\alpha = 0.33$ to match the empirical evidence of Gollin (2002). Following Ottaviano and Peri (2012), we choose the elasticity of substitution between skill groups and origin groups of, respectively, $\sigma_1 = 2$ and $\sigma_2 = 20$. In line with Chassamboulli and Palivos (2014) and Battisti et al. (2018), the monthly interest rate r is set to 0.4%. Further, we choose the matching elasticity parameter $\epsilon = 0.5$, which is within the range of estimates reported in Petrongolo and Pissarides (2001) and Mortensen and Nagypal (2007), and the bargaining power $\beta = 0.5$, so that the Hosios condition is met (see Hosios, 1990). Finally, we normalize the low-skilled vancancy cost c_l to the same value adopted in Battisti et al. (2018).[13]

TABLE 3.1: Parameters without country variation

Parameters	Description	Value	Source
α	Capital share	0.33	Gollin (2002)
σ_1	Elast. subst. between skills	2	Ottaviano and Peri (2012)
σ_2	Elast. subst. immig/natives	20	Ottaviano and Peri (2012)
c_l	Low-skilled vacancy cost	0.5	Battisti et al. (2018)
r	Interest rate (monthly)	0.004	Chassamboulli and Palivos (2014)
ϵ	Matching elasticity	0.5	Petrongolo and Pissarides (2001)
β	Worker bargaining power	0.5	Hosios (1990)

Calibration of country-specific parameters. Exogenous parameters varying across countries are listed in Table 3.2. The parameters x and λ are calibrated to match, respectively, the average return to skill w_h/w_l and the average native wage premium w_n/w_m. The separation rates δ_{os} are set to match the unemployment rates observed in the DIOC data. Specifically, separation rates are calibrated to be, on average, larger for migrants than for natives, since migrant workers are generally characterized by a higher unemployment rate. The vacancy ratio c_h/c_l is parameterized to match the wage ratio w_h/w_l, implying that it is more costly to have a high-skilled unfilled vacancy, rather than a low-skilled one, proportionately to the education

[13] As pointed out in Battisti et al. (2018), this is a normalization that does not affect the obtained results.

wage premium. The upper bound parameter related to the cost of acquiring education, $\bar{z}$, is set in order to match the share of high-skilled natives provided by DIOC data.

As far as fiscal parameters are concerned, the replacement rate μ matches the observed share of unemployment benefits in GDP. Further, we calibrate the level of public transfers so to match the government expenditure to GDP as well as transfers by different cohorts taken from the OECD *Annual National Accounts* database.

Finally, we normalize the total young workers population to one and parametrize the shares of total retirees by origin ($R_m \equiv \sum_s R_{ms}$ and $R_n \equiv \sum_s R_{ns}$) and young immigrants by skill (Q_{mh} and Q_{ml}) according to DIOC data.[14]

TABLE 3.2: Parameters varying across countries

Parameters	Description	Mean	S.d.	Moment matched
Labor market parameters				
x	Firms' preference to HS	0.521	0.038	Avg. return to skill w_h/w_l
λ	Firms' preference to natives	0.592	0.054	Avg. wage ratio w_n/w_m
δ_{nh}	Break-up rate of HS natives	0.064	0.044	Unempl. rate U_{nh}/Q_{nh}
δ_{nl}	Break-up rate of LS natives	0.072	0.052	Unempl. rate U_{nl}/Q_{nl}
δ_{mh}	Break-up rate of HS immigrants	0.07	0.046	Unempl. rate U_{mh}/Q_{mh}
δ_{ml}	Break-up rate of LS immigrants	0.113	0.075	Unempl. rate U_{ml}/Q_{ml}
c_h/c_l	Vacancy costs ratio	1.98	0.36	Avg. return to skill w_h/w_l
$\bar{z}$	Training cost (compared to US)	0.835	0.442	Share of HS native workers γ
Fiscal parameters				
μ	Replacement rate	0.4	0.11	OECD data
T^y_{nh}	Transfers to natives HS	0.194	0.047	Gov. exp./GDP
T^y_{nl}/T^y_{nh}	Transfers ratio NL/NH	0.938	0.163	OECD data
T^y_{mh}/T^y_{nh}	Transfers ratio MH/NH	1,365	0.453	OECD data
T^y_{ml}/T^y_{nh}	Transfers ratio ML/NH	1.276	0.438	OECD data
T^r_{nh}/T^y_{nh}	Transfers ratio ret. NH/NH	2.486	0.984	OECD data
T^r_{nl}/T^y_{nh}	Transfers ratio ret. NL/NH	1.748	0.489	OECD data
T^r_{mh}/T^y_{nh}	Transfers ratio ret. MH/NH	2.367	0.889	OECD data
T^r_{ml}/T^y_{nh}	Transfers ratio ret. ML/NH	1.908	0.788	OECD data
Demografic sizes (native workers population normalized to unity)				
Q^y_{mh}	Young migrants HS	0.09	0.088	OECD data
Q^y_{ml}	Young migrants LS	0.162	0.138	OECD data
R_m	Retired migrants	0.077	0.049	OECD data
R_n	Retired natives	0.353	0.085	OECD data

Using this parameters calibration, in the following section we simulate marginal increases in different types of migration flows taking, as reference, the described moments as the status quo.[15]

[14] Note that the total number of retirees by origin is exogenous, but the number of retirees by origin and skill is endogenous (e.g. $R_{nh} \equiv R_n\gamma$).

[15] Although we cannot obtain a closed-form solution for our model, we find that, under the described parametrization, a unique economically meaningful equilibrium exists in all the considered countries for the benchmark model.

3.4.2 Sensitivity to different specifications

In this section, we simulate a 1 percent increase in the labor force due to immigration under four different versions of the benchmark model described in Section 3.3. Our main goal is to analyze the effects of immigration on natives welfare, and to assess to what extent taking into account natives endogenous skill and age composition matters in such analysis.[16] To this end, we compare the results obtained by the benchmark version of the model with those obtained in models that differ for the following elements: (a) the economy is composed of only working-age individuals, i.e $R_{os} \equiv 0$ for each agent type (o, s) (henceforth referred as Model 2); (b) young natives never adjust their skill in response to migration, i.e. γ is exogenous (henceforth referred as Model 3); (c) there are no retirees in the economy and young natives never adjust their skill, i.e. $R_{os} \equiv 0$ and γ is exogenous (henceforth referred as Model 4).

Since many developed countries are moving towards more selective migration policies in order to attract highly educated workers, and the skill composition of the migration flows plays a key role for determining welfare effects (Borjas, 2003; Ottaviano and Peri, 2012), in the analysis we consider three different types of one-off migration shocks: (i) a shock of low-skilled immigrant workers (Q_{ml}); (ii) a shock of high-skilled immigrant workers (Q_{mh}); (iii) a shock of low- and high-skilled immigrant workers such that the immigrant skill composition does not change in the post-shock scenario. Henceforth we will refer to this latter scenario as the "skill-balanced" migration shock.

Moreover, as the impact of immigration on native welfare crucially depends on how the new influx of foreign-born workers affect the labor market and the fiscal balance of the domestic economy, we also analyze three main channels through which migration impacts native welfare: the average labor income of native workers ($w_n \equiv \sum_s E_{ns} w_{ns} / \sum_s E_{ns}$), the native unemployment rate ($u_n \equiv \sum_s U_{ns} / \sum_s Q_{ns}$), and the fiscal effect on the income tax rate (τ).[17]

The effects of low-skilled immigration

Figure 3.2 shows the effect of low-skilled immigration on the labor market, fiscal balance and native welfare of the 19 selected OECD countries.

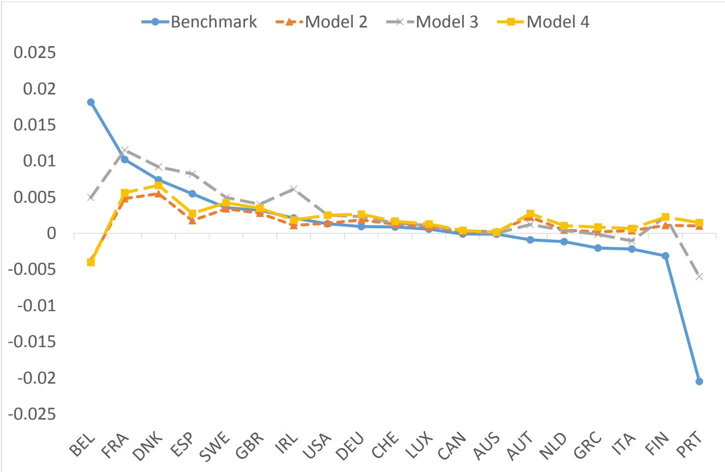
Under the benchmark version of the model, 8 out of 19 countries experience a decrease in native unemployment rate (see Figure 3.2a). A similar result is obtained for Model 3, whereas Model 2 and Model 4 find a decrease in the native unemployment rate only for Belgium. Moreover, native wages positively respond to low-skilled immigration under all specifications, but the benchmark model and Model 2 are noticeably more optimistic than the other models (see

[16] Battisti et al. (2018) simulate a shock of the same magnitude.

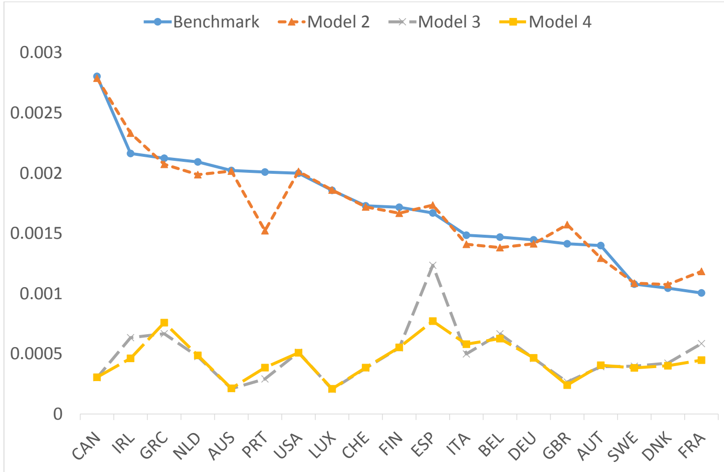
[17] As described in Section 3.3, the tax rate on labor income τ is assumed to always adjust to balance the government budget (3.21). This implies that, after a shock, if the domestic economy experiences an increase in income (expenditures), the government will set a lower (higher) tax rate until its budget balances again.

FIGURE 3.2: Effects of low-skilled immigration (1% of the total labor force) on 19 selected OECD countries

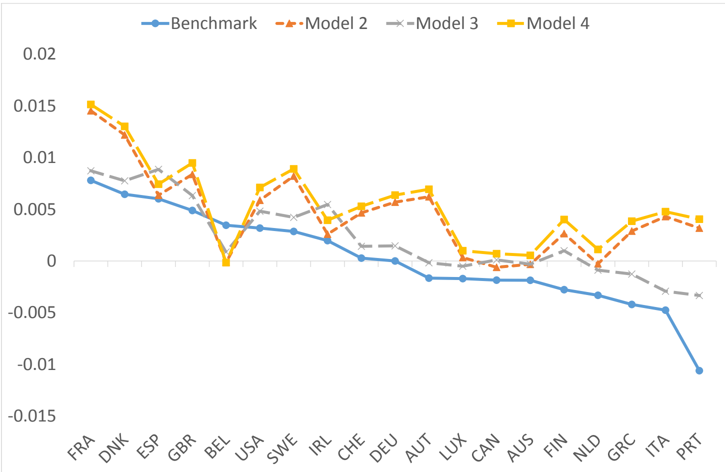
(A) Effect on avg. native unemployment rate



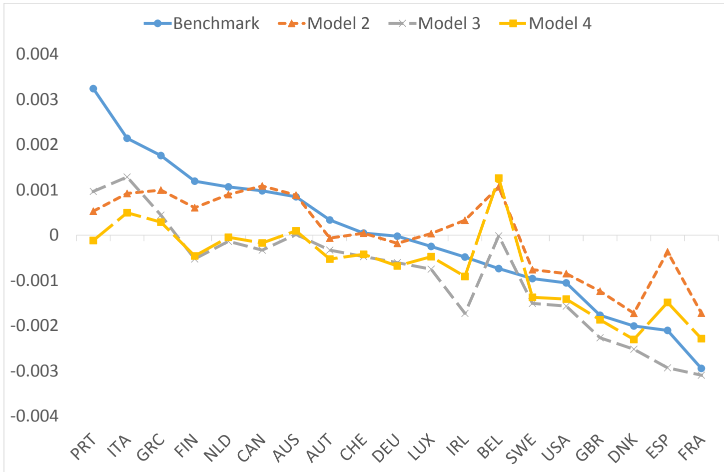
(B) Effect on avg. native wage



(C) Effect on labor income tax



(D) Effect on avg. native welfare



Note: Solid lines represent the benchmark model, whereas square-dotted, short-dashed and long-dashed lines represent Model 2, Model 3 and Model 4, respectively. Benchmark = endogenous skill acquisition, retirees included; Model 2 = endogenous skill acquisition, no retirees; Model 3 = exogenous skill acquisition, retirees included; Model 4 = exogenous skill acquisition, no retirees.

Figure 3.2b). This underlines the importance of taking into account natives skill acquisition: in the long-run, young natives decide to upgrade their skill and invest more in education in order to avoid the fiercer competition of the new influx of low-skilled migrants. As a consequence, in models with endogenous native skill a higher share of natives will be high-skilled in the post-shock scenario, making average wages raise and, on some countries, native unemployment rates decrease.[18]

As far as the fiscal impact is concerned, Figure 3.2c shows that the benchmark model is more optimistic than the others on all countries but Belgium. In particular, low-skilled immigration has a positive effect on government income in in 9 countries out of 19 under the benchmark model. Model 4 is the more pessimistic, as it finds a positive fiscal impact only for Belgium, whereas Model 2 and Model 3 find positive effects for 4 and 7 countries, respectively. This underlines that including both endogenous skill acquisition and age composition matters for assessing the fiscal impact of low-skilled immigration.

These results lead to an average native welfare effect which is positive only for a sub-group of OECD countries (see Figure 3.2d). Under the benchmark model, the average native welfare increases for 9 out of the 19 OECD countries. Table 3.3 shows average results for the aggregate group of the 19 selected OECD countries, weighted for their native population size (which includes retirees for the benchmark model and Model 3, but only working-age active natives for Model 2 and Model 4) in order to account for the differences in country size. Interestingly, Model 2 turns out to be the more optimistic model when assessing the native welfare average effect of the whole group of countries, though the benchmark model is still less pessimistic than Model 3 and Model 4.

TABLE 3.3: Weighted average effects of low-skilled immigration

Variable	Benchmark	Model 2	Model 3	Model 4
u_n	0.193	0.173	0.327	0.248
w_n	0.173	0.175	0.052	0.048
τ	0.2	0.603	0.373	0.702
$\mathcal{W}_n$	-0.064	-0.044	-0.127	-0.108

Note: all values indicate variations in percentage points. Each country is weighted according to its native population size. Appendix 3.B provides results for unweighted averages.

The effects of high-skilled immigration

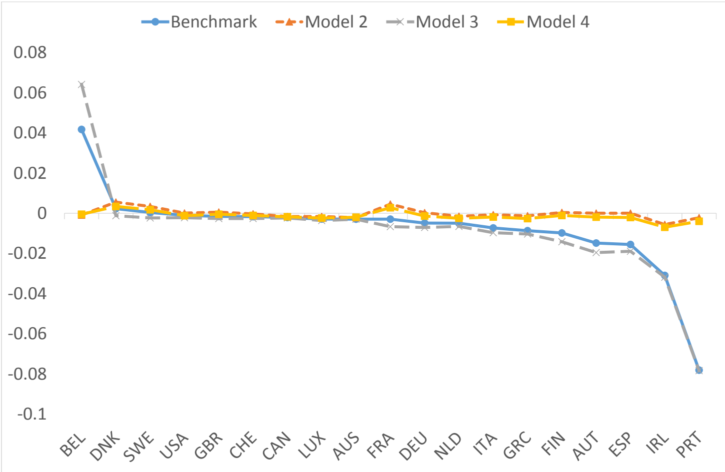
The steady-state variations of increasing the number of high-skilled immigrant by 1 percent of the total labor force population over the 19 OECD countries are illustrated in Figure 3.3.

Regarding the effects on the labor market outcomes, simulations of high-skilled immigration yield contrastant results that depend on the assumption on natives skill acquisition. In models in which natives skill acquisition is exogenous (Model 3 and Model 4), the higher competition in the high-skill sector makes, on average, native unemployment rate to slightly increase, though native wage rates increase as well (see Table 3.4). On the contrary, in models in which young natives are allowed to endogenously adjust their skill (Benchmark and Model 2), young natives

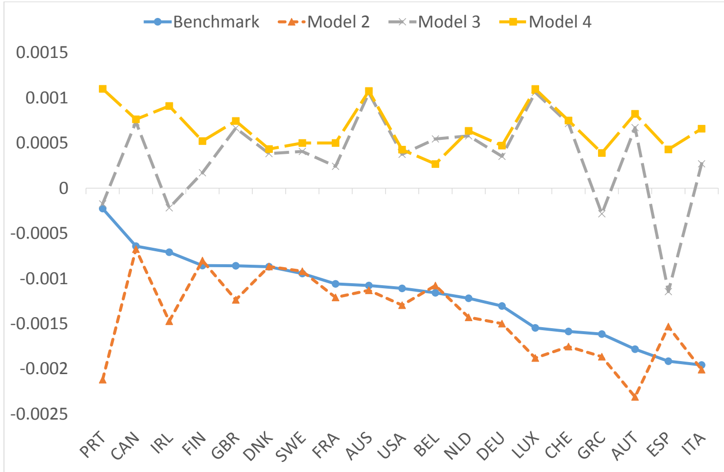
[18] Note that, as pointed out in Battisti et al. (2018), it is possible for unemployment rates to decrease after immigration, as firms may increase their profit after the shock and open more vacancies for both native and immigrant workers.

FIGURE 3.3: Effects of high-skilled immigration (1% of the total labor force) on 19 selected OECD countries

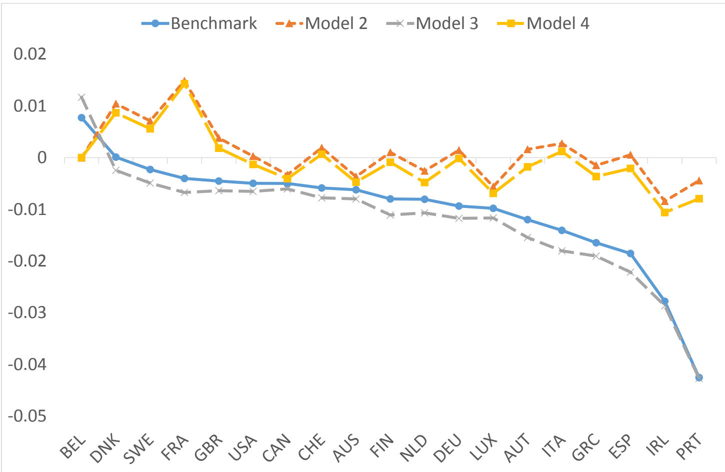
(A) Effect on avg. native unemployment rate



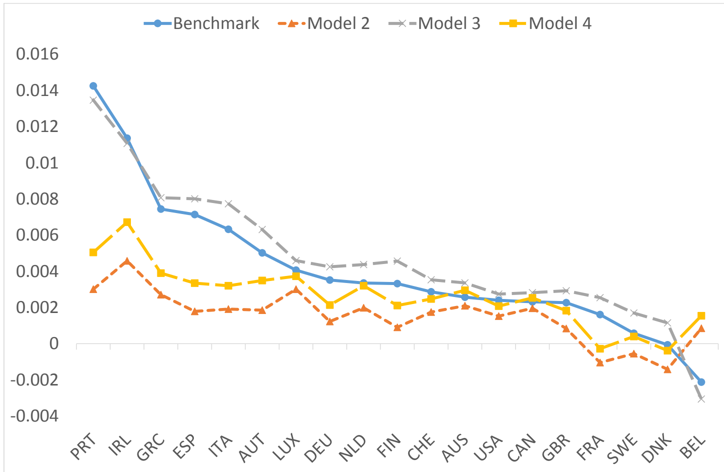
(B) Effect on avg. native wage



(C) Effect on labor income tax



(D) Effect on avg. native welfare



Note: Solid lines represent the benchmark model, whereas square-dotted, short-dashed and long-dashed lines represent Model 2, Model 3 and Model 4, respectively. Benchmark = endogenous skill acquisition, retirees included; Model 2 = endogenous skill acquisition, no retirees; Model 3 = exogenous skill acquisition, retirees included; Model 4 = exogenous skill acquisition, no retirees.

avoid the increasing competition in the high-skill sector by supplying low-skill labor. As a result, native unemployment rates, on average, decrease (Figure 3.3a shows that native unemployment rate decreases in all countries but Belgium, Denmark and Sweden for the benchmark model), but at the expense of average lower wage rates as, after the shock, more native people are now working in the low-skilled sector, which pays for a lower wage rate.

Figure 3.3c shows that when age composition is taken into account, the labor income tax rate decreases in almost all countries. In particular, under the benchmark model, high-skilled immigration has positive fiscal effects for all countries but Belgium and Denmark. Simulations on Model 2 and Model 4 produce similar results, which find an average negative effect of high-skilled migration on the domestic country fiscal balance. These results underline that endogenizing skill acquisition does not noticeably affect the fiscal impact of immigration on the OECD countries, whereas age composition plays a bigger role on assessing the fiscal effect of high-skilled immigration.

Native welfare effects are depicted in Figure 3.3d. The simulations yield positive native welfare impacts on most countries under all model variations. Interestengly, Model 3 is found to be the more optimistic model, underlining the fact that, when age composition is considered, high-skilled immigrants greatly alleviate the fiscal burden in the host country. Conversely, Model 2 and Model 4, which do not account for age composition, are the least optimistic. Finally, The benchmark model finds positive native welfare effect on all countries but Belgium and Denmark, which are the same countries for which simulations generate negative labor market outcomes in the post-shock scenario.

Table 3.4: Weighted average effects of high-skilled immigration

Variable	Benchmark	Model 2	Model 3	Model 4
u_n	-0.451	0.029	-0.601	0.104
w_n	-0.122	-0.138	0.029	0.054
τ	-0.794	0.191	-1.006	0.031
$\mathcal{W}_n$	0.339	0.130	0.401	0.217

Note: all values indicate variations in percentage points. Each country is weighted according to its native population size. Appendix 3.B provides results for unweighted averages.

The effects of skill-balanced immigration

Figure 3.4 provides our simulation results on an increase in the stock of young immigrants by 1 percent of the total labor force, holding constant their actual education composition.

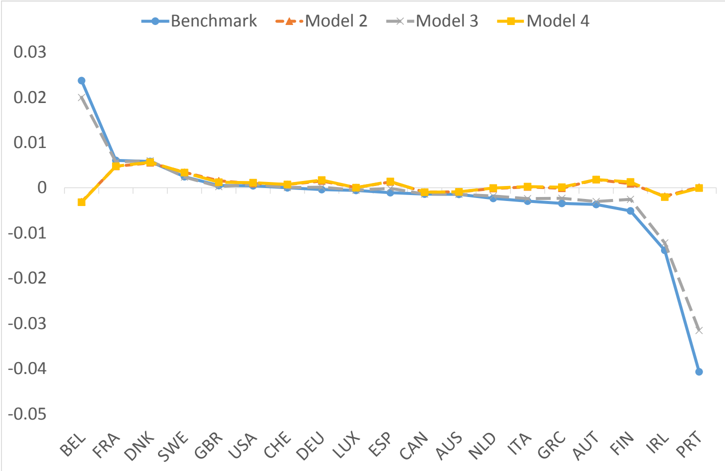
The benchmark model is the most optimistic model version for assessing the effect of skill-balanced migration on labor market outcomes. The native unemployment rate decreases in 12 out of 19 countries after the migration shock under the benchmark model. The other model variations find less optimistic results (see Figure 3.4a). In particular, Model 4 predicts a decrease in native unemployment rate only for 6 out of 19 countries. As far as labor income is concerned, native wages are found to increase for all countries under all of the four model versions, but slightly more when taking into account natives endogenous skill acquisition (see Figure 3.4b).

Figure 3.4c shows results for the fiscal effects of immigration over the 19 OECD countries. The benchmark model and Model 3 are found to be more optimistic than the other model versions for all countries but Belgium. In particular, 14 out of 19 countries experience a positive fiscal effect for the benchmark model and Model 3, while only 6 out of 19 countries experience positive fiscal effects under Model 2 and Model 4 after the skill-balanced immigration shock. This is coherent with the previous finding that taking into account age skill composition positively changes the fiscal impact of immigration on the domestic economy.

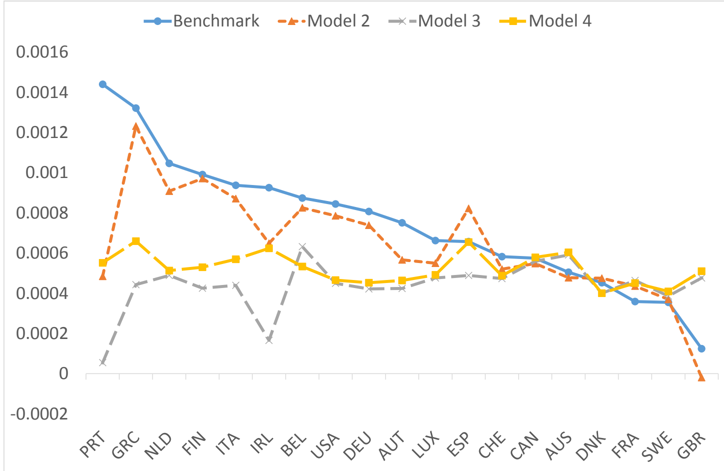
Because of a more positive labor outcome and fiscal impact, the benchmark model turns out to be the model version that predicts the highest increase in average native welfare when a skill-balanced immigration shock takes place in the considered OECD countries (see Table 3.5). As shown in Figure 3.4d, the average native welfare increases in all countries but Belgium, Denmark, France and Sweden under the benchmark model. The least optimistic version is Model 4, in which natives skill composition is exogenous and retirees are not accounted for, that predicts an increase in average native welfare for 13 of the considered 19 OECD countries.

Figure 3.4: Effects of skill-balanced immigration (1% of the total labor force) on 19 selected OECD countries

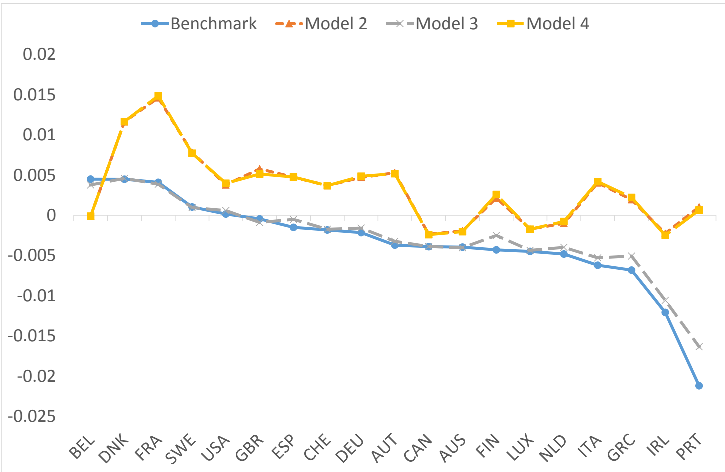
(a) Effect on avg. native unemployment rate



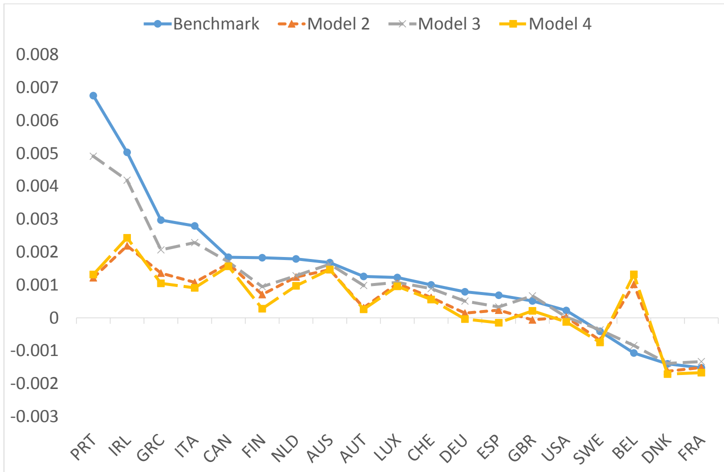
(b) Effect on avg. native wage



(c) Effect on labor income tax



(d) Effect on avg. native welfare



Note: Solid lines represent the benchmark model, whereas square-dotted, short-dashed and long-dashed lines represent Model 2, Model 3 and Model 4, respectively. Benchmark = endogenous skill acquisition, retirees included; Model 2 = endogenous skill acquisition, no retirees; Model 3 = exogenous skill acquisition, retirees included; Model 4 = exogenous skill acquisition, no retirees.

TABLE 3.5: Weighted average effects of skill-balanced immigration

Variable	Benchmark	Model 2	Model 3	Model 4
u_n	-0.022	0.117	0.019	0.126
w_n	0.072	0.067	0.045	0.05
τ	-0.133	0.454	-0.088	0.461
$\mathcal{W}_n$	0.07	0.018	0.048	0.006

Note: all values indicate variations in percentage points. Each country is weighted according to its native population size. Appendix 3.B provides results for unweighted averages.

3.4.3 Sensitivity to parameters

As there is empirical disagreement on the degree of substitutability between workers of different skill and origin (see Borjas et al., 2012) and these parameters play a key role for correctly assessing the impact of migration on the host country labor market, here we perform a ceteris paribus sensitivity analysis on the elasticities of substitution between high- and low- skilled workers, σ_1, and between native and immigrant workers, σ_2. In the benchmark parametrization, following Ottaviano and Peri (2012), we chose $\sigma_1 = 2$ and $\sigma_2 = 20$. In what follows, we set $\sigma_1 = 1.5$ and $\sigma_2 = 10000$ to check how robust our benchmark model is when high- and low- skilled workers are more complementary, and when native and immigrant workers can be considered as perfect substitutes (i.e. $\sigma_2 \to \infty$). We vary each parameter each time and perform the same skill-biased and skill-balanced immigration shocks we have discussed in the previous sections.

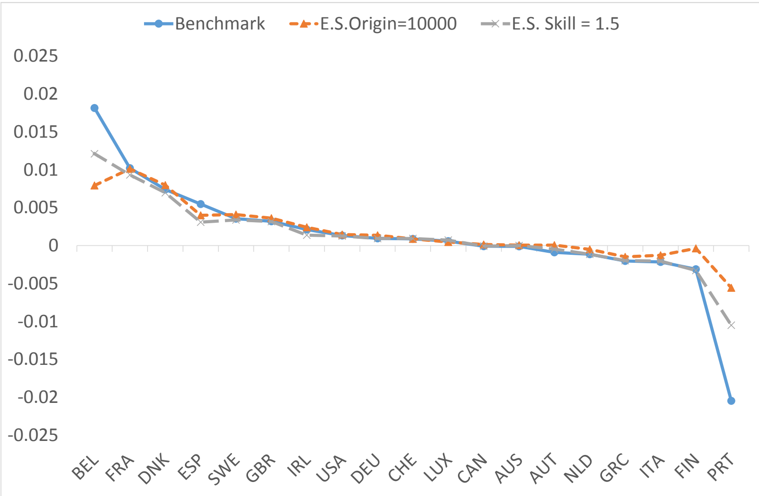
Figures 3.5, 3.6 and 3.7 illustrate the sensitivity of the immigration effects on labor market outcomes, labor income tax and average native welfare, under different calibrations of the benchmark model.

Let us start by considering the low-skilled immigration shock scenario (Figure 3.5). The unemployment rate is mostly insensitive to different parametrizations of σ_1 and σ_2 (see Figure 3.5a), with only Belgium and Portugal noticeably differing in the magnitude of effects, though not in the direction of the effects. Conversely, wage impacts are the ones that vary the most across different calibration (see Figure 3.5b), as σ_1 and σ_2 directly affect workers marginal productivity, and hence their wages. That being said, the countries ranking is mostly unaffected and the immigration effect on native wages is consistently positive even when the elasticity of substitution between immigrant and native workers tends to infinity. Results on the fiscal and native welfare impact are also rather robust (see Panels 3.5c and 3.5d), though calibrating $\sigma_2 = 10000$ yields, on average, slightly more pessimistic results, while setting $\sigma_1 = 1.5$ produces slightly more optimistic welfare gains.

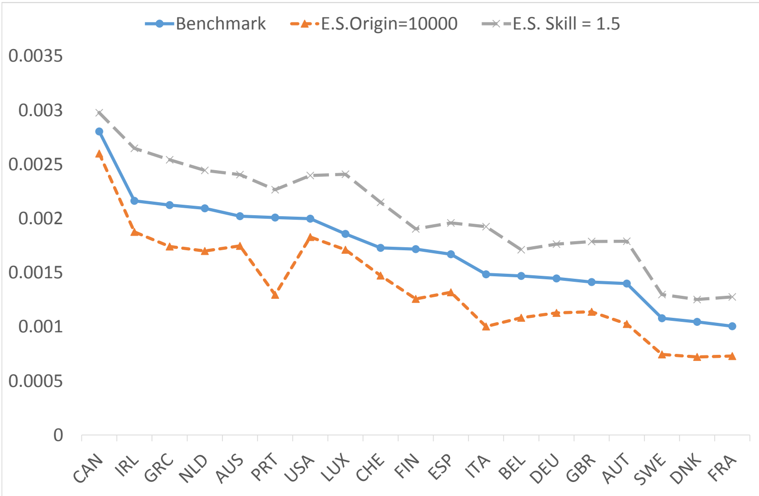
Let us now focus on the case in which the immigration shock is entirely characterized by high-skilled workers (Figure 3.6). The resulting effect of high-skilled immigration on the native

FIGURE 3.5: Effects of low-skilled immigration (1% of the total labor force) on 19 selected OECD countries - Sensitivity to parameters

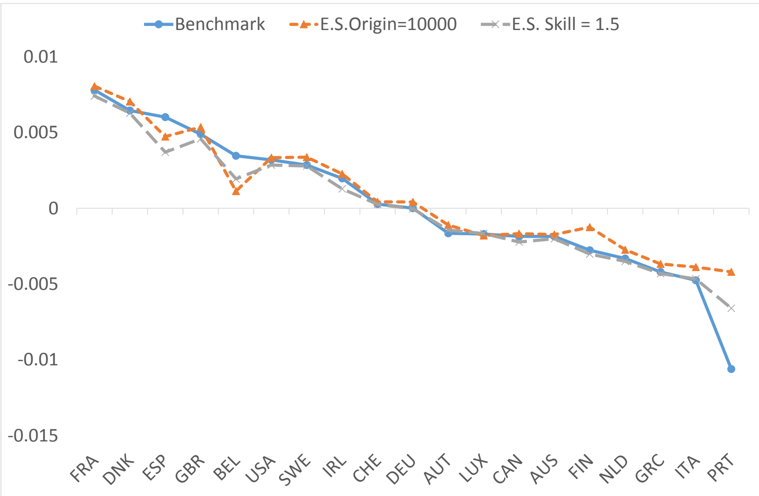
(A) Effect on avg. native unemployment rate



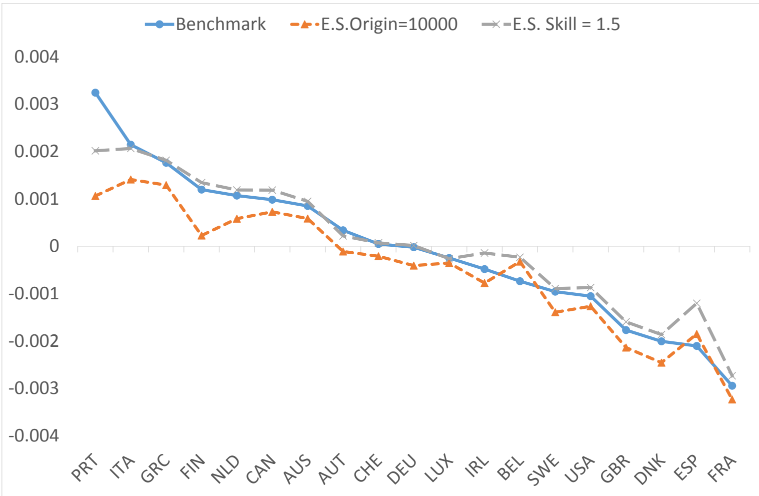
(B) Effect on avg. native wage



(C) Effect on labor income tax



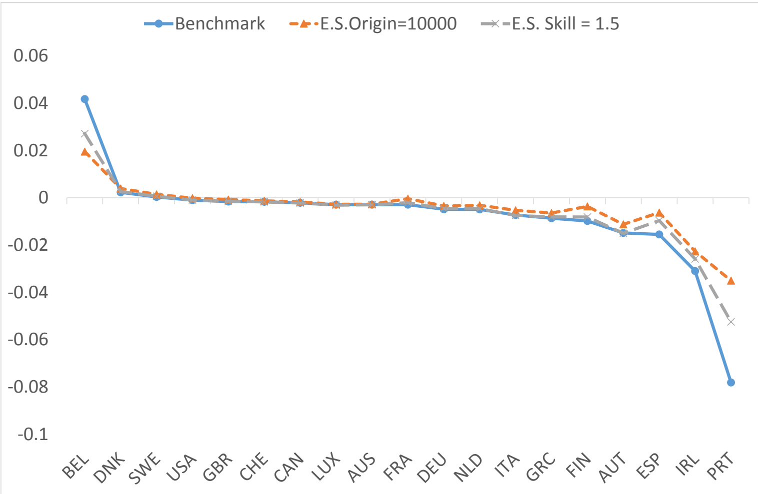
(D) Effect on avg. native welfare



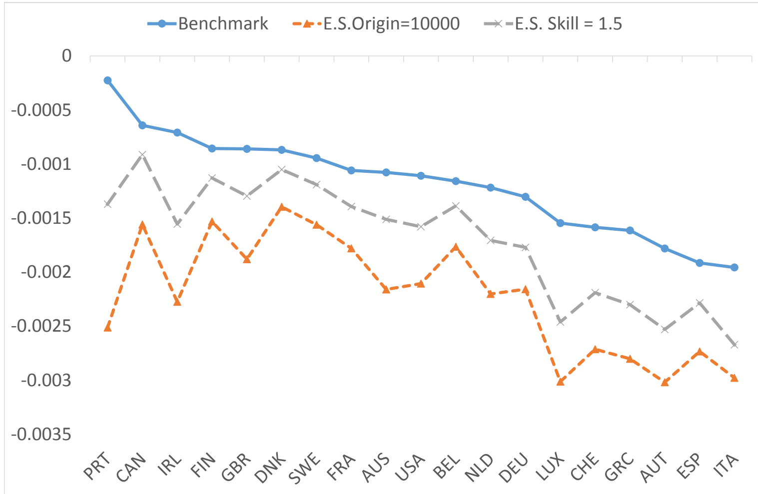
Note: Solid lines represent the benchmark parametrization, square-dotted lines indicates parametrization of $\sigma_1 = 10000$, dashed lines indicates parametrization of $\sigma_2 = 1.5$.

FIGURE 3.6: Effects of high-skilled immigration (1% of the total labor force) on 19 selected OECD countries - Sensitivity to parameters

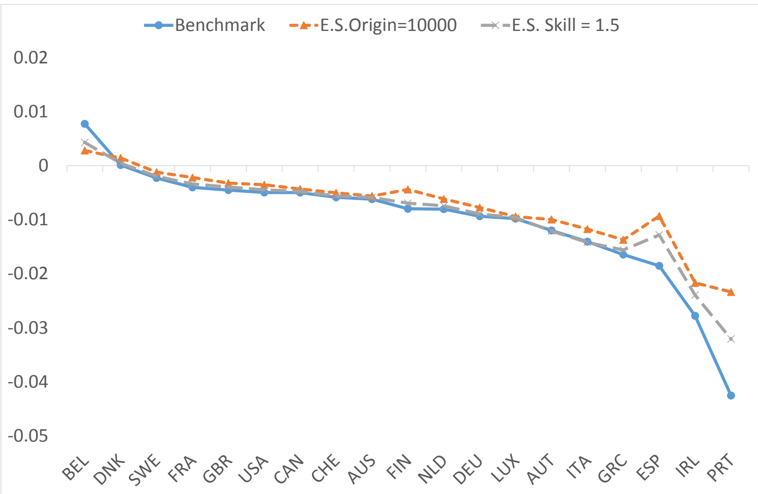
(A) Effect on avg. native unemployment rate



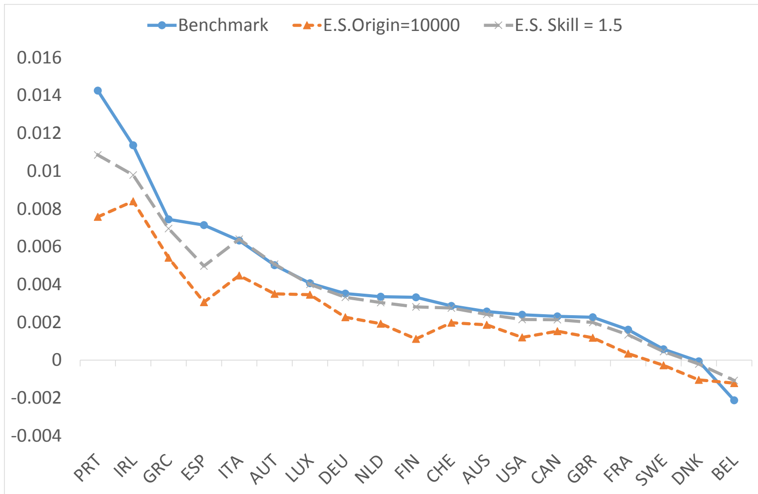
(B) Effect on avg. native wage



(C) Effect on labor income tax



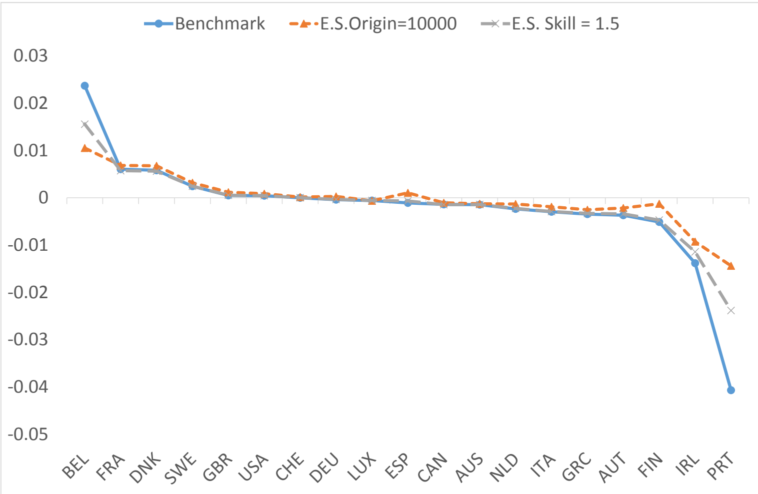
(D) Effect on avg. native welfare



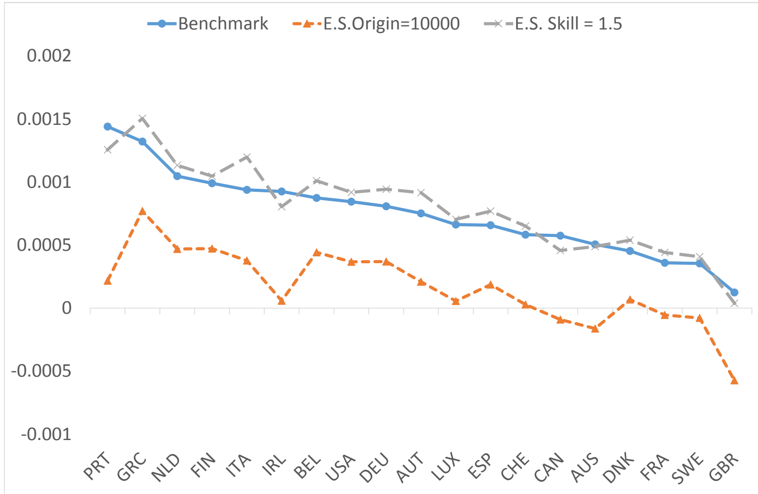
Note: Solid lines represent the benchmark parametrization, square-dotted lines indicates parametrization of $\sigma_1 = 10000$, dashed lines indicates parametrization of $\sigma_2 = 1.5$.

Figure 3.7: Effects of skill-balanced immigration (1% of the total labor force) on 19 selected OECD countries - Sensitivity to parameters

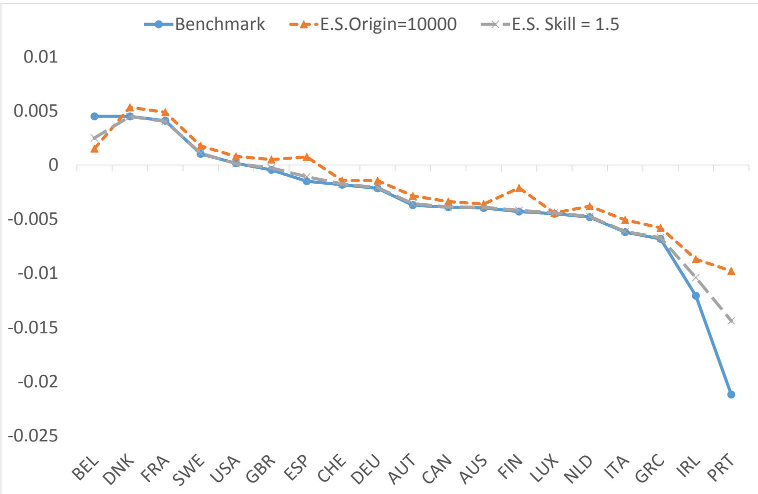
(a) Effect on avg. native unemployment rate



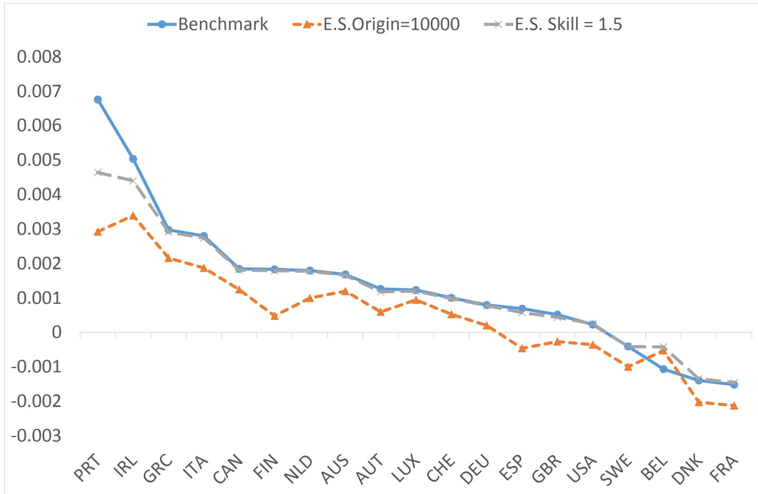
(b) Effect on avg. native wage



(c) Effect on labor income tax



(d) Effect on avg. native welfare



Note: Solid lines represent the benchmark parametrization, square-dotted lines indicates parametrization of $\sigma_1 = 10000$, dashed lines indicates parametrization of $\sigma_2 = 1.5$.

unemployment rate is highly robust under different calibration choices of the elasticity parameters (see Figure 3.6a). Native wages effects vary across different parametrizations, with the benchmark one yielding the most optimistic results (see Figure 3.6b). However, despite the difference in magnitudes effect and countries rankings, under all parametrizations we find a decrease in average native wage in response to high-skilled immigration. Fiscal and Welfare effects are found to be highly robust, with only Portugal and Spain noticeably varying across different parametrization choices (see Panels 3.6c and 3.6d).

Finally, we analyze how robust are our results in the case of a skill-balanced immigration shock (Figure 3.7). While native unemployment rate effects are highly robust in all countries but Portugal (see Figure 3.7a), native wages variations are sensible to the parametrization of the elasticity of substitution between migrant and native workers, σ_2 (see Figure 3.7b). Indeed, despite the countries ranking is mostly the same, the magnitude of the effects vary, so that when σ_2 tends to infinity, 5 out of 19 countries experience a negative native wage rate, whereas in the benchmark parametrization the native wages increase in all countries after the skill-balanced migration shock. As far as fiscal and welfare effects are concerned (Panels 3.7c and 3.7d), differences among different parametrizations are present but limited. In particular, setting $\sigma_2 = 10000$ we find that average native welfare decreases in 8 out of 19 countries, whereas in the benchmark parametrization it decreases in only 4 countries.

3.5 Concluding remarks

This chapter investigates the effects of immigration on the native welfare, by introducing two key features that have been so far mostly neglected in the growing literature of search models. The first feature is related to the recent empirical findings that natives tend to adjust their task specialization in response to immigration. The second feature regards individuals age composition and allows us to assess whether immigrant workers are able to alleviate the fiscal burden of aging populations. Both of these features are taken into account in our search model by endogenizing natives education decisions and by including different generations of workers. We focus our analysis on a selected group of 19 OECD countries (EU15 member states, Australia, Canada, Switzerland and USA) and perform a comparative statics analysis under different variations of immigration shocks and model versions in order to assess to what extent the introduced features affect welfare results.

Despite the heterogeneity in population and labor market characteristics across countries, our analysis finds the following results for the aggregate group of OECD countries considered. First, when young natives endogenously decide their education investment, natives are successfully able to avoid any displacement effect that a migration shock may generate. The only exception is for the case in which the migration shock consists of only low-skilled immigrants which, on average, generates a slight displacement effect. This latter negative effect is, however, offset by the increase on average native wages that takes place in all of the considered 19 countries. Second, migration influxes that include high-skilled workers have positive fiscal effects when age composition is taken into account. On the contrary, the other model versions that abstract from retired workers find negative fiscal effects under all immigration shock scenarios. Third, the features introduced in our benchmark model allow for an overall more optimistic prediction of the impact of immigration on natives' welfare. In particular, according to our benchmark model simulation, average native welfare increases in all countries but Belgium, Denmark, France and Sweden in response to a immigration shock that doesn't affect the observed immigrants education composition. However, these results change when the influx of migration is composed of only low-skilled workers, as only 9 of the analyzed 19 countries experience an increase in average welfare after the shock. Our results are mostly robust to sensitivity analysis on different degrees of substitution between workers of different skill and origin.

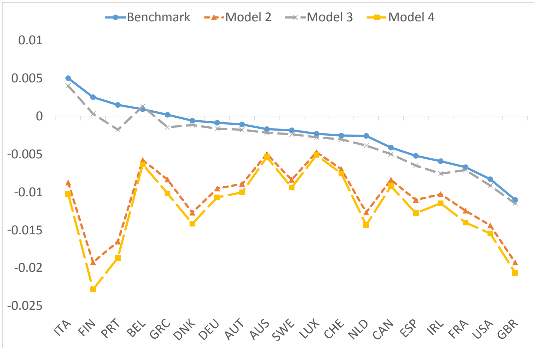
This study departs from a search model inspired by Battisti et al. (2018), in which we introduced intergenerational features. However, our analysis can still be extended to address several issues for future research. For example, one significant issue to be pursued in future work may be to allow for immigrants assimilation. Indeed, our model accounts for population dynamics regarding skill and age composition, but totally abstracts from immigrants assimilation. Long-term immigrants, and especially their offspring, may successfully integrate in the host country and eventually be considered the same as native workers under all respects. Furthermore, an interesting extension of the model could endogenize the migration process and its skill composition, so that immigrants may decide to upgrade their education as well in response to changes in the labor market sector.

Appendices

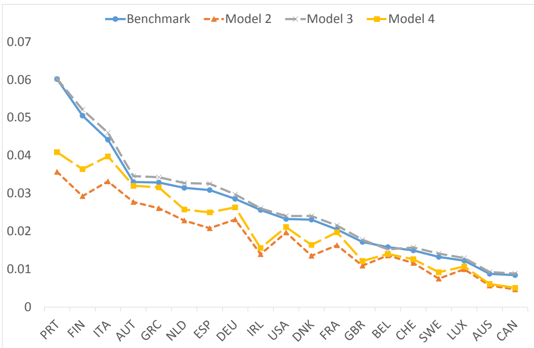
3.A Group-specific welfare effects

FIGURE 8: Immigration effect on avg. migrant welfare

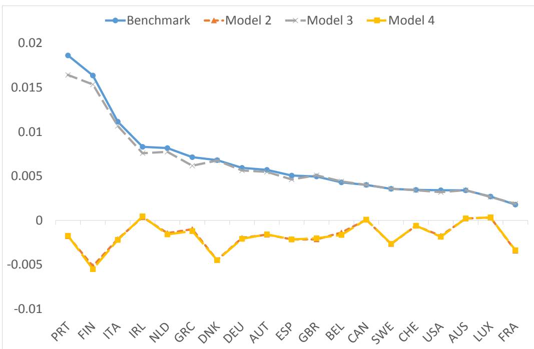
(A) Low-skilled immigration effect on migrants welfare



(B) High-skilled immigration effect on migrants welfare



(C) Skill-balanced immigration effect on migrants welfare



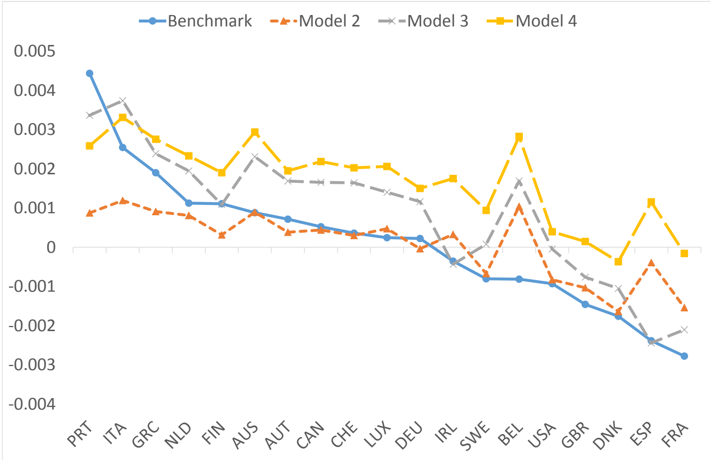
Note: we use the following average immigrant welfare index

$$\mathcal{W}_m \equiv \left(\sum_s E_{ms}\mathcal{J}^E_{ms} + \sum_s U_{ms}\mathcal{J}^U_{ms} + \sum_s R_{ms}\mathcal{J}^R_{ms}\right) \left(\sum_s (Q_{ms} + R_{ms})\right).$$

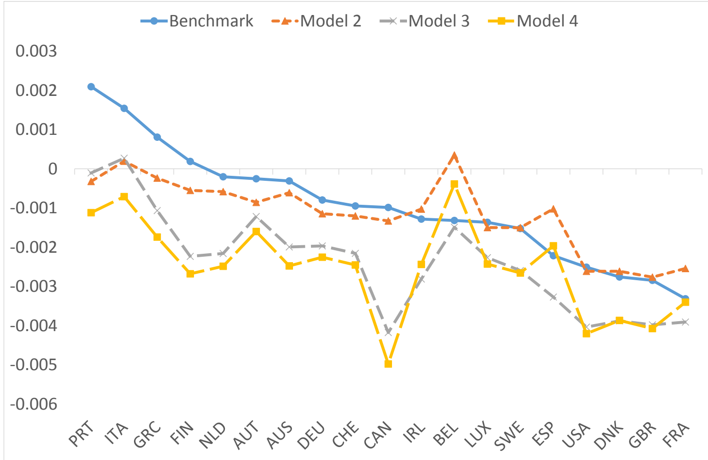
Benchmark = endogenous skill acquisition, retirees included; Model 2 = endogenous skill acquisition, no retirees; Model 3 = exogenous skill acquisition, retirees included; Model 4 = exogenous skill acquisition, no retirees.

FIGURE 9: Group-specific effects of low-skilled immigration (1% of the total labor force)

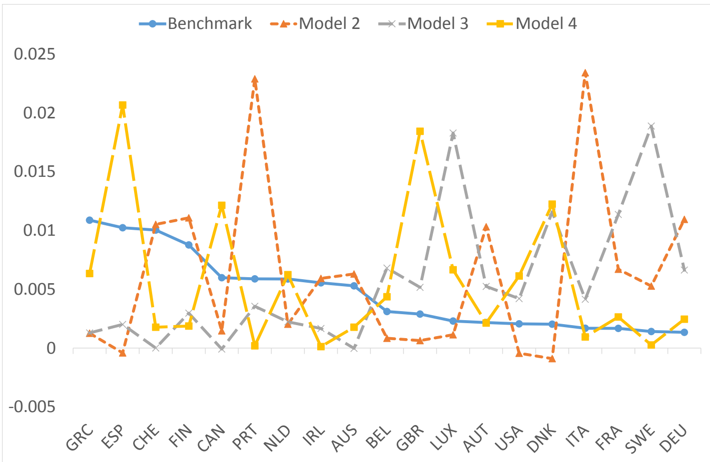
(A) High-skilled natives welfare



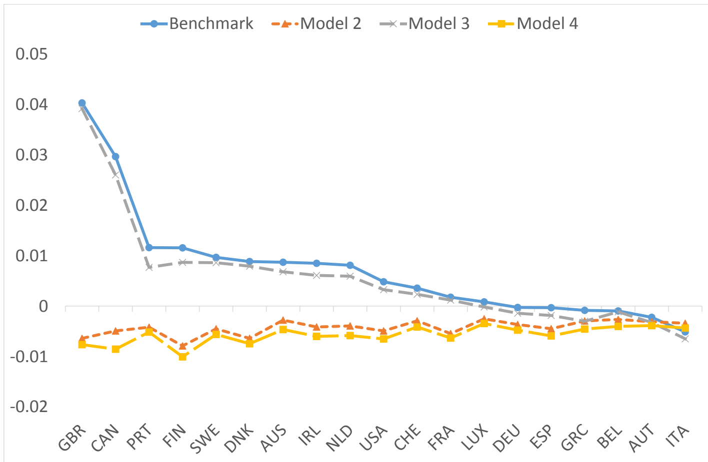
(B) Low-skilled natives welfare



(C) High-skilled immigrants welfare



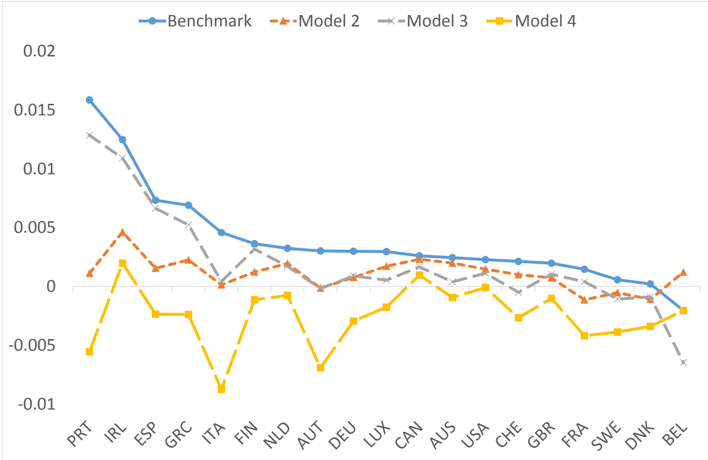
(D) Low-skilled immigrants welfare



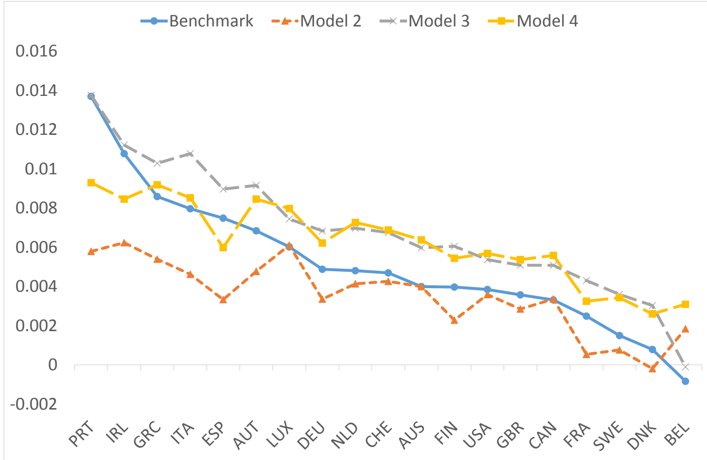
Note: we use the welfare index $\mathcal{W}_{nh} \equiv \frac{E_{nh}\mathcal{J}^E_{nh}+U_{nh}\mathcal{J}^U_{nh}-\frac{z^*}{2}Q_{nh}+R_{nh}\mathcal{J}^R_{nh}}{(Q_{nh}+R_{nh})}$ for native high-skilled; we use $\mathcal{W}_{os} \equiv \frac{E_{os}\mathcal{J}^E_{os}+U_{os}\mathcal{J}^U_{os}+R_{os}\mathcal{J}^R_{os}}{(Q_{os}+R_{os})}$ otherwise. Benchmark = endogenous skill acquisition, retirees included; Model 2 = endogenous skill acquisition, no retirees; Model 3 = exogenous skill acquisition, retirees included; Model 4 = exogenous skill acquisition, no retirees.

FIGURE 10: Group-specific effects of high-skilled immigration (1% of the total labor force)

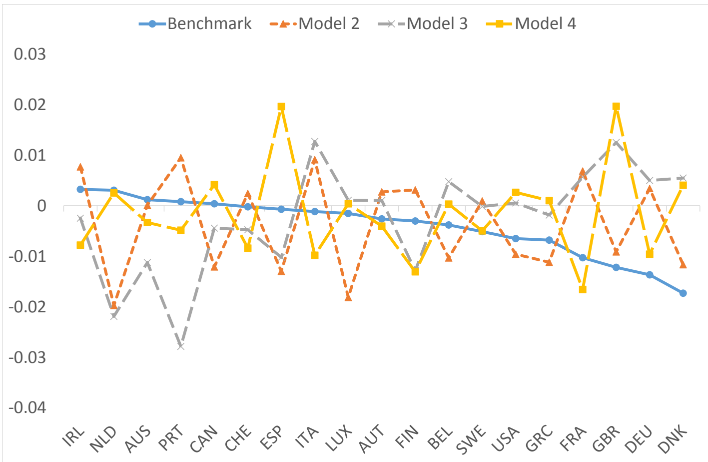
(A) High-skilled natives welfare



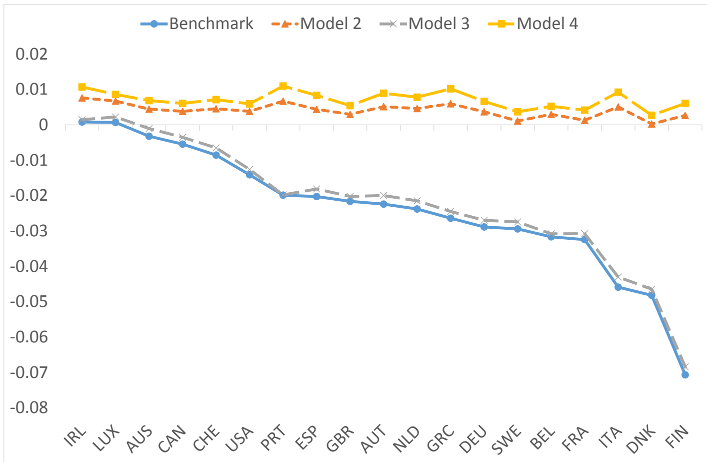
(B) Low-skilled natives welfare



(C) High-skilled immigrants welfare



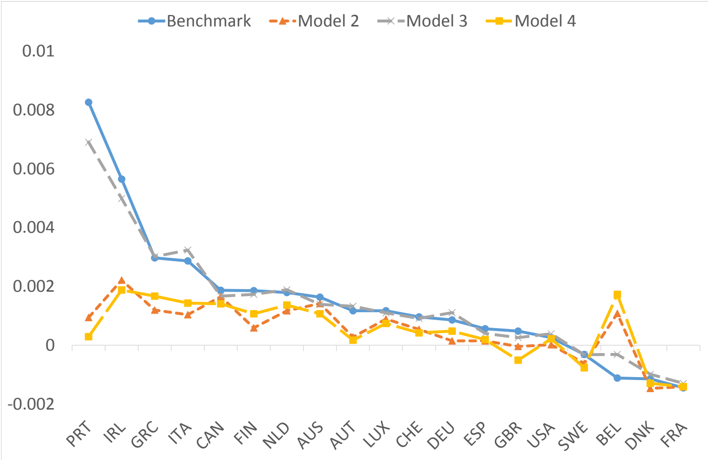
(D) Low-skilled immigrants welfare



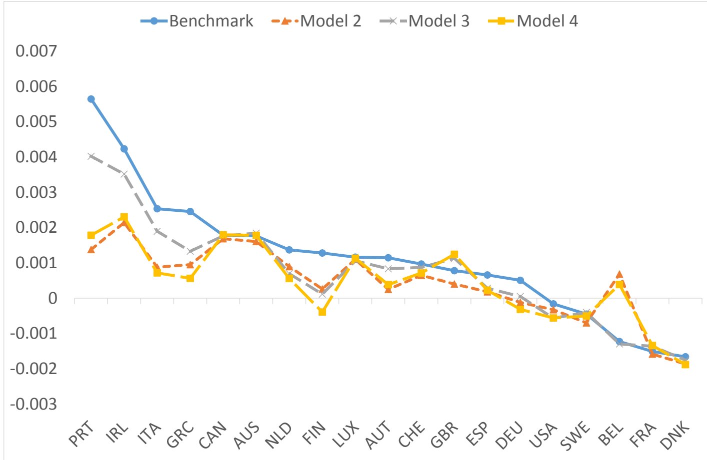
Note: we use the welfare index $\mathcal{W}_{nh} \equiv \frac{E_{nh}\mathcal{J}^E_{nh}+U_{nh}\mathcal{J}^U_{nh}-\frac{z^*}{2}Q_{nh}+R_{nh}\mathcal{J}^R_{nh}}{(Q_{nh}+R_{nh})}$ for native high-skilled; we use $\mathcal{W}_{os} \equiv \frac{E_{os}\mathcal{J}^E_{os}+U_{os}\mathcal{J}^U_{os}+R_{os}\mathcal{J}^R_{os}}{(Q_{os}+R_{os})}$ otherwise. Benchmark = endogenous skill acquisition, retirees included; Model 2 = endogenous skill acquisition, no retirees; Model 3 = exogenous skill acquisition, retirees included; Model 4 = exogenous skill acquisition, no retirees.

FIGURE 11: Group-specific effects of low-skilled immigration (1% of the total labor force)

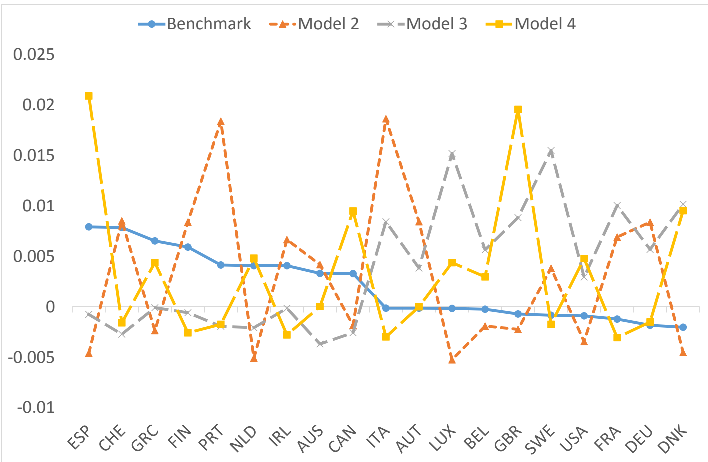
(A) High-skilled natives welfare



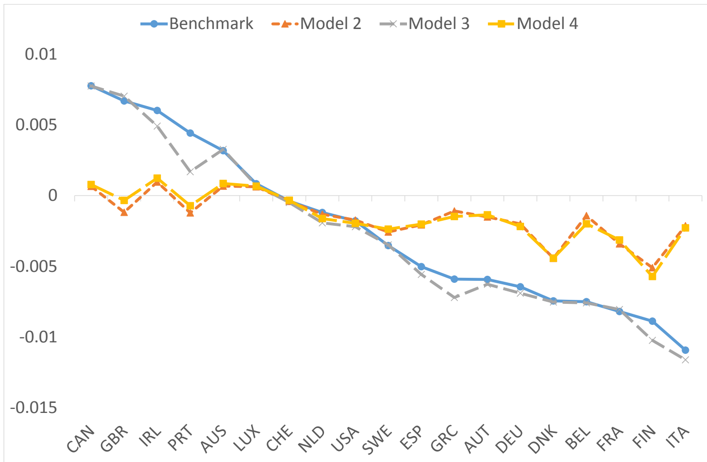
(B) Low-skilled natives welfare



(C) High-skilled immigrants welfare



(D) Low-skilled immigrants welfare

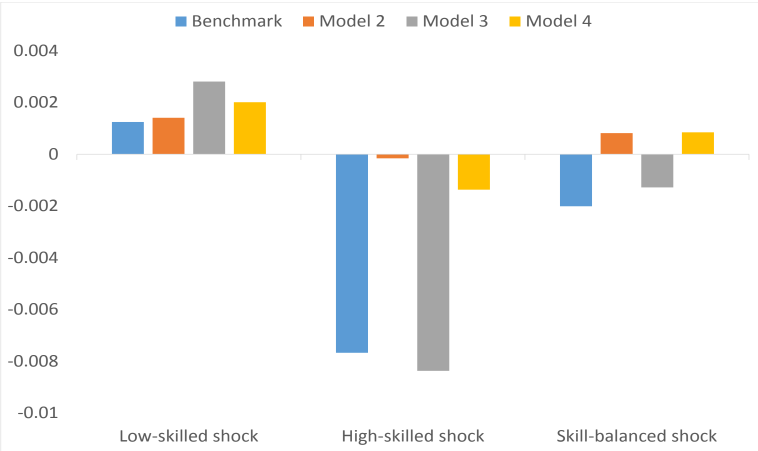


Note: we use the welfare index $\mathcal{W}_{nh} \equiv \frac{E_{nh}\mathcal{J}^E_{nh}+U_{nh}\mathcal{J}^U_{nh}-\frac{z^*}{2}Q_{nh}+R_{nh}\mathcal{J}^R_{nh}}{(Q_{nh}+R_{nh})}$ for native high-skilled; we use $\mathcal{W}_{os} \equiv \frac{E_{os}\mathcal{J}^E_{os}+U_{os}\mathcal{J}^U_{os}+R_{os}\mathcal{J}^R_{os}}{(Q_{os}+R_{os})}$ otherwise. Benchmark = endogenous skill acquisition, retirees included; Model 2 = endogenous skill acquisition, no retirees; Model 3 = exogenous skill acquisition, retirees included; Model 4 = exogenous skill acquisition, no retirees.

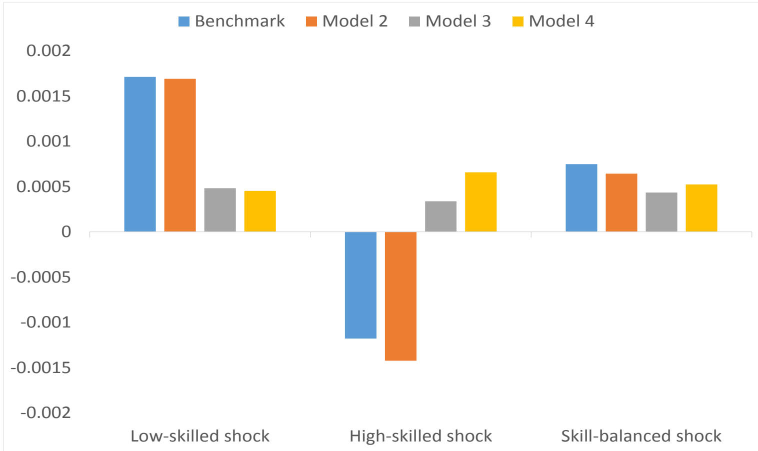
3.B Unweighted average effects of immigration

Figure 12: Unweighted average effects of immigration immigration (1% of the total labor force) on 19 selected OECD countries

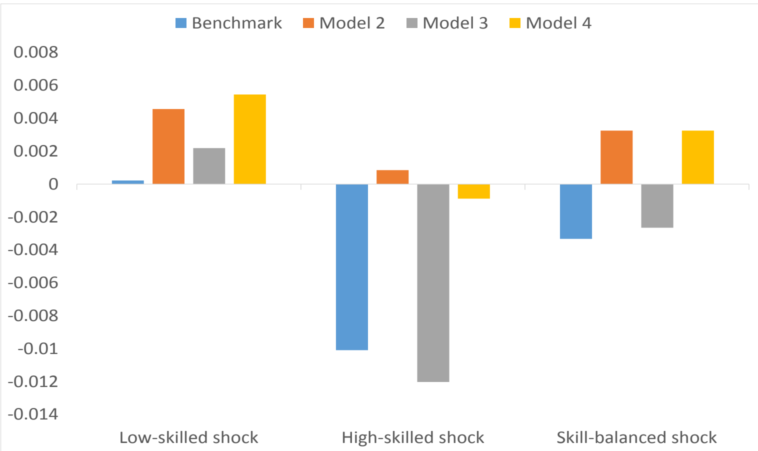
(a) Effect on avg. native unemployment rate



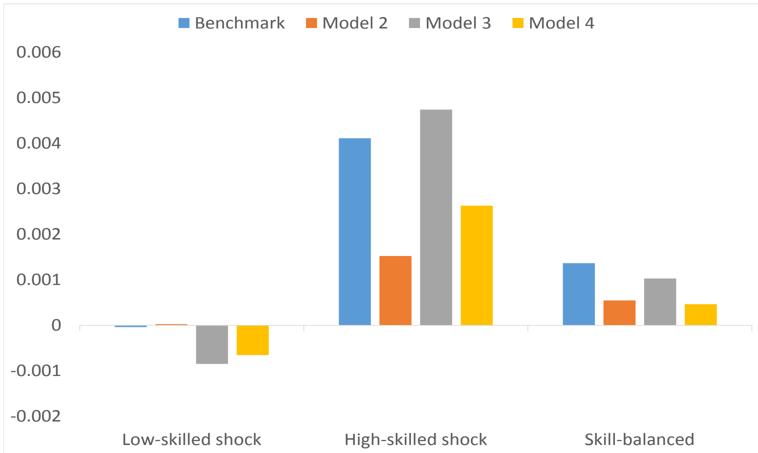
(b) Effect on avg. native wage



(c) Effect on labor income tax



(d) Effect on avg. native welfare



Note: Benchmark = endogenous skill acquisition, retirees included; Model 2 = endogenous skill acquisition, no retirees; Model 3 = exogenous skill acquisition, retirees included; Model 4 = exogenous skill acquisition, no retirees.

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