Asymmetric Shocks and Heterogeneous Worker Mobility*

Riccardo Franceschin† & Joseph-Simon Görlach‡

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Abstract

If workers differ in geographic mobility, complementarity in production reduces the shock absorption capacity of migration and leads to more polarizing welfare effects of local shocks. We quantify these effects by calibrating a dynamic equilibrium model in which workers differ in skill and migration preference. Migration, on average, compensates for one fifth of the welfare loss following a negative shock in one country, with gains accruing largely to high-skilled workers. Low-skilled workers benefit marginally and sometimes earn lower real wages than without migration. We use the quantified model to examine other integration margins and targeted migration policies.

Keywords: international migration, currency unions, worker heterogeneity, brain drain, convergence
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*We acknowledge financial support by the Volkswagen Foundation.
†Department of Economics, Sabanci University.
‡Department of Economics, Bocconi University; CEPR, RFBerlin and IZA; josephsimon.goerlach@unibocconi.it.

1 Introduction

International labor mobility has been highlighted as an important channel for the dissipation of asymmetric shocks across countries, and in particular within currency unions (Mundell, 1961). Moving to better performing countries improves not only migrants' own prospects, but also raises labor market tightness in their depressed origin countries, benefiting those left behind. However, when different skills are imperfect substitutes, heterogeneity in mobility implies that migration has polarizing welfare effects between different types of workers. Moreover, a skill bias in migration can affect the capacity of integrated labor markets to dissipate shocks also in the aggregate, an aspect neglected in existing models used to quantify the contribution of labor mobility to shock absorption. In fact, selective migration flows and the ensuing brain drain can in principle aggravate—rather than mitigate—macroeconomic shocks.

This paper quantifies the effects of labor market integration on welfare and labor market outcomes for different skill groups. To this end, we develop a spatial dynamic general equilibrium model with search frictions and different types of workers. We calibrate this model to harmonized data from the European Union Labour Force Survey, the Survey of Income and Living Conditions and macroeconomic data for 17 countries from both inside and outside the European Monetary Union. Our empirical analysis confirms that even conditional on observed employment and wage differentials across countries, it is generally less costly for high-skilled individuals to live and work in a foreign country. This reflects the fact that within Europe tertiary educated workers are not only consistently about twice as mobile as less educated ones, but also that their mobility is more tightly linked to changes in local unemployment, as we document. These high-skilled individuals are the beneficiaries of integrated labor markets. Instead, lower-skilled workers may see slight real wage losses and only small welfare gains following a negative shock to their country's productivity or demand, compared to a counterfactual in which migration is prohibited. We demonstrate the robustness of our results to a broad range of shocks and model specifications.

Our paper analyzes possible policy tools that could reduce the unequal effects of labor mobility and help share the gains from the free movement of labor. We find that, for instance, a shared fiscal budget and mobility incentives targeted to low-skilled workers would mitigate some of the negative spillovers from high-skilled migration to lower-skilled groups.

Location choices in our model depend on an individual's skill and country of origin, their current employment status, the costs of migration from their current location to alternative destinations, expected equilibrium labor market transition rates, wages, and taxes in all countries, as well as on idiosyncratic preferences. The latter are drawn from distributions that are skill- and country-pair-specific, allowing for a correlation between

skill and migration preference. High- and low-skilled workers are imperfect substitutes in production and heterogeneous in their valuation of local amenities. From our data, we can recover migration flows and stocks, as well as labor market outcomes. The calibration to these observed moments provides us with migration costs for workers and vacancy costs for firms, as well as with productivity and preference parameters. Output is tradable and consumed everywhere, but individuals have a bias for domestically produced goods, where we identify preferences from observed import shares and price differentials. To make the model applicable to the European context, where some but not all countries of the Single Market share the same currency, we expand our model adding downward nominal wage rigidity. This rigidity allows the model to generate realistic fluctuations in employment and wages and introduces a role for monetary policy, which may differ within and outside the euro zone.

The calibrated model facilitates an analysis of several key policies and institutions. First, we investigate the effect of integrated labor markets on the mitigation of asymmetric shocks, with a particular focus on labor market outcomes for non-migrants in a country experiencing a decline in either its productivity or in the demand for its output. We examine the role of migration both in steady state following permanent changes in demand or productivity, as well as the transitions between equilibria, and the effects of non-permanent shocks.

As a main scenario, we consider negative shocks to Italy, the largest economy that strongly suffered during the euro crisis, but also compare outcomes to a case in which several southern European countries simultaneously suffer similar changes. We find a remarkable robustness in the role of migration, irrespective of the source of the shock and the exact parameterization of the model. Despite the detrimental price implications of demand and productivity shocks, we find very similar effects of labor market integration on wages and welfare.

The low level of international migration between European countries implies limited effects on short-lived shocks, such as business cycles. We therefore focus our analysis on permanent changes, akin to a divergence in productivity or demand across countries. For both demand and productivity shocks, emigration mitigates between 40% and 50% of the welfare loss for high-skilled workers in Italy when demand or productivity changes permanently. For low-skilled workers, instead, the benefit from having the option to migrate is almost entirely offset by the emigration of high-skilled labor.[1] We find similar welfare effects of migration across a range of models with different elasticities of substitution between worker types. When aggregating across worker groups, the theoretical ambiguity regarding the effects of labor market integration for non-migrants in the adversely

[1]We use the discounted sum of utility flows as a welfare measure. In order to give welfare effects an interpretable scale, we compare welfare changes in response to shocks when individuals can migrate to welfare changes when migration is ruled out.

affected country is empirically resolved in favor of migration, which absorbs 18.7% of the aggregate Italian welfare loss following a permanent decline in the demand for Italian output. For comparison, a re-calibrated model with homogeneous labor predicts a 10% stronger shock absorption through migration than predicted by our full model with heterogeneous workers.

For other large euro-zone countries, the gains from migration when they suffer a demand shock are slightly weaker (e.g. 13% in France, 15% in Germany), whereas they amount to 35-40% for smaller countries like Austria, Belgium, and Denmark. We find a small negative impact of labor market integration on the real wages of low-skilled Italians.

Qualitatively, the result that welfare gains from migration are concentrated among high-skilled workers carries over to non-permanent shocks. However, migration being costly implies that labor mobility is a considerably weaker channel for shock absorption when workers anticipate that demand and productivity will revert back to their original levels.

We then use our model to evaluate three counterfactual policies that target different groups of workers or enhance economic integration: an integrated unemployment insurance, and subsidies of either high-skilled immigration or of the migration cost for low-skilled workers. In combination with our results on labor market integration, the first of these counterfactual scenarios sheds light on the distributional consequences of different margins of economic integration. The importance of labor mobility within a currency union derives in part from the lack of fiscal integration that could provide compensating transfers in response to asymmetric shocks. Such transfers, for instance in form of a common unemployment insurance, serve as a shock absorption channel, which we compare to labor market integration. We analyze a system in which part of the fiscal burden from a rise in unemployment following a negative shock is covered by taxpayers in other euro-zone countries. Since the beneficiary country unambiguously gains from these transfers, a more interesting comparison is that between the shock absorption capacity of integrated labor markets on the one hand and that of integrated unemployment insurance on the other. Fiscal transfers offer a faster channel to soften net wage losses in the country suffering the shock (Italy). However, for high-skilled workers, the longer-term gain in net wages due to the transfer system is modest compared to those from labor market integration, even for individuals who do not migrate. Low-skilled workers, instead, are better off with this form of fiscal integration than with labor market integration. Importantly, since the integrated transfer scheme lowers the domestic tax burden, it reduces emigration incentives and the risk job match dissolution. This implies an efficiency gain. We show that in the presence of migration, the welfare gains for Italy from an integrated unemployment insurance following a negative shock outweigh the aggregate welfare costs for other euro-zone countries.

Second, we examine the effects of a wage subsidy for high-skilled immigrants. Such a

policy is in place in Italy and other countries seeking to counteract brain drain. Our model predicts that devoting 1% of a country's social security budget to a wage subsidy for high-skilled foreign-born workers is not welfare improving. Although it reduces inequality, we do not find such a policy to mitigate the welfare costs of a negative shock in Italy.

As a third policy, we consider a reduction in the migration cost for low-skilled workers. In our model, this policy not only supports emigration as a way to avoid shocks for low-skilled workers. Through production complementarities, it also spills over to a further increase in high-skilled emigration. Overall, the cost to high-skilled workers, however, is considerably weaker than the benefit to low-skilled workers in the affected country.

Our paper expands the literature studying effects of labor market integration. Basso et al. (2019) investigate the co-movement of labor demand and migration in Europe and find that migration is cyclical, cushioning shocks. Kohler et al. (2023) compare aggregate and per capita fluctuations in output growth to evaluate the contribution of migration to risk sharing in the euro zone and in the United States. House et al. (2018) approach this question by formulating a dynamic equilibrium model with an explicit role for monetary policy. While their assumption of a representative household for each country facilitates a fine modeling of capital markets, it comes at the expense of assuming worker homogeneity and an abstraction from skill-biased migration, which is fundamental to the mechanisms laid out in this paper. Similarly, worker homogeneity is assumed in a related analysis for the U.S. by Hauser and Seneca (2022). Gonzalez-Aguado (2021) investigates the stabilizing role of labor mobility in the U.S. in a model with search frictions. Worker homogeneity is a common feature throughout these models. We build on this research, but argue that results may require a qualification if heterogeneous workers are imperfect substitutes and differ in their preference for migration. Our paper thus is the first to account for worker heterogeneity in both their productivity and their geographic mobility when investigating the capacity of labor mobility to absorb asymmetric shocks. Other important studies examining monetary and economic integration, such as Fornaro (2022) or Berriel et al. (2024), abstract from labor mobility.

The focus on convergence after permanent changes in demand or productivity links our paper to spatial economic analyses. Spatial equilibrium models featuring labor mobility have been used to examine regional convergence by Giannone (2022), and to evaluate the effects of trade exposure and factor market integration by Kovak (2013), Dix-Carneiro and Kovak (2017), Caliendo et al. (2019), Dix-Carneiro and Kovak (2019), Caliendo et al. (2021), and by Heise and Porzio (2021), although not for the evaluation of asymmetric shocks and without a role for monetary policy. Schivardi and Schmitz (2020) examine the contribution of the IT revolution to the divergence across European countries in an equilibrium model in which only high-skilled workers may migrate to Northern European countries. Docquier and Iftikhar (2019) examine brain drain using a growth model in which high-skilled individuals in low income countries have the option to emigrate.

On a theoretical level, international convergence through migration has been examined by Felbermayr et al. (2015). Farhi and Werning (2014) highlight the importance of distinguishing asymmetric shocks to tradable and non-tradable sectors. Relative to their setup, our model is too flexible for unambiguous predictions even when goods are tradable. An assessment of the net benefits of labor market integration thus becomes an empirical question. The impact of migration on natives through the demand for local output features prominently also in Galaasen et al. (2025). Our quantitative model accounts for this important channel.

Finally, our analysis complements research evaluating dynamic effects of migration on labor market outcomes for non-migrants. While most studies examine short run effects of immigration in static frameworks, exception such as Llull (2018) or Piyapromdee (2021) examine the effects of immigration on natives' wages, human capital investment and house prices in dynamic settings. Also related is a vivid literature that uses equilibrium models to evaluate the economic and welfare effects of immigration in different sets of countries (see e.g. Chassamboulli and Palivos, 2014; Di Giovanni et al., 2015; Aubry et al., 2016; Battisti et al., 2018; Iftikhar and Zaharieva, 2019; Burstein et al., 2020; Busch et al., 2020; Llull, 2020; Chassamboulli and Liu, 2024). Different from this literature, however, we model migration as an endogenous response to shocks. Moreover, migration in our model can be temporary, and we explicitly account for a subset of countries belonging to a currency union.

In what follows, we first provide empirical evidence for the skill bias in migration within Europe. Section 3 presents our model. We describe the data used, and the model's calibration in Sections 4 and 5. In Section 6, we present our main results concerning the capacity of labor mobility to mitigate the adverse effects of asymmetric shocks, whereas in Section 7, we analyze possible policy interventions.

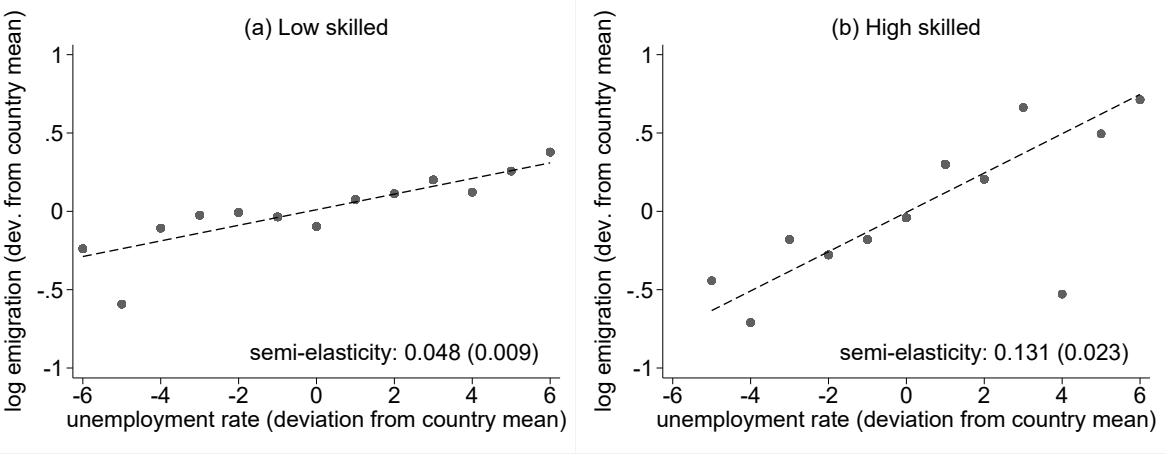
2 Skill bias in European mobility

Migrants are positively selected on marketable skills in many contexts (see Grogger and Hanson, 2011; Kennan and Walker, 2011; Mountford and Rapoport, 2011; Docquier and Rapoport, 2012; Notowidigdo, 2020; Autor et al., 2023; Amior, forthcoming, to cite just a few), and migration within Europe today is no exception. European Union Labour Force Survey (EU-LFS) data show consistently higher migration rates for more educated individuals. We draw on these data also for the calibration of the equilibrium model presented below, and explain the features of the EU-LFS in more detail in Section 4. The EU-LFS reports both an individual's current and previous year's country of residence. We use this information to compute the number of year-to-year migrants relative to their origin country population, separately for individuals with and without tertiary

education.[2] Appendix Figure A1 shows a more than twice as high migration rate for tertiary educated individuals compared to less educated ones, irrespective of whether all or only European nationals are considered. Appendix Figure A2 further confirms that the aggregate skill bias in migration is observed for migration flows from virtually any country covered by the EU-LFS.

Not only are migration rates higher for tertiary educated individuals, but they also respond more strongly to variation in unemployment rates. Figure 1 displays the correlations between the (log) number of emigrants and the unemployment rate in the previous year's country of residence, conditional on country effects. Note that the figure is based on aggregate country-year observations, and since we take out country effects, the figure can be read as showing correlations between deviations in emigration and unemployment rates from the respective country averages across years. Panel (b) shows a three times stronger semi-elasticity of emigration with respect to skill-specific origin unemployment rates for individuals with tertiary education compared to lower educated individuals (Panel a), which tallies with results by Basso et al. (2019), and Notowidigdo (2020).

Figure 1: Emigration and unemployment rates.



Note: Dots show conditional mean residuals of log emigration after taking out country effects, within bins of unemployment rate residuals, also net of country level effects. Dashed lines indicate the linear fit to country-year observations. Panel (a) shows the relation for individuals without, Panel (b) for those with tertiary education. Source: European Union Labour Force Survey.

In light of these facts, an analysis that is set to evaluate the impact of migration on macroeconomic outcomes must account for worker heterogeneity in the propensity to migrate following an economic shock. Part of the skill bias in migration may stem from international differences in the returns to education and thus in the benefits from migration in terms of expected wage gains. Other factors contributing to skill-biased migration may be less tangible. The model described in the next section explicitly accounts for labor market outcomes, including wages and unemployment risk, in an equilibrium framework.

[2]We considered workers "high skilled" if they possess at least an undergraduate degree.

In addition, by matching observed bilateral and skill-specific migrant numbers, we can identify heterogeneity in the preference for migration above and beyond what is explained by observed economic outcomes. In Section 5 we show that the estimated non-monetary costs of migration correlate strongly with language barriers.

3 A model of worker mobility in Europe

The choice of a model may well prelude its qualitative predictions. In equilibrium search models with homogeneous (or perfectly substitutable types of) workers, emigration of part of the labor force unambiguously benefits non-migrants staying behind, as emigration lowers competition for scarce jobs. The same applies to models with a fixed factor of production and a decreasing marginal product of labor. Instead, the opposite will be predicted by a frictionless model with constant returns to scale production technology in which heterogeneous workers are imperfect substitutes: when labor markets clear and workers are paid their marginal product, less-mobile workers in a country hit by a negative shock are bound to suffer from the emigration of more mobile, complementary workers. If the former group of workers constitutes a sufficiently large majority of the population, also the aggregate effect of labor mobility may be negative.

Both frameworks are unsatisfactory from an empiricist's point of view, as their structure dictates the direction of the effect under investigation. In this section, we thus bring a dynamic general equilibrium model to the data that features both search friction and worker heterogeneity. In that model, all workers may benefit from integrated labor markets and the option to migrate in response to adverse shocks. Yet, imperfect substitutability between different types of workers implies that selective emigration may impact negatively on some non-migrants and lower a country's overall productivity. The net effect of labor mobility thus becomes an empirical question, which this paper is set to answer. We tailor the model closely to the European context, where member countries of the European Union's Single Market have integrated labor and goods markets, but only some also share the euro as a common currency.

3.1 Consumption

Each period, an individual i consumes a basket of goods from N different countries. The valuation of goods depends on the country of residence $j_i \in \{1, ..., N\}$, so that a location bias in consumption may raise the share of income spent on domestic products. Moreover, each country provides amenities which are valued differently across individuals. The consumption vector $(c_{i,1}, ..., c_{i,N})$ of goods produced in different countries and location

amenities ϵ_{i,j_i} generate a utility flow

$$\mathcal{U}(c_{i,1}, ..., c_{i,N}; j_i) = \left(\sum_k \psi_{j_i,k} c_{i,k}^{\xi} \right)^{\frac{1}{\xi}} + \epsilon_{i,j_i}, \tag{1}$$

where ξ governs the substitutability across goods of different origin, and $\psi_{j_i,k}$ determines the relative demand for each country k's output, depending on individual i's country of residence j_i. Within each j_i, weights sum to one, $\sum_k \psi_{j_i,k} = 1$. In addition to utility from the consumption of goods, individuals derive utility from location amenities of the country j_i they reside in. The valuation of these amenities is individual-specific, and every period a vector of realizations $\boldsymbol{\epsilon}_i \equiv (\epsilon_{i,1}, ..., \epsilon_{i,N})$ for each country is drawn[3] from distributions with means $\boldsymbol{\mu}_{s_i,n_i} \equiv (\mu_{1,s_i,n_i}, ..., \mu_{N,s_i,n_i})$ that vary across individuals of different skill levels s and nationality n. This flexible specification allows for a correlation between innate location preferences and productivity. For an individual's country of origin $j_i = n_i$, we normalize the mean to $\mu_{n_i,s_i,n_i} = 0$.[4] The idiosyncratic preference component implies that individuals differ in the propensity to migrate even conditional on observed labor market outcomes.

Individuals receive labor income w_{j_i,s_i,n_i} if employed, and benefits b_{j_i} if unemployed. Given the labor market frictions detailed in Section 3.3 below, firms may generate positive profits that are redistributed across individuals in the same country. Residents in country j_i hence further receive capital income in form of a lump-sum transfer d_{j_i}.[5] Finally, individuals pay a percentage τ_{j_i} of their income in taxes, which the government uses to finance unemployment benefits.

Individuals consume their income, so that the budget constraint for an individual of skill s_i and nationality n_i who currently resides in country j_i is given by

$$\sum_k P_k c_{i,k} = [\mathbb{1}_{e_i} w_{j_i,s_i,n_i} + d_{j_i}](1 - \tau_{j_i}) + (1 - \mathbb{1}_{e_i}) b_{j_i} \equiv I_{j_i,s_i,n_i}(\mathbb{1}_{e_i})$$

where P_k denotes the price of goods from country k and $\mathbb{1}_{e_i}$ indicates whether individual i's works. In what follows, we denote individual i's disposable income as $I_{j_i,s_i,n_i}(\mathbb{1}_{e_i})$, which depends on the individual's country of residence, skill level, origin nationality and employment status.

Given the above utility function, demand by individual i for country k's output will

[3]To ease notation, we omit time subscripts in the presentation of the model for now, and hence also from $\boldsymbol{\epsilon}_i$.

[4]Since the information on origin that we use is based on nationality rather than on country of birth, we use "nationality" and "origin" interchangeably.

[5]Profits could alternatively be distributed among a country's nationals rather than its residents. Computationally, the two alternatives are equally feasible.

be[6]

$$c_{i,k} = \frac{I_{j_i,s_i,n_i}(\mathbb{1}_{e_i})}{\left(P^u_{j_i}\right)^{\frac{\xi}{\xi-1}}} \left(\frac{\psi_{j_i,k}}{P_k}\right)^{\frac{1}{1-\xi}}, \tag{2}$$

with a price index

$$P^u_{j_i} = \left(\sum_k P_k^{\frac{\xi}{\xi-1}} \psi_{j_i,k}^{\frac{1}{1-\xi}}\right)^{\frac{\xi-1}{\xi}} \tag{3}$$

that differs across countries and measures the price per unit of utility.

3.2 Production

Each country produces a consumption good variety that is internationally tradable. These final goods are assembled from intermediate inputs H_j and L_j, whose units each are produced by respectively a high or low-skilled worker, similar to the framework in Acemoglu (2001).[7] Firms in country j have a production function

$$Y_j = A_j \left(\alpha_j L_j^\rho + (1-\alpha_j) H_j^\rho\right)^{\frac{1}{\rho}} \tag{4}$$

with country-specific total factor productivity A_j and relative efficiency α_j of the two intermediate inputs. The parameter ρ dictates the elasticity of substitution $1/(1-\rho)$ between intermediate inputs. Given this technology, labor demand functions for high and low-skilled workers in country j are

$$H_j = Y_j \left(\frac{P_j(1-\alpha_j)A_j^\rho}{p_{j,H}}\right)^{\frac{1}{1-\rho}} \quad \text{and} \quad L_j = Y_j \left(\frac{P_j \alpha_j A_j^\rho}{p_{j,L}}\right)^{\frac{1}{1-\rho}}, \tag{5}$$

where $p_{j,H}$ and $p_{j,L}$ denote the prices of intermediate inputs. Whereas final goods are assembled by competitive firms, intermediate goods production is subject to labor market frictions, as detailed below.

[6] In Section 5, we identify parameters $\psi_{j_i,k}$ through import shares. In a model, in which $\psi_{j_i,k} \equiv \psi_k$ does not depend on a consumer's country of residence, import shares alternatively could be used to identify trade costs. We prefer the interpretation of variation in $\psi_{j_i,k}$ across countries j_i in which a variety k is consumed as location bias in consumption, which also proxies for a non-tradable sector. This model is no less flexible than a model with trade costs that assumes $\psi_{j_i,k} \equiv \psi_k$.

[7] An underlying assumption of our specification is free capital movement and therefore an equal marginal product of capital. Given this assumption, a shock to total factor productivity A_j will effectively include both the productivity shock and the following capital adjustment. In the presence of wage rigidities and interest rate adjustments to shocks, capital mobility moreover enforces exchange rate adjustments, as we detail in Section 3.7.

3.3 Labor Markets

Depending on their skill, workers search and can be matched with vacancies in either the high or the low-skilled sector. We first describe the timing within periods, before characterizing the dynamic problem of workers and firms. Time is discrete and a period represents one year. At the beginning of each period, workers draw the vector of preference shocks over locations and, based on these shocks, their employment status and expected equilibrium outcomes, choose a location. If previously unemployed, individuals are matched with an empty vacancy with the equilibrium job finding rate prevailing in their relevant labor market. Employed workers face an exogenous country- and skill-specific probability of losing their job. In addition, they separate endogenously from their job when choosing to migrate, although they need not go through an unemployment period if they locate a job right after arrival in the destination, which happens with that destination's skill-specific equilibrium job finding rate. When employed, each worker produces one unit of the intermediate good corresponding to their skill, with the values $p_{j,H}$ and $p_{j,L}$ of intermediate outputs in each country j being determined in equilibrium. Nominal wages are set through Nash-bargaining and vary across countries and sectors. In addition, immigrants face a skill-specific wage discount as we explain below. Wages can be re-bargained every period but are subject to rigid downward adjustment.[8] Finally, income from employment and transfers is spent on consumption goods as described by equation (2). Appendix Figure A3 illustrates this timing within each period.

We next describe the values associated with different employment states. These values are similar to those in a standard search and matching model, however augmented with location preferences and the possibility to migrate. To ease the exposition, we drop i-subscripts from the notation. The values (welfare) attributed to work and unemployment in country j by an individual of skill s and nationality n are given by

$$W_{j,s,n} = \frac{I_{j,s,n}(\mathbb{1}_e = 1)}{P_j^u} + \epsilon_j + \delta \mathbb{W}_{j,s,n} \quad \text{and} \quad U_{j,s,n} = \frac{I_{j,s,n}(\mathbb{1}_e = 0)}{P_j^u} + \epsilon_j + \delta \mathbb{U}_{j,s,n},$$

where δ discounts the expected continuation values $\mathbb{W}_{j,s,n}$ and $\mathbb{U}_{j,s,n}$, which we define in Section 3.4. With the preferences specified in (1), dividing nominal income $I_{j,s,n}(\mathbb{1}_e)$ by the price index P_j^u defined in equation (3) yields utility flows.

Values are also indexed by an individual's nationality n. First, the distributions from which the preference ϵ_j for each location is drawn is nationality-specific (with means $\boldsymbol{\mu}_{s,n}$, see above), allowing for a location bias. Second, as we explain below, earned income will depend on a worker's immigrant status. Finally, continuation values differ from those in a standard Mortensen and Pissarides (1994) model in that they are based on an

[8] As shown in a recent paper by Born et al. (2024), nominal downward rigidity (as opposed to both flexible wages and symmetric rigidity) helps rationalize a series of empirical macroeconomic patterns.

individual's expectation about future location choices and employment transitions, which again depend on the individual's nationality.

Job matches can be dissolved either exogenously with probability $x_{j,s}$, or because a worker decides not to stay in the current country of residence.[9] The latter occurs with an endogenous probability $(1 - \pi^j_{j,s,n,W})$, where we denote with $\pi^d_{j,s,n,W}$ the probability that an employed worker of skill s and nationality n in country j chooses to reside and search for jobs in country d. We specify this probability in Section 3.4. Hence, the value of filling a vacancy for an intermediate good producer in sector $s \in \{H, L\}$ of country j with a worker of nationality n is given by

$$J_{j,s,n} = \frac{p_{j,s} - w_{j,s,n}}{P^u_j} + \frac{\Big(x_{j,s} + (1 - x_{j,s})(1 - \pi^j_{j,s,n,W})\Big) Vac_{j,s} + (1 - x_{j,s})\pi^j_{j,s,n,W} J_{j,s,n}}{1 + r_j},$$

where r_j denotes the real interest rate in country j, and per-period profits are expressed in utility terms.

We assume that firms cannot discriminate based on the nationality of workers when they post a vacancy. Yet, following the empirical observation that conditional on education immigrants are paid lower wages than natives, firms apply a discount to immigrant wages. Specifically, we assume that wages $w_{j,s,j}$ paid to native workers are determined by Nash bargaining. Firms then apply a skill-specific discount ν_s to immigrant wages $w_{j,s,n} = \nu_s w_{j,s,j}$ for all $n \neq j$. When posting vacancies, firms anticipate the distribution of nationalities within the unemployment pool, and the corresponding expected profit $\Pi_{j,s} = \mathbb{E}_n J_{j,s,n}$, where the expectation is over the nationalities composition among searching workers.[10]

Open vacancies involve a cost $\kappa_{j,s}$, which like $J_{j,s,n}$ is expressed in utility terms. The value of an open vacancy then is given by $Vac_{j,s} = -\kappa_{j,s} + (q_{j,s}\Pi_{j,s} + (1 - q_{j,s})Vac_{j,s})/(1 + r_j)$, with $q_{j,s}$ denoting the probability that the vacancy is filled. Free firm entry reduces the value of a vacancy to zero for every country and skill, so that

$$(1 + r_j)\kappa_{j,s} = q_{j,s}\Pi_{j,s}. \tag{6}$$

This implies that the surplus of a match equals $S_{j,s,j} = J_{j,s,j} + W_{j,s,j} - U_{j,s,j}$. Nash bargaining determines the wage for natives by allocating a share β of this surplus to the

[9] The argument that search frictions make migration particularly costly for employed workers is made by Ransom (2022), who evaluates migration of employed and unemployed individuals within the U.S.

[10] This assumption is important for a stable equilibrium in the numerical solution of the model: A Nash-bargained nationality-specific wage would be subject to the expected duration of a job match, which depends on the emigrate rate. The latter in turn depends on expected wages. This implies an instability of equilibria. Our assumption of non-discrimination at the hiring stage circumvents this, while maintaining the empirical fact of lower immigrant wages.

worker. Wage $w_{j,s,j}$ thus is the transfer between firm and worker that satisfies

$$\beta J_{j,s,j} = (1-\beta)(W_{j,s,j} - U_{j,s,j}). \tag{7}$$

We assume a matching function

$$m\left(z_{j,s}, v_{j,s}\right) = \varsigma z_{j,s}^{\eta} v_{j,s}^{1-\eta}, \tag{8}$$

where ς is the matching efficiency, η the elasticity with respect to unemployment, and $z_{j,s}$ is the pool of searching individuals. This pool comprises individuals of different nationalities, and includes both unemployed individuals present in the country at the beginning of the period and newcomers from abroad. That is,

$$z_{j,s} = \sum_{n} \left(u_{j,s,n} + \sum_{\iota \neq j} \left(\pi^{j}_{\iota,s,n,W} e_{\iota,s,n} + \pi^{j}_{\iota,s,n,U} u_{\iota,s,n} \right) \right),$$

where $e_{\iota,s,n}$ and $u_{\iota,s,n}$ denote the population of employed and unemployed individuals of skill s and nationality n in foreign country $\iota \neq j$.

With market tightness $\theta_{j,s} = v_{j,s}/z_{j,s}$, the job finding probability becomes $f_{j,s} = \varsigma \theta_{j,s}^{1-\eta}$, whereas vacancies are filled with probability $q_{j,s} = \varsigma \theta_{j,s}^{-\eta} = f_{j,s}\theta_{j,s}$. The equilibrium employment level in each sector within a country then determines supply of the respective intermediate inputs

$$H_j = \sum_{n} e_{j,H,n} \quad \text{and} \quad L_j = \sum_{n} e_{j,L,n}. \tag{9}$$

3.4 Migration decision

Each period, individuals decide on a country of residence, which determines the amenities they will enjoy and the labor market in which they will work or search for a job. Moving between countries j and d entails a cost $k_{j,s,d}$ that varies across skills.

Under the assumption that preferences $\boldsymbol{\epsilon}$ are drawn from a type I extreme value distribution with mean $\mu_{j,s,n}$ and spread parameter σ, choice probabilities have a closed form solution. The probability that an individual in country j chooses to stay in that country takes the logistic form[11]

$$\pi^{j}_{j,s,n,W} = \frac{\exp(\mu_{j,s,n} + (1-x_{j,s})W_{j,s,n} + x_{j,s}U_{j,s,n})^{\frac{1}{\sigma}}}{\Xi^{W}_{j,s,n}} \tag{10}$$

[11]For better readability, we define and substitute for the denominators in (10)-(13) the terms $\Xi^{W}_{j,s,n} = \exp(\mu_{j,s,n} + (1-x_{j,s})W_{j,s,n} + x_{j,s}U_{j,s,n})^{\frac{1}{\sigma}} + \sum_{h\neq j} \exp(\mu_{h,s,n} + f_{h,s}W_{h,s,n} + (1-f_{h,s})U_{h,s,n} - k_{j,s,h})^{\frac{1}{\sigma}}$, and $\Xi^{U}_{j,s,n} = \exp(\mu_{j,s,n} + (1-f_{j,s})W_{j,s,n} + f_{j,s}U_{j,s,n})^{\frac{1}{\sigma}} + \sum_{h\neq j} \exp(\mu_{h,s,n} + f_{h,s}W_{h,s,n} + (1-f_{h,s})U_{h,s,n} - k_{j,s,h})^{\frac{1}{\sigma}}$.

if an individual is currently employed, and

$$\pi^{j}_{j,s,n,U} = \frac{\exp(\mu_{j,s,n} + f_{j,s}W_{j,s,n} + (1-f_{j,s})U_{j,s,n})^{\frac{1}{\sigma}}}{\Xi^{U}_{j,s,n}} \tag{11}$$

if not. The corresponding choice probabilities for moving from country j to country $d \neq j$ are given by

$$\pi^{d}_{j,s,n,W} = \frac{\exp(\mu_{d,s,n} + f_{d,s}W_{d,s,n} + (1-f_{d,s})U_{d,s,n} - k_{j,s,d})^{\frac{1}{\sigma}}}{\Xi^{W}_{j,s,n}} \tag{12}$$

$$\pi^{d}_{j,s,n,U} = \frac{\exp(\mu_{d,s,n} + f_{d,s}W_{d,s,n} + (1-f_{d,s})U_{d,s,n} - k_{j,s,d})^{\frac{1}{\sigma}}}{\Xi^{U}_{j,s,n}}. \tag{13}$$

A key parameter in our framework is $\mu_{j,s,n}$, the average preference of individuals of nationality n and skill s towards any given country j. This parameter enters the values $W_{j,s,n}$ and $U_{j,s,n}$ through expected realizations of $\boldsymbol{\epsilon}$, and thus determines expected migration flows. Importantly, $\mu_{j,s,n}$ accounts for heterogeneity in individual mobility across skill groups *conditional on labor market outcomes*.

Given the distributional assumptions on $\boldsymbol{\epsilon}$, the expected continuation values in the two employment states are

$$\begin{aligned}\mathbb{W}_{j,s,n} &= \sigma \log \Bigg[\exp((1-x_{j,s})W_{j,s,n} + x_{j,s}U_{j,s,n}) \\ &\quad + \sum_{d \neq j} \exp\left(f_{d,s}W_{d,s,n} + (1-f_{d,s})U_{d,s,n} - k_{j,s,d}\right) \Bigg] + \sigma\gamma \end{aligned} \tag{14}$$

and

$$\begin{aligned}\mathbb{U}_{j,s,n} &= \sigma \log \Bigg[\exp(f_{j,s}W_{j,s,n} + (1-f_{j,s})U_{j,s,n}) \\ &\quad + \sum_{d \neq j} \exp\left(f_{d,s}W_{d,s,n} + (1-f_{d,s})U_{d,s,n} - k_{j,s,d}\right) \Bigg] + \sigma\gamma, \end{aligned} \tag{15}$$

where $\gamma \approx 0.577$ is the Euler constant (see e.g. Rust, 1987).

With the above choice probabilities at hand, we can describe the different flows that characterize the labor markets in our model. The flow into the employed population of skill s and nationality n in a country j equals

$$infl^{e}_{j,s,n} = f_{j,s}\pi^{j}_{j,s,n,U}u_{j,s,n} + f_{j,s}\sum_{\iota \neq j}\left(\pi^{j}_{\iota,s,n,W}e_{\iota,s,n} + \pi^{j}_{\iota,s,n,U}u_{\iota,s,n}\right).$$

The first term in this expression represents unemployed individuals who decide to stay in the country, and find a job. The second term includes immigrants who have left unemployment or employment in their previous country of residence (indexed ι), and in country j find a job right away.

Similarly, the flow into unemployment is

$$infl^u_{j,s,n} = x_{j,s}\pi^j_{j,s,n,W}e_{j,s,n} + (1 - f_{j,s})\sum_{\iota \neq j}\left(\pi^j_{\iota,s,n,W}e_{\iota,s,n} + \pi^j_{\iota,s,n,U}u_{\iota,s,n}\right).$$

Outflows from unemployment and employment in turn equal

$$outfl^u_{j,s,n} = (1-\pi^j_{j,s,n,U}+f_{j,s}\pi^j_{j,s,n,U})u_{j,s,n} \quad \text{and} \quad outfl^e_{j,s,n} = (1-\pi^j_{j,s,n,W}+x_{j,s}\pi^j_{j,s,n,W})e_{j,s,n}.$$

In a steady state equilibrium, outflows and inflows for all countries, skills and nationalities are balanced, yielding the conditions

$$outfl^u_{j,s,n} = infl^u_{j,s,n} \quad \text{and} \quad outfl^e_{j,s,n} = infl^e_{j,s,n}. \tag{16}$$

3.5 Goods Markets and Government Budget

Given our assumptions about preferences, individuals spend their income on a consumption basket that contains output from all countries. Relative proportions are determined by the taste parameters $\psi_{j_i,k}$, allowing for a potential location bias that explains the disproportionate share of domestic goods and services consumed. Demand further is a function of final goods' prices P_j, and depends on the elasticity of substitution $1/(1-\xi)$ across goods (see equation (2)). The overall scale of consumption is determined by an individual's net income.

We assume that governments balance their budget, endogenously adjusting the tax rate to cover payments to unemployed individuals:

$$\forall j: \quad b_j \sum_s \sum_n u_{j,s,n} = \tau_j \left(\sum_s \sum_n e_{j,s,n}w_{j,s,n} + (e_{j,s,n} + u_{j,s,n})d_j\right). \tag{17}$$

Hence, total aggregate income in country j is given by the sum of pre-tax labor income $\sum_s \sum_n w_{j,s,n}e_{j,s,n}$ and cumulative dividends[12]

$$\sum_s \sum_n (e_{j,s,n} + u_{j,s,n})d_j = \sum_s \left(\sum_n e_{j,s,n}(p_{j,s} - w_{j,s,n}) - P^u_j \kappa_{j,s} v_{j,s}\right).$$

Equilibrium on the market of each country's final good then requires that supply matches

[12] Aggregate profits that are redistributed as dividends are net of vacancy costs.

demand

$$Y_j = \sum_k \frac{\sum_s \sum_n \left(w_{k,s,n} e_{k,s,n} + (e_{k,s,n} + u_{k,s,n}) d_k\right)}{(P_k^u)^{\frac{\xi}{\xi-1}}} \left(\frac{\psi_{k,j}}{P_j}\right)^{\frac{1}{1-\xi}}, \tag{18}$$

where $\psi_{k,j}$ is the taste parameter of consumers for good j while living in country k, and P_j is its price level.

3.6 Steady State Equilibrium

A steady state equilibrium is defined as the vector of prices $p_{j,H}, p_{j,L}, P_j$, wages $w_{j,s.n}$, intermediate and final output quantities H_j, L_j, Y_j, and agents' distribution $u_{j,s,n}, e_{j,s,n}$ across employment states and countries, for each skill level and nationality, such that

1. Demand (18) for the final good produced in each country equals supply (4);
2. Demand for intermediate goods (5) equals the respective supplies (9) in each country;
3. Government budged (17) is balanced;
4. Flows (16) into and out of employment states in each country and sector are balanced;
5. Free entry conditions (6) hold in each country and sector;
6. Matches are formed according to the matching function (8);
7. Wages in each country and sector share the surpluses according to (7);
8. Individuals maximize their utility in choosing the basket of goods (2) and the country of residence, (10)-(13).

3.7 Currency Adjustment and Monetary Policy

While our focus is on countries of the European Monetary Union, trade and migration links extend beyond the euro area. That is, while a number of countries share the euro as a currency subject to a common monetary policy, other countries have maintained national currencies and independent central banks. Central banks may intervene to adjust the interest rate and—through a no-arbitrage condition—to increase or decrease the value of their currency, affecting the prices of traded goods.

The monetary policy that we assume is a simple Taylor rule similar to those in Nakamura and Steinsson (2014) and House et al. (2018). Introducing time subscripts t, a national central bank reacts to deviations in per capita output $\Delta output_{j,t}$ and inflation $inflation_{j,t}$ in its currency area from the steady state, and sets nominal interest rates as

$$int_{j,t} = \bar{int} + \varphi\ int_{j,t-1} + (1-\varphi)\left(\phi_y \Delta output_{j,t} + \phi_p inflation_{j,t}\right), \tag{19}$$

where $\bar{int}$ is the long-run steady state interest rate and φ measures persistence of the interest rate. For the monetary union, the central bank considers the means of output per capita growth and inflation[13] among member states of the union, weighted by each country's GDP. We assume that the reaction parameters ϕ_y and ϕ_p are common to all currency areas.

To be explicit about different currency areas, we rewrite the price of a country's final good in euros as $P_{j,t} = E_{j,t} \cdot P^*_{j,t}$, where $E_{j,t}$ is the exchange rate in euros per local currency and $P^*_{j,t}$ is the price of the national good in local currency. We normalize the value of the euro to 1. The no-arbitrage condition between two countries j and j' in different currency areas then determines the evolution of exchange rates to satisfy $(1 + int_{j,t}) = (1 + int_{j',t})\mathbb{E}\left(\frac{E_{j',t+1}}{E_{j',t}} \cdot \frac{E_{j,t}}{E_{j,t+1}}\right)$.

3.8 Wage Rigidity

We want to study how integrated labor markets affect not only long-run equilibria, but also the transitions following asymmetric shocks within a currency union. As noticed by Shimer (2005), standard search and matching models with flexible wages lead to an elasticity of market tightness with respect to productivity shocks that is low relative to what is commonly observed in the data. The reason is that productivity shocks are largely absorbed by a change in wages. A certain degree of wage rigidity on the other hand can, for a given shock level, give rise to a more realistic response in unemployment (Shimer, 2004).

We thus embed a tractable form of nominal downward rigidity into the model. Specifically, we assume that euro-denoted wages in each country follow a path

$$w_{j,s,n,t} = \omega \max\left\{\frac{E_{j,t}}{E_{j,t-1}} w_{j,s,n,t-1}, w^*_{j,s,n,t}\right\} + (1-\omega) w^*_{j,s,n,t},$$

where $w^*_{j,s,n,t}$ is the wage in euro that would have split the surplus in period t according the Nash-bargaining protocol (7). In case of downward pressure, the wage actually paid by firms is a weighted average of this hypothetical equilibrium wage and the local currency wage prevailing in the previous period. The degree of wage rigidity is given by ω, where $\omega = 0$ implies that wages are fully flexible, whereas $\omega = 1$ corresponds to a model in which wages never decrease from an initial steady state level. Since rigidity applies to nominal wages in local currency, monetary policy can accelerate the adjustment process, reducing the real rigidity of wages by devaluating a currency.

Since we estimate parameters at the steady state, where wage rigidity does not play a role, the choice of ω does not affect estimation results. It does, however, impact the

[13] We measure both inflation and output changes in percent, so that $inflation_{j,t} \equiv (P_{j,t} - P_{j,t-1})/P_{j,t-1}$ and $\Delta output_{j,t} \equiv \left(\frac{Y_{j,t}}{\sum_{s,n} e_{j,s,n,t} + u_{j,s,n,t}} - \frac{Y_{j,t-1}}{\sum_{s,n} e_{j,s,n,t-1} + u_{j,s,n,t-1}}\right) / \frac{Y_{j,t-1}}{\sum_{s,n} e_{j,s,n,t-1} + u_{j,s,n,t-1}}$.

welfare implications of a shock. In the results section, we will show welfare effects both with and without wage rigidity.

4 Data

The European context is one where goods and labor markets are integrated beyond the monetary union, as the Single Market includes countries that have not adopted the euro. Some non-euro countries, like Poland, are major migrant sending countries to the euro zone, whereas others, like the United Kingdom have been major receiving countries of labor migrants from other parts of the European Union.[14] We thus calibrate the above model to data on migration and labor market outcomes in both euro-zone and non-euro-zone countries. We combine data from multiple sources. First, we use the micro-level European Union Labour Force Survey (EU-LFS) for the years 2012-2017, which provides harmonized data from national surveys in member countries of the European Union, as well as a number of other countries in Europe.

Although our empirical application focuses on the euro area, we include European non-euro countries as residual locations, distinguishing higher- and lower-income countries. While the model can accommodate non-European locations too, we exclude them from the empirical analysis in order to avoid too coarse approximations to the more detailed information we have for countries covered by the EU-LFS. Moreover, immigration restrictions severely limit the free flow of people from non-European countries into the EU based on economic incentives.

From the EU-LFS we recover information about migration flows, labor market transitions and education level, as well as on immigrant and total labor force stocks.[15] We refer to high-skilled individuals as those with at least a college degree, while low-skilled individuals comprise everyone else. Migration flows are generally difficult to measure, since countries have different rules with respect to the mandatory communications for moving in and out of the country. The EU-LFS does, however, inquire about respondents' country of residence in the previous year, which allows a construction of migration flows. For privacy concerns, we cannot observe the nationality of foreign citizens at the country level. Nevertheless, we do know whether a respondent is a citizen of their current country of residence or not (and if not, which broad country group their citizenship falls into). Under the assumption that agents only move (in either direction) between their country of citizenship and some foreign country rather than between foreign countries, we can construct a migration flow matrix.[16] Panel A of Table 1 shows that emigration

[14] Our data cover a period in which the UK was a member of the European Union.

[15] To calculate stocks, we sum all employed and unemployed respondents aged 15+ using sampling weights, and then average stocks across the waves 2012-2017. The restriction to labor force participants effectively restricts ages to below 65 in most countries.

[16] That is, we observe whether an individual surveyed in county j who previously resided in country

rates of foreign nationals exceed those of citizens of the country of residence by a factor of more than ten. In addition, unemployed individuals are more likely to move to a different country (Panel B).[17] To avoid small numbers of observed migrants in some single waves and to measure migration rates more precisely, we pool data for the years 2012-2017. See Appendix A for further details.

Table 1: Emigration rates.

Panel A: By citizenship			**Panel B: By employment status**		
	(1)	(2)		(3)	(4)
	Low skilled	High skilled		Low skilled	High skilled
Citizen	0.07%	0.24%	Working	0.13%	0.32%
Foreign	0.96%	2.87%	Unemployed	0.14%	0.40%

Note: The table shows annual emigration rates, calculated within each group as the ratio of the number of respondents reporting that one year ago they resided in a different country and the population of that country. Panel A shows emigration rates by skill and citizenship; Panel B shows emigration rates by skill and previous year's employment status. Source: European Labour Force Survey 2012-2017.

We measure earnings using the European Union Statistics of Income and Living Conditions (EU-SILC). Specifically, we use median earnings for different educational attainments to calculate skill premia. Aggregate data on countries' gross domestic product and relative price levels are drawn from Eurostat. Net replacement rates for unemployment benefits and import shares are taken from the OECD's statistical database. Finally, we use the GeoDist dataset compiled by the Centre d'études prospectives et d'informations internationales (CEPII, Mayer and Zignago, 2011a) for geographic distances and the contiguity of countries, which determine the bilateral cost of migration (more on this below). To be consistent with the migration data, we average outcomes for each country over the same years.

We base the calibration on information from a total of 17 countries. For the euro area, these include Austria, Belgium and Luxembourg[18], Denmark, France, Germany, Italy, The Netherlands, Portugal and Spain.[19] We account for the large economic disparity among countries that have not adopted the euro, but are nonetheless part of the European Single Market. In particular, we distinguish high income countries like Sweden and the UK from lower income and more recent member states of the European Union.

k is a citizen of j or not. If not, we assume they are a citizen of country k. A comparison with the available coarser information on nationality groups rejects this assumption in only 0.7% of cases.

[17] Like in Figures A1 and 1, we rely on the reported country of residence one year ago. For Panel B we further use information on the previous year's employment status.

[18] We merge these two states rather than excluding Luxembourg, which alone would have too few observed emigrants to other countries.

[19] In other countries, the number of immigrants recorded in the EU-LFS is too small. Specifically, we drop countries if more than 50% of their bilateral links have zero recorded migrant flows. The countries we omit are also small in terms of absolute trade volume, so that their omission is unlikely to affect our empirical analysis, which will focus on shocks to the Italian economy.

Rather than pooling all these into one residual location, the calibration thus considers two distinct outside locations: one which comprises the UK, Sweden and Switzerland[20]; and one that includes Poland, Romania, Czech Republic and Hungary. In our context, this distinction not only reflects the different productivity levels across the two groups, but also the fact that the former group are net immigration countries, whereas the latter are predominantly migrant sending countries. We provide further detail on all data sources we use in Appendix A.

5 Empirical Implementation

The model is solved by value function iteration, and we calibrate its steady state to moments observed in the previously described data sources. Specifically, we jointly calibrate a total of 293 parameters to a set of empirical moments, and take other parameters from the literature or estimate them directly from the data. Since we group a number of countries as described in the previous section, the calibrated model features eleven locations: nine euro-zone locations plus two residual locations outside the monetary union. A model period equals one year.

5.1 Identification

The parameters we calibrate internally are the average preference over a location $\mu_{j,s,n}$ for every country, skill and nationality, the skill-specific moving cost $k_{j,s,d}$ between countries j and d, the total factor productivity A_j for each country, the vacancy cost $\kappa_{j,s}$ for each country and skill group, the relative efficiency α_j of the two labor inputs for each country, the wage penalty for immigrants ν_s for each skill group, and the preference parameter $\psi_{j_i,k}$ for each country's final good, depending on country of residence. Although all moments jointly identify the model's parameters, Panel A of Table 2 systematically lists the different groups of parameters and the moments that contribute most directly to their identification.

Migration costs and preferences. Conditional on moving costs $k_{j,s,d}$, bilateral migration flows identify the mean $\mu_{j,s,n}$ of the distribution from which preference shocks are drawn, where we normalize $\mu_{n,s,n}$ for an individual's home country to zero. Jointly, $k_{j,s,d}$ and $\mu_{j,s,n}$ moreover govern the expected steady state migration duration and the implied stocks of resident migrants for each skill and country. Targeting both migration flows and stocks thus allows a separate identification of location preference parameters $\mu_{d,s,n}$ that govern expected per period payoffs in a given location, and migration costs

[20]Switzerland, although not formally part of the European Union Single Market, has access to important parts of it through separate agreements and is part of the European Free Trade Area.

$k_{j,s,d}$ that are incurred only at the time of a move. To limit the number of parameters to be estimated, we parameterize $k_{j,s,d}$ as a function of the distance and contiguity of countries, so that the cost of moving between countries j and d (in either direction) for an individual of skill s is given by $k_{j,s,d} = k_{0,s} + k_1 D_{j,d} + k_2 B_{j,d}$, where $k_{0,s}$, k_1 and k_2 are estimated parameters, $D_{j,d}$ denotes the natural logarithm of the distance between the capital cities of the two countries, and $B_{j,d}$ indicates whether countries j and d share a border. We take these variables from the GeoDist database, provided by CEPII. In the model, the cost $k_{j,s,d}$ limits migration flows and prevents excessive back and forth movements.[21]

Labor market parameters. The unemployment level identifies the vacancy cost $\kappa_{j,s}$ only conditional on the matching efficiency ς. We thus target the mean vacancy rate reported by Eurostat for the European Union in the years 2012-2017 in addition to the unemployment rate across countries and skill groups observed in the EU-LFS. This yields a $\varsigma = 0.77$, and a set of vacancy costs summarized in Table 2. Since job separations $x_{j,s}$ are constant in our model, we use the EU-LFS to compute yearly employment-to-unemployment transition rates separately for high and low-skilled workers, and use these as the exogenous separation rates in the model. Wage discounts ν_L and ν_H for low- and high-skilled immigrant workers are identified from the mean ratio across countries between median immigrant and native workers' wages.

Production function parameters. The skill premium in each country[22] identifies the production function parameters α_j, whereas the country-specific productivity A_j is identified by each country's GDP. We take the elasticity $1/(1-\rho) = 4$ between low- and high-skilled intermediate inputs from Caliendo et al. (2021), and show that our main results are very robust to variation in this important parameter. Specifically, we re-calibrate the model alternatively setting $1/(1-\rho)$ to 2 or 6. Table 3 in Section 6.5 compares the results.

Consumption parameters. Finally, to reduce the number of preference parameters to be estimated, we imposed a parametric restriction on consumer preferences $\psi_{j_i,k}$. In particular, we assume that utility from foreign goods consumption is discounted proportionately within each country. That is, for imported goods from any $k \neq j_i$, we let $\psi_{j_i,k} = \zeta_k \psi_{j_i,j_i}$. This specifications allows for demand being higher for local goods, while the parameters to be estimated are reduced to two per country (with the restriction that

[21] Alternatively, we could have estimated a cost parameter for each (j, s, d)-combination, and instead impose parametric restrictions on $\mu_{j,s,n}$. Since $\mu_{j,s,n}$ determines the expected utility loss from being in country j compared to an individual's country of origin n, whereas $k_{j,s,d}$ primarily serves to discipline the number of moves, we chose to parameterize the latter and maintain full flexibility of $\mu_{j,s,n}$.

[22] Measured as the ratio of the median wage for workers with a college degree over the median wage of workers without a degree.

$\sum_k \psi_{j_i,k} = 1$). These parameters are then identified by targeting observed price levels and total imports as a share of GDP in each country.

5.2 Calibration

Internal calibration. Given the large number of parameters, we use a block estimation strategy. In particular, we first calibrate all parameters while keeping the moving cost parameters $k_{0,s}$, k_1 and k_2, and the average preferences over a location $\mu_{j,s,n}$ fixed. Then, we calibrate the parameters $\mu_{j,s,n}$ keeping all other parameters fixed. Finally, we calibrate the cost parameters $k_{0,s}$, k_1 and k_2. We iterate these three steps until convergence. Our model is over-identified. Among the large number of migration-related moments, immigrant stocks, which have built up over years prior to our sample period, are most difficult to match. Yet, the overall fit of the model is very good, as visualized in Appendix Figure A4. We further examine the model's ability to replicate non-targeted patterns. To induce variation in emigration and unemployment rates, akin to Figure 1, we expose each country in turn to demand shocks of varying persistence and examine the correlation between changes in unemployment and emigration relative to the steady state.[23] Figure A5 in the appendix shows that the model replicates the tighter relation between unemployment and emigration for high- compared to low-skilled workers. Panel A of Table 2 lists the estimated parameter values, and in the last column indicates which of the targeted moments contribute most directly to identification of each set of parameters.

Preferences and costs. Across all country pair and skill combinations, the median expected annual utility cost $\mu_{j,s,n}P_j^u$ of residing in a foreign country is -12,779 euros.[24] The median utility cost at the time of moving, instead amounts to 92,392 euros. Note that this is not the median cost paid by migrants, but of all hypothetical moves, most of which never materialize. Actual costs are then determined by idiosyncratic draws $\boldsymbol{\epsilon}$ (see Kennan and Walker, 2011). Together, these estimated parameters allow the model to replicate observed bilateral migration flows and immigrant stocks. Moving costs and mean utility flows in foreign locations are heterogeneous across countries and nationalities, and Figure 2a displays the distributions of the estimated magnitudes of $(\mu_{j,s,n} - k_{j,s,n})P_j^u$ by skill group. Our estimates indicate that for the average country pair the total expected disutility that would be incurred at the time of moving by low-skilled workers exceeds that for high-skilled workers by 16,717 euros.

[23] We explain the exact specification of permanent and non-permanent demand shocks in Sections 6.1 and 6.4.

[24] Since $\mu_{j,s,n}$ is measured in utility units, we convert it to euros using the country-specific utility price P_j^u.

Table 2: Parameters and identifying information.

Panel A: Joint internal calibration					
parameter(s)	Notation	Percentiles of estimates			Target
		25th	50th	75th	(Source)
Location preference	$\mu_{j,s,n}P_j^u$	-50.414	-12.779	18.894	Migrations flows (EU-LFS)
Migration cost	$(k_{0,s} + k_1 D_{j,j'} + k_2 B_{j,j'})P_{j'}^u$	74.706	92.392	98.884	Migration stocks (Eurostat)
Consumption weights	$\psi_{j,j}$	0.137	0.176	0.194	Price level (Eurostat)
Consumption location bias	ζ_j	0.366	0.487	0.581	Import share (OECD)
Vacancy cost	$\kappa_{j,s}P_j^u$	20.958	34.940	61.524	Unemployment (EU-LFS)
TFP	A_j	143.9	181.5	189.4	GDP (Eurostat)
Low skill efficiency	α_j	0.430	0.450	0.478	Skill premium (EU-SILC)
Migrant wage penalty	ν_L: 0.982		ν_H: 0.999		Income difference (EU-SILC)
Matching efficiency	ς		0.769		Vacancy rate (Eurostat)

Panel B: Exogenously set parameters					
Parameter(s)	Notation	Percentiles of estimates			Source
		25th	50th	75th	
Replacement ratio	$b_j/w_{j,L,j}$	60.1%	70.3%	83.4%	OECD
Separation rates	$x_{j,s}$	0.022	0.035	0.051	EU-LFS
Goods elasticity	$1/(1-\xi)$		4		Feenstra et al. (2018)
Skills elasticity	$1/(1-\rho)$		4		Caliendo et al. (2021)
Migration elasticity	$1/\sigma$		0.5		Caliendo et al. (2021)
Bargaining power	β		0.72		Shimer (2005)
Matching elasticity	η		0.72		Shimer (2005)
Interest rate persistence	φ		0.75		Nakamura and Steinsson (2014)
Weight of growth	ϕ_y		0.5		House et al. (2018)
Weight of inflation	ϕ_p		1.5		House et al. (2018)
Baseline interest rate	int		2%		

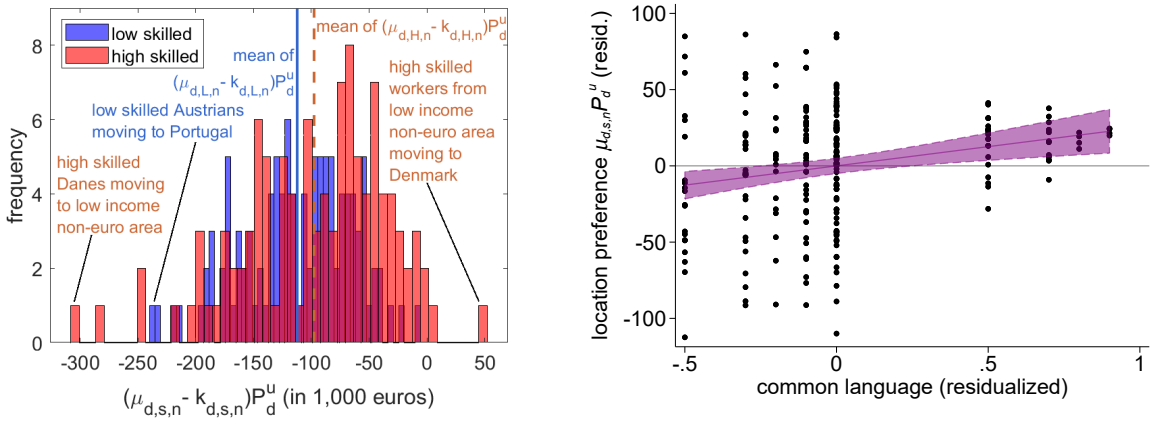
Note: The table shows calibrated model parameters. In Panel A, identifying information are empirical moments targeted in the calibration. For better interpretability, means of location preference distributions, migration costs and vacancy costs are multiplied by each country j's utility price P_j^u to obtain numbers in thousands of euros. Parameters listed in Panel B are set to values taken from the literature or data as indicated.

Plausibility of estimated preferences. To illustrate that these structural parameters carry economic content, we match each country pair to data from the CEPII GeoDist database. These data provide information on bilateral ties, including indicators for common languages across country pairs. We correlate our estimates of the mean utility gain $\mu_{j,s,n}P_j^u$ when residing in a foreign country j with an indicator for a country j sharing an official language with origin country n, after taking out origin-skill effects. Panel (b) of Figure 2 shows a significant positive correlation between our estimated preference parameters and common official languages. On average, sharing a language is associated with an increase in the utility flow when residing in a foreign country by about 25,000 euros.

Figure 2: Location preferences.

(a) Disutilities of moving

(b) Preferences and common language



Note: Panel (a) displays estimated values of expected utility flows (net of utility from consumption) minus moving costs ($(\mu_{d,s,n} - k_{d,s,n})P_d^u$) by workers of different nationalities n for destination countries d, separately for low-skilled workers (blue, solid line for the mean) and high-skilled workers (red, dashed line). Panel (b) displays the correlation between estimated utility flow differences (net of utility from consumption) $\mu_{d,s,n}P_d^u$ on the one hand, and countries n and d sharing an official language on the other, each residualized after controlling for origin-skill effects; shaded area indicates 95% confidence interval on the linear fit; when countries are grouped for the model, a group has a language if at least one country in the group has it as an official language; source: CEPII GeoDist database.

External parameters. Panel B of Table 2 lists the parameters we set externally, either based on previous studies, or taken from the data directly. In Tables 3 and A10, we show that our main results are extremely robust to numerous variation on the values of these parameters. For instance, we vary the elasticity of substitution between goods of different origins between 2 and 6. Our preferred value $\xi = 0.75$ (implying an elasticity of substitution of 4) is taken from Feenstra et al. (2018). Similarly, while we set the elasticity of substitution between workers of different types to 4, as estimated by Caliendo et al. (2021), we also re-calibrate the model for elasticities of 2 and 6—a range which comprises, for instance, the elasticity of substitution of 5 estimated by Dustmann et al. (2009).

Section 6 shows adjustment paths for rigidity in wages of $\omega = 0.66$, which corresponds to a quarterly persistence of 0.9 and is similar to the value estimated by Smets and Wouters (2007). Yet, our results are also robust to flexible wages, as we show in Tables 3 and A10. In Appendix D.1 we describe all chosen parameter values and their sources in more detail.

6 Labor Mobility and Asymmetric Shock

We use the calibrated model to evaluate the contribution of labor mobility to the mitigation of asymmetric shocks in the euro area. We therefore compare the effects of shocks in the model with spatially integrated labor markets to the same outcomes that would result if migration were prohibited. As a baseline, we first analyze responses to a shock that permanently lowers demand for the output produced in one country (Italy). We contrast this to shocks to a group of countries in Section 6.2, and to a shock to total factor productivity in Section 6.3. In Section 6.4, we further compare these results to the effects of migration when shocks are non-permanent. To demonstrate the robustness of our baseline results, we compare them in Section 6.5 to the predictions obtained under a large array of variations in the underlying assumptions. These include alternative parametrizations regarding the substitutability of workers in production and of goods in consumption, different discounting, flexible wages, and a model without adjustments in monetary policy following a shock. In that section, we also compare our main results for Italy to what would be obtained for other countries.

6.1 Baseline: Permanent Demand Shock

To simulate our baseline demand shock, we permanently lower the preference parameter $\psi_{j,j}$ governing demand for Italian output by 1 percent.[25] We model this as an "MIT shock"—a shock that is permanent, unexpected for the agents, and which leads to a deterministic aggregate path towards the new steady state. Such permanent shocks also shed light on the likely implications of integrated labor markets when countries are diverging economically.

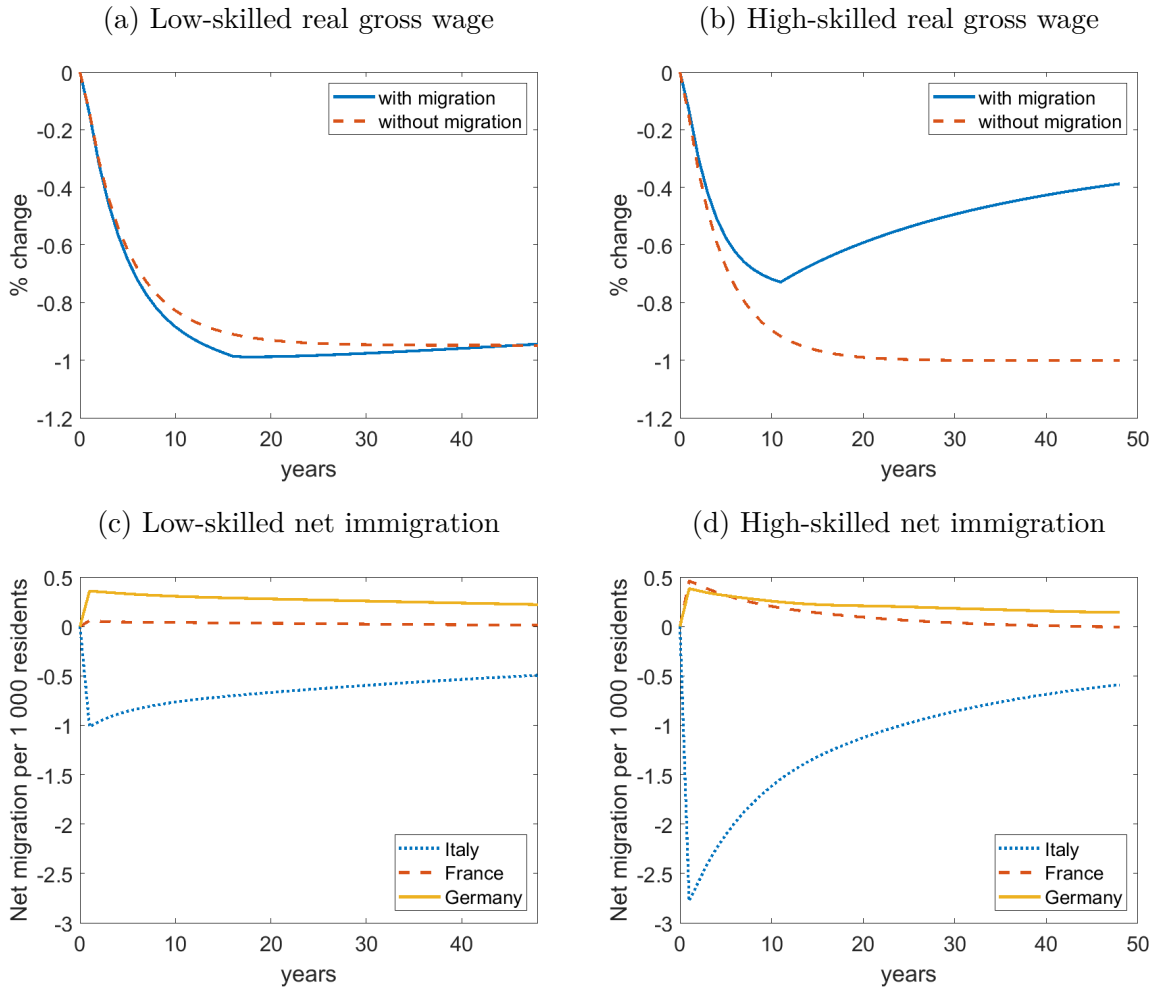
Migration and real wages. Absent migration, the shock reduces wages for both groups of workers in Italy, indicated as red dashed lines in Panels (a) and (b) of Figure 3. When labor markets are integrated, workers will emigrate, shown as negative net immigration rates by the blue dotted lines in Panels (c) and (d).[26] Beyond labor market

[25] We readjust $\psi_{j,k}$ to preserve the property $\sum_k \psi_{j,k} = \sum_k \zeta_k \psi_{j,j} = 1$. Due to our parameterisation, the taste for a country's output declines proportionately in all countries.

[26] These panels also show the net immigration in the main receiving countries of Italian migrants, France and Germany. High and low-skilled Italians sort differently into these destinations, which is

prospects, the extent to which the option to migrate is used depends on the distribution of workers' preferences and migration costs for different destinations. In line with the descriptive evidence in Figure 1, the model predicts that emigration in response to an adverse shock is concentrated among high-skilled workers, so that migration mitigates much of the negative effect on their wages (solid blue line in Panel b).[27]

Figure 3: Effects of a permanent reduction in the taste for Italian output by 1 percent.



Note: The figure shows transitions of outcomes following a permanent reduction in consumers' taste for Italian output by 1 percent. Panels (a) and (b) show real gross wages of low and high-skilled workers; blue solid lines indicate paths predicted by the full calibrated model with migration; red dashed lines compare these to a counterfactual scenario in which migration is prohibited. Panels (c) and (d) show net immigration by low and high-skilled workers to France (red dashed), Germany (yellow solid) and Italy (blue dotted).

Although low-skilled workers emigrate as well, reducing pressure on low-skilled stayers, the latter see a counteracting effect arising from the stronger response in the emigration

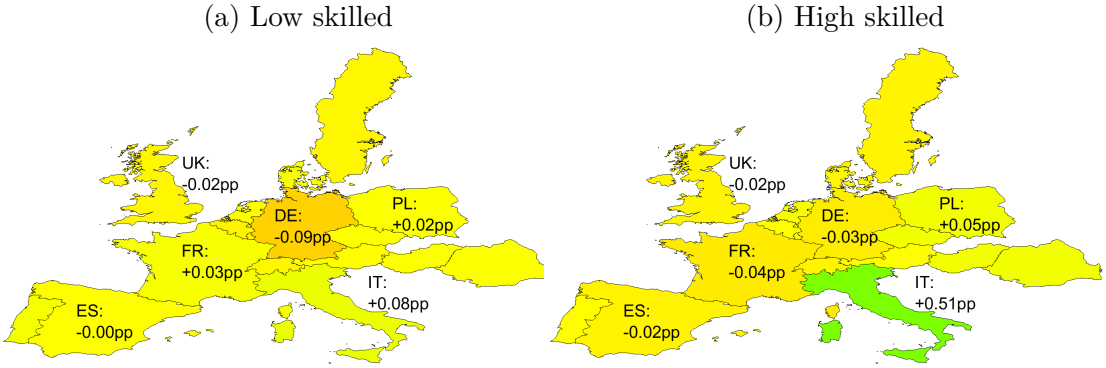
driven by different compositions of immigrant stocks in the data leading to relatively more favorable payoffs for low-skilled Italians moving to Germany.

[27]The kink in wage profiles derives from our assumption of downward nominal wage rigidity, while wages can adjust freely upwards.

of high-skilled workers. We find that this second effect fully offsets the benefits from integrated labor markets for low-skilled workers. In fact, real wages are slightly lower compared to the non-migration scenario. Panels (a) and (b) of Appendix Figure A6 show the same for labor market tightness. Since emigration is concentrated among the unemployed, losses in output per capita and the rise in the unemployment rate are cushioned by migration. Following the (sluggish) adjustment in wages, output per capita and the unemployment rate initially revert back, see Panels (c) and (d) of Appendix Figure A6. However, the continued emigration of high-skilled workers changes the composition of the Italian work force, with the decline in averages skills leading to a longer-term reduction in output per capita, as well as a gradual increase in the unemployment rate.

Welfare. To show welfare effects of labor market integration, we calculate how welfare elasticities with respect to a shock change between the status quo with migration and a counterfactual scenario in which migration is prohibited. We define welfare to be the discounted sum of utility flows. Figure 4 visualizes the differences between these two scenarios as a measure for the welfare gains from labor market integration. We compare steady states, so that colors (and numbers for the largest countries) indicate elasticity differences in how welfare changes relative to the initial steady state in scenarios with and without migration.[28]

Figure 4: Welfare effects of labor market integration following a negative 1% shock to demand for Italian output.



Note: The figure shows welfare effects of labor market integration, measured as differences between steady state welfare elasticities with respect to the shock with and without migration following a permanent reduction in consumers' taste for Italian output by 1 percent. Panel (a) shows welfare effects for low-skilled individuals, Panel (b) for high-skilled individuals.

The option to migrate absorbs about half of the welfare loss to high-skilled Italians following a negative demand shock to Italian output. For the less mobile workers with

[28] As an example, a 1% drop in the demand for Italian output decreases welfare for high-skilled workers in Italy by 0.58%. This loss would amount to 1.09% if migration was prohibited. Panel (b) of Figure 4 shows the percentage point difference between these two numbers. Note that in our model, percentage changes are interpretable, since utility is proportional to income.

lower skill level, instead, labor market integration mitigates much less of the welfare effect of the shock. However, low-skilled individuals in the main recipient countries of high-skilled Italian migrants (most notably France) benefit from this inflow. The shock to Italy shifts demand towards the output of other countries, some of which are major destinations for migrants from countries in central and eastern Europe. Workers of all skills in these countries thus benefit from the option to migrate to Germany and other countries. This large influx leaves a negative impact on German workers. The large effect on low-skilled workers in Germany (see Panel a of Figure 4) moreover stems from a disproportionate attraction of low-skilled Italians to Germany, in line with Figure 3c.

Wage rigidity and asymmetries. In comparison to a model with full wage flexibility, wage rigidity amplifies the effects on labor market tightness (see Appendix Figure A6). Yet, a model with flexible wages yields very similar, though slightly smaller welfare effects, which we show in Table 3 below. The fact that rigidity is present for downward adjustment in wages suggests asymmetries also for negative versus positive shocks. Indeed many factors in the model will contribute to such asymmetries. In particular differences between the preference of Italians to emigrate and of non-Italians to migrate to Italy (conditional on consumption) contribute to an asymmetric effect of positive shocks. When simulating a 1% *increase* in the demand for Italian output, we nonetheless find a similar pattern as for the welfare effects of negative shocks shown in Figure 4: labor market integration in this case offsets welfare gains from a *positive* shock by almost twice as much for high- relative to low-skilled Italians.[29]

6.2 Demand Shock to southern Europe

While the model's mechanisms are more transparently illustrated by our focus on shocks to only one economy, shocks are often correlated across several countries. We thus compare the above predictions to a situation in which not only Italy, but also Portugal and Spain experience the same decline in the demand for their output.

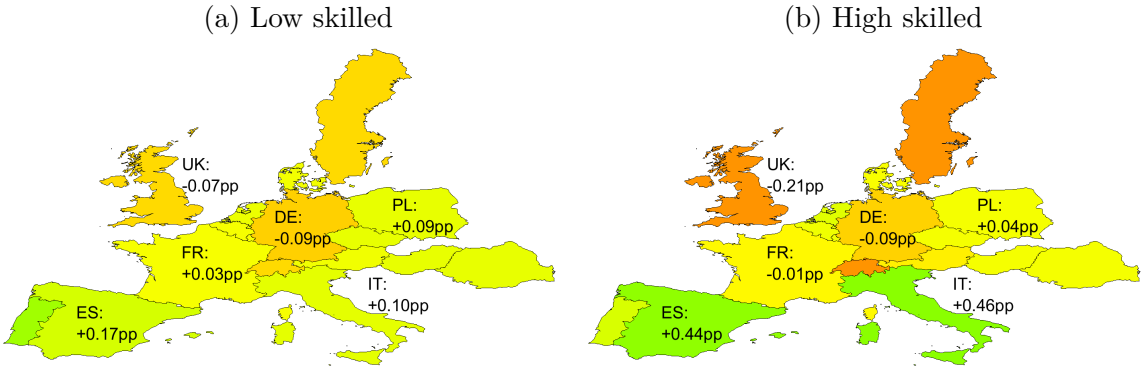
Figure 5 suggests that the distributional effects are qualitatively unaffected compared to the above results. Appendix Figure A7 further shows the transition paths of real wages and net immigration of low- and high-skilled workers in Italy following a simultaneous decrease in the demand for Italian, Portuguese and Spanish output by each 1 percent.

As before, we calculate the welfare effects of labor market integration as the difference between the (negative) welfare elasticity with respect to the shock in the full model with international migration and the (negative) elasticity obtained in a constrained model that rules out migration. The main deviation from the case where Italy alone experiences

[29]Our model predicts an 11.0pp smaller welfare gain for low- and a 19.2pp smaller welfare gain for high-skilled Italians following a 1% increase in demand for Italian output when workers can migrate vs when migration is prohibited.

a negative shock is that labor market integration has a slightly more equal effect on Italians. This is because the response in high-skilled Italian emigration is weakened through two channels. First, other adversely affected countries are no longer attractive destinations for Italian emigrants. Second, an additional outflow of high-skilled migrants from Portugal and Spain to similar destinations as those favored by high-skilled Italians (primarily France) worsens labor market prospects abroad. Together, these effects reduce the emigration incentive for high Italians, and with it the negative spillovers on low-skilled workers in Italy. Yet, high-skilled workers continue to be the main beneficiaries (Panels (b) of Figures 5 and A7).

Figure 5: Welfare effects of labor market integration following a negative 1% shock to demand for Italian, Portuguese and Spanish output.



Note: The figure shows welfare effects of labor market integration, measured as differences between steady state welfare elasticities with respect to the shock with and without migration following a permanent reduction in consumers' taste for Italian, Portuguese and Spanish output by 1 percent. Panel (a) shows welfare changes for low-skilled individuals, Panel (b) for high-skilled individuals.

6.3 Productivity Shock

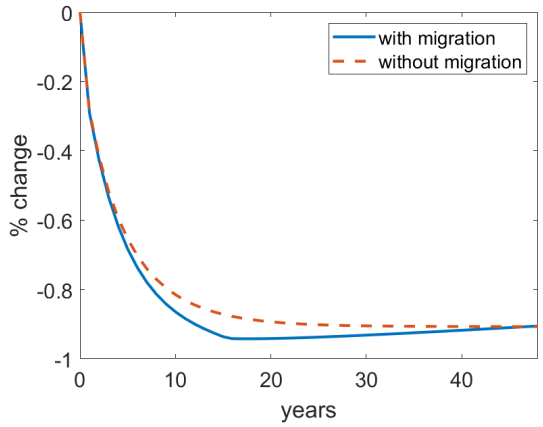
To understand the robustness of the above results to different types of shocks, we further compare them to supply and to non-permanent shocks. Figure 6 shows that the wage effects of migration following a shock to total factor productivity (TFP), lowering Italy's country-specific productivity A_j permanently by 1 percent, are qualitatively identical to those following a demand shock. This is despite the opposite effect that the two types of shock have on prices. The reason is that, irrespective of the price effects of shocks, both a decline in TFP and in demand reduce labor market tightness and the wage of new hires in Italy. The resulting emigration and the reduction in employment and production always have a positive effect on the price of Italian output.[30] Hence, although migration

[30]Note that through the bias towards consuming local goods, emigration also lowers demand for Italian output. However, given that goods are also traded, the consumption effect will never dominate the effect of production.

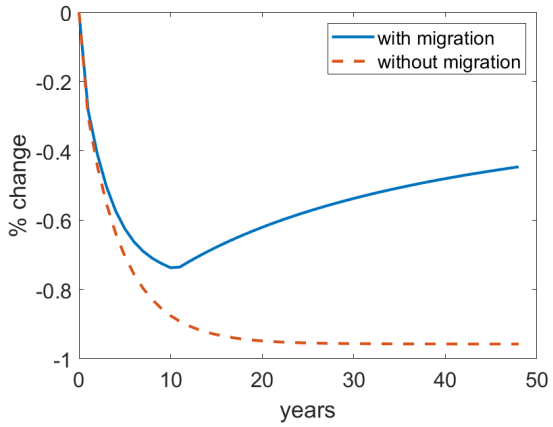
mitigates price effects of a demand shock, but amplifies price effects of a productivity shock, the direction of the price effects of emigration is the same.

Figure 6: Effects of a permanent reduction in Italian total factor productivity by 1 percent.

(a) Low-skilled real gross wage



(b) High-skilled real gross wage



Note: The figure shows transitions of real gross wages of low and high-skilled workers in Italy following a permanent reduction in Italian total factor productivity by 1 percent; blue solid lines indicate paths predicted by the full calibrated model with migration; red dashed lines compare these to a counterfactual scenario in which migration is prohibited.

Productivity shocks, however, trigger a weaker response in emigration (see Panels (a) and (b) in Appendix Figure A8), leading to a larger gain for low-skilled workers in Italy. The smaller emigration is the result of a lower incentive to emigrate as a drop in Italian productivity has negative spillovers on other countries, which see the demand for their output decline. Appendix Figure A9 reports the same measure for the welfare effects of labor market integration as above, applied to the case of a shock to Italy's TFP. Different from demand shocks, the effect on other countries overall is a negative one, although skill biased emigration of Italians to different destinations offsets the negative effect for some groups of workers.

6.4 Non-permanent shocks

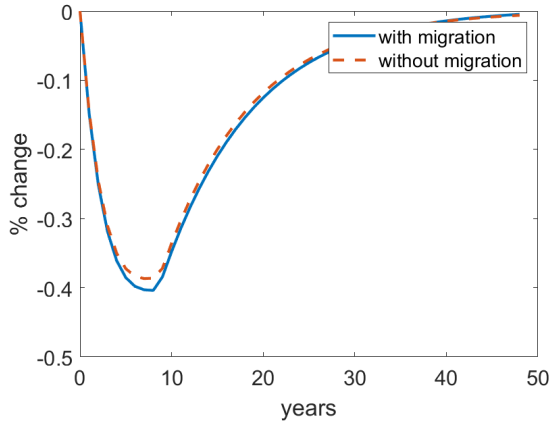
The relatively low empirical migration rates observed between European countries imply that the contribution of migration to the absorption of short-lived shocks may be limited. We show this by examining a more temporary shock that initially reduces consumers' taste for Italian output as before by 1 percent. Instead of remaining on this lower level, we now assume that demand gradually reverts back to its initial steady state, following the simple process

$$\psi_{j,j,t} = \rho_\psi \psi_{j,j,t-1} + (1 - \rho_\psi)\psi_{j,j,0}, \quad \forall t > 1 \tag{20}$$

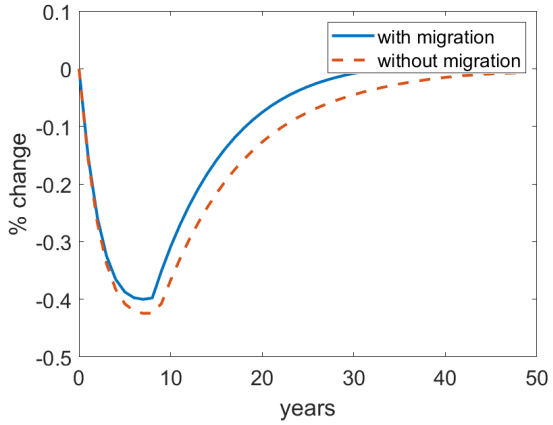
where $\psi_{j,j,0}$ is the steady state parameter pertaining to country j's (Italy's) output prior to the shock. This process follows an initial 1% reduction $\psi_{j,j,1} = 0.99\psi_{j,j,0}$ in period 1.[31] If agents foresee the path of $\psi_{j,j,t}$, the incentive for a costly migration is strongly reduced. Accordingly, while the qualitative effects are unchanged, migration becomes a much less powerful shock absorption channel, as illustrated by the wage profiles in Figure 7 for a persistence $\rho_\psi = 0.9$.[32]

Figure 7: Effects of a temporary demand shock.

(a) Low-skilled real gross wage



(b) High-skilled real gross wage



Note: The figure shows transitions of real gross wages in Italy following a temporary reduction in the demand for Italian output by 1 percent, which reverts back with persistence $\rho_\psi = 0.9$ (see equation (20)).

6.5 Welfare

Institutions and policies, such as an integration of national labor markets, determine how shocks will be absorbed, and, as our results suggest, can have major distributional consequences. In this section, we summarize these under the main types of shocks considered above, and we examine the robustness of our model's predictions to an array of variations in assumptions and parameterizations.

Like in Figures 4 and 5, Table 3 displays the welfare effects of migration calculated as the difference between the (negative) welfare elasticity with respect to the shock as predicted by the calibrated model when migration is allowed on the one hand, and the (negative) welfare elasticity as predicted by the model when migration is ruled out on the other. We show all welfare effects both as level differences between elasticities (columns 1 and 2) as described and as percentage changes (columns 3 and 4). The latter allows

[31] As with the permanent reduction in demand for a country's output, we adjust the demand parameters for all other countries to ensure $\sum_k \psi_{j,k} = \sum_k \zeta_k \psi_{j,j} = 1$.

[32] Appendix Figure A10 displays the corresponding profiles for a temporary shock 1% to Italian productivity, following a path $A_{IT,t} = \rho_A A_{IT,t-1} + (1 - \rho_A) A_{IT,0}$, where $A_{IT,0}$ is the calibrated total factor productivity in Italy and $\rho_A = 0.9$ the shock's persistence. We show welfare effects for these scenarios in Table 3.

for a better comparison of the absorption of permanent and non-permanent shocks. In addition to distinguishing effects for low- and high-skilled individuals in Italy, columns (3) and (4) of Appendix Table A10 also show the effects on workers in other euro-zone countries.

Permanent shocks. For both permanent demand and productivity shocks, migration reduces the welfare loss for high-skilled workers in Italy by 40-50% (see rows A.I and A.II of Table 3). For the less mobile workers with lower skill level, instead, labor markets integration absorbs only up to 10% of welfare losses. When weighted by their shares in the Italian work force, we obtain an aggregate welfare effect of migration of 18.7% for Italy (see also the effects for other countries in Figure 8 below). For comparison, we calibrated a model with homogeneous labor that produces each country's output through linear production functions. All other features are identical to our model presented above. From the model with homogeneous labor, we obtain a 10% stronger welfare effect of migration of 20.5%.[33] Accounting for worker heterogeneity thus not only reveals a stark inequality in the effects of migration, but also sightly reduces the overall capacity of labor mobility to contribute to asymmetric shock absorption.

Non-permanent shocks. In line with Figure 7, row (A.III) shows that already a persistence level $\rho_\psi = 0.9$ strongly reduces the contribution of migration to shock absorption for high-skilled workers in Italy by more than two thirds (13.5% vs 47% for permanent shocks). Row (A.IV) shows similar welfare effects for a non-permanent reduction in Italian TFP by 1 percent which reverts at an annual rate of 0.1 back to its steady state level. An implication of these results is that while migration can mitigate a large part of the negative labor market consequences following a persistent divergence of countries, at least for high-skilled workers, mobility in Europe appears to be too costly and on a too low level to play a major role in the absorption of shorter-term variations, such as business cycles.

Robustness. We demonstrate the robustness of results obtained from our baseline model to several variations in the model's specification. First, we predict the welfare effects of labor market integration following the baseline demand shock under alternative parameterizations of the substitutability between different types of workers. The elasticity of substitution $1/(1-\rho)$ between high and low-skilled workers is set to 4 in our baseline calibration, based on estimates by Caliendo et al. (2021). A higher substitutability reduces the spillovers from migration across worker types following a shock

[33] This alternative model thus eliminates any skill heterogeneity and replaces production function (4) with $Y_j = A_j L_j$. Absent migration, the welfare loss following a demand shock to Italian output amounts to a 1.06% reduction in discounted utility flows, very similar to the losses of 1.02% for low- and 1.09% for high-skilled Italians when we distinguish these skill groups.

Table 3: Welfare effects of migration

		(1)	(2)	(3)	(4)
		As Difference in Levels		As Percentage	
		low skilled	high skilled	low skilled	high skilled
Panel A: Baseline welfare effects					
(A.I)	Permanent demand shock	+0.077	+0.513	+7.6%	+47.0%
(A.II)	Permanent productivity shock	+0.108	+0.481	+10.5%	+43.7%
(A.III)	Non-perm. demand shock	−0.002	+0.024	−0.9%	+13.5%
(A.IV)	Non-perm. productivity shock	−0.001	+0.020	−0.8%	+12.0%
Panel B: Robustness					
(B.I)	Shock to southern Europe	+0.101	+0.457	+11.5%	+48.7%
(B.II)	Lower skill substitutability	+0.038	+0.593	+3.8%	+53.4%
(B.III)	Higher skill substitutability	+0.093	+0.465	+9.1%	+42.8%
(B.IV)	Lower goods substitutability	+0.298	+0.669	+27.9%	+58.4%
(B.V)	Higher goods substitutability	+0.002	+0.433	+0.2%	+40.7%
(B.VI)	Higher discounting	+0.002	+0.295	+0.2%	+26.7%
(B.VII)	Flexible wages	+0.068	+0.503	+6.8%	+46.7%
(B.VIII)	Without monetary policy	+0.078	+0.515	+7.7%	+47.1%

Note: The table shows the welfare effects of migration under different scenarios. Welfare effects are calculated as the difference between the (negative) welfare elasticity with respect to the shock as predicted by the calibrated model when migration is allowed and the (negative) welfare elasticity as predicted by the model when migration is ruled out. In column (3) and (4) effects are shown as percentage effects of migration (positive numbers indicate a lower loss). Rows in Panel A show effects in our calibrated model with unexpected permanent 1% drop in demand for Italian output (A.I) or Italian TFP (A.II); the same shocks reverting back at an annual rate of 10% (A.III) and (A.IV). Panel B shows variations for a permanent 1% drop in demand for Italian output when there is a simultaneous 1% drop in demand for Portuguese and Spanish output (B.I); welfare effects of migration following a permanent 1% drop in demand for Italian output when we re-calibrate the model with an elasticity of substitution between skills of 2 (B.II) and 6 (B.III), respectively; when we re-calibrate the model with an elasticity of substitution in the preference for different goods of respectively 2 (B.IV) and 6 (B.V); when re-calibrating with discounting of 4% rather than 2% (B.VI); when wages are flexible, i.e. $\omega = 0$ (B.VII); or when interest rates are fixed (B.VIII).

to the Italian economy. Yet, while this is an important parameter in our analysis, rows (B.II) and (B.III) show that our predicted effects of migration are in fact very robust when we re-calibrate the free parameters of our model after setting the skill elasticity to either 2 or 6, which approximately covers the range of estimates in the literature (see the discussion in Section 5.2).

Second, we re-calibrate the model after changing the elasticity of substitution $1/(1-\xi)$ between goods of different origins. Based on Feenstra et al. (2018), our baseline specification assumes an elasticity of substitution equal to 4. Rows (B.IV) and (B.V) show predictions from the re-calibrated model after setting the elasticity between goods to either 2 or 6. Given individuals' disproportionate preference for local output, migration out of a depressed country amplifies the decline in demand. This adverse side effect is more pronounced the more substitutable goods are, undercutting the benefits of labor market integration. However, the numbers also show that our main result—the strong shock mitigation capacity of labor market integration for high-skilled and the more modest one for low-skilled individuals—prevails.

Finally, the other rows in Panel B of Table 2 show that this conclusion is robust also to different discount factors (row B.VI), assuming full wage flexibility (B.VII), or eliminating monetary policy by assuming fixed interest rates (B.VIII).

The bigger picture. We find that accounting for worker heterogeneity does not prove wrong the aggregate positive effect of labor mobility also for those staying behind in an adversely affected country, as estimated for instance by Hauser and Seneca (2022). Yet, our very robust results indicate that gains may be smaller and in particular that the welfare gap in Italy widens following different adverse shocks.

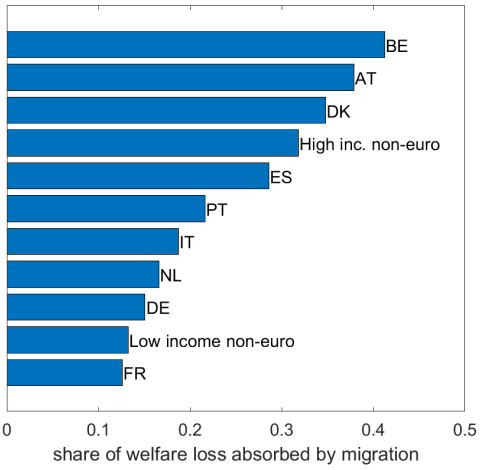
Our analysis focuses on Italy as the largest economy strongly hit by recent economic crises. Aggregating across worker types, we estimate that labor market integration mitigates 18.7% of the overall welfare loss following a permanent decline in the demand for Italian output. We repeat this calculation for each of the other locations in our model. Panel (a) of Figure 8 shows the welfare gains of labor market integration for each location when it suffers a 1% decrease in the demand for its output. Across all countries, such a shock leads to very similar welfare losses of around 1% in the country suffering the shock when migration is ruled out. While there is considerable variation in the share of this welfare loss that can be absorbed through migration, Italy is just below the mean gain across countries. Our model predicts that when weighted by the size of their labor force, the average gain across different euro-zone countries amounts to 19.6%. Including higher and lower income non-euro-zone countries, we obtain a weighted average of 20.6%. For comparison, Hauser and Seneca (2022), calibrating their model to U.S. data, predict gains in the range of 31%-96%, see Table 6 in Hauser and Seneca (2022). On the one hand, we would expect the sizable federal budget in the U.S. to make labor mobility relatively less important. On the other hand, migration within the U.S. is higher than in Europe (see

also House et al., 2018).

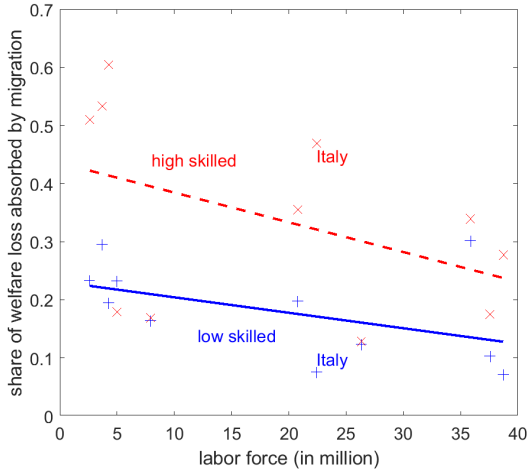
Panel (b) of Figure 8 confirms that in most countries the welfare gains of labor market integration is higher for high-skilled workers. The figure further shows that labor market integration plays a more important role for smaller countries, which—due to smaller internal labor markets—display higher international labor mobility. Appendix Figure A11 further plots gains against features of the unemployment system. It shows, first, that the option to migrate is particularly beneficial for high-skilled workers from countries with generous unemployment protection, which boosts the tax burden when unemployment rises. For low-skilled workers, who are the prime beneficiaries of unemployment protection, the relation is more muted. Second, temporary migration following a shock is less costly when job finding rates are higher. Domestic labor market institutions thus play an important role in the effects of migration on shock absorption.

Figure 8: Cross-country comparison of shock absorption through migration.

(a) By country



(b) By skill and country size



Note: Panel (a) shows, separately for each location in the model, welfare effects of labor market integration. Welfare effects are measured as the difference between aggregate steady state welfare elasticities with respect to the shock with and without migration following a permanent reduction in the demand for the respective location's output by 1 percent. Panel (b) distinguishes welfare effects for low-skilled workers (blue '+' markers and solid fitted line) and high-skilled workers (red '×' markers and dashed fitted line), and plots welfare effects against locations' labor force size.

7 Counterfactual Policy Evaluations

The uneven distribution of the benefits from labor market integration point towards a potential role for complementing policies, including re-distribution across national borders. In this section, we thus examine another margin of integration and key policies that interact with migration. First, increased fiscal integration is an equally sensitive margin of closer economic integration in the European Union, and policies such as the

NextGenerationEU recovery plan following the pandemic are steps in this direction. Second, subsidies for high-skilled immigrants have been implemented in several countries with the aim of attracting qualified workers and to counter brain drain. Finally, we examine a policy that eases geographic mobility for low-skilled workers by reducing their cost of migration.

7.1 Common Fiscal Policy

Part of the importance of labor mobility within monetary unions stems from the lack of fiscal transfers across countries. A policy that would substitute migration and which our model is suited to analyze is a transfer system that covers the burden of additional unemployment benefits in the event of an asymmetric crisis. We model this as an aggregation of the government budget constraint across all euro-zone countries for any costs that are to be paid on top of the initial steady-state level. The government budget constraint then becomes

$$\sum_{j\in euro} b_j \sum_s \sum_n (u_{j,s,n} - \bar{u}_{j,s,n}) = \tau_{extra} \sum_{j\in euro} \sum_s \sum_n \left(e_{j,s,n} w_{j,s,n} + (e_{j,s,n} + u_{j,s,n}) d_j\right), \quad (21)$$

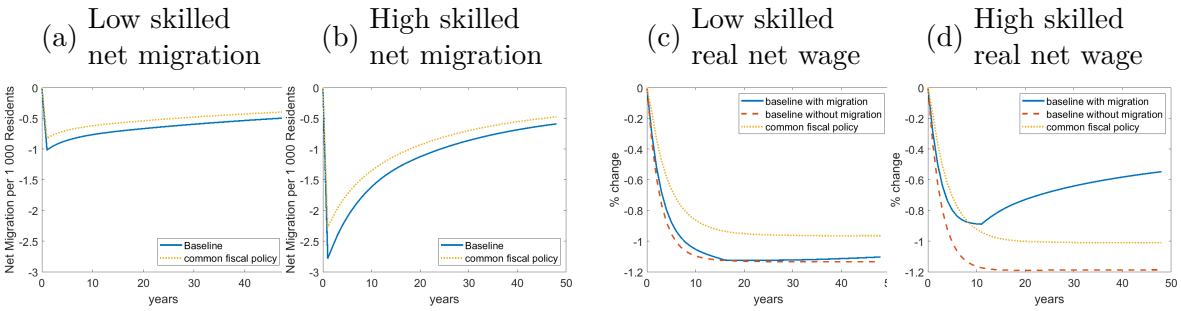
where $\bar{u}_{j,s,n}$ denotes steady state unemployment rates. That is, following a shock, each country's tax rate adjusts by τ_{extra} percentage points to satisfy the aggregate budget constraint in each period.[34]

Migration and real wages. Labor market and fiscal integration are two alternative channels for shock absorption. Since the latter unambiguously benefits the recipient country (Italy), we focus on the separate contribution of the two forms of integration to shock absorption. Figure 9 shows the evolution of net immigration and real net wages following the decrease in demand for Italian output that we considered in Section 6.1. Panels (a) and (b) show that the migration response to the shock is weaker under the fiscal transfer system (yellow dotted lines). Panels (c) and (d) display the paths of real net wages in Italy, separately for the baseline with integrated labor markets but no fiscal transfers (blue solid lines) and for a counterfactual scenario in which migration is prohibited, while the transfer system described above is in place (yellow dotted lines). As before, these can be compared to the case of when neither of the two integration margins is in place (red dashed lines). Downward rigidity of gross wages implies that the reduction in taxes primarily raises net rather than reducing gross wages when part of the tax burden is on other countries. The effect on labor market tightness and unemployment hence are comparatively small (see Appendix Figure A12). Given their low preference for

[34]Recall that whereas we use benefit levels b_j from the data, the tax rate τ_j in our model is adjusted endogenously such that budgets balance.

migration, low-skilled workers are better off with this fiscal integration than with labor market integration. For high-skilled workers, instead, the status quo with migration converges to a steady state with higher net wages than what would be obtained with only fiscal transfers as a risk sharing tool.

Figure 9: Integrated unemployment insurance.



Note: The figure shows transitions in net migration and real net wages following a permanent reduction in the demand for Italian output by 1 percent. Panels (a) show (b) net immigration to Italy in our baseline model without fiscal integration (blue solid lines) and with fiscal integration (yellow dotted); Panels (c) and (d) show real net wages in the baseline with national unemployment insurance and migration (blue solid line), with national unemployment insurance without migration (red dashed line), and with an integrated unemployment insurance but without migration (yellow dotted line).

Welfare. With migration in place, the relative welfare gains from fiscal integration are similar across skill groups, as shown in row (A.I) of Table 4: fiscal integration of the kind we consider would offset between 16% and 17% of the welfare loss for both types of workers. For other euro-zone countries, row (A.I) of Table A11 shows mildly negative welfare effects of the policy, always allowing for migration. These welfare costs are smaller than the gains to Italy even when scaling by population sizes. The reason are efficiency gains due to the reduced emigration incentive, which lowers the probability that job matches are dissolved.[35] Note, of course, that we keep the level of unemployment benefits at their current empirical level, and abstract in our counterfactual from political economy considerations, which may lead to higher benefit levels in countries that are net transfer recipients.

In row (B.I) of Table 4 we show instead the welfare effects effect of migration under the policy. That is, we repeat the calculations from row (A.I) of Table 3, but assume that the excess cost of unemployment is shared across countries as specified by (21). Rows (C.I) and (D.I) of Table 4 show outcomes following a non-permanent shock, when demand for Italian output reverts back to the steady state at an annual rate of 10%. For either type of shock, the benefits of migration for Italy are weakened when fiscal policy acts as an additional shock mitigation channel—see rows (B.I) and (D.I) of Table 4 in comparison to rows (A.I) and (A.III) of Table 3. Like the reduction in migration shown in

[35]For this cross-country comparison, welfare is evaluated at the prices of local consumption baskets.

Panels (a) and (b) of Figure 9, this suggests a substitutability between different margins of integration.

7.2 Subsidizing High-Skilled Immigration

Several countries (including Italy) subsidize—typically in form of a tax break—high-skilled immigration. Such a subsidy has an ambiguous effect on low-skilled natives, who cannot benefit directly from the policy. On the one hand, they will see their taxes increased to finance the subsidy. On the other hand, the attraction or retention of high-skilled workers raises low-skilled productivity through the production complementarity. We use our model to evaluate which of these effects dominates. Specifically, we simulate the effects of the same demand shock considered above, but Italy spending 1 percent of its public budget on a subsidy for high-skilled immigrants. The subsidy hence is substantial when the policy is concentrated among few high-skilled immigrants, but it declines when the number of high-skilled immigrants becomes larger.

Migration and real wages. We simulate a scenario where this policy is implemented with the shock. Panel (b) of Figure 10 shows a sizable increase in net high-skilled migration to Italy, a country with a comparably small stock of high-skilled immigrants. Together with the cost of the policy, the increased competition by high-skilled immigrants implies a sizable loss in real net wages for high-skilled Italians, shown in Panel (d) of the figure. For low-skilled Italians, instead, the overall effect on real net wages arising from the two counteracting channels described above is negative immediately following the shock when the additional tax burden is high, but the stock of high-skilled immigrants still builds up. In the longer run, the overall effect on real net wages turns positive, implying that the gains from the increased presence of high-skilled workers more than compensate the part of the cost of this policy that is borne by low-skilled workers.

Welfare. Calculating welfare as the sum of discounted utility flows, however, leaves a negative welfare effect of the policy also for low-skilled workers. While, as row (B.II) of Table 4 shows, a subsidy of high-skilled immigration limits the distributional impact of labor market integration, the policy itself is not welfare improving as a response to permanent shocks (row A.II). We conclude that for the question of asymmetric shock absorption, on which this paper focuses, high skill subsidies are not an effective tool.

7.3 Reducing Low-Skilled Migration Costs

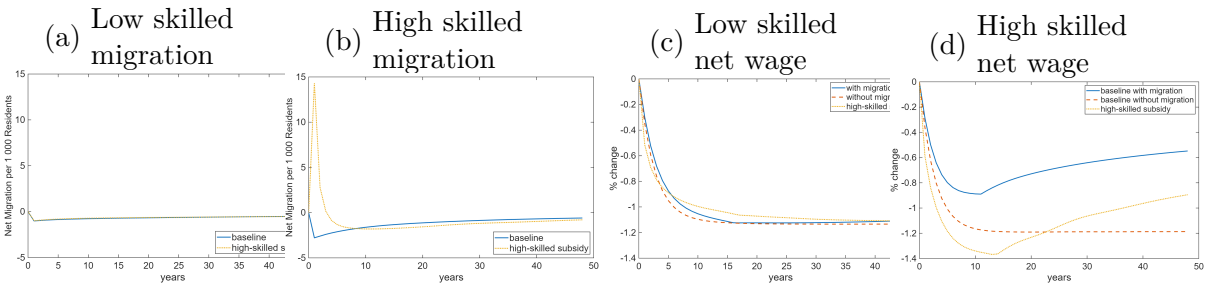
The uneven distribution of welfare gains from labor mobility also derives from different estimated migration costs, with low-skilled workers facing higher costs when moving. Similarly to the analysis for high-skilled immigration subsidies in the previous section, we

Table 4: Welfare effects for counterfactual policies

		(1)	(2)	(3)	(4)
		As Difference in Levels		As Percentage	
		low skilled	high skilled	low skilled	high skilled
Panel A: Effect of policy - permanent shock					
(A.I)	Common fiscal policy	+0.167	+0.182	+16.4%	+16.6%
(A.II)	Skilled immigration subsidy	−0.015	−0.319	−1.6%	−55.1%
(A.III)	Reduced low-skilled migr. cost	+0.123	−0.022	+13.0%	−3.9%
Panel B: Effect of migration - permanent shocks					
(B.I)	Common fiscal policy	+0.047	+0.414	+5.5%	+45.4%
(B.II)	Skilled immigration subsidy	+0.088	+0.104	+8.4%	+10.4%
(B.III)	Reduced low-skilled migr. cost	+0.200	+0.490	+19.6%	+44.9%
Panel C: Effect of policy - non-permanent shock					
(C.I)	Common fiscal policy	+0.028	+0.031	+16.1%	+17.4%
(C.II)	Skilled immigration subsidy	+0.015	−0.124	+8.6%	−81.5%
(C.III)	Reduced low-skilled migr. cost	+0.047	−0.042	+26.1%	−27.6%
Panel D: Effect of migration - non-permanent shock					
(D.I)	Common fiscal policy	−0.001	+0.020	−0.4%	+13.9%
(D.II)	Skilled immigration subsidy	+0.035	−0.084	+17.6%	−43.9%
(D.III)	Reduced low-skilled migr. cost	+0.066	−0.002	+33.3%	−1.2%

Note: The table shows the welfare effects of migration and different policies following an unexpected 1% drop in demand for Italian output. Panels A and B assume a permanent drop; Panels C and D assume a reversion of demand back to the state as in equation (20), with $\rho_\psi = 0.1$. Welfare effects of policies in columns (1) and (2) of Panels A and C are calculated as the difference between the (negative) welfare elasticity with respect to the shock when the policy is in place and the (negative) welfare elasticity as predicted by the calibrated model without the policy, migration being allowed in both cases. Welfare effects of migration in columns (1) and (2) of Panels B and D are calculated as the difference between the (negative) welfare elasticity with respect to the shock as predicted by the calibrated model when migration is allowed and the (negative) welfare elasticity as predicted by the model when migration is ruled out, the respective policy being in place in both cases. Column (3) and (4) show the effects of policies and of migration in percent. The three policies are as outlined in Sections 7.1, 7.2 and 7.3.

Figure 10: Subsidy of high-skilled immigration.



Note: The figure shows transitions between steady states in net migration and real net wages following a permanent reduction in the demand for Italian output by 1 percent, with and without a wage subsidy to high-skilled immigrants. The aggregate volume of the subsidy amounts to 1 percent of the government budget. Panels (a) show (b) net immigration to Italy in our baseline model without the subsidy (blue solid lines) and with a subsidy to high-skilled immigrants in Italy (yellow dotted); Panels (c) and (d) show real net wages in the baseline with migration but without the subsidy (blue solid lines), without migration (red dashed lines), and with a subsidy to high-skilled immigrants in Italy (yellow dotted line).

examine a counterfactual policy which lowers the cost of migration for low-skilled Italians when demand for Italian goods declines. Specifically, we assume that the migration cost for low-skilled Italians is reduced permanently to match that of high-skilled individuals. This scenario mimics policies that subsidize geographic labor mobility or provide support with initial integration—such as a recognition of foreign degrees—targeted directly or indirectly at low-skilled workers. We assume that these subsidies are financed through an increase in the income tax, and that as in the previous cases, the policy is implemented with the shock.

Migration and real wages. Panel (a) of Figure 11 shows a notable decline in net low-skilled immigration to Italy, as more low-skilled Italians find it profitable to emigrate. The reduced supply of low-skilled workers in Italy has two effects: first, it increases the wages of those who stay, due to tighter labor market conditions and reduced competition (Panel c); second, it lowers the real wages of high-skilled workers, who are complements to low-skilled labor (Panel d). A migration subsidy for low-skilled workers thus spills over to high-skilled labor. Over time, this decline in high-skilled wages further incentivizes emigration. Importantly, the direct fiscal cost of subsidizing low-skilled emigration is minimal, given the small number of people affected.[36] Hence, the observed effects are not driven by direct redistribution, but emerge from general equilibrium effects.

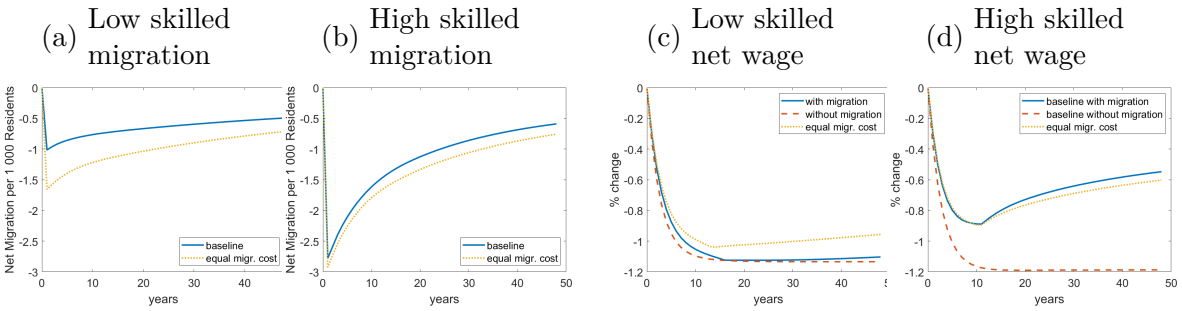
Welfare. In our baseline model, the difference in migration costs is an important reason for the difference in emigration rates following a shock. A reduction in the migration cost for low-skilled worker thus helps overcome this inequality, with implications also for the welfare effects of labor market integration. Row (B.III) of Table 4 shows

[36]The total government budget increase is less than 0.05%.

that with the subsidy, benefits of labor market integration accrue to both skill groups and are distributed more equally. The policy itself, however, has a small negative welfare effect on high-skilled workers, see Rows (A.III) and (C.III) respectively for permanent and non-permanent shocks.

Overall, the policy increases the average welfare among Italians, not least given the high benefit of migration for less-educated workers. In our rich model, the policy does not eliminate all heterogeneity in the gains from labor market integration, which remains more favorable to high-skilled individuals. However, it seems an effective tool for narrowing the gap. Panels (c) and (d) of Appendix Figure A13 show positive effect of the changing labor force composition on output per capita and the reduction in unemployment in Italy through the policy. High-skilled workers in other countries benefit from the influx of low-skilled labor, whereas low-skilled workers in destination countries suffer a rise in competition, see columns (3) and (4) of Appendix Table A11.

Figure 11: Reduction in low-skilled migration costs.



Note: The figure shows transitions between steady states in net migration and real net wages following a permanent reduction in the demand for Italian output by 1 percent, with and without a reduction in low-skilled migration costs to the level of migration costs for high-skilled workers. Panels (a) show (b) net immigration to Italy in our baseline model without the reduction (blue solid lines) and with the reduction in migration costs for low-skilled immigrants (yellow dotted); Panels (c) and (d) show real net wages in the baseline with migration but without the migration cost reduction (blue solid lines), without migration (red dashed lines), and with the reduction for low-skilled migrants (yellow dotted line).

8 Conclusion

Labor mobility is one of the pillars of the European Single Market, and an important adjustment channel when exchange rates are fixed by a common currency, while fiscal policy has not been integrated across countries (Blanchard and Katz, 1992; Boeri and Brücker, 2005; Lane, 2006). Data from the European Union Labour Force Survey show recent migrants in Europe are positively selected. These data also suggest that high-skilled workers react more strongly to changes in local unemployment.

On a theoretical level, labor market integration thus may potentially aggravate asymmetric shocks if migration is very skill biased. To examine this, we formulate a spatial

dynamic equilibrium model with search frictions in which we acknowledge the heterogeneity in productivity and mobility across workers. In particular, we allow workers to differ in terms of their preference distributions over locations and the costs they face when migrating.

Calibrating this model to labor market outcomes, migration stocks and flows across European countries, we find that labor mobility does play a positive role in mitigating the effects of an asymmetric shock. Migration hence is an important factor for the aggregate stability of a currency union. Nonetheless, since its benefits are highly heterogeneous across the workforce, other compensating policies that concur in the debate may be needed. In particular, we find that the integration of labor markets favors high-skilled workers. Fiscal policy, instead, would be to the relative advantage of lower-skilled parts of the population, but is a policy dimension that largely has been left in national hands. Our results thus speak to concerns voiced for instance by Carlin (2013) and Krugman (2013) who highlight the role of fiscal integration as an accompanying adjustment channel.

Non-migrant stayers, on whom our analysis focuses, are of primary concern to policy makers. Yet, the main beneficiaries of integrated labor markets, of course, are migrants themselves, and the aggregate economy unambiguously gains from free geographic mobility.

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Appendix

A Data Sources

This appendix lists the precise sources from which data used in the calibration were drawn.

European Union Labour Force Survey. The EU-LFS is conducted in member states of the European Union, as well as in several other countries, including Switzerland. The EU-LFS is compiled from household surveys collected by statistical institutes across Europe and contains data that are comparable across countries. We use the years 2012-2017, comprising a total of 20.8 million individuals in the countries covered by our model. We extract individuals who are aged 15+ and are either employed or unemployed. Data are publicly available. For further information, see https://doi.org/10.2907/LFS1983-2018V.1.

European Union Statistics on Income and Living Conditions. To estimate relative productivity of the skill groups in our model, we calibrate it to match the ratio of median incomes of individuals with and without a tertiary degree in the EU-SILC. These are publicly available through the Eurostat database on https://ec.europa.eu/eurostat/web/income-and-living-conditions/data/database.

Eurostat. To estimate total factor productivity, we target average gross domestic product over the years 2012-2017, taken from Eurostat's annual national accounts. Eurostat data are also used as a source for the vacancy rate in the European Union during the same years. To estimate preference parameters in the demand for different countries' goods, we target relative levels of Eurostat's harmonized index of consumer prices, as well as the ratio of import volumes to GDP taken from the OECD's statistical database (see below). Eurostat are publicly available at https://ec.europa.eu/eurostat/data/database.

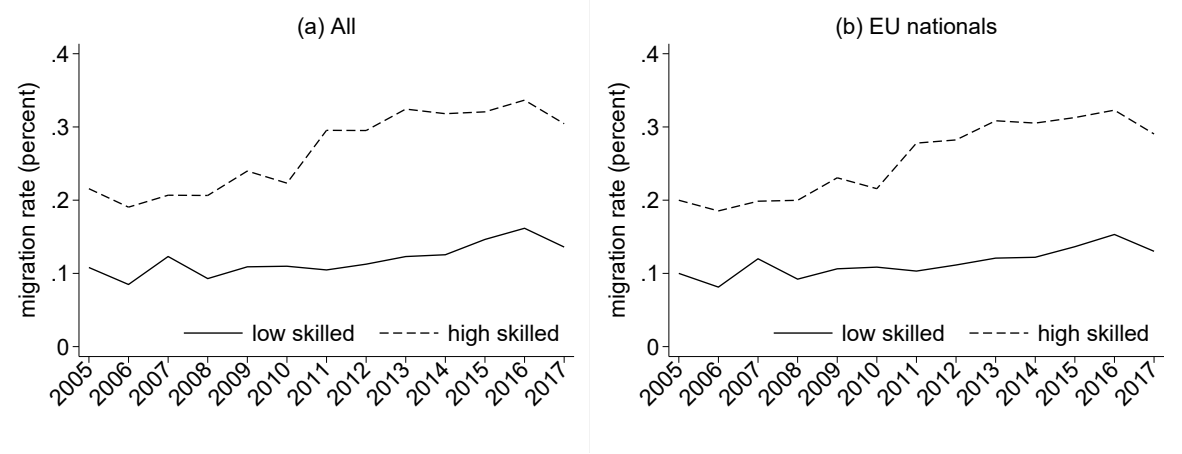
Organisation for Economic Cooperation and Development Statistical Database. We take replacement ratios for unemployment benefits in each country from the OECD. To estimate preference parameters for demand for different countries' goods, we target (besides relative levels of Eurostat's harmonized index of consumer prices, see above) import volumes in each country as a share of gross domestic product. All data are publicly available at https://stats.oecd.org/.

GeoDist Database from the Centre d'études prospectives et d'informations internationales. We account for bilateral distances in (log of) kilometers between capital cities in our calibration of migration costs, as well as for the contiguity of countries. These are compiled in the GeoDist file provided by the CEPII. For Figure 2b, we further use the indicator for a common official language being used by two countries, which is part of the same dataset. These data are publicly available through http://www.cepii.fr, see Mayer and Zignago (2011b) for further details.

B Descriptive evidence

We use European Union Labour Force Survey data to compute the number of year-to-year migrants relative to their origin country population, separately for individuals with and without tertiary education.[37] Figure A1 shows a more than twice as high migration rate for tertiary educated individuals compared to less educated ones, irrespective of whether all or only European nationals are considered. While our model considers the two skill groups displayed in the figure, the skill bias in migration applies to finer levels as well. If we split the lower-educated group into those with up to lower-secondary and those with upper-secondary education, migration rates increase across all education levels.[38] Figure A2 further confirms that the aggregate skill bias in migration displayed in Figure A1 is observed for migration flows from virtually any country covered by the EU-LFS.

Figure A1: Migration rates by education level.



Note: Individuals residing in a country different from their country of residence one year ago, relative to the overall population, using EU-LFS sampling weights. The figure distinguishes low-skilled individuals without tertiary education (solid lines) and high-skilled individuals with at least some tertiary education (dashed lines). Panel (a) includes individuals of any origin, whereas panel (b) considers only European Union nationals. Source: European Union Labour Force Survey.

[37] We considered workers "high skilled" if they possess at least an undergraduate degree.

[38] For the years shown in Figure A1, aggregate migration rates are 0.08% for up to lower-secondary, 0.15% for upper-secondary, and 0.28% for tertiary educated individuals, which are the three education groups distinguished in the EU-LFS.

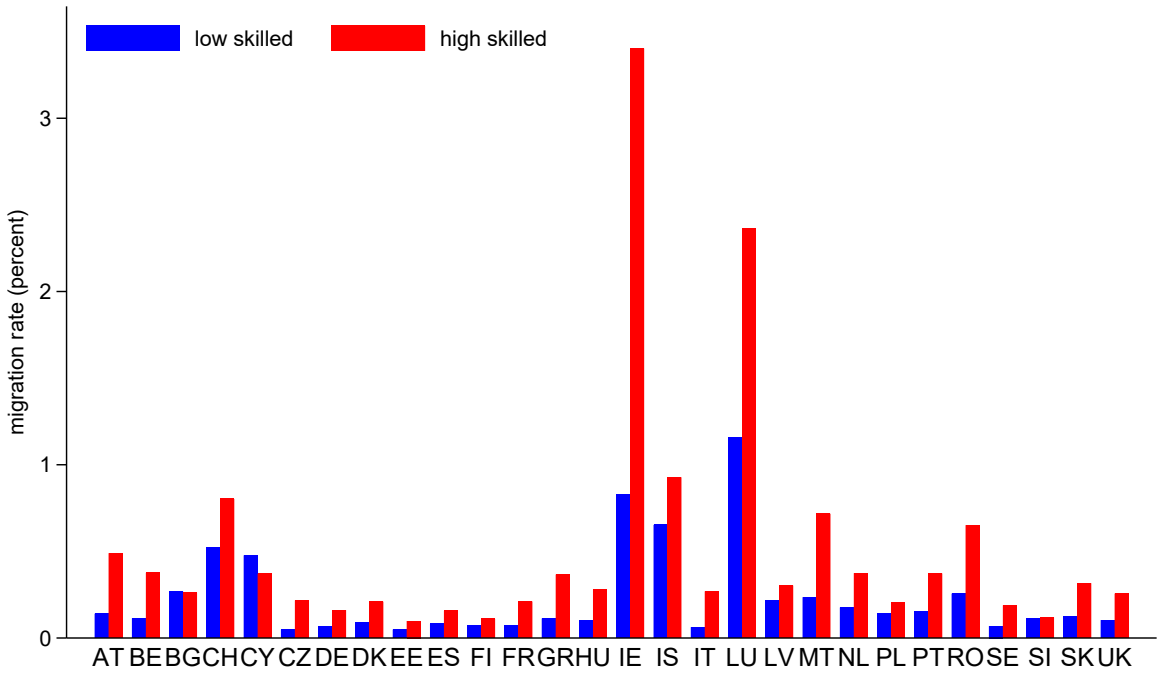
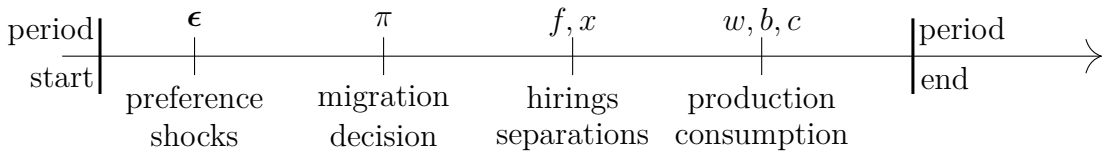


Figure A2: Individuals residing in a country different from their country of residence one year ago, shown as a percentage of the population of previous year's country of residence. The figure distinguishes low-skilled individuals without tertiary education (in blue) and high-skilled individuals with at least some tertiary education (in red). Source: European Union Labour Force Survey 2005-2017.

C Model Timing

Figure A3: Assumed timing within each period in the model.



D Calibration

In this appendix we provide details on the calibration of model parameters. We first describe all externally set parameters, taken from the literature, before explaining the joint calibration of the remaining parameters.

D.1 Externally Set Parameters

Discount Factor. In the calibration, a time period is taken to be one year, and we assume an annual interest rate of 2%, which implies a discount factor of 0.9804. Tables 3 and A10 display the main results also for an annual rate of 4%.

Elasticity of consumption goods. We set the elasticity parameter in the CES part of consumers' utility function (1) to $\xi = 0.75$. This yields an elasticity of substitution between national goods of 4, in line with estimates by Feenstra et al. (2018). Tables 3 and A10 display the main results also from a re-calibrated model when elasticities of substitution between consumption goods are set to 2 or 6.

Elasticity of substitution between high- and low-educated workers. The elasticity parameter in the production function (4) is set to $\rho = 0.75$, implying an elasticity of substitution between workers of different types equal to 4. This is the value estimated by Caliendo et al. (2021) using Portuguese matched employer-employee data. Tables 3 and A10 display the main results also from a re-calibrated model when elasticities of substitution between workers are set to 2 or 6.

Unemployment benefit. We use the net replacement ratio of unemployment benefits collected by the OECD for different worker categories. We use the replacement ratio calculated for single workers without children who have been unemployed for 6 months and earned a previous wage equal to 2/3 the average wage. We then calculate the average replacement ratio reported for our sample period (2012-2017) for each country, and set the unemployment benefit in each country to this replacement ratio times the equilibrium wage for low-skilled workers.

Matching function and bargaining power. We take the unemployment coefficient in the matching function from the estimation by Shimer (2005), borrowed also by House et al. (2018), and hence set $\eta = 0.72$. Vacancy cost $\kappa_{j,s}$ and matching efficiency ς are jointly identified by unemployment and vacancy rates. We thus target both the mean vacancy rate in the European Union reported by Eurostat for the years 2012-2017 and country and skill specific unemployment rates calculated from the EU-LFS. As it common in the literature (Hosios, 1990; Mortensen and Pissarides, 1999), we set the bargaining power of the worker equal to the elasticity of the matching function with respect to unemployment, $\beta = 0.72$.

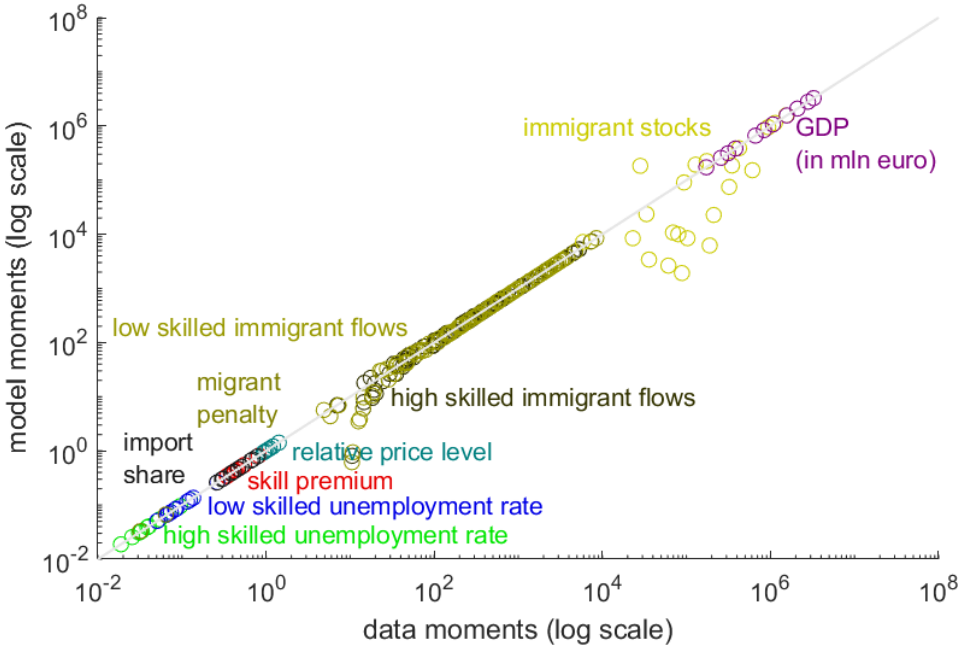
Separation rates. We use the European Union Labour Force Survey to compute yearly employment-to-unemployment transition rates separately for high- and low-educated workers, based on respondents' employment status in the previous year. For each skill level and country analyzed, we compute the average of these transition rates for the years considered, and use these as the exogenous separation rates in our model.

Taylor-rule parameters We follow House et al. (2018) and Nakamura and Steinsson (2014), who set persistence in the Taylor-rule to 0.75 using quarterly data. Since in our model a period is one year, we set ρ to 0.75^4, in order to capture a similar amount of stickiness. We set $\phi_y = 0.5$ and $\phi_p = 1.5$ as in House et al. (2018).

D.2 Jointly Estimated Parameters and Targeted Moments

Figure A4 visualizes the overall fit of the model, whereas Figure A5 shows the correlations between unemployment and emigration, which are not targeted. Tables A1-A9 shows the fit to individual moments.

Figure A4: Model fit.



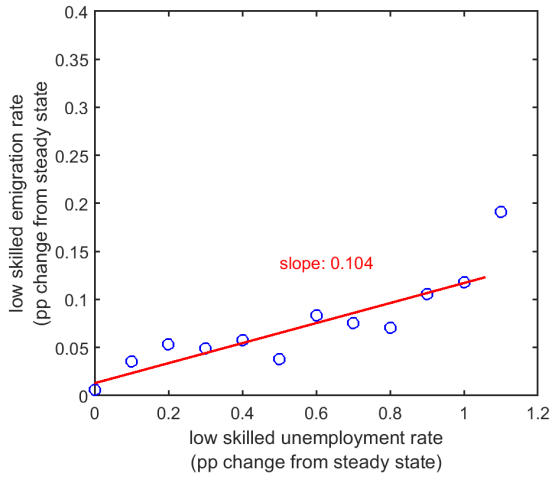
Note: The figure plots moments predicted by the model against their empirical counterparts. Since moments are measured in different units, we normalize them by their empirical standard deviation.

	Target	Model
GDP AT	313,276	313,330
GDP BE	382,537	382,559
GDP DE	2,793,109	2,793,367
GDP DK	257,628	257,672
GDP ES	1,069,143	1,069,356
GDP FR	2,095,771	2,095,693
GDP IT	1,564,054	1,563,991
GDP NL	662,271	662,255
GDP PT	172,392	172,445
GDP Rich	3,262,022	3,260,995
GDP Poor	837,226	837,338

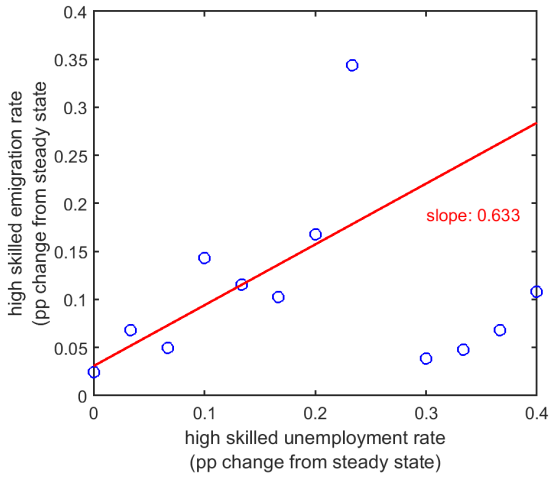
Table A1: Model fit: GDP (in millions of euros).

Figure A5: Non-targeted relation between emigration and unemployment rates.

(a) Low skilled



(b) High skilled



Note: The figure shows correlations between unemployment and emigration rates predicted by the model. Simulated data consist of changes in unemployment rates and migration rates following shocks which, in turn, decrease demand for each country's output by 1%. Each country is exposed to shocks that revert back as in equation (20), with persistencies $\rho_\psi \in \{0.9, 0.91, ..., 1\}$, creating a dataset of $11 \times J$ data points per skill. Circles show conditional means of changes in emigration rates, within bins of unemployment rate changes, each compared to the steady state. Lines indicate the linear fit to country-shock persistence observations. Panel (a) shows the relation for individuals without, Panel (b) for those with tertiary education.

	Target	Model
Skill Premium AT	1.340	1.340
Skill Premium BE	1.432	1.432
Skill Premium DE	1.510	1.510
Skill Premium DK	1.348	1.348
Skill Premium ES	1.549	1.549
Skill Premium FR	1.422	1.422
Skill Premium IT	1.416	1.416
Skill Premium NL	1.455	1.455
Skill Premium PT	1.381	1.381
Skill Premium Rich	1.386	1.386
Skill Premium Poor	1.820	1.820

Table A2: Model fit: Skill premium for tertiary educated workers.

	AT	BE	DE	DK	ES	FR	IT	NL	PT	Rich	Poor
AT	0.031	0.813	0.004	0.055	0.064	0.073	0.006	0.001	0.153	2.630	
	0	*0.024*	*0.822*	*0.013*	*0.048*	*0.056*	*0.079*	*0.014*	*0*	*0.152*	*2.640*
BE	0.010	0	0.280	0.001	0.582	1.564	0.331	0.501	0.193	0.121	0.709
	0.014	*0*	*0.287*	*0.011*	*0.590*	*1.574*	*0.340*	*0.511*	*0.201*	*0.116*	*0.712*
DE	3.007	0.573	0	0.601	3.219	2.872	1.398	2.277	0.473	2.621	8.474
	3.014	*0.581*	*0*	*0.604*	*3.222*	*2.882*	*1.391*	*2.286*	*0.472*	*2.630*	*8.482*
DK	0.146	0.070	0.335	0	0.434	0.253	0.073	0.070	0.042	0.155	0.304
	0.154	*0.072*	*0.345*	*0*	*0.440*	*0.259*	*0.069*	*0.036*	*0.155*	*0.842*	*0.313*
ES	0.001	0.173	0.902	0.203	0	0.801	0.319	0.138	0.236	3.408	1.000
	0.000	*0.181*	*0.911*	*0.211*	*0*	*0.811*	*0.327*	*0.145*	*0.243*	*3.400*	*0.992*
FR	0.044	1.677	2.078	0.214	0.791	0	0.704	0.255	0.482	1.827	0.956
	0.047	*1.686*	*2.087*	*0.219*	*0.800*	*0*	*0.714*	*0.260*	*0.484*	*1.837*	*0.959*
IT	0.021	0.102	0.283	0.001	0.103	0.193	0	0.012	0.001	0.888	2.252
	0.029	*0.111*	*0.287*	*0.000*	*0.100*	*0.194*	*0*	*0.019*	*0.000*	*0.894*	*2.245*
NL	0.125	3.243	3.223	0.033	0.001	0.148	0.036	0	0.006	0.298	2.393
	0.133	*3.242*	*3.227*	*0.028*	*0.000*	*0.144*	*0.035*	*0*	*0.005*	*0.306*	*2.398*
PT	0.001	0.150	0.379	0.007	0.461	2.745	0.011	0.566	0	0.436	0.061
	0.000	*0.147*	*0.384*	*0.007*	*0.471*	*2.740*	*0.018*	*0.557*	*0*	*0.444*	*0.062*
Rich	0.206	0.041	3.842	0.845	1.960	4.811	0.214	0.001	1.188	0	7.278
	0.215	*0.047*	*3.838*	*0.843*	*1.969*	*4.806*	*0.220*	*0.000*	*1.197*	*0*	*7.286*
Poor	0.026	0.030	1.269	0.037	0.096	0.001	0.004	0.001	0.004	0.001	0
	0.033	*0.023*	*1.279*	*0.039*	*0.086*	*0.000*	*0.013*	*0.000*	*0.006*	*0.011*	*0*

Table A3: Model fit: Annual emigration flows for low-skilled individuals in thousands; model predictions compared to *observed targets in italics*. Rows are receiving countries, columns are sending countries.

	AT	BE	DE	DK	ES	FR	IT	NL	PT	Rich	Poor
AT	0	0.046	0.744	0.013	0.084	0.019	0.053	0.048	0.001	0.090	0.329
	0	*0.046*	*0.753*	*0.019*	*0.076*	*0.024*	*0.057*	*0.050*	*0.000*	*0.097*	*0.339*
BE	0.072	0	0.517	0.057	0.251	1.071	0.058	0.295	0.001	0.373	0.586
	0.065	*0*	*0.527*	*0.051*	*0.248*	*1.081*	*0.050*	*0.302*	*0.000*	*0.371*	*0.591*
DE	2.238	0.418	0	0.379	1.126	1.414	0.650	1.368	0.162	2.817	1.743
	2.244	*0.428*	*0*	*0.389*	*1.115*	*1.423*	*0.643*	*1.377*	*0.171*	*2.825*	*1.753*
DK	0.051	0.101	0.152	0	0.140	0.150	0.108	0.136	0.001	0.266	0.007
	0.044	*0.108*	*0.156*	*0*	*0.133*	*0.142*	*0.104*	*0.141*	*0.000*	*0.271*	*0.007*
ES	0.430	0.352	1.677	0.012	0	1.112	0.472	0.026	0.260	2.089	0.248
	0.428	*0.356*	*1.686*	*0.020*	*0*	*1.122*	*0.472*	*0.035*	*0.270*	*2.091*	*0.256*
FR	0.265	5.239	3.586	0.351	2.136	0	2.313	0.370	0.001	2.202	0.558
	0.274	*5.238*	*3.592*	*0.355*	*2.144*	*0*	*2.324*	*0.375*	*0.000*	*2.210*	*0.568*
IT	0.087	0.001	0.287	0.008	0.050	0.036	0	0.027	0.018	0.708	0.327
	0.096	*0.000*	*0.286*	*0.015*	*0.047*	*0.042*	*0*	*0.029*	*0.020*	*0.715*	*0.334*
NL	0.246	1.596	1.989	0.038	0.217	0.217	0.001	0	0.007	0.610	0.644
	0.255	*1.603*	*1.995*	*0.035*	*0.215*	*0.210*	*0.011*	*0*	*0.007*	*0.618*	*0.653*
PT	0.001	0.018	0.223	0.010	0.287	0.306	0.110	0.233	0	0.634	0.121
	0.000	*0.015*	*0.214*	*0.018*	*0.292*	*0.297*	*0.101*	*0.224*	*0*	*0.628*	*0.121*
Rich	0.276	0.211	5.285	0.505	4.643	7.398	0.150	0.001	0.563	0	4.442
	0.286	*0.218*	*5.296*	*0.510*	*4.652*	*7.413*	*0.158*	*0.000*	*0.561*	*0*	*4.448*
Poor	0.006	0.022	0.690	0.085	0.539	0.305	0.001	0.001	0.041	0.259	0
	0.014	*0.018*	*0.700*	*0.077*	*0.540*	*0.295*	*0.000*	*0.000*	*0.033*	*0.250*	*0*

Table A4: Model fit: Annual emigration flows for high-skilled individuals in thousands; model predictions compared to *observed targets in italics*. Rows are receiving countries, columns are sending countries.

	Target (%)	Model (%)
AT	5.10	5.10
BE	8.55	8.54
DE	5.07	5.07
DK	6.59	6.59
ES	26.34	26.34
FR	11.51	11.51
IT	12.37	12.37
NL	6.96	6.96
PT	13.57	13.57
Rich	7.36	7.36
Poor	8.27	8.27

Table A5: Model fit: Unemployment rates for low-skilled individuals.

	Target (%)	Model (%)
AT	2.55	2.55
BE	3.32	3.31
DE	1.88	1.89
DK	4.03	4.03
ES	12.48	12.48
FR	5.41	5.41
IT	6.49	6.49
NL	3.20	3.20
PT	9.52	9.52
Rich	3.09	3.09
Poor	3.87	3.87

Table A6: Model fit: Unemployment rates for high-skilled individuals.

	Target Unskilled	Model Unskilled	Target Skilled	Model Skilled
AT	0.189	0.006	0.089	0.002
BE	0.211	0.023	0.103	0.008
DE	1.130	1.135	0.349	0.186
DK	0.080	0.010	0.036	0.003
ES	0.423	0.388	0.175	0.224
FR	0.322	0.075	0.129	0.193
IT	0.609	0.152	0.069	0.011
NL	0.094	0.090	0.034	0.024
PT	0.028	0.183	0.006	0.007
Rich	1.545	1.572	0.942	0.948
Poor	0.061	0.003	0.023	0.008

Table A7: Model fit: Total stock of migrants (in millions).

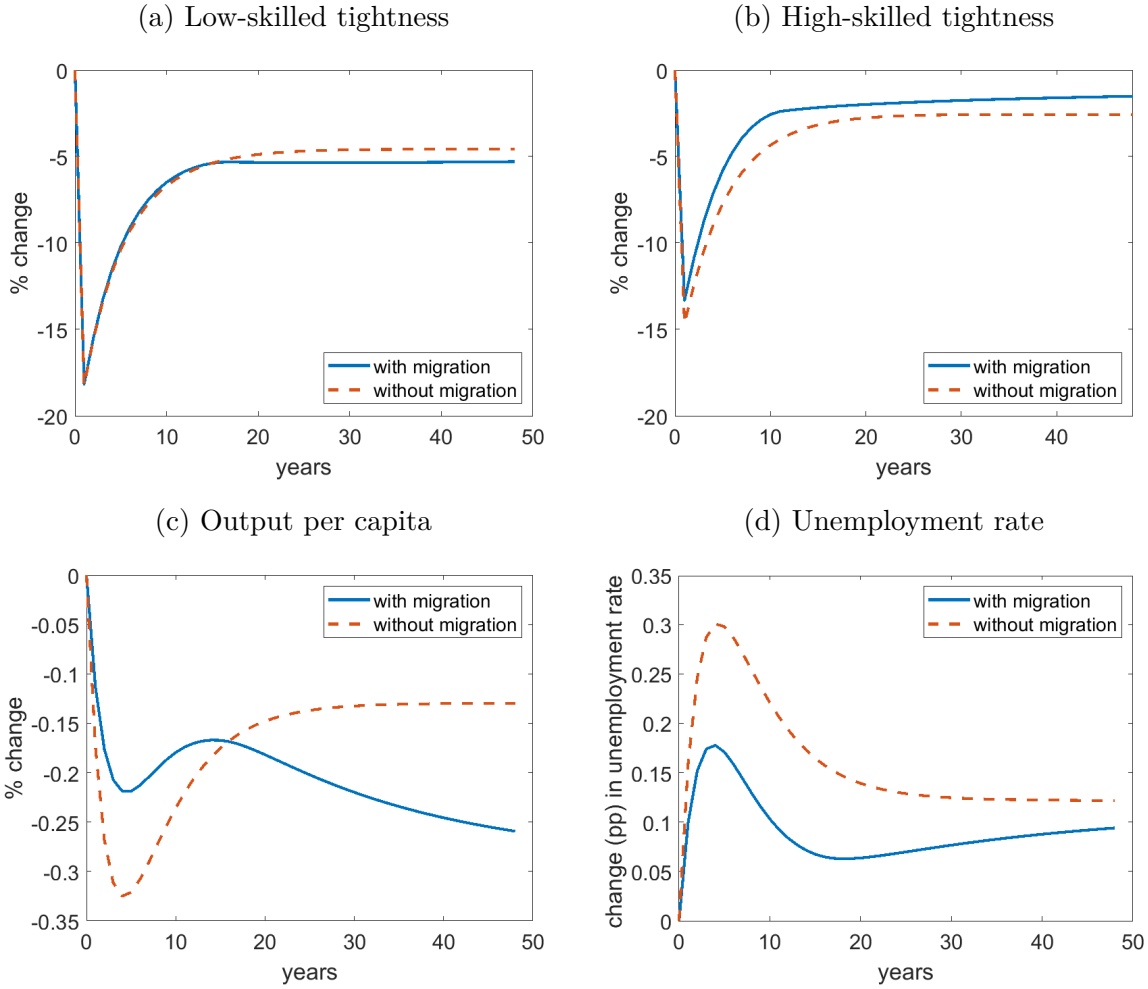
	Target	Model
AT	1.21	1.21
BE	1.10	1.11
DE	1.05	1.05
DK	1.42	1.42
ES	0.93	0.93
FR	1.10	1.10
IT	1.11	1.11
NL	0.98	0.98
PT	0.94	0.94
Rich	1.21	1.21
Poor	0.70	0.70

Table A8: Model fit: Price level (1 corresponds to the average price level in the EU28).

	Target	Model
Unskilled	0.9358	0.9334
Skilled	0.9682	0.9672

Table A9: Model fit: Migrant wage penalty (median immigrant wage over median native wage)

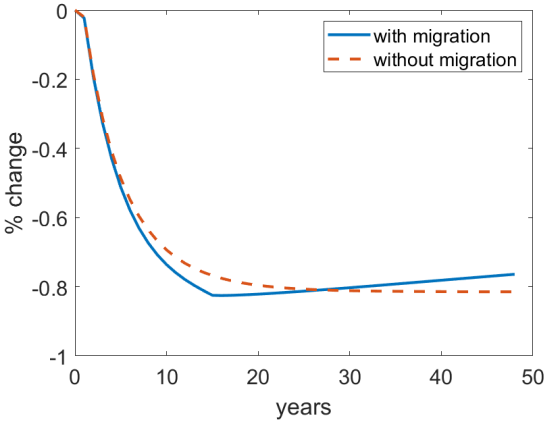
Figure A6: Effects of a permanent reduction in the taste for Italian output by 1 percent.



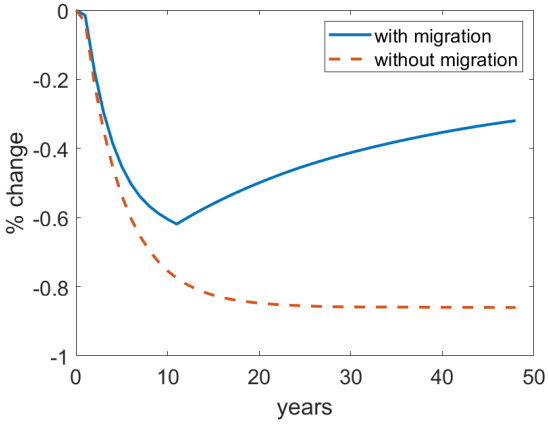
Note: The figure shows transitions of outcomes following a permanent reduction in consumers' taste for Italian output by 1 percent. Panels (a) and (b) show labor market tightness for low- and high-skilled workers; Panel (c) shows changes in output per capita, Panel (d) changes in the unemployment rate; blue solid lines indicate paths predicted by the full calibrated model with migration; red dashed lines compare these to a counterfactual scenario in which migration is prohibited.

Figure A7: Effects of a permanent reduction in demand for southern European output by 1 percent.

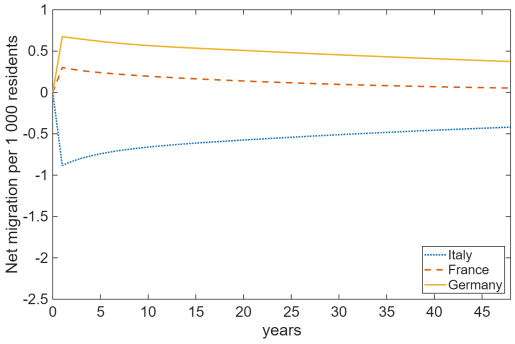
(a) Low-skilled real wage



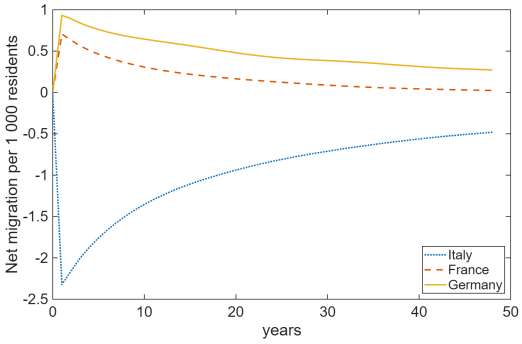
(b) High-skilled real wage



(c) Low-skilled net immigration



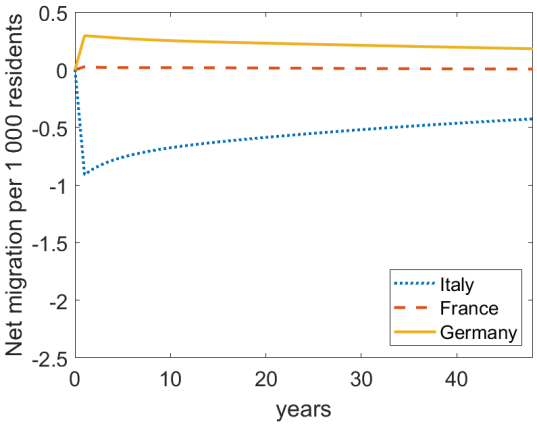
(d) High-skilled net immigration



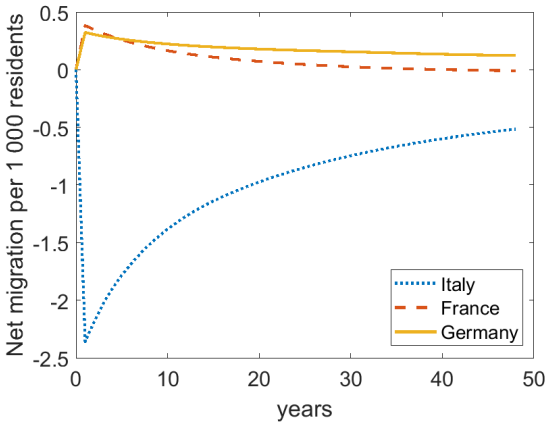
Note: The figure shows net immigration by low- and high-skilled workers from Italy (blue dotted line) following a permanent reduction in demand for Italian, Spanish and Portuguese output by 1 percent, as well as net immigration to the main destinations France (red dashed) and Germany (yellow solid).

Figure A8: Effects of a permanent reduction in Italian total factor productivity by 1 percent.

(a) Low-skilled net immigration



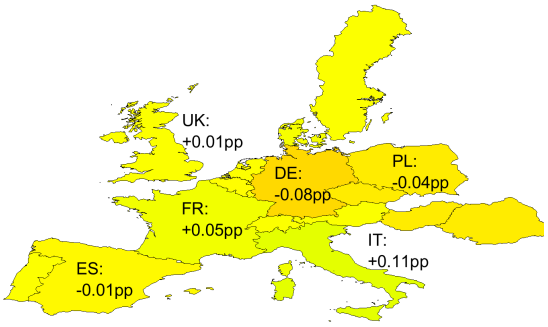
(b) High-skilled net immigration



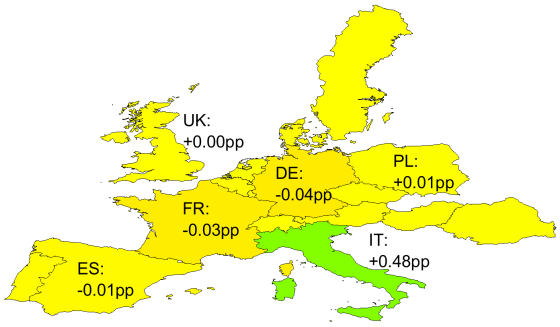
Note: The figure shows net immigration by low- and high-skilled workers from Italy (blue dotted line) following a permanent reduction in Italian total factor productivity by 1 percent, as well as net immigration to the main destinations France (red dashed) and Germany (yellow solid).

Figure A9: Welfare effects of labor market integration following a negative 1% shock to Italian total factor productivity.

(a) Low skilled



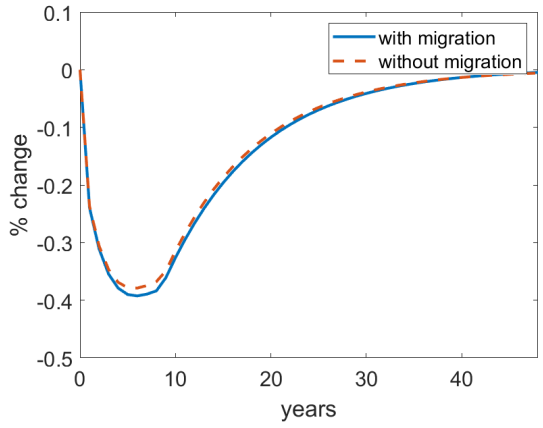
(b) High skilled



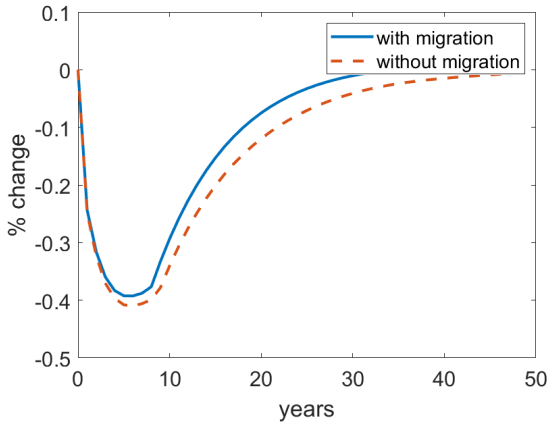
Note: The figure shows welfare effects of labor market integration, measured as differences between steady state welfare elasticity with respect to the shock with and without migration following a permanent reduction in Italian total factor productivity by 1 percent. Panel (a) shows welfare effects for low-skilled individuals, Panel (b) for high-skilled individuals.

Figure A10: Effects of a temporary productivity shock.

(a) Low-skilled real gross wage



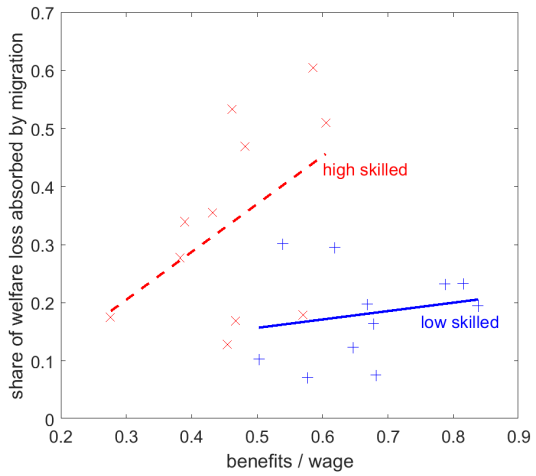
(b) High-skilled real gross wage



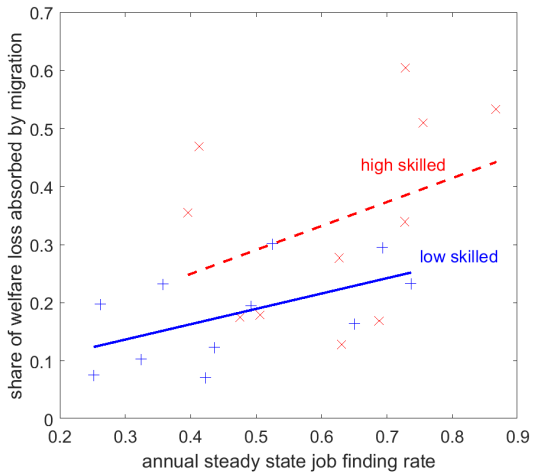
Note: The figure shows transitions for real gross wages in Italy following a temporary reduction in Italian total factor productivity by 1 percent, which reverts back with persistence $\rho_A = 0.9$ (see footnote 32).

Figure A11: Shock absorption by unemployment benefits and job finding rates.

(a) By replacement ratio



(b) By job finding rate



Note: The figure shows, separately for each location in the model, welfare effects of labor market integration for low-skilled workers (blue '+' markers and solid fitted line) and high-skilled workers (red '×' markers and dashed fitted line). Welfare effects are measured as the difference between aggregate steady state welfare elasticities with respect to the shock with and without migration following a permanent reduction in the demand for the respective location's output by 1 percent. Panel (a) plots welfare effects against steady state ratios of unemployment benefits and gross wages. Panel (b) plots welfare effects against steady state job finding rates.

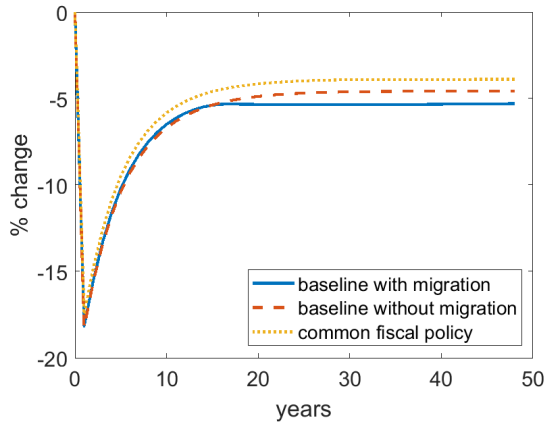
Table A10: Welfare effects of migration

		(1)	(2)	(3)	(4)
		Italian workers		Other euro-zone workers	
		low skilled	high skilled	low skilled	high skilled
Panel A: Baseline welfare effects					
(A.I)	Permanent demand shock	+0.077	+0.513	−0.014	−0.011
(A.II)	Permanent productivity shock	+0.108	+0.481	−0.015	−0.013
(A.III)	Non-perm. demand shock	−0.002	+0.024	+0.000	−0.002
(A.IV)	Non-perm. productivity shock	−0.001	+0.020	+0.000	−0.002
Panel B: Robustness					
(B.I)	Shock to southern Europe	+0.101	+0.457	+0.028	+0.012
(B.II)	Lower skill substitutability	+0.038	+0.593	−0.025	+0.010
(B.III)	Higher skill substitutability	+0.093	+0.465	−0.007	−0.012
(B.IV)	Lower goods substitutability	+0.298	+0.669	−0.039	−0.031
(B.V)	Higher goods substitutability	+0.002	+0.433	−0.003	−0.002
(B.VI)	Higher discounting	+0.002	+0.295	+0.001	−0.012
(B.VII)	Flexible wages	+0.068	+0.503	−0.014	−0.010
(B.VIII)	Without monetary policy	+0.078	+0.515	−0.014	−0.008

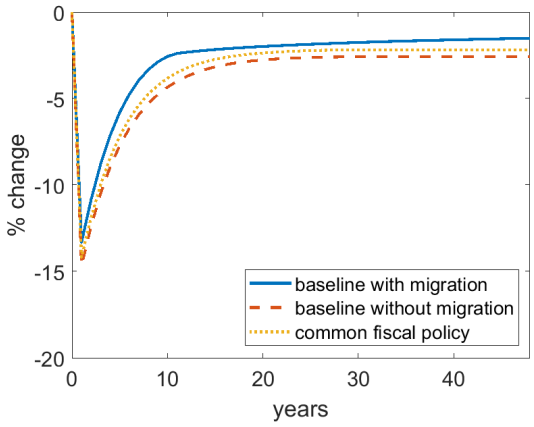
Note: The table shows the welfare effects of migration under different scenarios. Welfare effects are calculated as the difference between the (negative) welfare elasticity with respect to the shock as predicted by the calibrated model when migration is allowed and the (negative) welfare elasticity as predicted by the model when migration is ruled out. Effects are shown separately for Italian and other euro-zone workers without and with tertiary education. Rows in Panel A show effects in our calibrated model with unexpected permanent 1% drops in demand for Italian output (A.I) or Italian TFP (A.II); the same shocks reverting back at a rate of 10% (A.III) and (A.IV). Panel B shows variations for a permanent 1% drop in demand for Italian output when there is a simultaneous 1% drop in demand for Portuguese and Spanish output (B.I); welfare effects of migration following a permanent 1% drop in demand for Italian output when we re-calibrate the model with an elasticity of substitution between skills of 2 (B.II) and 6 (B.III), respectively; when we re-calibrate the model with an elasticity of substitution of respectively 2 (B.IV) and 6 (B.V) in the preference for different goods; when re-calibrating with discounting by 4% rather than 2% (B.VI); when wages are flexible, i.e. $\omega = 0$ (B.VII); or when interest rates are fixed (B.VIII).

Figure A12: Other outcomes with an integrated unemployment insurance

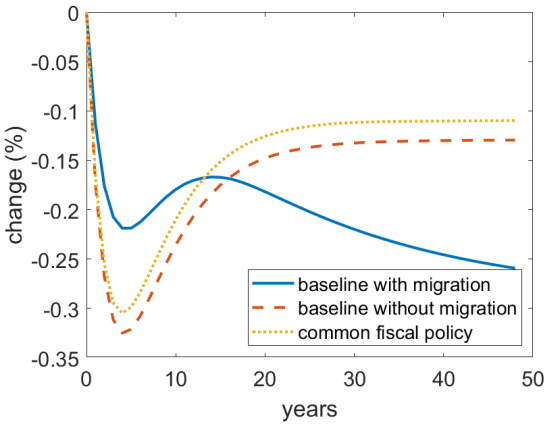
(a) Low-skilled tightness



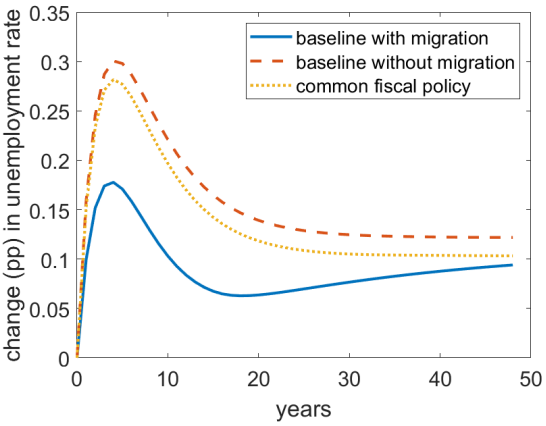
(b) High-skilled tightness



(c) Output per capita

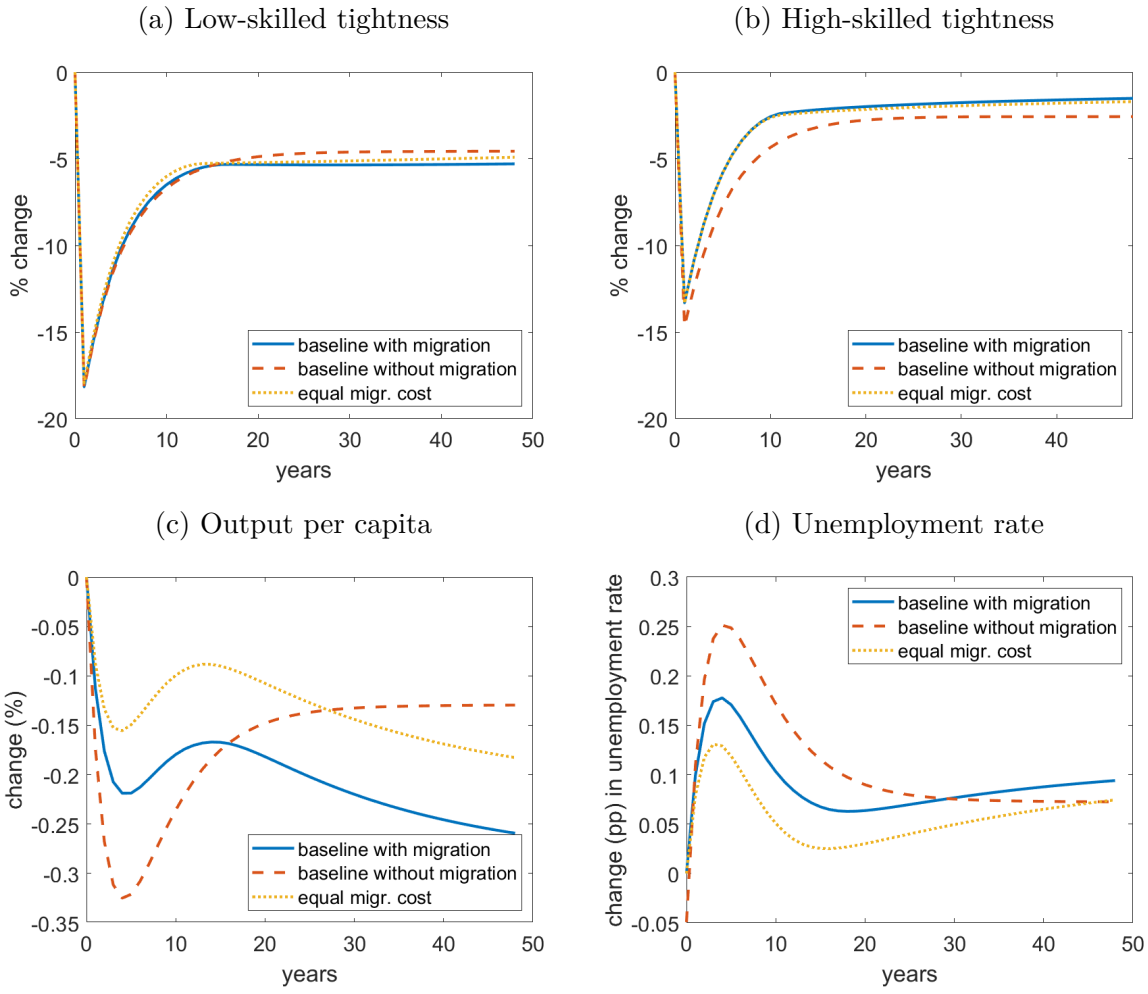


(d) Unemployment rate



Note: The figure shows transitions of outcomes following a permanent reduction in consumers' taste for Italian output by 1 percent. Panels (a) and (b) show labor market tightness for low- and high-skilled workers; Panel (c) shows changes in output per capita, Panel (d) changes in the unemployment rate; blue solid lines indicate paths predicted by the full calibrated model with migration and national unemployment insurance; red dashed lines compare these to a counterfactual scenario in which migration is prohibited; yellow dotted lines show paths without migration, but with an integrated unemployment insurance.

Figure A13: Other outcomes with reduction in low-skilled migration costs



Note: The figure shows transitions of outcomes following a permanent reduction in consumers' taste for Italian output by 1 percent. Panels (a) and (b) show labor market tightness for low- and high-skilled workers; Panel (c) shows changes in output per capita, Panel (d) changes in the unemployment rate; blue solid lines indicate paths predicted by the full calibrated model; red dashed lines compare these to a counterfactual scenario in which migration is prohibited; yellow dotted lines show paths if low-skilled migration costs are reduced to the level of migration costs for high-skilled workers.

Table A11: Welfare effects for counterfactual policies

		(1)	(2)	(3)	(4)
		Italian workers		Other euro-zone workers	
		low skilled	high skilled	low skilled	high skilled
Panel A: Effect of policy - permanent shock					
(A.I)	Common fiscal policy	+0.167	+0.182	-0.011	-0.013
(A.II)	Skilled immigration subsidy	-0.015	-0.319	-0.013	+0.023
(A.III)	Reduced low-skilled migr. cost	+0.123	-0.022	-0.017	+0.004
Panel B: Effect of migration - permanent shocks					
(B.I)	Common fiscal policy	+0.047	+0.414	+0.003	+0.004
(B.II)	Skilled immigration subsidy	+0.088	+0.104	-0.029	+0.014
(B.III)	Reduced low-skilled migr. cost	+0.200	+0.490	-0.031	-0.007
Panel C: Effect of policy - non-permanent shock					
(C.I)	Common fiscal policy	+0.028	+0.031	-0.002	-0.002
(C.II)	Skilled immigration subsidy	+0.015	-0.124	-0.005	+0.010
(C.III)	Reduced low-skilled migr. cost	+0.047	-0.042	-0.012	+0.004
Panel D: Effect of migration - non-permanent shock					
(D.I)	Common fiscal policy	-0.001	+0.020	+0.001	-0.001
(D.II)	Skilled immigration subsidy	+0.035	-0.084	+0.002	+0.014
(D.III)	Reduced low-skilled migr. cost	+0.066	-0.002	+0.046	+0.011

Note: The table shows the welfare effects of migration and different policies following an unexpected 1% drop in demand for Italian output. Panels A and B assume a permanent drop; Panels C and D assume a reversion of demand back to the state as in equation (20), with $\rho_\psi = 0.1$. Welfare effects of policies in Panels A and C are calculated as the difference between the (negative) welfare elasticity with respect to the shock when the policy is in place and the (negative) welfare elasticity as predicted by the calibrated model without the policy, migration being allowed in both cases. Welfare effects of migration in Panels B and D are calculated as the difference between the (negative) welfare elasticity with respect to the shock as predicted by the calibrated model when migration is allowed and the (negative) welfare elasticity as predicted by the model when migration is ruled out, the respective policy being in place in both cases. Effects are shown separately for Italian and other euro-zone workers without and with tertiary education. The three policies are as outlined in Sections 7.1, 7.2 and 7.3.