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

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Abstract

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. 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.

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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?

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, Frattini, and Preston (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.

[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.

Thirdly, other authors developed general equilibrium models calibrated on broad categories of individuals for a single country; Storesletten (2000) and Chojnicki, Docquier, and Ragot (2011) incorporate interactions between transmission channels (e.g. labor market, public budget, education) into the analysis of economic responses to US immigration. Fourthly, Aubry, Burzyński, and Docquier (2016), Battisti, Felbermayr, Peri, and Poutvaara (2018) and Burzyński, Docquier, and Rapoport (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 (Battisti et al., 2018; Chassamboulli & Palivos, 2014) 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 paper is organized as following. Section 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 3. In Section 4, we discuss the calibration and present our results. Section 5 concludes.

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 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.

It can be seen in Figure 1 (a), 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 1 (b) 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.

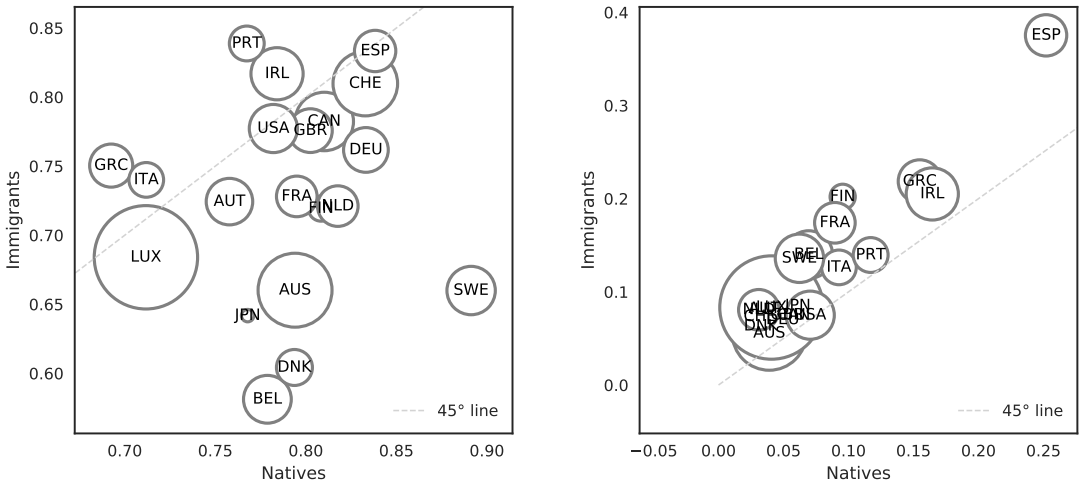
Figure 1 (c) depicts origin-specific employment rates. The correlation between native and immigrant employment rates is poor (0.276). On average (unweighted mean), the employment rate of immigrants is 16 percentage points smaller. It is 20-30 percentage points smaller in Belgium, Denmark and Sweden. 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 1 (d). 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).

Figure 1: Labor market status of immigrants and natives in 20 OECD countries

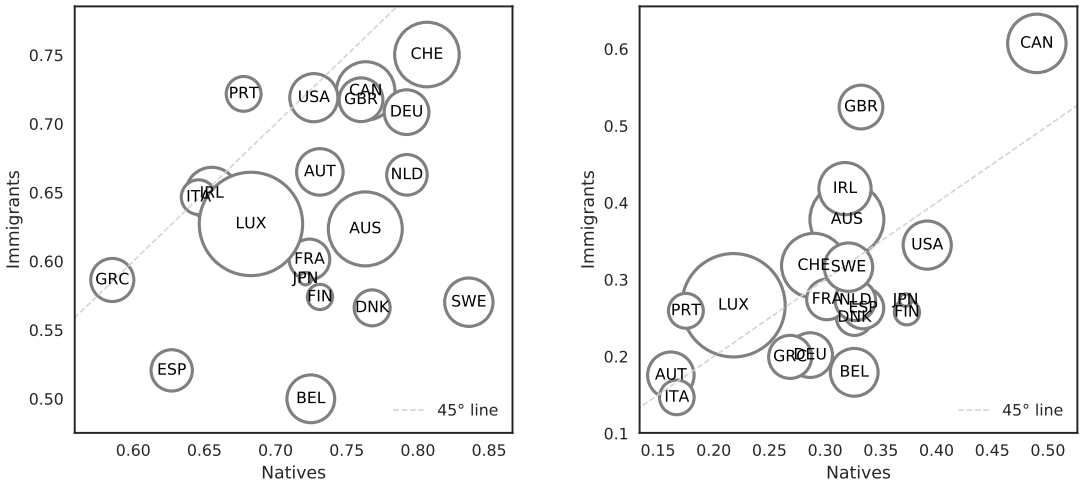
(a) Participation rate

(b) Unemployment rate



(c) Employment rate

(d) Share of college graduates



Notes: Figure 1 shows the results for 20 selected countries: the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.

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 3.1 and Section 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 3.3 and Section 3.4. Finally, we define the public sector in Section 3.5 and characterize the steady-state equilibrium in Section 3.6.

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]

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

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:

$$C^a_{o,s} = \left[\int_0^B c^a_{o,s}(i)^{\frac{\epsilon-1}{\epsilon}} di\right]^{\frac{\epsilon}{\epsilon-1}}, \tag{2}$$

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

[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.

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:

$$\begin{aligned}\int_0^B c^a_{o,s}(i)(1+v)p(i)di =&(1-\ell^a_{o,s})\left[(1-u_{o,s})w_{o,s}(1-\tau)+u_{o,s}b_{o,s}\right]+T^a_{o,s},\\ C^a_{o,s}(1+v)P =&(1-\ell^a_{o,s})\varpi_{o,s}+T^a_{o,s},\end{aligned} \tag{3}$$

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 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. (1) subjet to (2) and (3). The solution of the problem reads:

$$1-\ell^a_{o,s} = \left(\frac{\varpi_{o,s}}{\Phi^a_{o,s}(1+v)P}\right)^{\frac{1}{\eta}}, \tag{4}$$

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.

Finally, substituting Eq. (4) in (3) and (1), we obtain the optimal consumption and utility of each type of individual:

$$C^a_{o,s} = \Phi^a_{o,s}\left(\frac{\varpi_{o,s}}{\Phi^a_{o,s}(1+v)P}\right)^{\frac{1+\eta}{\eta}} + \frac{T^a_{o,s}}{(1+v)P}, \tag{5}$$

$$\mathcal{U}^a_{o,s} = \frac{\eta C^a_{o,s}}{1+\eta} + \frac{T^a_{o,s}}{(1+\eta)(1+v)P}. \tag{6}$$

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

[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.

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, Manning, & Wadsworth, 2012; Ottaviano & 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:

$$Y = A\left[(1-\alpha)Y_h^{(\sigma_1-1)/\sigma_1} + \alpha Y_l^{(\sigma_1-1)/\sigma_1}\right]^{\sigma_1/(\sigma_1-1)}, \tag{7}$$

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

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 that their price, $\widetilde{p}_{o,s}$, equals their marginal productivity :

$$\widetilde{p}_{m,h} = A(1-\alpha)\lambda Y^{\frac{1}{\sigma_1}} Y_h^{-\frac{1}{\sigma_1}} \left(\frac{Y_h}{Y_{m,h}}\right)^{\frac{1}{\sigma_2}} \tag{8}$$

$$\widetilde{p}_{m,l} = A\alpha\lambda Y^{\frac{1}{\sigma_1}} Y_l^{-\frac{1}{\sigma_1}} \left(\frac{Y_l}{Y_{m,l}}\right)^{\frac{1}{\sigma_2}} \tag{9}$$

$$\widetilde{p}_{n,h} = A(1-\alpha)(1-\lambda) Y^{\frac{1}{\sigma_1}} Y_h^{-\frac{1}{\sigma_1}} \left(\frac{Y_h}{Y_{n,h}}\right)^{\frac{1}{\sigma_2}} \tag{10}$$

$$\widetilde{p}_{n,l} = A\alpha(1-\lambda) Y^{\frac{1}{\sigma_1}} Y_l^{-\frac{1}{\sigma_1}} \left(\frac{Y_l}{Y_{n,l}}\right)^{\frac{1}{\sigma_2}}. \tag{11}$$

Final goods are instead produced under monopolistic competition and their optimal price setting will be described in Section 3.4.

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:

$$M(U_s, V_s) = \xi U_s^{\nu} V_s^{1-\nu}, \tag{12}$$

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.

[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.

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:

$$r\mathcal{J}_s^V = -\kappa_s + q(\theta_s)\left[(1-\phi_s)\,\mathcal{J}_s^{n,F} + \phi_s\mathcal{J}_s^{m,F} - \mathcal{J}_s^V\right], \tag{13}$$

$$r\mathcal{J}_s^{o,F} = \widetilde{p}_{o,s} - w_{o,s} - \delta_{o,s}\left[\mathcal{J}_s^{o,F} - \mathcal{J}_s^V\right], \tag{14}$$

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:

$$r\mathcal{J}_s^{o,E} = (1-\tau)w_{o,s} - \delta_{o,s}\left[\mathcal{J}_s^{o,E} - \mathcal{J}_s^{o,U}\right] + T_{o,s}^y, \tag{15}$$

$$r\mathcal{J}_s^{o,U} = b_{o,s} + m\left(\theta_s\right)\left[\mathcal{J}_s^{o,E} - \mathcal{J}_s^{o,U}\right] + T_{o,s}^y. \tag{16}$$

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 $T_{o,s}^y$. 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:

$$\mathcal{J}_s^V = 0. \tag{17}$$

Combining Eqs. (13) and (14), in steady-state the job creation condition is thus given by:

$$\frac{\kappa_s}{q\left(\theta_s\right)} = (1-\phi_s)\left[\frac{\widetilde{p}_s^n - w_s^n}{r+\delta_s^n}\right] + \phi_s\left[\frac{\widetilde{p}_s^m - w_s^m}{r+\delta_s^m}\right]. \tag{18}$$

Eq. (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, $\widetilde{p}_{o,s} - w_{o,s}$, 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:

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

By combining the asset value Eqs. (13)-(16) and considering the free entry condition (17), the bargained wage rates are given by:

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

which can be seen as a weighted average between the marginal productivity $\widetilde{p}_{o,s}$, 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:

$$w_{o,s} = \frac{\beta \left[r + \delta_{o,s} + m\left(\theta_s\right) \right] \widetilde{p}_{o,s}}{\left(r + \delta_{o,s} \right) \left[1 - \left(1 - \beta \right) \left(\tau + \mu \right) \right] + \beta m\left(\theta_s\right)}. \tag{19}$$

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:

$$E_{o,s} = \frac{m\left(\theta_s\right) Q_{o,s}}{\delta_{o,s} + m\left(\theta_s\right)}, \tag{20}$$

$$U_{o,s} = \frac{\delta_{o,s} Q_{o,s}}{\delta_{o,s} + m\left(\theta_s\right)}, \tag{21}$$

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 (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:

$$\frac{Y_{o,s}}{Q_{o,s}} \equiv e_{o,s} = \frac{m\left(\theta_s\right)}{\delta_{o,s} + m\left(\theta_s\right)}, \tag{22}$$

$$\frac{U_{o,s}}{Q_{o,s}} \equiv u_{o,s} = \frac{\delta_{o,s}}{\delta_{o,s} + m\left(\theta_s\right)}. \tag{23}$$

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

$$P = p(i) B^{\frac{1}{1-\epsilon}}. \tag{24}$$

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 $\widetilde{p}_{o,s}$ (i.e. intermediate firms are in perfect competition). Hence, retailers maximize their profits by setting the following price:

$$p = \frac{\epsilon}{\epsilon - 1}\frac{\widetilde{p}}{A}, \tag{25}$$

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:

$$\begin{aligned} \widetilde{p} &= \left[(1-\alpha)\widetilde{p}_h^{(\sigma_1-1)/\sigma_1} + \alpha\widetilde{p}_l^{(\sigma_1-1)/\sigma_1}\right]^{(\sigma_1)/\sigma_1-1}, \\ \widetilde{p}_s &= \left[(1-\lambda)\left(\widetilde{p}_{n,s}\right)^{(\sigma_2-1)/\sigma_2} + \lambda\left(\widetilde{p}_{m,s}\right)^{(\sigma_2-1)/\sigma_2}\right]^{\sigma_2/(\sigma_2-1)}, \text{ for } s = (h,l). \end{aligned} \tag{26}$$

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. (24) and (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:

$$B = \frac{Z}{\epsilon\psi}. \tag{27}$$

Eq. (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.

3.5 Government

The government imposes a fixed tax on consumption v 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

[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.

steady-state the government budget is balanced. Hence, the government budget constraint writes:

$$(v+\tau)\,Y = \mu \sum_{o,s} U_s^o w_{o,s} + \sum_{a,o,s} N_{o,s}^a T_{o,s}^a. \tag{28}$$

The left-hand side of Eq. (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. (28) is satisfied again.

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* $\{\alpha, \lambda, A, \delta_{o,s}, \psi, \mu, v, T_{o,s}^a\}$, *and a set of origin-specific parameters* $\{\Phi_{o,s}^a, N_{o,s}^a\}$, *the economic equilibrium is a set of endogenous variables* $\{w_{o,s}, c_{o,s}^a, \ell_{o,s}^a, E_{o,s}, U_{o,s}, \theta_s, y, \widetilde{p}_{o,s}, p, P, B, \tau\}$ *that satisfies the following conditions:*

1. *individuals maximize their utility (1) subject to (2) and (3),*
2. *the intermediate goods market clear, so that Eqs.* (8)-(11) *are satisfied,*
3. *the job creation condition (18) for each skill type* s *is satisfied,*
4. *the Nash bargaining optimality condition (19) holds for each worker type* (o, s),
5. *the number of employed and unemployed workers are given by Eqs.* (20) *and* (21) *for each worker type* (o, s),
6. *the retailers' free entry condition* (27) *holds,*
7. *the government budget (28) is balanced.*

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

[8] Note that, because of the relationship between utility (Eq. 6) and consumption (Eq. 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 ($-dP/P$).

thus given 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

$$C_{n,s}^y = \frac{(1-\ell_{n,s}^y) w_{n,s} (1-u_{n,s})(1-\tau)\Gamma_{n,s}^y + T_{n,s}^y}{(1+v)P}, \tag{29}$$

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:

$$\frac{d\overline{C}_n^y}{\overline{C}_n^y} \simeq \frac{N_{n,h}^y C_{n,h}^y}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y} \cdot \frac{dC_{n,h}^y}{C_{n,h}^y} + \frac{N_{n,l}^y C_{n,l}^y}{\left(N_{n,h}^y + N_{n,l}^y\right)\overline{C}_n^y} \cdot \frac{dC_{n,l}^y}{C_{n,l}^y}, \tag{30}$$

$$\frac{dI_n^y}{I_n^y} \simeq \frac{dC_{n,h}^y}{C_{n,h}^y} - \frac{dC_{n,l}^y}{C_{n,l}^y}. \tag{31}$$

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 & 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 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 4.1 we explain our calibration strategy for the benchmark model. Then, we analyze the welfare and inequality effects of immigration in Sections 4.2. Finally, we analyze the robustness of our findings to key elasticities in Section 4.3.

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, 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, Ozden, and Peri (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 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, Mooij, and Vuuren (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 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, Mooij, and Vuuren, 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 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 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]

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

[10] In Section 4.3 we consider alternative levels of $\epsilon, \sigma_1, \sigma_2, \eta$ and κ_l in our robustness analysis.

[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: 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

the immigration shock (low-skilled, high-skilled, actual destination-specific mix). We first describe the average welfare effects, and then discuss the inequality effects.

4.2.1 Average welfare effects

The average welfare effects of immigration are described in Figure 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 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.
- 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).

Figures 2 (b) to 2 (d) 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 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 (a), 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 (b) to 2 (d)), 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. (29), the welfare responses to immigration for type-s natives is the sum of these six transmission channels:

$$\frac{dC^y_{n,s}}{C^y_{n,s}} \simeq \frac{C^y_{n,s} - T^y_{n,s}}{C^y_{n,s}} \left[\frac{d(1-\ell^y_{n,s})}{(1-\ell^y_{n,s})} + \frac{dw_{n,s}}{w_{n,s}} + \frac{d(1-u_{n,s})}{(1-u_{n,s})} + \frac{d(1-\tau)}{(1-\tau)} + \frac{d\Gamma^y_{n,s}}{\Gamma^y_{n,s}} \right] - \frac{dP}{P}, \tag{32}$$

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

Substituting this expression into Eq. (30), the average welfare effect of immigration can be expressed as

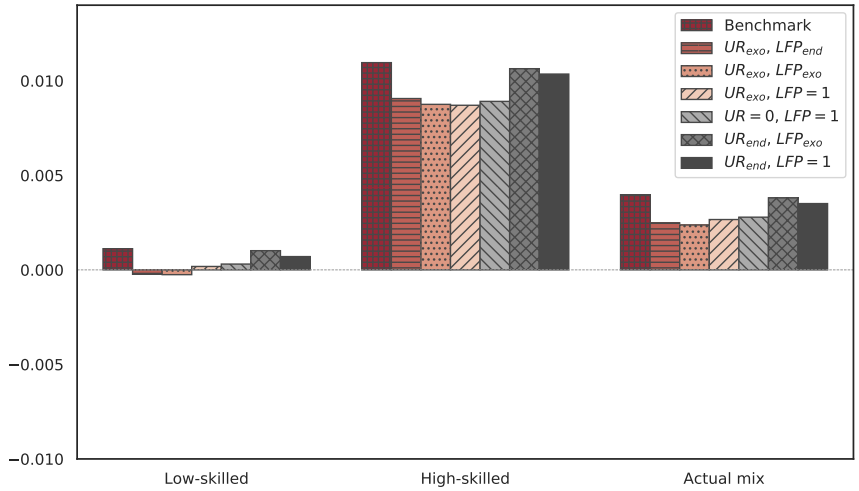
$$\frac{d\overline{C}^y_n}{\overline{C}^y_n} \simeq \left.\frac{d\overline{C}^y_n}{\overline{C}^y_n}\right|_{partic} + \left.\frac{d\overline{C}^y_n}{\overline{C}^y_n}\right|_{wage} + \left.\frac{d\overline{C}^y_n}{\overline{C}^y_n}\right|_{empl} + \left.\frac{d\overline{C}^y_n}{\overline{C}^y_n}\right|_{fiscal} + \left.\frac{d\overline{C}^y_n}{\overline{C}^y_n}\right|_{resid} + \left.\frac{d\overline{C}^y_n}{\overline{C}^y_n}\right|_{price} \tag{33}$$

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

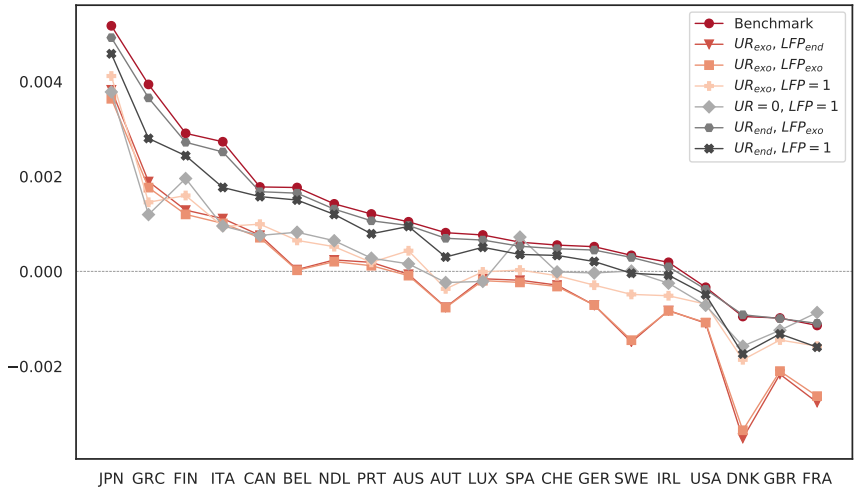
[13] See Appendix B for details on the analytical decomposition of the six channels.

Figure 2: Average welfare effect of immigration (1% of the total labor force) – Sensitivity to labor market modeling

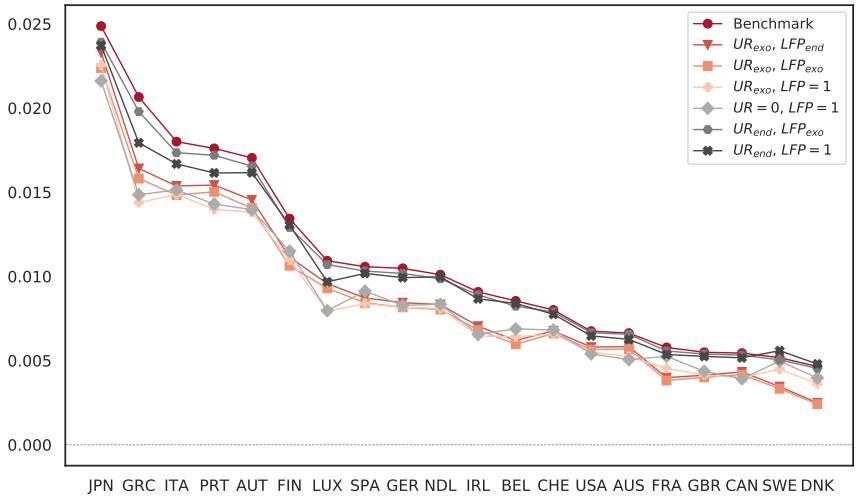
(a) Unweighted mean effect



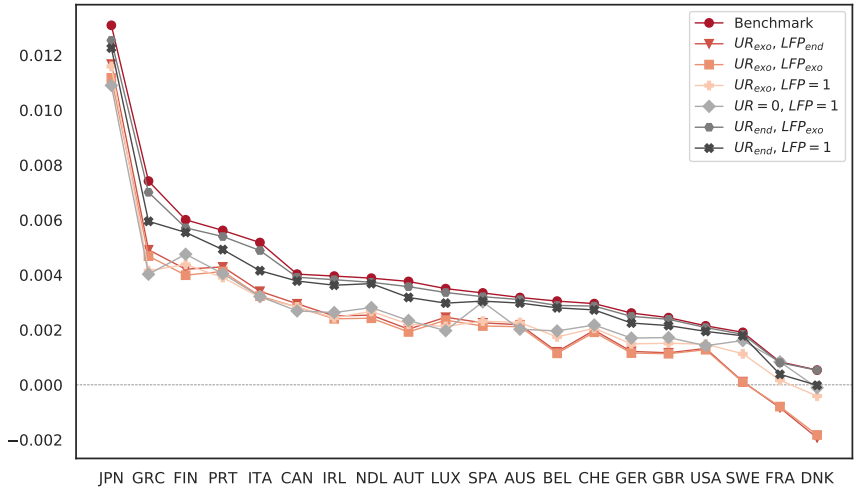
(b) Effect by country: low-skilled immigration



(c) Effect by country: high-skilled immigration



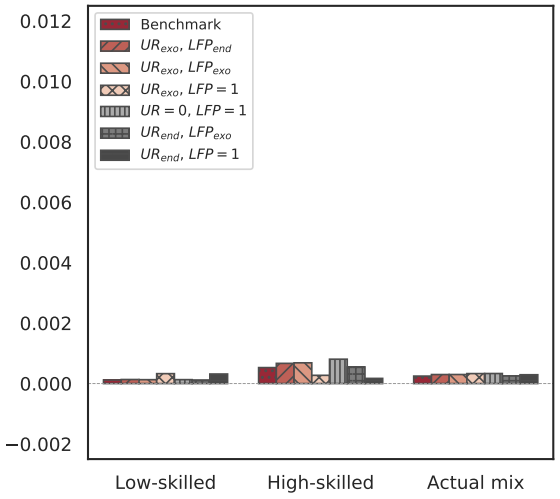
(d) Effect by country: actual education mix



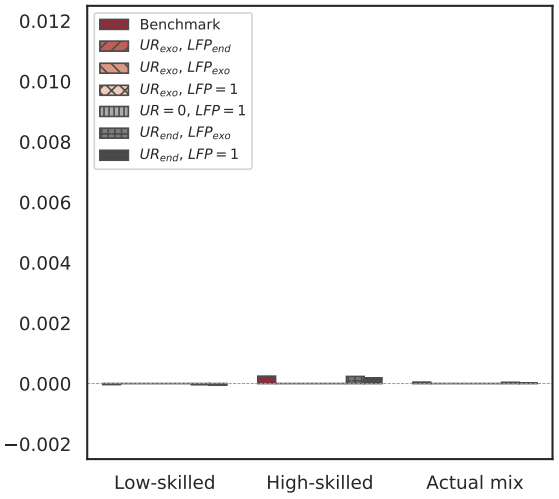
Notes: Figure 2 shows the results for 20 selected countries: the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.

Figure 3: Decomposition of unweighted mean welfare effect of immigration (1% of the total labor force) – Sensitivity to labor market modeling

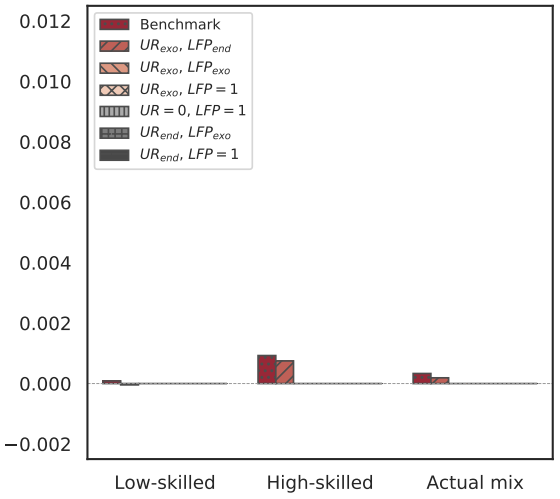
(a) Wage effect



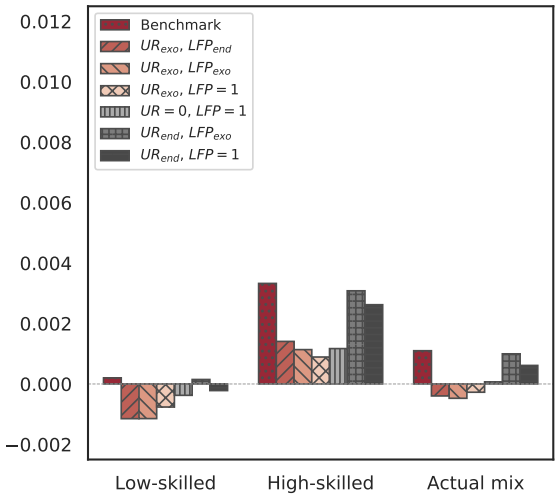
(b) Employment effect



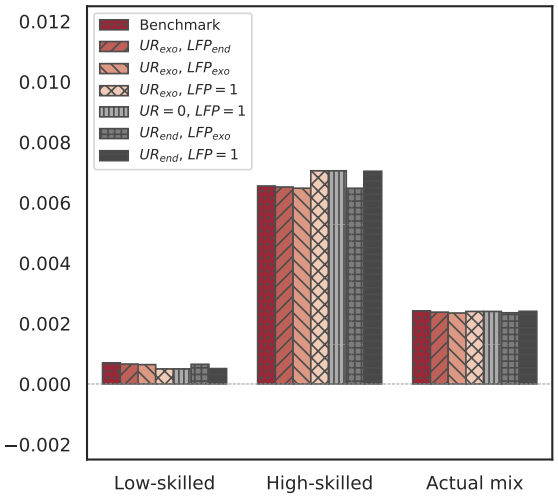
(c) Labor force participation effect



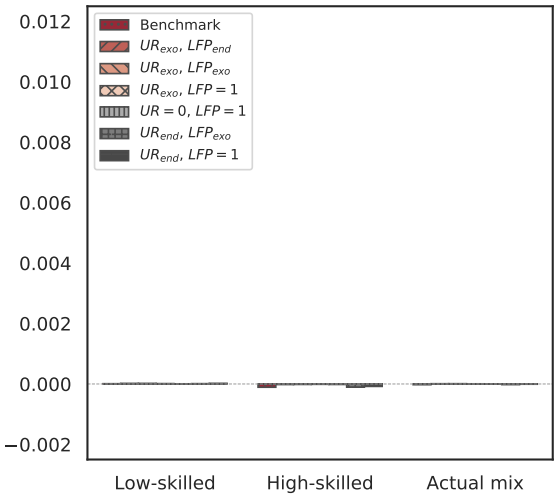
(d) Fiscal effect



(e) Price effect



(f) Residual



Notes: Figure 3 shows the results for 20 selected countries: the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.

Figure 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 (a). 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 3 (b) 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 B.1 in Appendix A). 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 3 (d). 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.

4.2.2 Inequality effects

The inequality effects of immigration are described in Figure 4. We consider the same labor market specifications and immigration shocks as in the previous section.

Figures 4 (b) to 4 (d) 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 4 (a), 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. (32) into Eq. (31), the inequality effect of immigration can be expressed as[14]

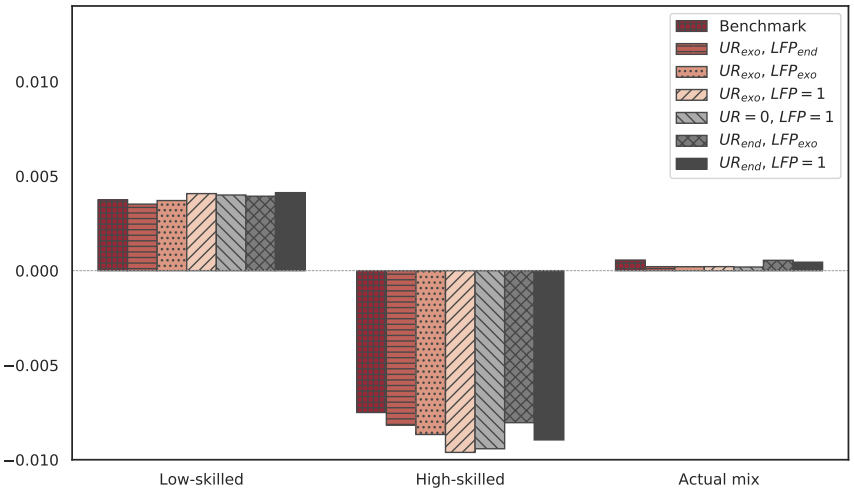
$$\frac{dI_n^y}{I_n^y} \simeq \left.\frac{dI_n^y}{I_n^y}\right|_{partic} + \left.\frac{dI_n^y}{I_n^y}\right|_{wage} + \left.\frac{dI_n^y}{I_n^y}\right|_{empl} + \left.\frac{dI_n^y}{I_n^y}\right|_{fiscal} + \left.\frac{dI_n^y}{I_n^y}\right|_{resid} + \left.\frac{dI_n^y}{I_n^y}\right|_{price}. \quad (34)$$

Figure 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 4 (a). 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.

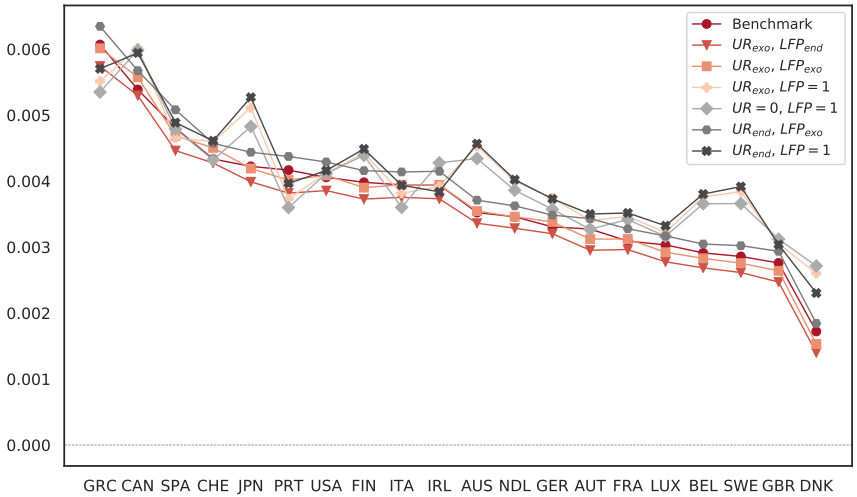
[14] See Appendix B for details on the analytical decomposition of the six channels.

Figure 4: Inequality effect of immigration (1% of the total labor force) – Sensitivity to labor market modelling

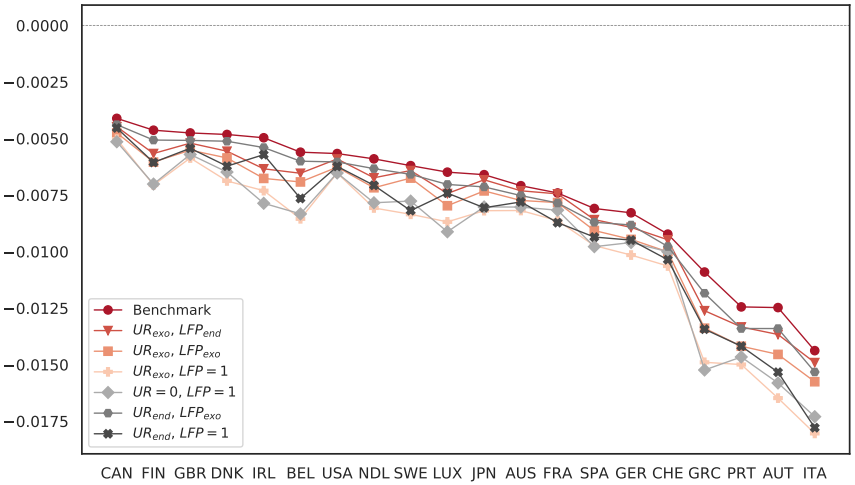
(a) Unweighted mean effect



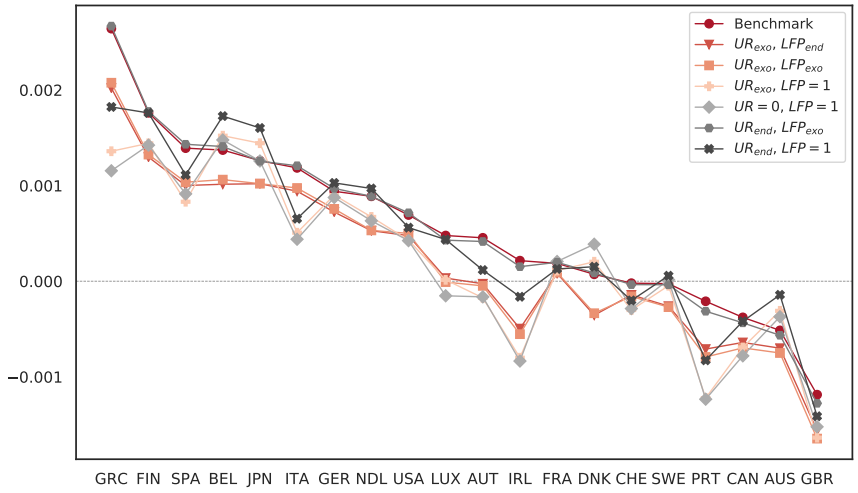
(b) Effect by country: low-skilled immigration



(c) Effect by country: high-skilled immigration



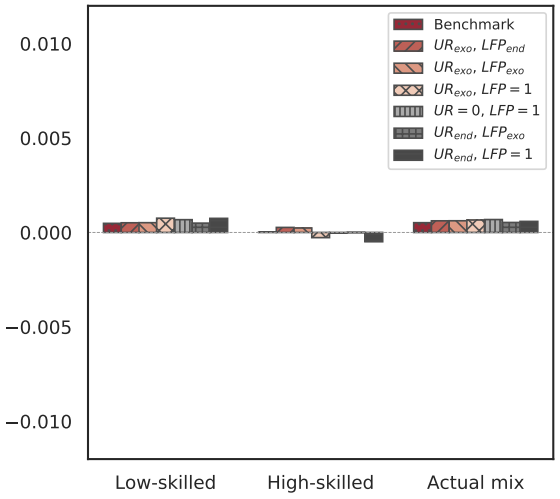
(d) Effect by country: actual education mix



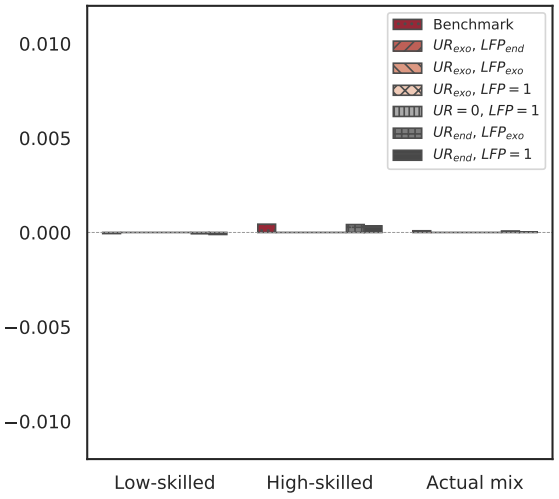
Notes: Figure 4 shows the results for 20 selected countries: the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.

Figure 5: Decomposition of inequality effect of immigration (1% of the total labor force) – Sensitivity to labor market modeling

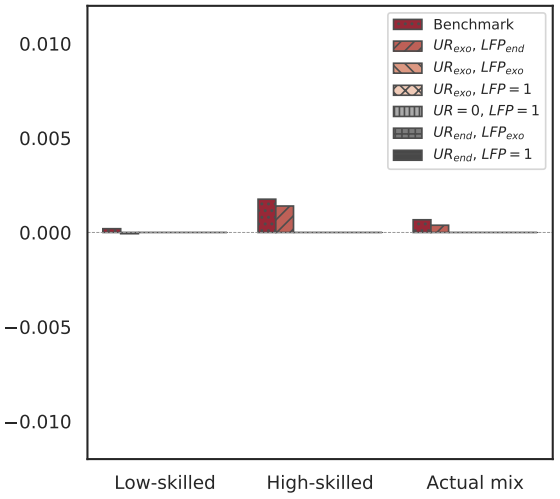
(a) Wage effect



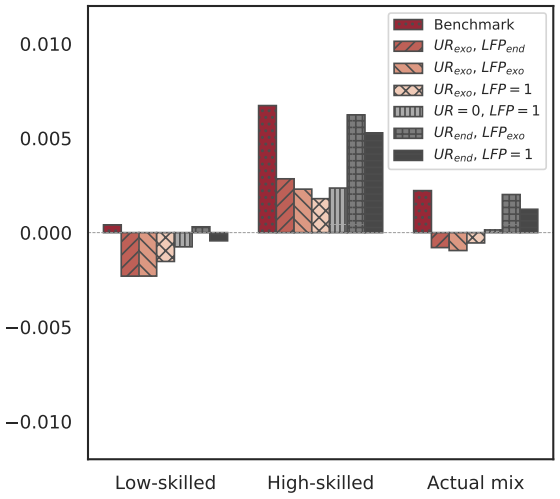
(b) Employment effect



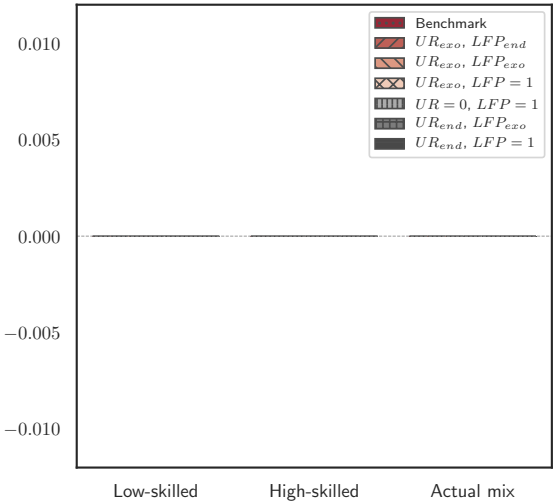
(c) Labor force participation effect



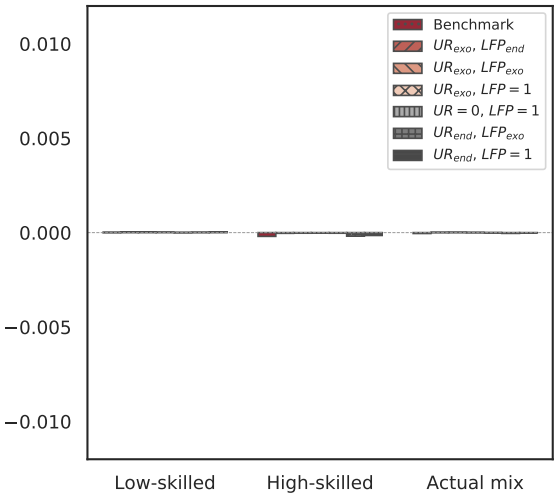
(d) Fiscal effect



(e) Price effect



(f) Residual



Notes: Figure 5 shows the results for 20 selected countries: the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.

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.

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 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 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 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.

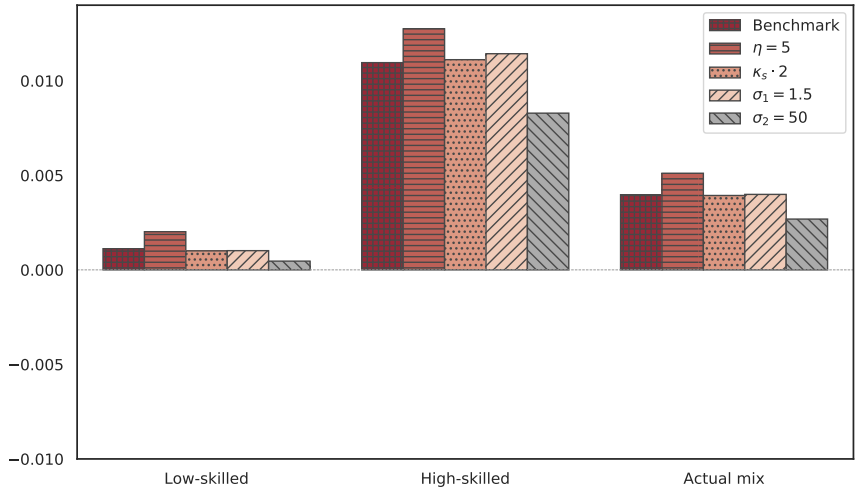
5 Concluding remarks

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

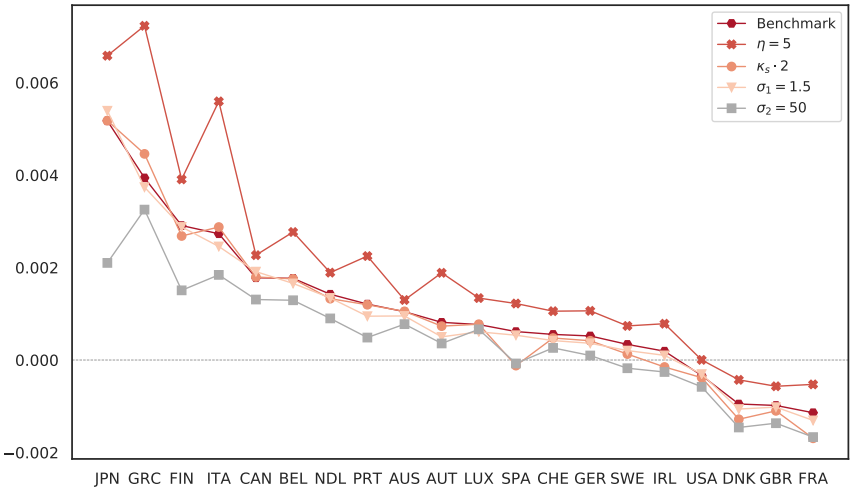
[15] Figure B.2 in Appendix A provides further sensitivity checks with respect to the inverse labor supply elasticity. In a review of the literature, Card (1991) points to a range of $[2, 20]$ for this parameter. We find no major changes in our results when setting η equal to these bounds.

Figure 6: Average welfare effect of immigration (1% of the total labor force) – Sensitivity to parameters

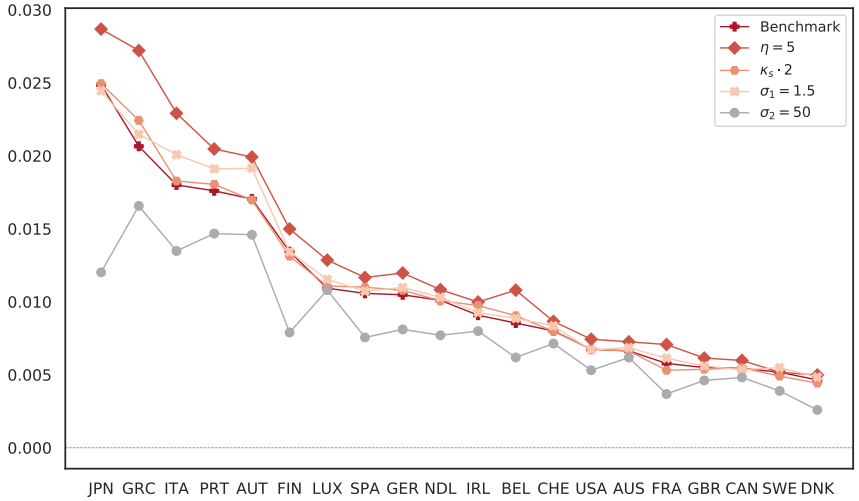
(a) Unweighted mean effect



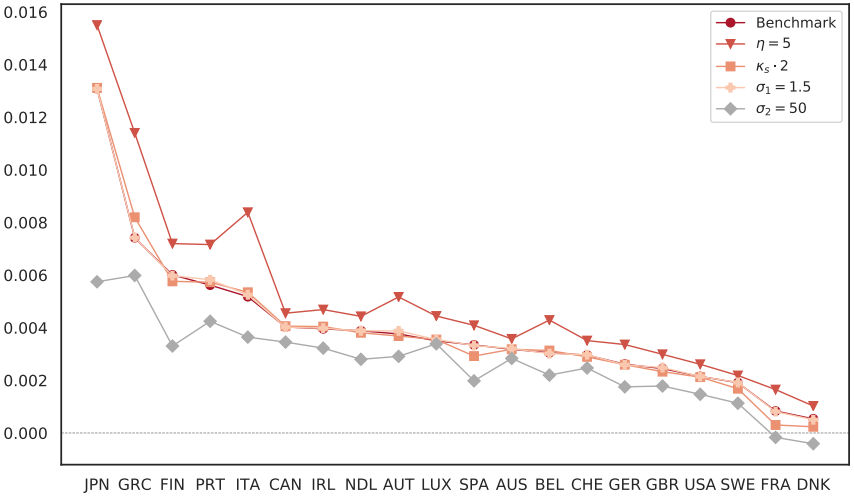
(b) Effect by country: low-skilled immigration



(c) Effect by country: high-skilled immigration



(d) Effect by country: actual education mix



Notes: Figure 6 shows the results for 20 selected countries: the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.

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.

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A Appendix

The six transmission channels used to calculate Eq. 33 are weighted sums of skill-specific effects, which are given by

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

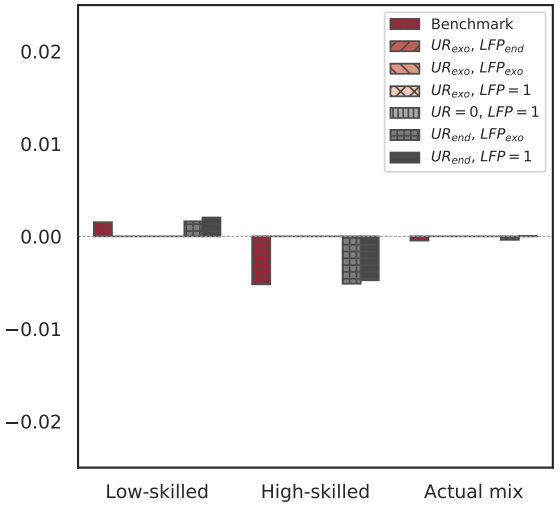
Similarly, Eq. 34 is obtained by the sum of the following partial effects

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

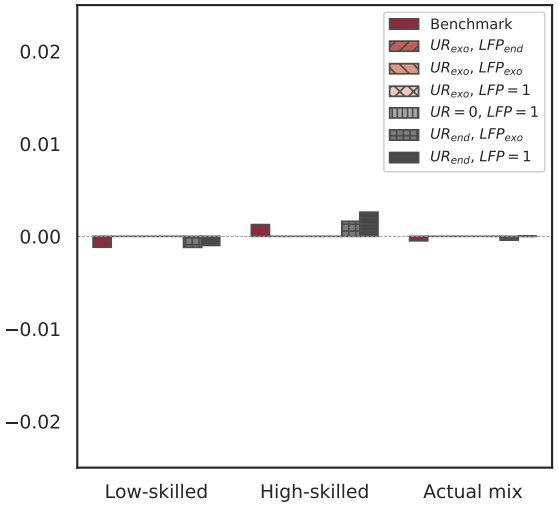
B Appendix

Figure B.1: Unemployment rate changes

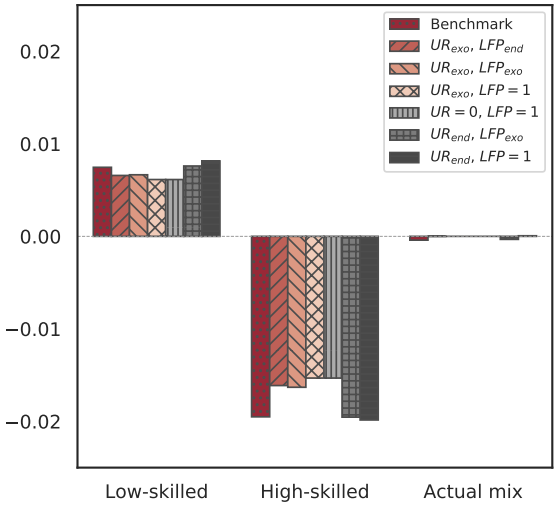
(a) $\frac{U^{**}_{ml}}{Q^{**}_{ml}} / \frac{U^{*}_{ml}}{Q^{*}_{ml}} - 1$



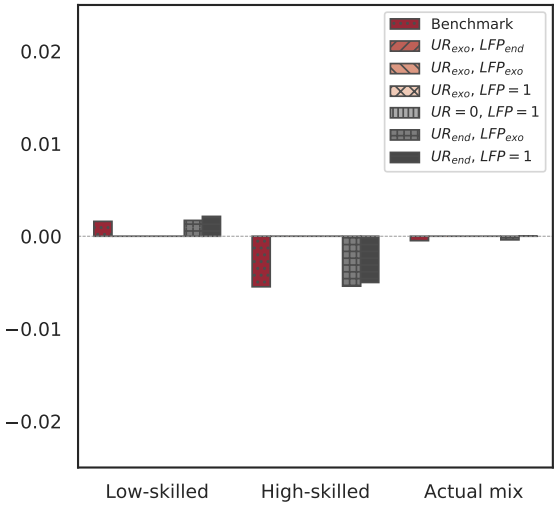
(b) $\frac{U^{**}_{mh}}{Q^{**}_{mh}} / \frac{U^{*}_{mh}}{Q^{*}_{mh}} - 1$



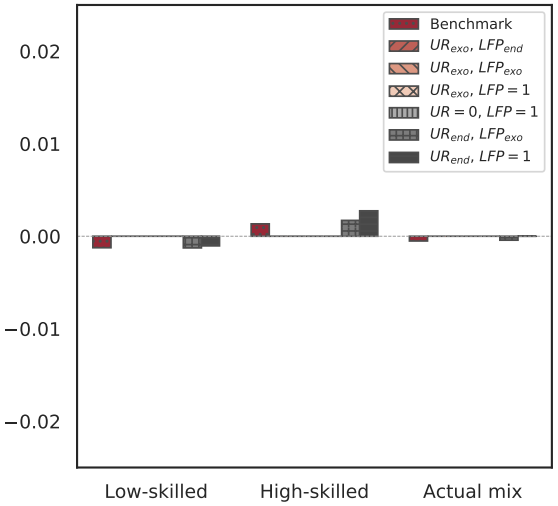
(c) $\frac{U^{**}_{ml}+U^{**}_{mh}}{Q^{**}_{ml}+Q^{**}_{mh}} / \frac{U^{*}_{ml}+U^{*}_{mh}}{Q^{*}_{ml}+Q^{*}_{mh}} - 1$



(d) $\frac{U^{**}_{nl}}{Q^{**}_{nl}} / \frac{U^{*}_{nl}}{Q^{*}_{nl}} - 1$



(e) $\frac{U^{**}_{nh}}{Q^{**}_{nh}} / \frac{U^{*}_{nh}}{Q^{*}_{nh}} - 1$



(f) $\frac{U^{**}_{nl}+U^{**}_{nh}}{Q^{**}_{nl}+Q^{**}_{nh}} / \frac{U^{*}_{nl}+U^{*}_{nh}}{Q^{*}_{nl}+Q^{*}_{nh}} - 1$

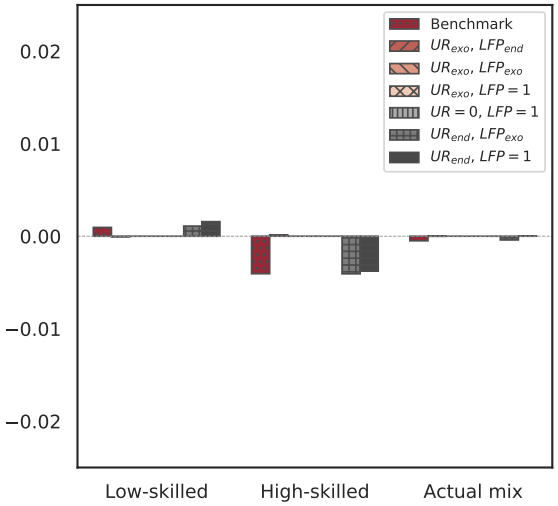
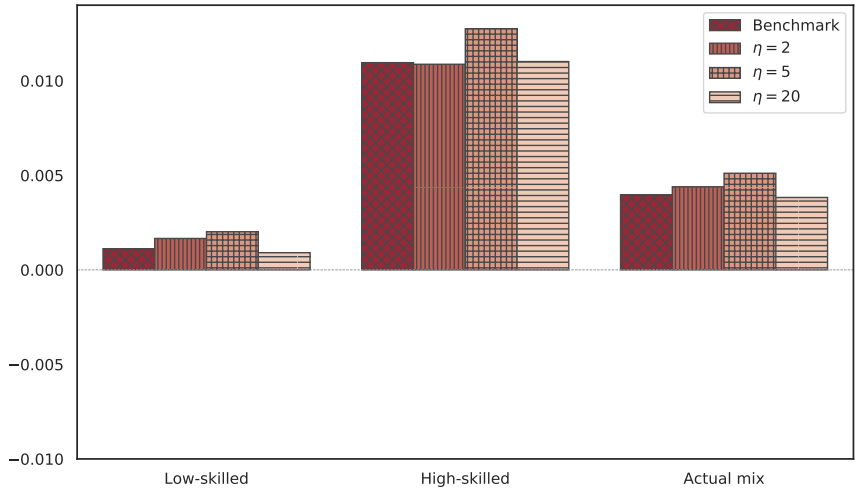
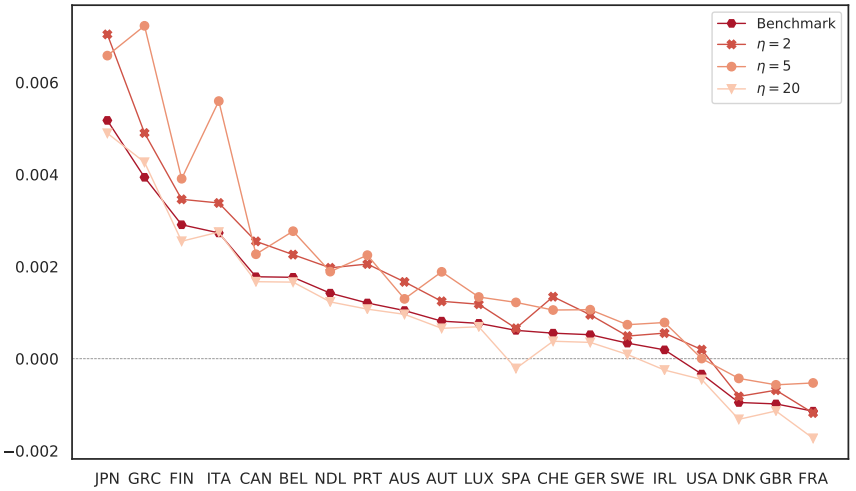


Figure B.2: Average welfare effect of immigration (1% of the total labor force) – Sensitivity to η

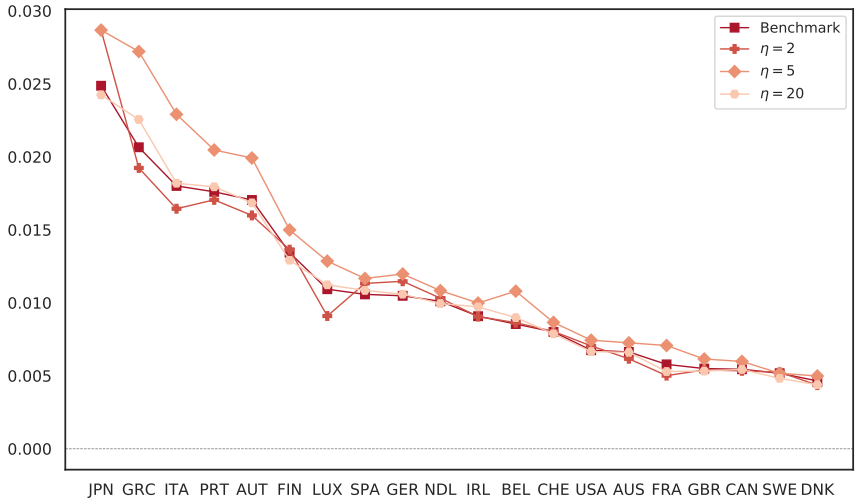
(a) Unweighted mean effect



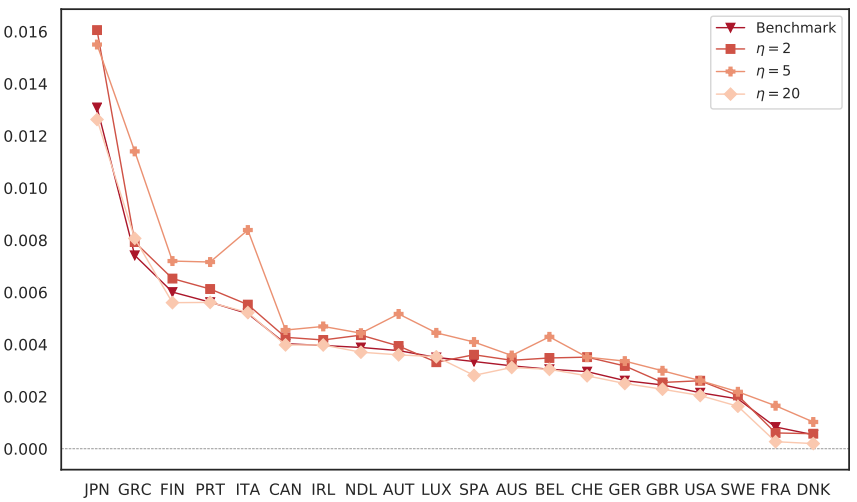
(b) Effect by country: low-skilled immigration



(c) Effect by country: high-skilled immigration



(d) Effect by country: actual education mix



Notes: Figure B.2 shows the results for 20 selected countries:
the 15 members states of the European Union (EU15), the US, Canada, Australia, Switzerland and Japan.