Asymmetric Shocks and Heterogeneous Worker Mobility in the Euro Zone*

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Abstract

Labor migration can help absorb asymmetric shocks within a currency union. However, if workers are complementary in production and heterogeneous in their geographic mobility, this may thwart the mitigating effect of integrated labor markets. We document a higher mobility among more educated Europeans, and develop a dynamic spatial equilibrium model in which workers differ in skill and in their preference for migration. We calibrate this model to European data, and find that following a negative shock to a country's productivity or demand integrated labor markets improve outcomes primarily for high skilled workers. While emigration mitigates part of the rise in unemployment for all skill groups, low skilled workers see a deterioration in their real wages as high skilled workers leave in larger numbers. Yet, mobility in Europe is too low to leave an overall negative effect of open borders on the low skilled, who benefit from integrated labor markets, albeit to a lower degree.

Keywords: international migration, monetary unions, worker heterogeneity
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1 Introduction

Labor mobility is a corner stone in optimal currency area theory pioneered by Mundell (1961), which has received renewed attention since the introduction of the euro. When currencies cannot adjust and fiscal policy has not been integrated, international labor mobility is an important channel for the dissipation of asymmetric shocks across members of a currency union: this mobility allows workers to move to better performing countries, improving both their own labor market prospects and raising labor market tightness in their depressed countries of origin. A common assumption in models used to analyze this, however, is that workers, who respond to macroeconomic conditions and shape equilibrium outcomes, are homogeneous and/or perfect substitutes in production.

In this paper we argue that if different types of workers are imperfect substitutes, any heterogeneity in their propensity to migrate can thwart the potential of labor mobility to absorb asymmetric shocks. Absent international fiscal compensations, selective migration flows may in fact aggravate—rather than mitigate—macroeconomic shocks. This is not a theoretical curiosity, as mobility has repeatedly been shown to be stronger for higher skilled workers (Grogger and Hanson, 2011; Kennan and Walker, 2011; Docquier and Rapoport, 2012; Amior, 2019; Bütikofer and Peri, 2021; Schmutz et al., 2021). We first show that inner-European migration is no exception to this empirical regularity, by documenting that within Europe tertiary educated workers are consistently about twice as mobile as less educated ones. We then develop a dynamic equilibrium model with search frictions and different types of workers to evaluate the contribution of labor mobility to the absorption of asymmetric shocks. 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 European countries. Our calibration confirms that even conditional on observed employment and wage differentials across countries, it is generally less costly for skilled individuals to live and work in a foreign country. The model allows us to evaluate the degree to which the effects of asymmetric demand and productivity shocks on unemployment and wages are altered by integrated labor markets, accounting for the empirical fact that high skilled workers are generally more mobile.

In our model, workers are differentiated by skill and country of origin, and location choices further depend on their country of residence, employment status, the equilibrium wage they receive if working, and on idiosyncratic preferences. Skilled and unskilled workers are not perfect substitutes in production, and are heterogeneous in the attachment to their home country. From our data, we can recover migration flows as well as labor market outcomes. The calibration to these data provides us with migration costs for workers and vacancy costs

for firms, as well as with productivity and preference parameters. Together with equilibrium wages and unemployment rates in each country, these preferences determine migration flows at the steady state. Output is tradable and consumed everywhere, but consumers have a bias for domestically produced goods, where we identify preferences for different countries' goods 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 nominal wage rigidity. This introduces a role for monetary policy, and allows us to reproduce realistic fluctuations in employment.

Our analysis provides several key insights. First, we examine the effect of integrated labor markets on the dissipation of shocks, with a particular focus on non-migrants in the country experiencing a decline in either its productivity or in the demand for its output. Second, we use our model to evaluate how the ability of an integrated unemployment insurance system to smooth asymmetric shocks compares to integrated labor markets as a mitigation channel. Third, we estimate the effects of a tax scheme that aims at retaining skilled workers in the country.

We first compare the responses in migration, unemployment and wages under the baseline, in which migration costs and other parameters are estimated to match observed migration levels, to the same outcomes when migration is prohibited. We examine both the effects of permanent changes in productivity and demand parameters on the steady state, as well as the transition between equilibria, and the effects of non-permanent shocks. As our main scenario, we consider negative shocks to Italy, as 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 responses of wages, unemployment and output per capita, irrespective of the source of the shock. For both productivity and demand shocks, skill biased emigration mitigates most of the drop in nominal wages and in the rise in unemployment for high skilled non-migrants, and to a much lesser degree for the low skilled. While demand and productivity shocks have opposite effects on prices, continued emigration from the adversely affected economy reduces its output in either case, and correspondingly pushes up prices relative to a situation in which migration was prohibited. This rise in prices leads to a real wage loss for low skilled non-migrants as a result of integrated labor markets. Yet, given the cushioning effect of migration on unemployment, the decline in real wages is insufficient to imply an overall welfare loss even for low skilled workers. The "brain drain" from high skilled emigration and its pressure on the value of complementary low skilled jobs however does widen the welfare gap across skill groups.[1] The main difference between demand and productivity shocks is that a negative

[1]Since the ability to migrate is always welfare improving, we compare welfare changes in response to

shock to consumers' taste for one country's output raises expenditure on goods produced in other countries, and correspondingly triggers a stronger response in migration from low to high demand countries. A negative productivity shock in one economy, on the other hand, decreases overall income, and thus also harms foreign economies too.

We then use our comprehensive model to evaluate two important policies: an integrated unemployment insurance system and a taxation of skilled migration. The importance of labor mobility within a currency union partly derives from the lack of fiscal integration that could provide compensating transfers in response to asymmetric shocks. Such transfers, for instance in form of an integrated unemployment insurance, may serve as an additional shock absorption channel. When some of the fiscal burden from a rise in unemployment is covered by foreign tax payers, gross (net) wages decrease (increase) as firms appropriate part of the gain. Since the beneficiary country unambiguously gains from these transfers, a more interesting comparison is that between the capabilities of integrated labor markets on the one hand and of integrated unemployment insurance on the other to absorb asymmetric shocks. We thus compare the status quo of integrated labor markets and non-integrated unemployment insurance to a counterfactual scenario in which the cost of unemployment benefits is shared across countries while shutting down the migration channel. This counterfactual has a theoretically ambiguous effect on net wages in a country suffering an adverse shock: the inability to emigrate following a negative shock, puts downward pressure on wages. Since unemployment insurance contributions are born by other countries, however, net wages may increase. Again for the case of a decline in demand for Italian output, we find that the positive effect on net wages dominates in the short run. That is, fiscal transfers provide a faster remedy compared to the relatively slow adjustment in migration flows. Instead, the negative effect of restricting mobility dominates in the long run, with a shared unemployment insurance being unable to lift net wages to the equilibrium level that is achieved with migration. Finally, the Italian unemployment rate for all skill types is higher with the shared unemployment insurance compared to migration. As a second policy counterfactual we examine the effects of an emigration tax for high skilled workers. We find that any tax on high skilled emigrants is welfare decreasing in the aggregate. Instead, it is a re-distributive element that benefits low skilled workers through two channels: first, a balanced budget can be achieved with a lower level of income taxes as revenues from the emigration tax contribute to the fiscal budget. Second, the decrease in high skilled emigration in response to the tax benefits low skilled job creation and wages.

We examine the robustness of our main results to alternative specifications of the model and the structure of shocks. Migration in response to less persistent shocks is much less

economic shocks within scenarios that either allow or rule out migration.

pronounced also for skilled workers if agents anticipate the non-permanence of shocks, and reverts back once the labor market recovers. The qualitative result that migration benefits high skilled workers whereas low skilled workers suffer a loss in real wages, however, applies also to non-permanent shocks to either productivity or demand. The response in migration also is weaker if rather than affecting a single country (Italy), several (Southern European) countries are exposed simultaneously to negative shocks. This is because a higher concentration of migrants in a smaller number of destination countries limits the incentive for further migration. The finding that open borders primarily benefit high skilled workers also carries over for different parameterizations of the model, including a model without wage rigidity, and different elasticities of substitution between goods in consumption, and between skill inputs in production.

Importantly, the calibration of our model to data from a large set of European countries shows that the theoretical ambiguity regarding the role of labor mobility within the European Monetary Union in the absorption of asymmetric shocks is empirically resolved in favor of migration, although gains are concentrated among higher skilled workers and low skilled workers do suffer a real wage loss. Yet, the mitigating effect on unemployment also for low skilled workers implies an overall gain in life time income and in welfare also for them. The reason for this empirical result is that migration rates in Europe are generally too low for a net negative effect due to the brain drain of high skilled workers from depressed countries. This is in stark contrast to a model without any frictions, full employment and market clearing wages. We demonstrate that in such a simplified model a positive correlation between workers' productivity and their preference for migration implies an unambiguously negative effect both on low skilled wages and on output per capita in the less productive country.

Our paper contributes to the literature studying labor mobility within the euro area. Beyer and Smets (2015) document that migration rates in Europe and the United States converge, but that adjustment through migration in Europe is slow. Basso et al. (2019) investigate the co-movement of labor demand and migration in Europe and find that migration is both cyclical and cushions asymmetric shocks. Kohler et al. (2021) 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 U.S. House et al. (2018) formulate a dynamic equilibrium model with an explicit role for monetary policy. Relatedly, a recent paper by Gonzalez-Aguado (2021) studies 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 both complementary in production and differ in their preference for migration. Our study

thus is the first that accounts for worker heterogeneity in both their productivity and their geographic mobility when investigating the capacity of labor mobility to absorb asymmetric shocks in a monetary union. Earlier papers analyzing macroeconomic adjustments in the euro zone, like Smets and Wouters (2003), have abstracted from labor mobility.

On a theoretical level, international convergence through migration has been examined by Ottaviano (1999), Grossmann and Stadelmann (2011) and 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, and welfare effects are ambiguous even when goods are tradable. An assessment of the net benefits of labor market integration thus becomes an empirical question.

Spatial equilibrium models featuring labor mobility are also used to evaluate the effects of trade exposure and factor market integration (Kovak, 2013; Caliendo et al., 2017, 2019; Dix-Carneiro and Kovak, 2017, 2019; Heise and Porzio, 2021), though not for an evaluation of asymmetric shocks and no role for monetary policy. Schivardi and Schmitz (2020) evaluate the contribution of the IT revolution to the divergence across European countries in an equilibrium model in which high skilled workers may migrate to Northern European countries.

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 settings, Braun and Weber (2016) and Monras (2020), for instance, examine labor market adjustments over time following the post-World War II refugee migration shock in Germany and the Mexican peso crisis, respectively. Llull (2018) and Piyapromdee (2021) examine the effects of immigration on natives' wages, human capital investment and house prices in the United States. Evidence on firm level responses has been provided by Lewis (2011), who finds that the adoption of automation technologies is slowed by unskilled immigration, and by Dustmann and Glitz (2015), who find evidence supporting the Rybczynski theorem that sectors using an abundant factor more intensively expand in response to migration. More similar to our framework are studies by Chassamboulli and Palivos (2014), Di Giovanni et al. (2015), Battisti et al. (2018) and Zaharieva and Iftikhar (2019), who use equilibrium models to evaluate the economic and welfare effects of immigration in different sets of countries. Our paper differs from these papers in several dimensions, most importantly in that we endogenize migration, in that migration can be temporary, and in that we explicitly account for a subset of countries belonging to a currency union. More broadly, our paper adds to the knowledge base on the welfare effects of international migration, which have been estimated for instance by Kennan (2013) and Docquier et al. (2015).

In what follows we first provide empirical evidence for the skill bias in migration within the European Union. We use Section 3 to sort ideas about the conditions under which

international mobility of labor may have adverse effects on less productive countries. This motivates the model presented in Section 4. We describe the data used, and the model's calibration in Sections 5 and 6, and finally present the results of our analysis in Section 7.

2 Skill bias in European mobility

Migrants are positively selected on marketable skills in many contexts. Grogger and Hanson (2011) show that emigrants from virtually any country in the world to the OECD are positively selected on education. Migration within Europe today is no exception. While migrant populations that have their origins in the guest worker agreements of the 1950s and 60s were predominantly low skilled, the higher mobility of college-educated individuals in later years has changed the picture. Using aggregate data from Eurostat on foreign-born populations, Figure 1 reveals that since the early 2000s, Europeans residing in a euro zone country different from their euro zone country of birth have surpassed native host country populations in terms of education. This gap continuously widens, indicating the positive selection also of more recent migrants.

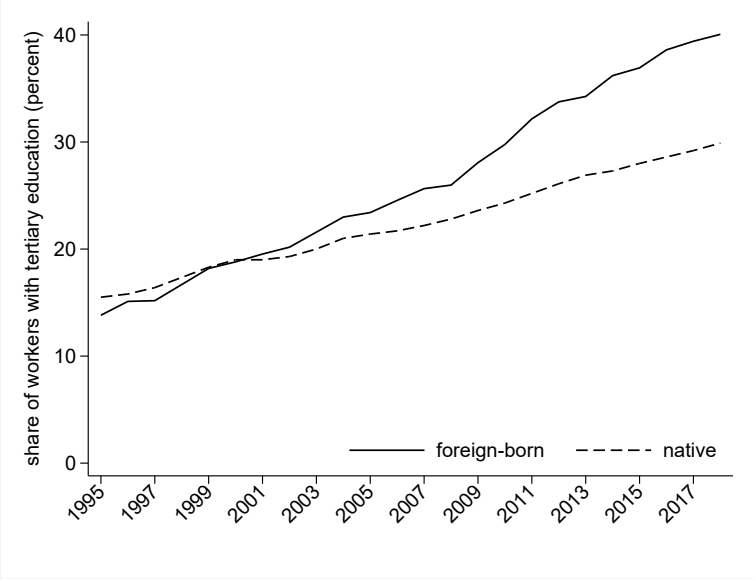


Figure 1: Skilled migration within the euro zone. The figure shows percentages of tertiary educated individuals within the working-age population, separately for natives and immigrants born in another euro zone country. Source: Eurostat.

To illustrate the difference in high and low skilled migration flows more directly, we use individual level data from the European Union Labour Force Survey (EU-LFS). We draw heavily on this dataset also for the calibration of the equilibrium model presented below, and explain the features of the EU-LFS in more detail in Section 5. The EU-LFS reports both

an individual's current and previous year's country of residence. We use this information to compute the share of recent immigrants in each country, separately for individuals with and without tertiary education.[2] Figure 2 shows a more than twice as high migrant share among tertiary educated individuals compared to less educated ones, irrespective of whether all or only European nationals are considered.

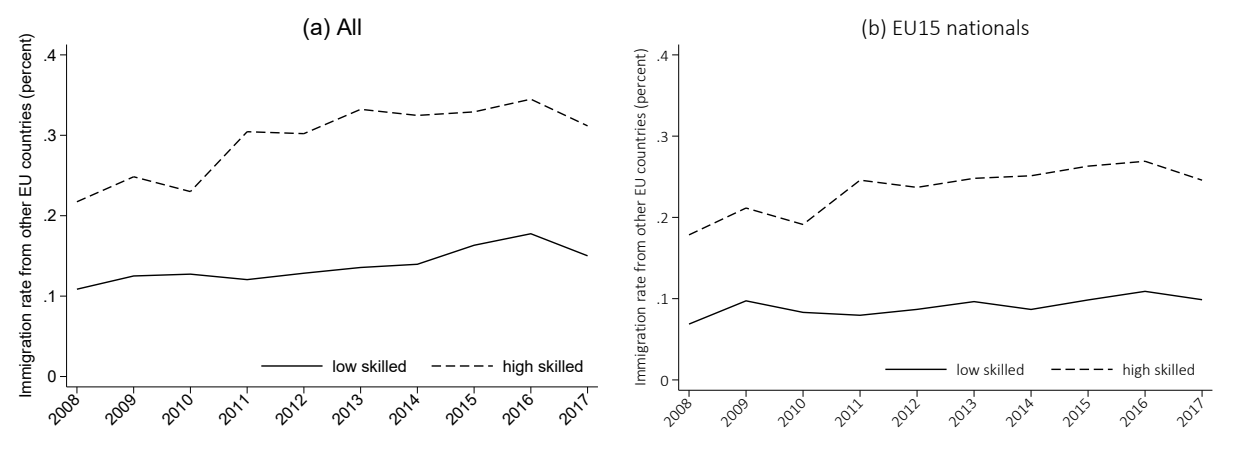


Figure 2: Shares of individuals arrived during previous year among individuals with and without tertiary education, considering (a) individuals of any origin and (b) only European nationals. Source: European Union Labour Force Survey.

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. Part of the skill bias in migration may stem from international differences in the returns to education, and hence in the benefits from migration in terms of wage gains. The model described in the next section explicitly accounts for labor market outcomes in an equilibrium framework. By matching observed bilateral migrant numbers it can isolate heterogeneity in the preference for migration above and beyond economic outcomes.

3 Considerations in the choice of appropriate models

The choice of a model may well prelude its qualitative predictions. Existing equilibrium models that are used to evaluate the contribution of labor market integration to reducing cross-country variation in economic outcomes following asymmetric shocks within a currency union assume a homogeneous labor force (House et al., 2018; Hart and Clemens, 2019; Hauser and Seneca, 2019). In these models, labor markets are characterized by search frictions, and

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

workers can choose to emigrate when wages or employment prospects in their country of origin deteriorate. With only one type (or perfectly substitutable types) of workers, emigration of part of the labor force necessarily benefits non-migrants staying behind, as emigration lowers competition for scarce jobs. The question in these model hence only can be about the absolute magnitude, not about the direction of the effect integrated labor markets have on non-migrants.

On the other hand, a frictionless model in which workers are heterogeneous in their preference for migration and complementary in production, but where labor markets clear and workers are paid their marginal product, will predict the opposite: less mobile workers in a country hit by a negative shock are bound to suffer from the emigration of workers who are complementary in production as long as technology is constant returns to scale. In Appendix A we formulate such a model and simulate the wage effects of emigration.

Both frameworks are unsatisfactory from an empiricist's point of view, as their structure dictates the direction of the effect under investigation. In Section 4, we thus bring a dynamic general equilibrium model that features both search friction and worker heterogeneity to the data. In that model, all workers may benefit from integrated labor markets and the option to migrate in response to adverse shocks. Yet, complementarity 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. To obtain more realistic responses in wages and unemployment rates, the model features nominal wage rigidity, which simultaneously introduces a role for monetary policy.

4 A model of worker mobility in Europe

The theoretical argument on the importance of migration in a currency union, together with the above evidence on the mobility of different groups of workers, motivate our modeling choice: a spatial equilibrium model in which search frictions and sticky wages generate both unemployment and a role for monetary policy. Monetary policy within and outside the monetary union may respond differently to any given shock. Importantly, the model distinguishes workers of different skill levels, who are geographically mobile, but heterogeneous in their preference for different locations.

4.1 Consumption

Each period, an individual i consumes a basket of goods from N different countries that we indicate with subscript $j \in \{1, ..., N\}$. The individual derives utility from consuming different countries' goods and from amenities in the current country of residence, indexed as j_i. The valuation of goods depends on the country of residence, so that a home bias in consumption may raise the share of income spent on local 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

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

where ξ governs the substitutability across goods of different origin, and ψ_{j,j_i} determines the relative demand for each country j's output, depending on the country of residence j_i. Within each j_i, we normalize $\sum_j \psi_{j,j_i} = 1$. 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 $\boldsymbol{\epsilon}_i \equiv (\epsilon_{i,1}, ..., \epsilon_{i,N})$ with realizations for each country is drawn[3] from distributions with means $\boldsymbol{\mu}_{s,n} \equiv (\mu_{1,s,n}, ..., \mu_{N,s,n})$ that varies 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 $j = n$, we normalize the mean to $\mu_{n,s,n} = 0$ (more on this below). The idiosyncratic preference component implies that individuals differ in the propensity to migrate conditional on 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 4.3 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 equal lump-sum transfer d_{j_i}. Finally, individuals pay lump-sum taxes T_{j_i}, 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

$$\sum_j P_j c_{i,j} = b_{j_i} + \mathbb{1}_{e_i}(w_{j_i,s_i,n_i} - b_{j_i}) + d_{j_i} - T_{j_i} \equiv I_i$$

where P_j denotes the price of goods from country j and $\mathbb{1}_{e_i}$ indicates individual i's employ-

[3]To ease notation, we omit time subscripts throughout the presentation of the model, thus also from $\boldsymbol{\epsilon}_i$.

ment status. In what follows, we denote individual i's income as I_i, which depends on the individual's skill level, origin nationality, employment status and country of residence.

These preferences yield a convenient price index $P^u_{j_i}$, which differs across countries and measures the price per unit of utility:

$$P^u_{j_i} = \left(\sum_j P_j^{\frac{\xi}{\xi-1}} \psi_{j,j_i}^{\frac{1}{1-\xi}} \right)^{\frac{\xi-1}{\xi}}. \tag{2}$$

Further, given the above utility function, the optimal quantity of good $c_{i,j}$ consumed by individual i will be

$$c_{i,j} = \frac{I_i}{\left(P^u_{j_i}\right)^{\frac{\xi}{\xi-1}}} \left(\frac{\psi_{j,j_i}}{P_j} \right)^{\frac{1}{1-\xi}}.$$

4.2 Production

Each country produces a consumption good variety that is internationally tradable. These final goods are produced using national intermediate inputs H_j and L_j from two sectors that employ high and low skilled workers, respectively. Firms in country j have a production function

$$Y_j = A_j \left(\alpha_j L_j^\rho + (1-\alpha_j) H_j^\rho \right)^{\frac{1}{\rho}} \tag{3}$$

with country-specific total factor productivity A_j, and a country-specific relative efficiency α_j of the intermediate inputs. Given this technology, demand functions for the intermediate inputs in country j are

$$H_j = Y_j \left(\frac{P_j (1-\alpha_j) A_j^\rho}{p_{j,H}} \right)^{\frac{1}{1-\rho}}, \tag{4}$$

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

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

4.3 Labor Markets

Labor markets in each intermediate good sector operate in a Diamond-Mortensen-Pissarides (DMP) search and matching framework. Depending on their skill, workers can be employed in either the high or the low skilled sector, where each worker produces one unit of the respective intermediate good. The values $p_{j,H}$ and $p_{j,L}$ of intermediate goods in country j are determined in equilibrium. Nominal wages are determined by Nash-bargaining and vary across countries and sectors. Wages can be re-bargained every period but are subject to rigid adjustment.

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 this shock, their employment status and expected equilibrium outcomes, choose a location. If previously unemployed, individuals are matched with an empty vacancy with the prevailing equilibrium job finding rate, whereas employed workers face a country- and skill-specific probability of losing their job. Finally, depending on the realized employment status, individuals receive either labor income or unemployment benefits that are spent on consumption goods as described above. Figure 3 illustrates this timing within each period.

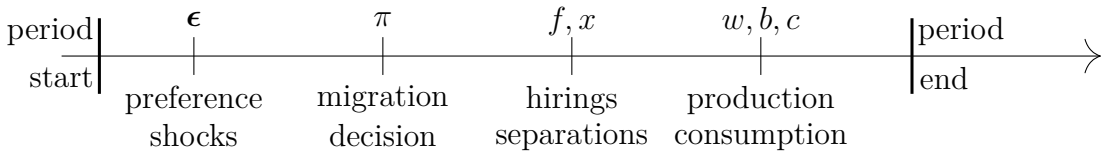


Figure 3: Assumed timing within each period in the model.

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 the i-subscripts from the notation. The values attributed to working and unemployment in country j by an individual of skill s and nationality n are given by

$$\begin{aligned} W_{j,s,n} &= \frac{w_{j,s,n} + d_j - T_j}{P_j^u} + \epsilon_j + \delta \mathbb{W}_{j,s,n} \\ U_{j,s,n} &= \frac{b_j + d_j - T_j}{P_j^u} + \epsilon_j + \delta \mathbb{U}_{j,s,n}, \end{aligned} \tag{6}$$

where the expected continuation values are respectively denoted by $\mathbb{W}_{j,s,n}$ and $\mathbb{U}_{j,s,n}$, and are discounted with a factor δ. Prices are endogenous, and income is expressed in nominal terms. With the preferences specified in (1), dividing income by the price index P_j^u defined in equation (2) yields utility flows.

Values are also indexed by nationality, since the distribution of preferences over different locations is nationality-specific (with mean $\boldsymbol{\mu}_{s,n}$, see above) and thus allows for a home bias. The realization of that preference for a specific country j, instead, is given by ϵ_j. Continuation values differ from those in a standard DMP model in that they are based on individuals' expectations about future location choices and employment transitions, as formally described in Section 4.4 below.

Job matches can be separated either exogenously with probability $x_{j,s}$, or because a worker decides to not stay in the current country of residence. 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 a worker of skill s and nationality n in country j chooses to relocate to country $d \neq j$. We specify this probability in Section 4.4 below. Hence, the value of a filled vacancy for an intermediate good producer in sector $s \in \{H, L\}$ is given by

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

where r denotes the real interest rate. Since we divided the per-period profits by the price index, the value of a filled vacancy is expressed in utility terms.

Open vacancies involve a cost $\kappa_{j,s}$, also expressed in utility terms. Hence, the value of an open vacancy is

$$Vac_{j,s} = -\kappa_{j,s} + \frac{q_{j,s}\Pi_{j,s} + (1 - q_{j,s})Vac_{j,s}}{1 + r},$$

where $q_{j,s}$ is the probability that the vacancy is filled. If matched, the firm generates an expected profit $\Pi_{j,s}$. Free firm entry reduces the value of a vacancy to zero for every country and skill, so that

$$(1 + r)\kappa_{j,s} = q_{j,s}\Pi_{j,s}. \tag{7}$$

For natives workers, we assume Nash bargaining, which shares the surplus $S_{j,s,j} = J_{j,s,j} - Vac_{j,s} + W_{j,s,j} - U_{j,s,j}$ of a match between a firm and a worker. The resulting wage $w_{j,s,j}$ is the transfer between firm and worker that satisfies the condition

$$\beta J_{j,s,j} = (1 - \beta)(W_{j,s,j} - U_{j,s,j}), \tag{8}$$

where β is the bargaining power of workers, j indicates the country and nationality of workers, and s their skill level.

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, we assume that firms apply a discount to immigrant wages.[4]

Specifically, firms pay non-natives an amount that is linked to the natives wage through a positive coefficient ν_s.

$$\forall n \neq j : \; w_{j,s,n} = \nu_s w_{j,s,j}. \tag{9}$$

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 the unemployed. Since firms cannot discriminate based on workers' nationality before a match is formed, searching workers are matched with empty vacancies at random within country and skill sectors. We assume a matching function

$$m\left(\sum_n u_{j,s,n}, v_{j,s}\right) = \varsigma \left(\sum_n u_{j,s,n}\right)^{\eta} v_{j,s}^{1-\eta} \tag{10}$$

where ς is the matching efficiency, and η the elasticity with respect to unemployment. The unemployment pool $u_{j,s} = \sum_n u_{j,s,n}$ comprises individuals of different nationalities, and includes both unemployed individuals present in the country at the beginning of the period and newcomers from abroad. Vacancies $v_{j,s}$ are not targeted at specific nationalities, but are country and sector specific.

New empty vacancies are posted by firms until the free entry condition (7) is satisfied. Defining market tightness as

$$\theta_{j,s} = \frac{v_{j,s}}{u_{j,s}},$$

the job finding probability can be written as

$$f_{j,s} = \varsigma \theta_{j,s}^{1-\eta},$$

whereas the vacancy filling probability is given by

$$q_{j,s} = \varsigma \theta_{j,s}^{-\eta} = f_{j,s}\theta_{j,s}.$$

The equilibrium employment level in each sector within a country then determines supply of

[4]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 with respect to small variations in parameter values. Our assumption of non-discrimination circumvents this, while maintaining the empirical fact of lower immigrant wages.

the respective intermediate inputs

$$H_j = \sum_n e_{j,H,n} \tag{11}$$

and

$$L_j = \sum_n e_{j,L,n}. \tag{12}$$

4.4 Migration decision

Each period, individuals decide on a country of residence, whose amenities they will enjoy, and on whose labor market they will work or search for a job. From their respective country of origin, individuals can either stay or move to any of the other $N-1$ countries. For individuals already residing abroad, we restricted the choice set to either staying in the current location or returning to the country of origin.[5] When moving from country j to country d, individuals pay a cost $k_{j,d}$. This cost is country pair-specific and depends on the distance between the two countries.[6]

Under the assumption that preference realizations $\boldsymbol{\epsilon}$ are drawn from a type I extreme value distribution with mean $\mu_{j,s,n}$, the probability that an individual in country j chooses to move to any given destination d has a closed form solution and is given by[7]

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

if an individual is currently employed, and by

$$\pi^d_{j,s,n,U} = \frac{\exp(\mu_{d,s,n} + f_{d,s}W_{d,s,n} + (1-f_{d,s})U_{d,s,n} - k_{j,d})}{\Xi^U_{j,s,n}} \tag{14}$$

if not.

Staying in the current country of residence does not involve a moving cost, and thus the

[5] We maintain this assumption due to the small number of migrations between different foreign countries observed in the data. The assumption is not required on a theoretical level.

[6] We specify the cost of migration and its dependence on distance in Section 6.

[7] To simplify notation in equations (13)-(16), we define and substitute for the denominators expressions $\Xi^W_{j,s,n} = \exp(\mu_{j,s,n} + (1-x_{j,s})W_{j,s,n} + x_{j,s}U_{j,s,n}) + \sum_{h\neq j}\exp(\mu_{h,s,n} + f_{h,s}W_{h,s,n} + (1-f_{h,s})U_{h,s,n} - k_{j,h})$ and $\Xi^U_{j,s,n} = \exp(\mu_{j,s,n} + (1-f_{j,s})W_{j,s,n} + f_{j,s}U_{j,s,n}) + \sum_{h\neq j}\exp(\mu_{h,s,n} + f_{h,s}W_{h,s,n} + (1-f_{h,s})U_{h,s,n} - k_{j,h})$.

corresponding choice probabilities are given by

$$\pi^{j}_{j,s,n,W} = \frac{\exp(\mu_{j,s,n} + (1 - x_{j,s})W_{j,s,n} + x_{j,s}U_{j,s,n})}{\Xi^{W}_{j,s,n}} \tag{15}$$

and

$$\pi^{j}_{j,s,n,U} = \frac{\exp(\mu_{j,s,n} + f_{j,s}W_{j,s,n} + (1 - f_{j,s})U_{j,s,n})}{\Xi^{U}_{j,s,n}}. \tag{16}$$

An important 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 determines migration flows, and accounts for heterogeneity in individual mobility across skill groups, *conditional on labor market outcomes*.

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

$$\mathbb{W}_{j,s,n} = \log\left[\exp((1 - x_{j,s})W_{j,s,n} + x_{j,s}U_{j,s,n}) + \sum_{d \neq j} \exp\left(f_{d,s}W_{d,s,n} + (1 - f_{d,s})U_{d,s,n} - k_{j,d}\right)\right] + \gamma$$

and

$$\mathbb{U}_{j,s,n} = \log\left[\exp(f_{j,s}W_{j,s,n} + (1 - f_{j,s})U_{j,s,n}) + \sum_{d \neq j} \exp\left(f_{d,s}W_{d,s,n} + (1 - f_{d,s})U_{d,s,n} - k_{j,d}\right)\right] + \gamma,$$

where $\gamma \approx 0.577$ is the Euler constant (see e.g. Rust, 1987). That is, workers migrating to another country d are subject to the destination country's job finding rate.

We now can describe the different flows that characterize this labor market. The stocks of employed and unemployed workers are measure at the end of each period, before the new preference shocks are drawn and individuals start to relocate. s The flow into the unemployed population of skill s and nationality n in a country j equals

$$infl^{u}_{j,s,n} = x_{j,s}\pi^{j}_{j,s,n,W}e_{j,s,n} + (1 - f_{j,s})\left(\sum_{\iota \neq j} \pi^{j}_{\iota,s,n,W}e_{\iota,s,n} + \sum_{\iota \neq j} \pi^{j}_{\iota,s,n,U}u_{\iota,s,n}\right), \tag{17}$$

where $e_{j,s,n}$ is the number of employed workers for a given country-skill-nationality combination. The first term in equation (17) represents workers who decide to stay in the country, but lose their job. The second term includes immigrants who have left unemployment or employment in their previous country of residence (index ι), and fail to find a job right away.

The flow into employment in turn is

$$infl^e_{j,s,n} = f_{j,s}\pi^j_{j,s,n,U}u_{j,s,n} + f_{j,s}\left(\sum_{\iota\neq j}\pi^j_{\iota,s,n,W}e_{\iota,s,n} + \sum_{\iota\neq j}\pi^j_{\iota,s,n,U}u_{\iota,s,n}\right). \tag{18}$$

Again, the first term in (18) represents the unemployed workers who find a job after deciding to stay in the country, whereas the second term captures immigrants who have left unemployment or employment in their previous country of residence, and find a job immediately.

Outflows from unemployment and employment, respectively, equal

$$outfl^u_{j,s,n} = (1 - \pi^j_{j,s,n,U} + f_{j,s}\pi^j_{j,s,n,U})u_{j,s,n}$$

and

$$outfl^e_{j,s,n} = (1 - \pi^j_{j,s,n,W} + x_{j,s}\pi^j_{j,s,n,W})e_{j,s,n}.$$

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

$$outfl^u_{j,s,n} = infl^u_{j,s,n} \tag{19}$$

and

$$outfl^e_{j,s,n} = infl^e_{j,s,n}. \tag{20}$$

4.5 Goods Markets

Given our assumptions about preferences, all individuals resident in a country consume the same proportions of the goods produced in each country, using all their income. The relative proportions are determined by the taste parameters ψ_{j,j_i}, final goods' prices P_j, and the elasticity of substitution $1/(1-\xi)$ across goods (see equation (1)). However, residents in different countries have different tastes for national goods: we assume the presence home-biased preferences that explains the observed larger share of local goods consumed by individuals. The overall scale of consumption is determined by an individual's income.

Note first that under the assumption of a balanced government budget, (lump-sum) tax receipts in each country equal payments to unemployed individuals:

$$\forall j: \quad b_j \sum_s \sum_n u_{j,s,n} = T_j \sum_s \sum_n \left(e_{j,s,n} + u_{j,s,n}\right). \tag{21}$$

Hence, total aggregate demand of a country is given by the sum of labor income $w_{j,s,n}$ and

dividends D_j[8]:

$$I_j = \int_i I_i \mathrm{d}i = D_j + \sum_s \sum_n w_{j,s,n} e_{j,s,n}.$$

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

$$Y_j = \sum_k \frac{I_k}{(P_k^u)^{\frac{\xi}{\xi-1}}} \left(\frac{\psi_{j,k}}{P_j} \right)^{\frac{1}{1-\xi}}, \tag{22}$$

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

4.6 Steady State Equilibrium

A steady state equilibrium is define as the vector of prices $p_{j,H}, p_{j,L}, P_j$, wages $w_{j,s.n}$, intermediate and final goods quantities H_j, L_j, Y_j, and agents' distribution $u_{j,s,n}, e_{j,s,n}$ over employment states for each country, skill level and nationality, such that the following conditions are satisfied:

1. Demand (22) for the final good produced in each country equals supply (3);
2. Demand for intermediate goods (4) and (5) equals supply (11) and (12), for each country;
3. Government budged (21) is balanced;
4. Flows into and out of employment and unemployment in each country and sector are balanced, (19) and (20);
5. Free entry conditions (7) hold in each country and sector;
6. Wages in each country and sector share the surpluses according to (8);
7. Individuals maximize their utility in choosing the basket of goods and the country of residence;
8. Matches are formed according to the matching function (10).

4.7 Currency Devaluation and Monetary Policy

To adapt our model to the European context, we not only investigate economic outcomes within a monetary union, but also allow for different currency areas that are interlinked

[8]We denote with D_j the sum of all nominal profits generated by firms in the country.

via goods and labor markets. 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. Yet, all these countries are part of the European Single Market, with integrated goods and factor markets. Some of those 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.

We thus allow for different monetary policies in countries inside and outside the monetary union. In particular, 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. To be explicit, we introduce time subscripts t and rewrite the price of a country's final good 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 monetary policy that we assume is a simple Taylor-rule similar to those in House et al. (2018) and Nakamura and Steinsson (2014). A national central bank reacts to deviations in per capita output and inflation from the steady state, and sets nominal interest rates as

$$int_{j,t} = \bar{int} + \rho\ int_{j,t-1} + (1-\rho)\left(\phi_y \Delta output_{j,t} + \phi_p inflation_{j,t}\right) \tag{23}$$

where $\bar{int}$ is the long run steady state interest rate and ρ measures persistence of the interest rate. For the monetary union, the central bank considers the means of output per capita growth and inflation[9] among member states of the union, weighted by each country's GDP. We assume that the reactions parameters ϕ_y and ϕ_p are common to all currency areas.

The no-arbitrage condition between two countries j and j' then determines the evolution of exchange rates to satisfy

$$(1 + int_{j,t}) = (1 + int_{j',t})\mathbb{E}\left(\frac{E_{j',t+1}}{E_{j',t}} \cdot \frac{E_{j,t}}{E_{j,t+1}}\right). \tag{24}$$

4.8 Wage Rigidity

We want to study how integrated labor markets affect not only long run equilibria, but also the effects of migrant flows on the transitions following asymmetric shocks within a currency

[9] In percent, so that $\Delta output_{j,t} \equiv \left(\frac{Y_{j,t}}{\sum_{s,n} e_{j,s,n,t}+u_{j,s,n,t}} - \frac{Y_{j,t-1}}{\sum_{s,n} e_{j,s,n,t-1}+u_{j,s,n,t-1}}\right) / \frac{Y_{j,t-1}}{\sum_{s,n} e_{j,s,n,t-1}+u_{j,s,n,t-1}}$ and $inflation_{j,t} \equiv (P_{j,t} - P_{j,t-1})/P_{j,t-1}$.

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 wage rigidity into the model. Specifically, we assume that euro-denoted wages in each country follow a path

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

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. The wage actually paid by firms is a weighted average of this hypothetical wage and the 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 deviate from an initial steady state level. Realistically, rigidity applies to nominal wages in the local currency. Monetary policy therefore can accelerate the adjustment process, reducing the real rigidity of wages by devaluating the currency.

The choice of the wage rigidity does not affect the estimation of the parameters of the model, since they are estimated at the steady state, where wage rigidity does not play a role. It does, however, become crucial for the welfare implications of a shock. In the results section, we will show welfare effects both in presence or in absence of wage rigidity.

5 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. We thus calibrate the above model to data on migration and labor market outcomes in both euro zone and non-euro zone countries. The dataset that fits our purpose best is the micro-level European Union Labour Force Survey (EU-LFS). The EU-LFS collects harmonized data from national surveys of the labor force in member countries of the European Union, as well as a number of other countries in Europe.

From these surveys we recover information about population stocks, migration flows, labor transitions and education level. More specifically, we refer to high skilled labor as workers with at least a college degree, while low skilled labor includes all other workers.

Migration flows are generally difficult to measure since different countries have different

rules with respect to the mandatory communications (if any) for moving in and out of a country. The EU-LFS does, however, inquire about respondents' country of residence in the previous year. For privacy concerns, we cannot observe the nationality of foreign citizens at a country level. Nevertheless, we do know whether a respondent is a native citizen or not. Under the assumption that agents only move (in either direction) between their country of citizenship and some foreign country rather than between third countries, this is sufficient for us to construct a migration flow matrix. 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.

The calibration will be based on information from a total of 17 countries. For the euro area, these include Austria, Belgium and Luxembourg[10], Denmark, France, Germany, Italy, Netherlands, Portugal and Spain. To represent the non-euro zone location of the model more realistically, we account for the large economic disparity among countries of the European Single Market that are not part of the monetary union, which on the one hand include high income countries like Sweden and the UK, and on the hand the lower income and more recent member states of the European Union. Rather than pooling all these into one residual location, the calibration thus considers two distinct outside locations, which comprise the UK, Sweden and Switzerland[11] on the one hand, and Poland, Romania, Czech Republic and Hungary on the other. In our context, this distinction not only reflects the different productivity levels across those groups, but also the fact that the former group are net immigration countries, whereas the latter are predominantly migrant sending countries. We complement our micro data with macroeconomic measures from Eurostat, such as countries' GDP and median wages for different educational attainments[12], and we take unemployment benefit replacement ratios from the OECD.[13]

To be consistent with the choice of merging migration data from 2012 to 2017, we use average GDP of the countries analyzed for the same years, the median wage for high and low educated workers, and the average stocks of natives in each country. We also compute the average stocks of non-citizens living in a country, but exclude non-European workers, which are not part of our analysis.

[10]We merge these two state rather than excluding Luxembourg.

[11]Switzerland, although not formally part of the European Union Single Market, has access to important parts of it through separate agreements.

[12]This information is provided by the European Union Statistics on Income and Living Conditions EU-SILC

[13]Appendix A lists these sources in more detail.

6 Empirical Implementation

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 locations outside the monetary union. We jointly calibrate a total of 299 parameters to moments from the data, and take others from the literature.

6.1 Identification

The calibration fits the model to a set of data moments observed for the years 2012-2017. Structural parameters we estimate are the average preference over a location $\mu_{j,s,n}$ for every country, skill and nationality, the moving cost $k_{j,d}$ between countries j and d, 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 country and skill group, and the preference parameter ψ_{j,j_i} for each country's final good, depending on country of residence. While different moments jointly identify the model's parameters, Panel A of Table 1 systematically lists the different groups of parameters and the moments most directly contributing to their identification.

The calibration provides us with parameter values that make the model's steady state predictions consistent with the data. In particular, observed migrant numbers identify agents' preference parameters, and our targeting of both migration flows and stocks further allows a separate identification of location preference parameters $\mu_{d,s,n}$ and migration costs $k_{j,d}$. Intuitively, the number of European non-nationals in each of the countries considered identifies the preference parameters $\mu_{j,s,n}$, whereas return migration flows for every country and skill, as described in Section 5, identify moving costs $k_{j,d}$. To limit the number of parameters to be estimated, we parameterize $k_{j,d}$ as a function of the distance between countries, so that the cost of moving between countries j and d (in either direction) is given by

$$k_{j,d} = k_0 + k_1 D_{j,d}.$$

where k_0 and k_1 are estimated parameters identified from migrant flows observed in the EU LFS, and $D_{j,d}$ denotes the distance between the capital cities of the two countries. We take this distance from the GeoDist database, provided by CEPII. In the model, the cost $k_{j,d}$ limits migration flows and prevents excessive back and forth movements. Conditional on $k_{j,d}$, the mean $\mu_{j,s,n}$ of the distribution from which preference shocks are drawn then governs the scale of migration and the stocks of resident migrants in each country and for each skill and origin nationality.

The unemployment level only jointly identifies the vacancy cost $\kappa_{j,s}$ and the matching efficiency parameter ς. In the absence of a direct measure for the cost of vacancies, we thus set $\varsigma = 0.25$, and calibrate the corresponding vacancy cost to match unemployment rates. Note that as long as one free parameter is calibrated to match unemployment rates, the fixing of the other parameter neither affects estimates for other parameters nor the model's counterfactual predictions.[14]

The skill premium in each country[15] identifies the production function parameters α_j, whereas the country-specific productivity A_j will be identified by each country's GDP.

Finally, to reduce the number of parameters to be estimated, we imposed a parametric restriction on consumer preferences ψ_{j,j_i}. In particular, we assume that utility from foreign goods consumption is discounted proportionately. That is, for imported goods from any $k \neq j$, we let $\psi_{j,k} = \zeta_k \psi_{j,j}$. This specifications leads to demand being higher for local goods, while the parameters to be estimated are reduced to two per country. These parameters are then identified by targeting observed price levels and total imports as a share of GDP.

6.2 Calibration

The model's parameters are calibrated by minimizing the distance between observed data moments and their counterparts simulated from the model. Given the large number of parameters, we use a blocking estimation strategy. In particular, we first estimate all parameters keeping the moving cost parameters k_0, k_1 and the average preferences over a location $\mu_{j,s,n}$ fixed. Then, we estimate the preference parameters keeping k_0 and k_1 fixed. Finally, we estimate the parameters k_0 and k_1, keeping all the rest fixed. We iterate these three steps until convergence. Table 1 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.

Our estimates of mean preferences $\mu_{j,s,n}$ imply that the median individual foregoes 89% of one year's expected real net income. This disutility is heterogeneous across countries and nationalities, and Figure 4a displays the distributions of the estimated values of $\mu_{j,s,n}$ by skill group. For movers, the cost of migration, $k_0 + k_1 D_{j,d}$, comes on top and is subtracted from an agent's payoff. Our estimates indicate that relative to their expected income, high skilled workers tend to suffer a lower disutility from living abroad, equivalent to 57% of their expected annual real net income. Unskilled workers, instead forego utility equivalent to 1.12

[14]Since job separations 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.

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

Panel A: Joint Calibration					
Parameter(s)	Notation	Percentiles of estimates			Target
		25th	50th	75th	(Source)
Means of location shock distributions	$\mu_{d,s,n}$	-4.207	-0.886	2.757	Migrations flows (EU-LFS)
Migration cost	$k_0 + k_1 D_{j,d}$	3.978	4.397	5.132	Migration stocks (Eurostat)
Taste for different goods	$\psi_{j,j}$	0.068	0.077	0.109	Price level (Eurostat)
Consumption home bias	ζ_j	0.303	0.499	0.551	Import share (OECD)
Vacancy cost	$\kappa_{j,s}$	0.019	0.034	0.050	Unemployment (EU-LFS)
TFP	A_j	130.1	167.9	186.9	GDP (Eurostat)
Low skill efficiency	α_j	0.423	0.438	0.477	Skill premium (EU-SILC)
Migrant wage penalty	ν_j	0.943	0.968	0.973	Income difference (EU-SILC)
Panel B: Exogenously Set Parameters					
Parameter(s)	Notation	Percentiles of estimates			Source
		25th	50th	75th	
Replacement ratio	b_j	60.1%	70.3%	83.4%	OECD
Separation Rates	x_j	0.022	0.035	0.051	EU-LFS
Skills elasticity	$1/(1-\rho)$		4	(tried 2-6)	Caliendo et al. (2017)
Goods elasticity	$1/(1-\xi)$		4	(tried 2-6)	Feenstra et al. (2018)
Bargaining power	β		0.72		Shimer (2005)
Matching elasticity	η		0.72		Shimer (2005)
Discount Rate	r		5%	(tried 1-10%)	

Table 1: Parameters and identifying information. In Panel A, identifying information are empirical moments targeted in the calibration; parameters listed in Panel B are set to values taken from the literature or data as indicated.

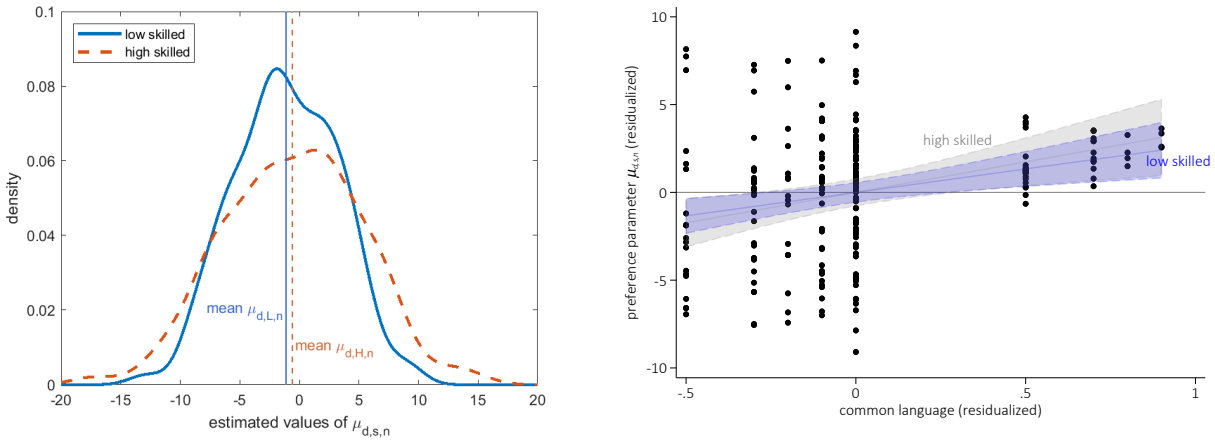
years of expected real net income.

In our estimation, parameters $\mu_{j,s,n}$ allow us to match observed bilateral migration flows. To illustrate that these structural parameters carry economic content, we match each country pair to data from the CEPII GeoDist database. These data have widely been used in the trade literature, and provide information on bilateral ties, including indicators for common language use across country pairs. We correlate our estimates of preference parameters $\mu_{j,s,n}$ with an indicator for a country pair sharing an official language, after taking out origin and skill effects. Panel (b) of Figure 4 shows a strong positive correlation both skill types between our estimated preference for residing in a foreign country and that country sharing an official language with an individual's country of origin.

Figure 4: Location preferences.

(a) Estimated preferences

(b) Correlation with common language



Note: The figure shows (a) estimated values of mean preferences $\mu_{d,s,n}$ by workers of different nationalities n for destination countries d, separately for low skilled workers (solid line) and high skilled workers (dashed line); and (b) the correlation of estimated bilateral preference parameters $\mu_{d,s,n}$ with countries n and d sharing an official language, each residualized after controlling for origin-skill effects; shaded areas indicate 95% confidence intervals 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.

Panel B of Table 1 lists the parameters we set externally, either based on previous studies, or taken from the data directly. We performed several robustness checks that we detail in Appendix B.1. In particular, 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, we set the elasticity of substitution between workers of different types to 4. This is the value reported by Caliendo et al. (2017), which they estimate on Portuguese matched employer-employee data. Other estimates in the

literature range between 1.5 (Ottaviano et al., 2012) and 5 (Dustmann et al., 2009), and we again examined the robustness of our results on a similar range of values, see Appendix B.1. In that appendix we also describe other chosen parameter values and their sources in more detail.

7 Results and Counterfactual Scenarios

In this section, we use the calibrated model to evaluate the role of labor mobility in the absorption of asymmetric shocks to productivity or to consumers' preference for the output of a given country in a currency union.

7.1 Productivity and Demand Shocks

We first analyze the response of the economy to two types of asymmetric permanent shocks:[16] a total factor productivity (TFP) shock that hits one country (Italy, in our example), lowering permanently its country-specific productivity A_j by 1 percent, and a similarly asymmetric demand shock. To simulate the latter, we permanently lower the preference parameter $\psi_{j,j}$ governing demand for a country's national good by 1 percent.[17] These are "MIT shocks"—shocks that are permanent, unexpected for the agents, and which lead to a deterministic aggregate path towards the new steady state. We therefore can compare not only the two steady states, but also examine the transition period between equilibria.[18]

Our aim is to compare the effects of these shocks in the baseline scenarios with spatially integrated labor market to the same outcomes if migration was prohibited. Figures 5 and 6 show the adjustment paths for rigidity in wages of $\omega = 0.9$. We show the corresponding results for a model with flexible wages below. In each graph, the baseline is labeled "MIG", while the counterfactual scenario without migration is labeled "No MIG".

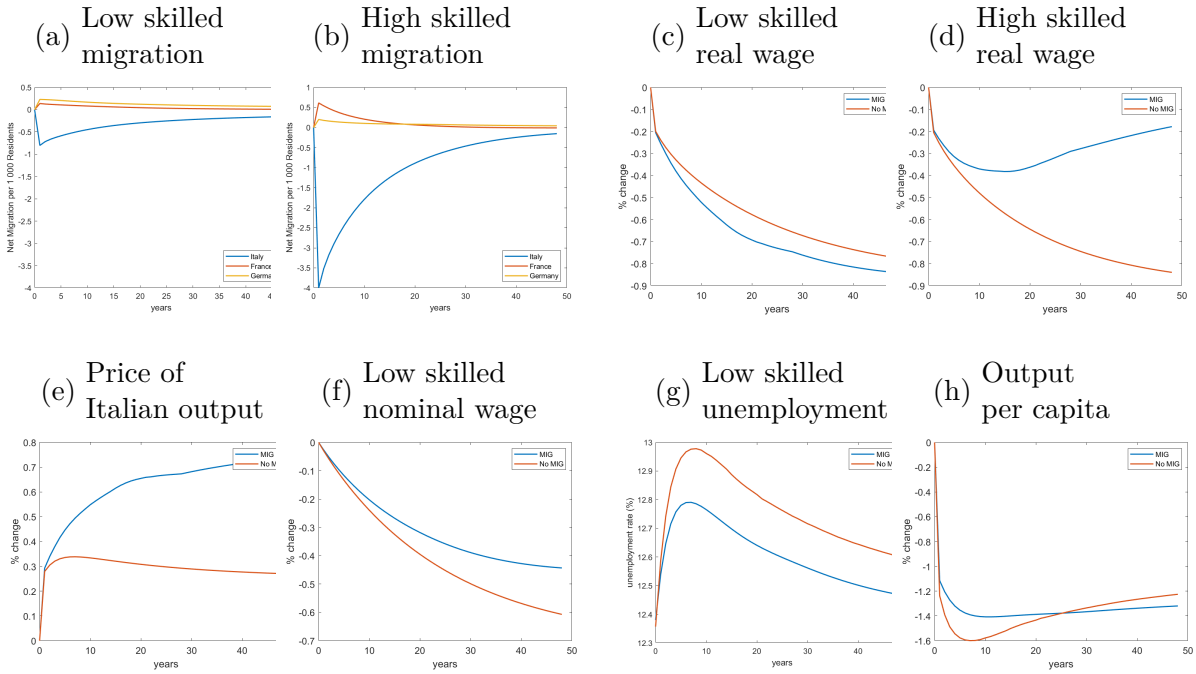
The simulations show that the effects of negative demand and productivity shocks are very similar, despite their detrimental effect on prices, which increases after a productivity shock and the ensuing collapse in production (Figure 5e), but decreases when demand of this output falls (Figure 6e). In the absence of migration, both types of shocks depress wages for both groups of workers in the country hit by the shock (Italy), see the orange lines in Panels

[16] We contrast this to the effects of non-permanent shocks in Section 7.3 and to shocks to a group of countries in Section 7.2.

[17] We readjust $\psi_{j,j}$ for all countries in order to preserve the property $\sum_j \psi_{j,k} = \sum_j \zeta_k \psi_{j,j} = 1$.

[18] Note that in a setup in which agents expect TFP or demand to follow a persistent stochastic processes, the dimensionality of the problem would rapidly explode, since our model features 11 locations between which agents can migrate. The model thus would have 11 (possibly correlated) stochastic processes, which renders computation of the agents' value functions infeasible.

Figure 5: Effects of a permanent reduction in Italian total factor productivity by 1 percent.



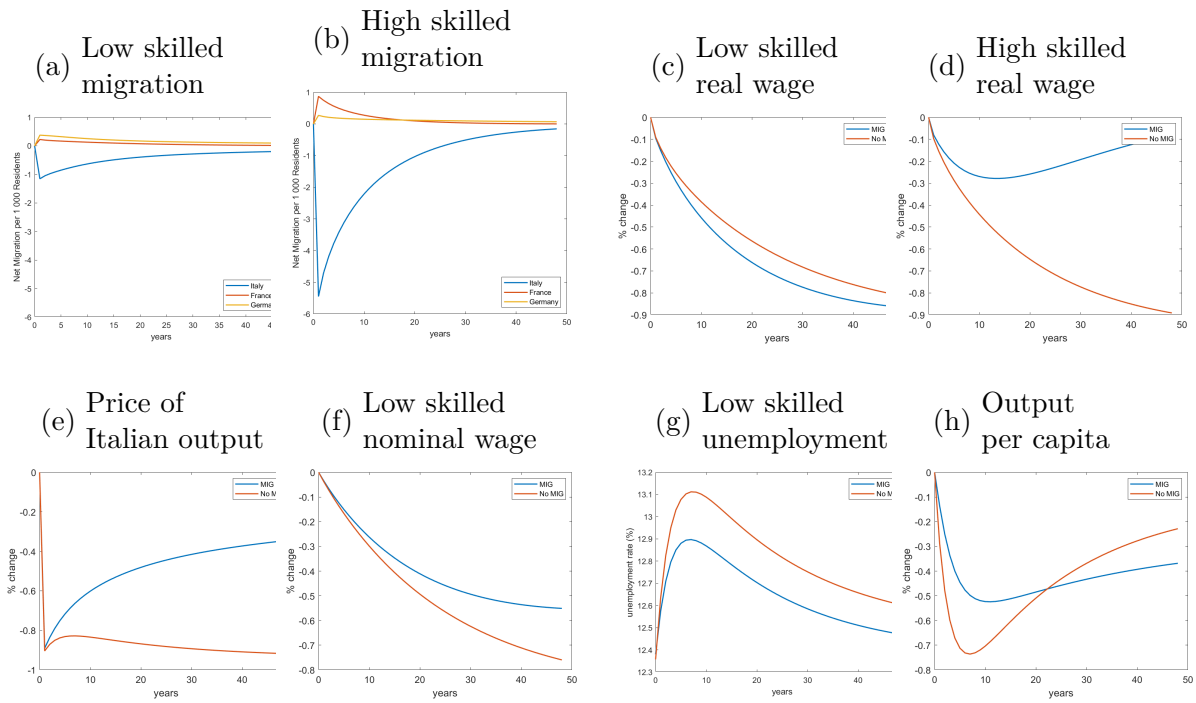
Note: The figure shows transitions between steady states for outcomes following a permanent reduction in Italian total factor productivity by 1 percent.

(c) and (d) of Figures 5 and 6.

When labor markets are integrated, workers—in particular the unemployed—will emigrate if labor market prospects in the country of origin have worsened (blue lines Panels (a) and (b) of Figures 5 and 6). Beyond wages and labor market tightness, the extent to which the option to migrate is used depends workers' preferences for different locations, which we calibrated to match observed migrant numbers. Our estimates suggest that low skilled workers suffer a relatively larger disutility from living outside their country of origin. Emigration in response to an adverse shock hence is concentrated among high skilled workers. For these workers, migration mitigates much of the negative wage effect (Panel d).

Instead, low skilled workers see a deterioration of their real wages trough migration. This effect is somewhat indirect: While the emigration of complementary high skilled workers is insufficient to depress nominal wages below the level that would have prevailed in the absence of migration (Panel f), the rise in prices that results from the additional drop in output due to emigration, put additional pressure on real wages. Yet, the emigration of some unemployed low skilled workers does raise market tightness and help to mitigate part of the adverse effects on the low skilled unemployment rate (Panel g). Taken together, life-time income and welfare increases also for low skilled workers, albeit to a lesser degree than for

Figure 6: Effects of a permanent reduction in the taste for Italian output by 1 percent.



Note: The figure shows transitions between steady states for outcomes following a permanent reduction in consumers' taste for Italian output by 1 percent.

high skilled workers.

A difference between the two types of shocks we consider is that the more immediate effect of a productivity shock (Figure 5h) decreases output more strongly than a shock to the taste for Italian output (Figure 5h), which materializes only after the decrease in hiring has reduced employment in the economy. Sluggish wage adjustment in turn implies that hiring picks up with delay, so that output, just like unemployment, reverts back. Note that in the long run, the permanent decrease in the Italian skill ratio through brain drain depresses output per capita below the level that would be achieved if migration was prohibited.

We compare these results from the full model with wage rigidity to a model with fully flexible wages. Effects in both cases are qualitatively similar, but the presence of wage rigidity amplifies effects on the labor market. In particular, in a model with flexible wages, shocks are mostly absorbed by the immediate change in wages, with a less pronounced change in unemployment. We relegate these predictions to Figure A3 in the Appendix, which display the effects of a TFP shock and a demand shock in a model with flexible wages.

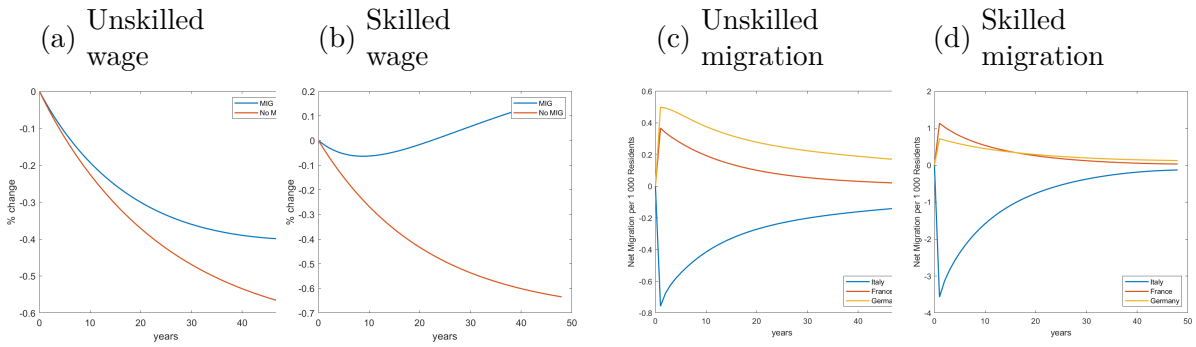
7.2 Productivity Shock to Southern Europe

While the model's mechanisms are more transparently illustrated by our focus on changes in the productivity or demand for only one economy, adverse shocks are often correlated across several countries. We thus examine the sensitivity of the above results to a situation in which not only Italy, but also Portugal and Spain experience the same decline in productivity, or alternatively in consumers' taste for the goods produced in these countries.

Figure 7 shows that the qualitative results we presented above are largely unaffected by this modification. The figure shows the core outcomes for Italy for the case of a decline in productivity in Italy, Portugal and Spain by each 1 percent. The main difference is that the response in Italian emigration is weakened due to two effects. First, other adversely affected countries are no longer attractive destinations for Italian emigrants. Second, an additional outflow of migrants from other Southern European countries to similar destinations as those favored by Italian migrants (primarily France and Germany) worsen labor market prospects abroad.

A correlation in the macroeconomic shocks to multiple countries ultimately implies a lower asymmetry of these shocks. Our simulation demonstrates the lower shock mitigation through labor mobility in this case. Not also that the selectivity in migration following shocks to several economies varies across countries, as indicated in Panels (c) and (d) of Figure 7. This selectivity follows from the calibration of the model to observed migrant numbers across different education levels and countries, with emigration from Italy being relatively more tilted towards high skilled workers than emigration from Portugal or Spain.

Figure 7: Effects of a permanent reduction in Southern European total factor productivity by 1 percent on outcomes in Italy.



Note: The figure shows transitions between steady states for outcomes in Italy following a permanent reduction in Italian, Portuguese and Spanish total factor productivity by 1 percent.

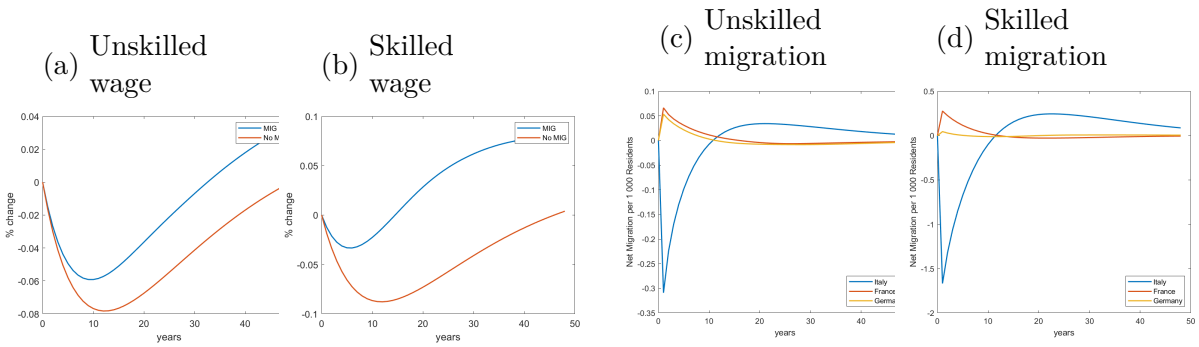
7.3 Non-permanent Shock

We further contrast the effects of a permanent shock as described above to those of a more temporary shock that initially reduces Italian TFP by 1 percent. Productivity then gradually reverts back to the initial level, following the simple process

$$A_{j,t} = \rho_A A_{j,t-1} + (1 - \rho_A) A_{j,0}, \tag{25}$$

where $A_{j,0}$ is country j's (Italy's) initial productivity level prior to the shock.[19] Panels (a) and (b) of Figure 8 show the evolution of wages for a persistence value $\rho_A = 0.8$.[20]

Figure 8: Effects of a non-permanent reduction in Italian total factor productivity.



Note: The figure shows transitions between steady states following a non-permanent reduction in Italian total factor productivity by 1 percent, which reverts back to the initial productivity level with persistence $\rho_A = 0.8$.

Besides the obvious difference to a permanent shock that effects on the labor market are weaker when productivity is expected to revert to its initial level, a non-permanent shock further leads to a smaller response in migration (Panels (c) and (d) of Figure 8). In our model agents suffer a moving cost in addition to the transitory shock to their taste for a location. As agents anticipate that productivity ultimately reverts to its initial level, the cost to moving prevents a strong response in migration.

An implication of this finding is that while migration can mitigate a large part of the negative labor market consequences following a permanent asymmetric shock at least for high skilled workers, mobility in Europe appears to be too low to play a major role in the absorption of shorter-term variations, such as business-cycle effects.

The anticipation that the reduction in productivity is temporary further implies a rather mild reduction in welfare due to the shock, as we show in the next section.

[19] We assume that agents foresee this path of $A_{j,t}$.

[20] For $\rho_A = 1$, results are as for the permanent shock discussed above, whereas the effects of the shock become ever smaller as ρ_A approaches 0.

7.4 Welfare Considerations

Institutions and policy choices, such as an integration of national labor markets, determine how shocks can be absorbed, and thus have real welfare implications. In this section, we investigate the welfare effects of different types of shocks for low and high skilled workers. We then show how these translate into changes in the welfare gap between workers of different skill levels.

A change in total factor productivity in one country affects welfare in other countries even in the absence of migration through integrated goods markets. Panels (a) and (b) of Figure 9 show welfare changes following a permanent 1 percent drop in Italian TFP when labor is geographically immobile. We compare steady states, so that colors (and numbers for the largest countries) indicate percentage deviations in welfare from the initial steady state.

A comparison of Panels (a) and (c) for low skilled individuals on the one, and of Panels (b) and (d) for high skilled individuals on the other hand shows that the option to migrate dissipates the negative shock in one country (Italy) much more for high than for low skilled individuals. Integrated labor markets reduce the welfare loss for high skilled workers in Italy by almost one half, whereas for the less mobile workers with lower skill level, the mitigation through migration amounts to less than 22 percent.

A permanent reduction in consumers' taste for Italian goods by 1 percent leads to a similar difference between skill groups, as shown in Figure 10.[21] However, as mentioned earlier, an important distinction between the two types of shocks is that a loss in productivity in one country and the ensuing loss in income harms foreign producers as well. A shift in taste for the output of one country to that of other countries, instead, implies that the latter benefit. This also leads to migration in response to a demand shock being amplified by economic pull factors in foreign destinations.

The welfare gap between skill groups consequently widens. To illustrate this, we compare the changes in $W_{j,H,n}/W_{j,L,n}$ following a permanent shock to Italian TFP in the when labor markets are integrated vs the counterfactual case in which they are not. We then perform the same exercise for a permanent decrease in the demand for Italian goods. Figure 11 shows that following both types of shocks the welfare gap between skill groups widens in Italy. In contrast, both the flow of high skilled Italians to other European countries and reduced high skilled migration to Italy benefits low skilled workers in other countries, and reduces the welfare gap there.

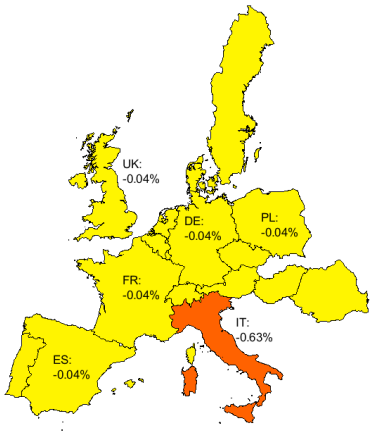
This increase in welfare inequality parallels the results on skills sorting by Diamond (2016) within the United States. The mechanisms are different, however, with inequality in our setting rising within rather than across locations.

[21] See Section 7.1 for the transition between steady states for these scenarios.

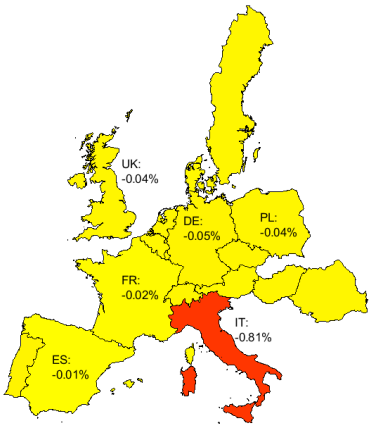
Figure 9: Welfare effects following a negative 1% shock to Italian TFP.

(a) Low skilled individuals, no migration

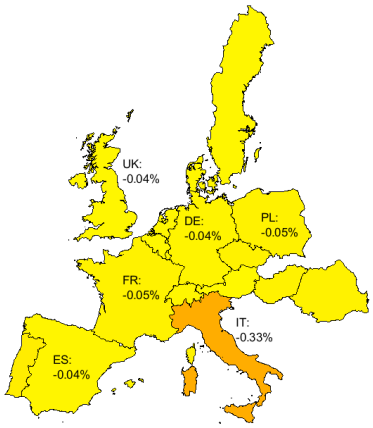
(b) Skilled individuals, no migration



(c) Low skilled individuals, with migration



(d) Skilled individuals, with migration

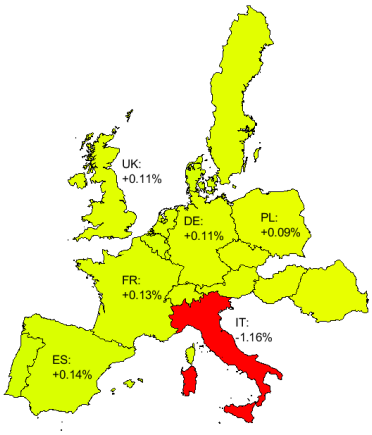


Note: The figure shows welfare effects, measured as the change in steady state welfare following a permanent reduction in Italian total factor productivity by 1 percent. The top panels show welfare changes if migration was prohibited for low skilled (panel a) and high skilled individuals (panel b); panels (c) and (d) show the same for integrated labor markets.

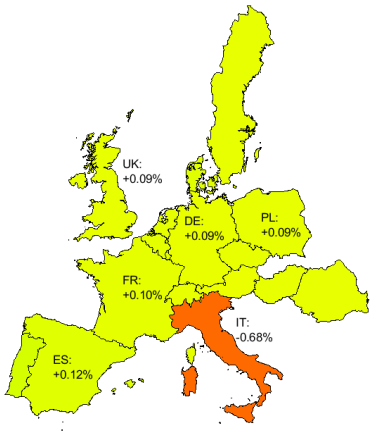
Less than permanent shocks as discussed in Section 7.3 naturally affect welfare by less. In our framework, it moreover leads to a disproportionately weaker response in migration, so that labor mobility plays an ever smaller role in shock absorption. This is due to emigration and return migration being costly, and agents anticipating a reversion towards the economy's initial productivity level. Figure 12 shows the welfare losses for different persistence levels of the negative shock specified in equation (25). The figure shows that welfare losses, but also the mitigating role of migration increase with shock persistence. It further shows that at all

Figure 10: Welfare effects following a negative 1% shock to demand for Italian output.

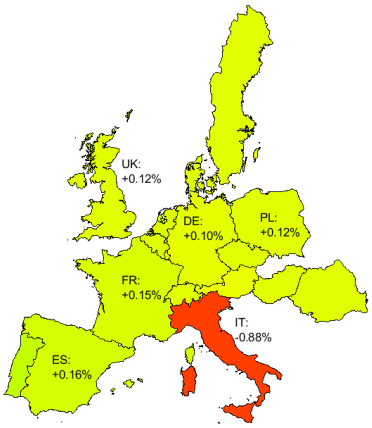
(a) Low skilled individuals, no migration



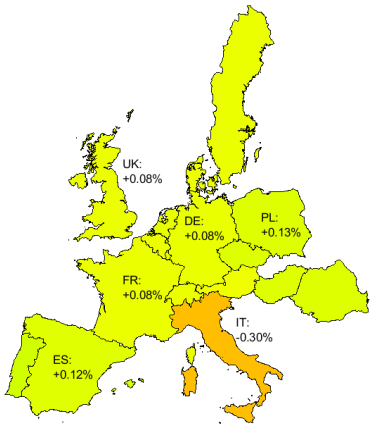
(b) Skilled individuals, no migration



(c) Low skilled individuals, with migration



(d) Skilled individuals, with migration



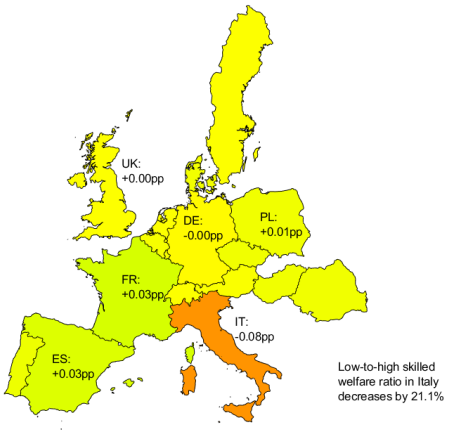
Note: The figure shows welfare effects, measured as the change in steady state welfare following a permanent reduction in consumers' taste for Italian output by 1 percent. The top panels show welfare changes if migration was prohibited for low skilled (panel a) and high skilled individuals (panel b); panels (c) and (d) show the same for integrated labor markets.

levels of persistence high skilled workers benefit more from migration, as indicated by the larger difference between welfare losses under closed borders (orange bars) and when workers can migrate (blue bars).

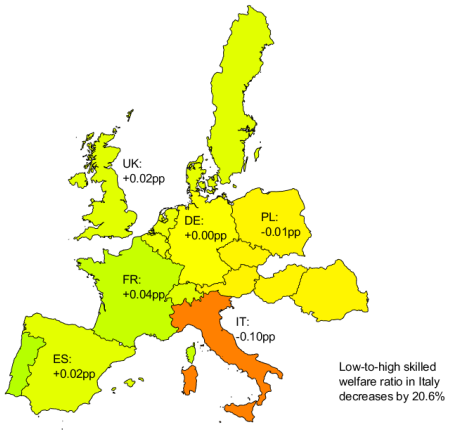
In sum, these results show that accounting for worker heterogeneity does not prove wrong the idea of labor mobility as an element of stabilization in a monetary union. Nonetheless, the gains from migration are distributed unevenly. In line with the primary concern for policy makers, our analysis focuses on the labor market outcomes for non-migrants. Yet, the main

Figure 11: Changes in the welfare gap between skill groups.

(a) Permanent TFP shock



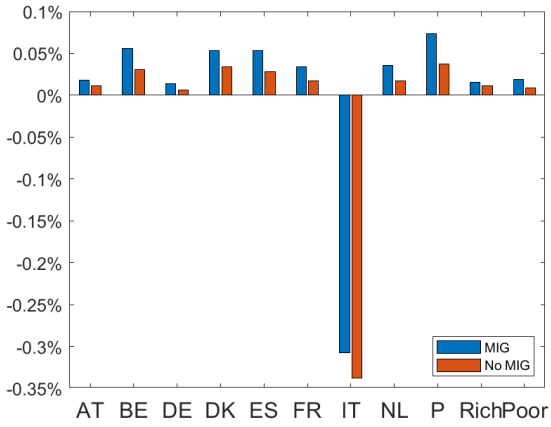
(b) Permanent Demand shock



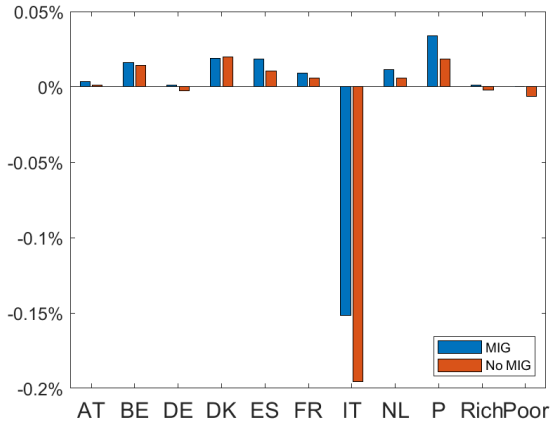
Note: The figure shows the difference in welfare gap changes between the case of integrated labor markets and when migration is prohibited. Panel (a) shows the change following a permanent reduction in Italian productivity by 1 percent; panel (b) following a permanent reduction in consumers' taste for Italian output by 1 percent.

Figure 12: Effects of a non-permanent productivity shock on welfare

(a) Unskilled welfare change following a non-permanent TFP shock



(b) Skilled welfare change following a non-permanent TFP shock



Note: The figure shows welfare effects as the decrease in steady state welfare following a temporary reduction in Italian total factor productivity by 1 percent, with different levels of persistence in the process of equation (25).

beneficiaries of integrated labor markets are—in economic terms —migrants themselves,[22] and the aggregate economy unambiguously gains from free geographic mobility. Our results

[22] Although their employment prospects and incomes rise, they also bear the cost of migration and, on average, suffer a disutility from living abroad.

ultimately point towards a role for other policies, including re-distribution across national borders, which may be required to absorb asymmetric shocks that cannot fully be mitigated through trade or factor movements in a currency union.

7.5 Counterfactual Policy Evaluations

In this section, we evaluate two key policies affecting the mitigation of asymmetric shocks in a currency union. First, increased fiscal integration is an equally decisive and sensitive margin of closer economic integration in the European Union, and policies such as the NextGenerationEU recovery plan are steps in this direction. Second, taxation of high skilled emigrants or a subsidy of high skilled immigrants may be a tempting policy counteracting overly skilled biased migration responses.

7.5.1 Common Fiscal Policy

Part of the importance of labor mobility within monetary unions stems from the lack of fiscal transfers in response to asymmetric shocks. An policy that would substitute migration, which our model is suited to analyze, is a transfer system that covers the burden of additional unemployment benefit in the event of an asymmetric crisis. We model this as an extension of the government budget constraint to all euro area countries for any costs that are to be paid on top of the initial steady-state level. In this case, the government budget constraint becomes

$$\sum_{j \in euro} b_j \sum_s \sum_n u_{j,s,n} = \sum_{j \in euro} T_j \sum_s \sum_n \left(e_{j,s,n} + u_{j,s,n} \right). \tag{26}$$

Whereas we use benefit levels b_j from the data, the level taxes T_j in our model is adjusted endogenously to changes in the number employed and unemployed workers $e_{j,s,n}$ and $u_{j,s,n}$, such that the budget is balanced. Unemployment insurance is unlikely to be fully integrated across European countries anytime soon, and our aim is to evaluate a policy that would foresee transfers in the event of a crisis that cover the excess burden of a rise in unemployment. We specify our counterfactual scenario accordingly: each resident in a country j pays a level T_j determined by the initial steady state level of taxes, augmented (or decreased) by an amount that is uniform across all euro area countries, and which satisfies the integrated budget constraint (26).

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. Figure 13 shows the evolution of net wages

following the decrease in demand for Italian output that we considered in Section 7.1. The figure shows this separately for the baseline with integrated labor markets but no fiscal transfers (blue line) and for a counterfactual scenario in which migration is prohibited, while the transfer system described above is in place (yellow line). As before, these can be compared to the case of neither of the two integration policies (red line). Figure 13 provides three main insights: first, a fiscal transfers are a fast relief than the relatively slow adjustment through migration. For both low (Panel a) and high skilled (Panel b) workers, the yellow line with fiscal transfers initially decreases at a lower rate than the blue line resulting from migration. Second, in the long run, 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 for high-skilled workers. For low-skilled workers, the common fiscal policy allows them to enjoy a higher net wage even in the long-term. Finally, different from integrated labor markets, fiscal transfers do not favor high skilled workers, and lead to a similar decline in net wages for both skill groups.

(a) Low skilled real net wage

(b) High skilled real net wage

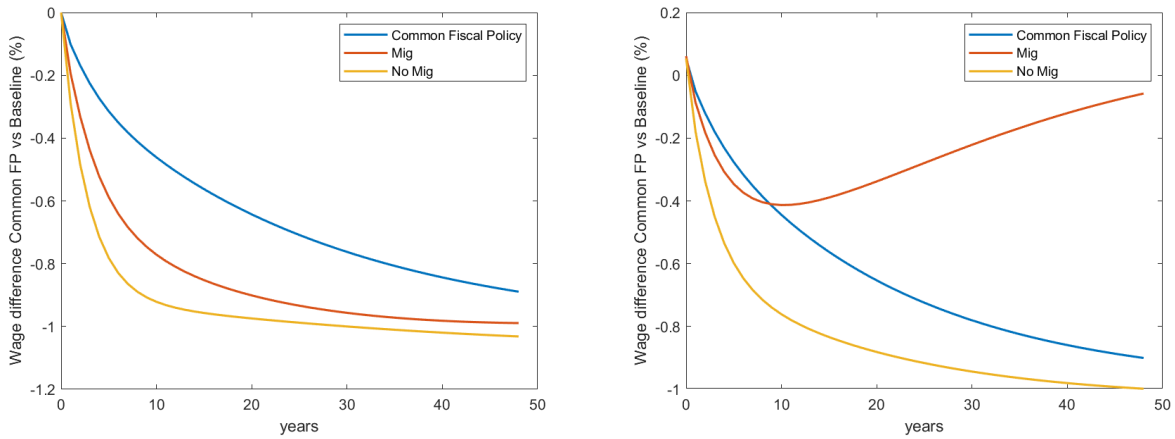
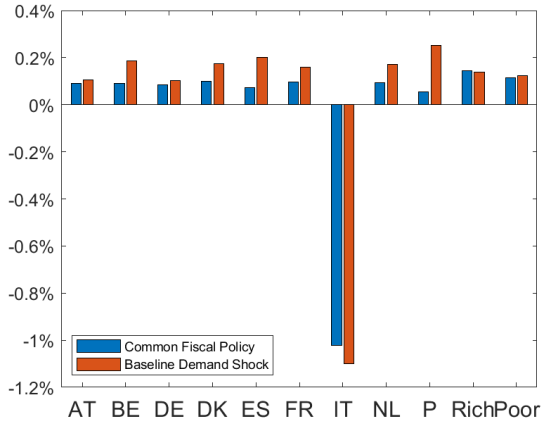


Figure 13: Net nominal wages following a negative 1% shock to demand for Italian output. Comparison between scenarios: no-migration and no fiscal transfers (red line), migration and no fiscal transfers (blue line), and no-migration with fiscal transfers (yellow line).

In terms of welfare gains, Figure 14 shows that fiscal integration combined with closed borders is rather costly for the high skilled individuals, who face an increase in their unemployment rate and a decline in wages compared to the case in which they could leave the country. On the other hand, the policy is slightly welfare beneficial for the low-skilled workers, given that the emigration channel is much less used by this group of individuals.

(a) Low skilled welfare



(b) High skilled welfare

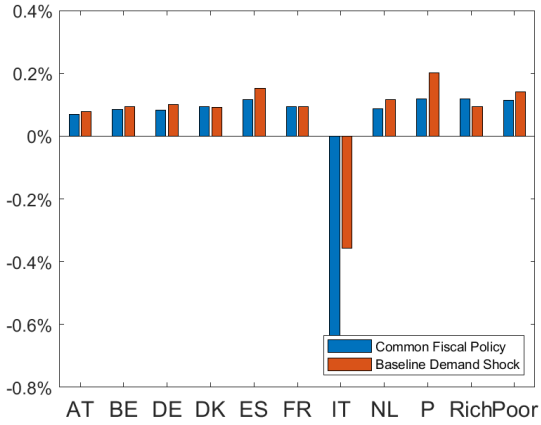


Figure 14: Welfare effects following a negative 1% shock to demand for Italian output and implementation of a Common Fiscal Policy within the Euro Area regarding additional unemployment benefits.

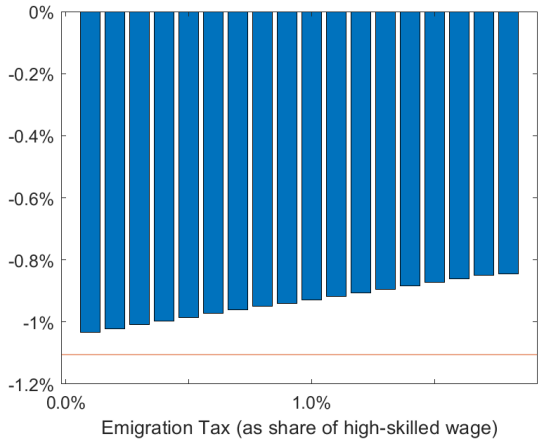
7.5.2 Taxation of High Skilled Emigration

In this section we analyze the welfare implications of the implementation of group-specific taxation. Suppose the government of the country hit by the negative shock, collects a wage tax from its own high skilled citizens living abroad. The Pareto-optimal tax is unambiguously zero, since such a tax inefficiently reduces the ability of mobile workers to move to more productive countries. Yet, such a tax may be an effective redistributive measure, equalizing the relative welfare losses across the different groups of individuals. In particular, this equalization operates not primarily through a lowering of the tax burden for domestic workers, but through a disincentive for high skilled workers to leave the country, which raises the value of low skilled vacancies.

In Figure 15, we show the welfare losses of a negative demand shock on Italian goods, for different levels of a tax on the wages earned by high skilled Italians abroad. The higher the tax, the milder the welfare losses for low skilled Italians in Italy. The negative effect of the shock for the welfare of high skilled Italians, instead, naturally instead. The tax hence acts as a transfer of resources between the two groups.

The level of taxation that equalize the relative welfare losses of the shock across groups is 1.4%. A tax of that level approximately equalizes the emigration rates for low and high skilled workers from Italy, which we display in Panels (a) and (b) of Figure 16. Panels (c) and (d) show the effect on wages is similarly equalized, benefiting low skilled workers at the expense of the high skilled.

(a) Low skilled welfare change following perm. Demand shock



(b) High killed welfare change following perm. Demand shock

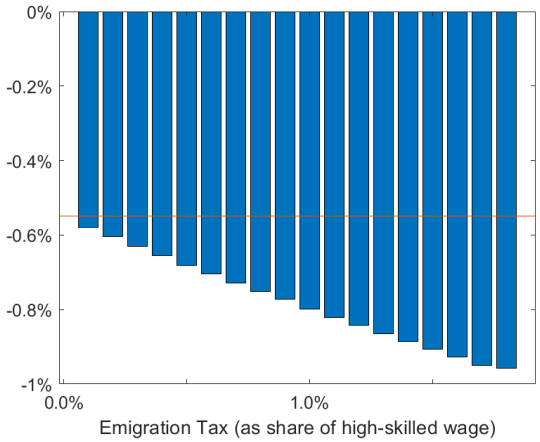


Figure 15: Welfare effects following a negative 1% shock to demand for Italian output for different levels of a wage tax on high skilled Italians abroad.

8 Conclusion

Labor mobility has been described as a viable alternative to monetary and fiscal policies in order to sustain a monetary union characterized by price rigidity, when exchange rate adjustments are prevented by the common currency (Blanchard and Katz, 1992; Boeri and Brücker, 2005; Lane, 2006). In this work, we show that, at current levels of migration flows in Europe, migration can mitigate the economic consequences of asymmetric shocks for more mobile high skilled workers, but barely so for lower skilled parts of the population.

To examine this, we formulate a spatial equilibrium model with search frictions in which we acknowledge the heterogeneity in skill levels and mobility among workers. We assume that some degree of complementarity exists between different types of workers, and allow worker types to differ in terms of their preference distributions over locations. Data from the European Union Labour Force Survey show recent migration in Europe to be predominantly positively selected. On a theoretical level, labor mobility may thus aggravate the condition for a country hit by a negative shock to demand or productivity, if this reinforces selective migration.

Calibrating the model to EU-LFS data on labor market outcomes and migrant flows, however, confirms that labor mobility reduces the welfare loss following asymmetric economic shocks to either productivity or to consumers' demand of a given country's output. However, given the higher relative mobility of high skilled workers, this shock mitigation is distributed very unevenly, with little loss reduction for low skilled workers. This shows that labor mobility is an important factor for the stability of a currency union, but that it is not a full substitute

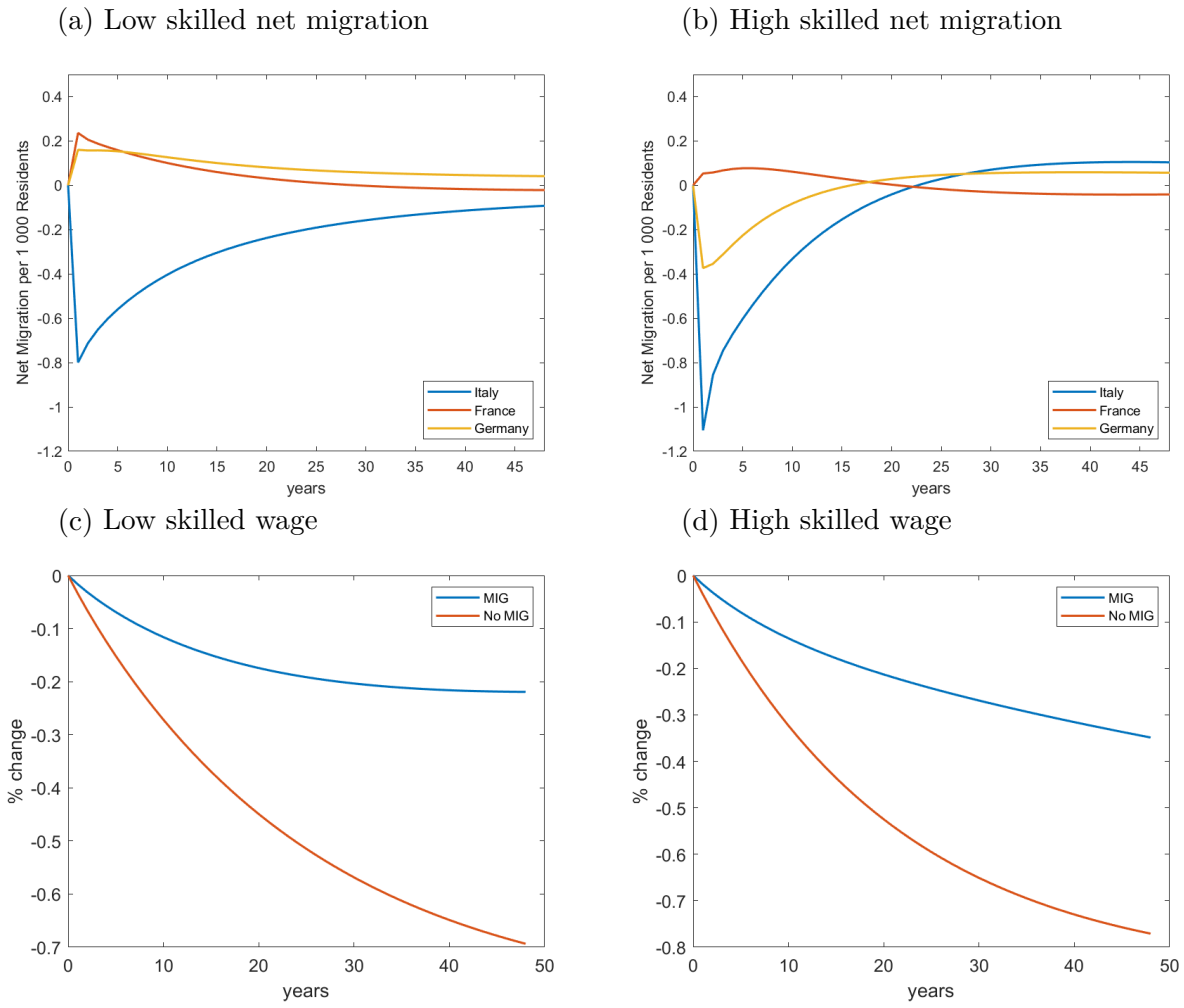


Figure 16: Net migration and wages following a negative 1% shock to demand for Italian output with a wage tax of 1.4% on high skilled Italians abroad.

of other compensating policies that concur in the debate, such as a more coordinated fiscal policy. Our results thus confirm concerns voiced for instance by Carlin (2013) and Krugman (2013), not least to maintain political support for economic unions like the European (cf Gancia et al., 2020).

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A Skills, complementarity and moving costs

In this appendix, we formulate a simple frictionless model of the type referred to in Section 3. The model demonstrates the theoretical possibility of a negative effect of high skilled emigration on low skilled non-migrants in a country suffering from decreased productivity. However, we also use this model to illustrate that in standard frictionless settings this negative effect is in fact an unambiguous outcome. In addition to different types of workers, the model we use in Section 4 hence crucially features friction (both search and nominal frictions), so that the effect of integrated labor markets becomes an empirical question.

For now, suppose that there are only two countries $j \in \{1, 2\}$, whose national production derives from the input of H_j high skilled and L_j low skilled workers according to a production function

$$Y_j = A_j(\alpha L_j^{\rho} + (1-\alpha)H_j^{\rho})^{1/\rho},$$

with total factor productivity A_j, income shares α and $(1-\alpha)$ for low and high skilled workers, and an elasticity of substitution $1/(1-\rho)$ between the two inputs. In the simplified model presented in this appendix, suppose that workers are paid their marginal product and that location choices only depend on wages w and local amenities ϵ. These amenities, however, are valued differently across individuals, with the payoff for individual i of nationality n from working in country j given by

$$u_{n,j}^{L} = w_j^{L} + \epsilon_{i,j}^{L} = \alpha A_j^{\rho}(Y_j/L_j)^{1-\rho} + \epsilon_{i,j}^{L},$$

if the individual is low skilled, and by

$$u_{n,j}^{H} = w_j^{H} + \epsilon_{i,j}^{H} = (1-\alpha) A_j^{\rho}(Y_j/H_j)^{1-\rho} + \epsilon_{i,j}^{H},$$

if not, where the valuation of amenities $\epsilon_{i,j}$ is drawn from a nationality and skill-specific distribution. In Section 4, a dynamic model with search frictions and country specific income shares is matched to the distribution of wages and unemployment rates across countries and skill types. If the idiosyncratic valuations for location amenities are drawn from a type I extreme value distribution with mean $\mu_{n,j}^{s}$ for workers with skill $s \in \{H, L\}$ and origin nationality $n \in \{1, 2\}$, a fraction

$$\text{prob}(u_j^s > u_n^s) = \frac{\exp(w_j^s + \mu_{n,j}^s)}{(\exp(w_j^s + \mu_{n,j}^s) + \exp(w_n^s + \mu_{n,n}^s))}$$

would derive higher utility from moving to j than from staying in n. Yet, migration of workers of either skill type will affect wages. If allowed, migration will thus continue until payoffs for each skill type are equalized across countries.

For $\alpha < 0.5$, $H_j \leq L_j$ and $A_1 < A_2$, two fundamentals in this simple model determine the effect which allowing for migration has on the wages of non-migrants in the less productive country: the degree of complementarity between high and low skilled workers, ρ, and the average relative preference for different locations, $\mu^s_{n,j}$. To make the case, suppose $\mu^L_{n,j} < \mu^L_{n,n} = \mu^H_{n,j} = \mu^H_{n,n}$, so that on average low skilled worker suffer a moving cost relative to high skilled workers, and relative to staying in the country of their nationality n. In this case, integrated labor markets depress (raise) the wage of low (high) skilled workers the more, the more negative $\mu^L_{n,j}$ and the lower the substitutability ρ between the different types of workers is. Figure A1 illustrates this for a set of baseline parameters $\alpha = 0.4$, $H_j = L_j = 1$, $A_1 = 1$, $A_2 = 2$, $\rho = 0.75$, $\mu^L_{n,j} = -1$ and $\mu^L_{n,n} = \mu^H_{n,j} = \mu^H_{n,n} = 0$. Specifically, the figure shows—for varying values of ρ and $\mu^L_{n,j}$—the percentage changes in skill-specific equilibrium wages in low productivity country 1 when moving from autarky to internationally integrated labor markets. Panel (a) shows a marked decrease in the wage of low skilled non-migrants in country 1 when skill types are complement ($\rho < 0$). For the given set of parameters, this wage loss amounts to 6 percent even for a value of $\rho \approx 0$. In this simple frictionless model the loss only vanishes as workers become perfect substitutes ($\rho = 1$). Panel (b) shows the corresponding changes for different moving costs of low skilled workers, keeping ρ at a value of 0.75 common in the literature (see e.g. Caliendo et al., 2017). Again, as high skilled workers leave for the more productive country, low skilled workers suffer a wage loss, whereas high skilled workers staying in country 1 gain.

Note that without frictions and with constant returns to scale, less mobile workers who are less than perfect substitutes to other input factors are bound to lose from integrated labor markets. This is does not necessarily hold in the more realistic and dynamic model that we bring to the data in Sections 4-7. In particular, search frictions imply that emigration may be a means to reduce unemployment in the emigration country. Accordingly, the actual capability of internationally integrating labor markets to buffer asymmetric shocks is an empirical question, which this paper is set to answer. The global welfare effect of facilitating international mobility of labor, that is a removal of barriers, is necessarily positive in either model. Hence, there is in principal scope for welfare improving redistribution even in case labor market integration has a negative effect on some types of workers.

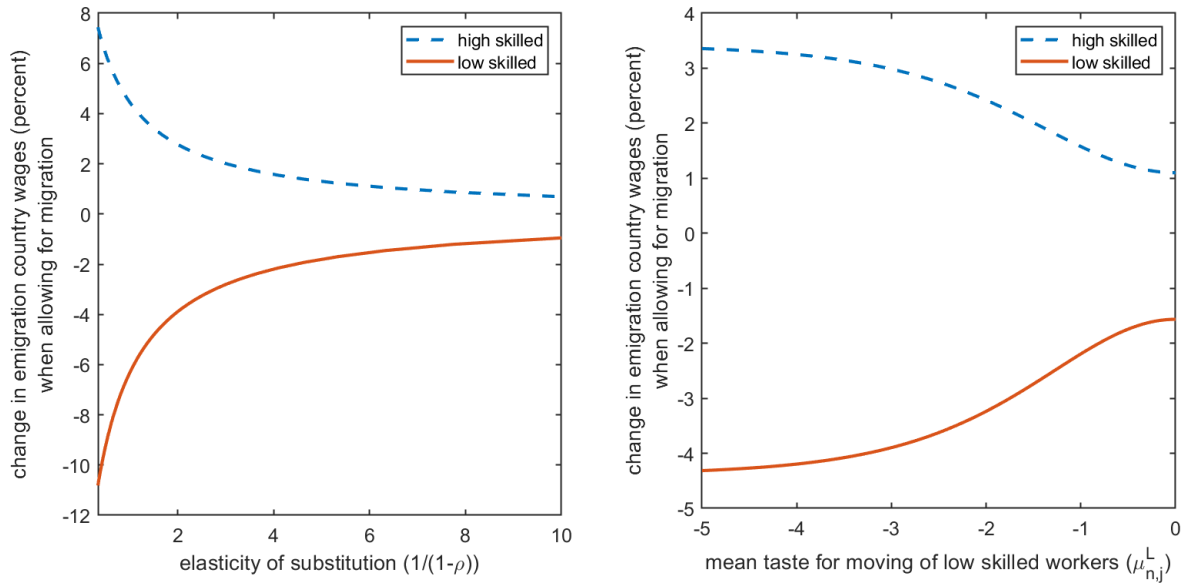


Figure A1: Percentage change in equilibrium wages in low productivity country 1 when moving from autarky to internationally integrated labor markets; (a) for different degrees of substitutability, and (b) different levels of moving costs for low skilled workers. Baseline parameterization: $\alpha = 0.4$, $H_j = L_j = 1$, $A_1 = 1$, $A_2 = 2$, $\rho = 0.75$, $\mu^L_{n,j} = -1$ and $\mu^L_{n,n} = \mu^H_{n,j} = \mu^H_{n,n} = 0$.

B Data

In this appendix we describe the data sources we used in the calibration:

- European Union Labour Force Survey from 2012 to 2017 for labor and migration data;
- Eurostat Annual National Account for GDP data;
- Eurostat Statistics on Income and Living Conditions (EU-SILC);
- Eurostat Harmonised index of consumer prices for the price level;
- OECD net replacment rates in unemployment;
- GeoDist Database by CEPII for country distances.

Appendix B: Calibration

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

B.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 5%, which implies a discount factor of 0.9524.

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).[23]

Elasticity of substitution between high and low educated workers. The elasticity parameter in the CES production function of intermediate goods (3) is set to $\rho = 0.75$, implying an elasticity of substitution between workers of different types equal to 4. This is the value reported by Caliendo et al. (2017), which they estimate on Portuguese matched employer-employee data. Other estimates in the literature range between 1.5 (Ottaviano et al., 2012) and 5 (Dustmann et al., 2009).[24]

Unemployment benefit. We use the net replacement ratio of unemployment benefits collected by the OECD for different worker categories. For our purpose, we take the average replacement ratio during the years considered (2012-2017) for each country in our sample, considering a single worker without children, who has been unemployed for 6 months and earned a previous wage equal to 2/3 the average wage. We then 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 $\eta = 0.72$. The unemployment level only jointly identifies the vacancy cost $\kappa_{j,s}$ and the matching efficiency parameter ς. We thus set the latter to $\varsigma = 0.25$, and calibrate the corresponding vacancy cost to match unemployment rates. Note that as long as one free parameter is calibrated to match observed unemployment rates, the fixing of the other parameter neither affects estimates for other parameters nor the model's counterfactual predictions. 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 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' working condition 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.

[23] We performed robustness checks for elasticities of substitution ranging between 2 and 6, and found no qualitative changes, see Appendix B.5.

[24] Robustness checks varying the elasticity of substitution between 2 and 6 showed to affect mostly the labor market response to a shock, but our main result are qualitatively robust to different values, see Appendix B.4.

Taylor-rule parameters We set the Parameters following the papers by House et al. (2018) and Nakamura and Steinsson (2014). They set the Taylor-rule for quarterly data, while in this work the period is 1 year. Since they use 0.75 as auto-regressive term for describing the Taylor-rule, we set ρ to 0.75^4, in order to capture a similar amount of stickiness. Then we set $\phi_y = 0.5$ and $\phi_p = 1.5$.

B.2 Jointly Estimated Parameters and Targeted Moments

Tables A1-A9 list the moments targeted and show the fit of the model to the data.

	Target	Model
GDP AT	313,276	313,085
GDP BE	382,537	382,208
GDP DE	2,793,109	2,770,827
GDP DK	257,628	256,606
GDP ES	1,069,143	1,087,904
GDP FR	2,095,771	2,097,604
GDP IT	1,564,054	1,563,994
GDP NL	662,271	661,580
GDP PT	172,392	172,684
GDP Rich	3,262,022	3,269,844
GDP Poor	837,226	837,466

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

	Target	Model
Skill Premium AT	1.340	1.341
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	1.548
Skill Premium FR	1.422	1.423
Skill Premium IT	1.416	1.417
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	0.002	3.054	0.168	0.000	0.034	0.015	0.121	0.000	0.229	0.020
	0	*0.014*	*3.014*	*0.154*	*0*	*0.047*	*0.029*	*0.133*	*0*	*0.215*	*0.033*
BE	0.010	0	0.589	0.076	0.188	1.705	0.100	3.296	0.136	0.035	0.008
	0.024	*0*	*0.581*	*0.072*	*0.181*	*1.686*	*0.111*	*3.242*	*0.147*	*0.047*	*0.023*
DE	0.822	0.300	0	0.358	0.891	2.065	0.290	3.211	0.385	3.853	1.275
	0.822	*0.287*	*0*	*0.345*	*0.910*	*2.087*	*0.287*	*3.227*	*0.384*	*3.838*	*1.279*
DK	0.001	0.000	0.614	0	0.211	0.209	0.000	0.013	0.000	0.868	0.025
	0.012	*0.011*	*0.604*	*0*	*0.211*	*0.219*	*0*	*0.028*	*0.007*	*0.842*	*0.039*
ES	0.054	0.597	3.266	0.422	0	0.805	0.115	0.006	0.482	1.982	0.076
	0.048	*0.590*	*3.222*	*0.440*	*0*	*0.800*	*0.010*	*0*	*0.471*	*1.969*	*0.086*
FR	0.068	1.585	2.929	0.273	0.807	0	0.198	0.138	2.792	4.896	0.003
	0.056	*1.574*	*2.882*	*0.259*	*0.811*	*0*	*0.194*	*0.144*	*2.740*	*4.806*	*0*
IT	0.077	0.351	1.419	0.083	0.313	0.717	0	0.022	0.004	0.235	0.001
	0.079	*0.340*	*1.391*	*0.069*	*0.327*	*0.714*	*0*	*0.035*	*0.018*	*0.220*	*0.013*
NL	0.006	0.525	2.322	0.066	0.131	0.260	0.005	0	0.557	0.001	0.002
	0.014	*0.510*	*2.286*	*0.065*	*0.145*	*0.260*	*0.019*	*0*	*0.557*	*0*	*0*
PT	0.001	0.211	0.490	0.045	0.258	0.488	0.000	0.001	0	1.219	0.001
	0	*0.201*	*0.472*	*0.036*	*0.243*	*0.484*	*0*	*0.005*	*0*	*1.197*	*0.006*
Rich	0.153	0.108	2.638	0.169	3.379	1.819	0.882	0.302	0.428	0	0.001
	0.152	*0.116*	*2.630*	*0.155*	*3.40*	*1.837*	*0.894*	*0.306*	*0.444*	*0*	*0.010*
Poor	2.664	0.727	8.625	0.328	0.990	0.975	2.268	2.418	0.069	7.397	0
	2.640	*0.712*	*8.480*	*0.313*	*0.992*	*0.959*	*2.245*	*2.398*	*0.061*	*7.286*	*0*

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

	AT	BE	DE	DK	ES	FR	IT	NL	PT	Rich	Poor
AT	0	0.055	2.259	0.044	0.424	0.258	0.089	0.248	0.000	0.283	0.000
	0	*0.064*	*2.244*	*0.044*	*0.428*	*0.274*	*0.096*	*0.255*	*0*	*0.286*	*0.014*
BE	0.035	0	0.432	0.123	0.361	5.311	0.001	1.632	0.000	0.222	0.003
	0.046	*0*	*0.428*	*0.108*	*0.356*	*5.238*	*0*	*1.603*	*0.015*	*0.218*	*0.018*
DE	0.749	0.539	0	0.171	1.712	3.528	0.288	1.993	0.201	5.200	0.686
	0.753	*0.527*	*0*	*0.157*	*1.686*	*3.593*	*0.286*	*1.996*	*0.214*	*5.296*	*0.700*
DK	0.005	0.036	0.388	0	0.006	0.370	0.000	0.021	0.003	0.515	0.062
	0.019	*0.051*	*0.389*	*0*	*0.020*	*0.355*	*0.015*	*0.035*	*0.018*	*0.510*	*0.077*
ES	0.088	0.254	1.106	0.136	0	2.051	0.062	0.225	0.278	4.454	0.526
	0.076	*0.248*	*1.115*	*0.133*	*0*	*2.143*	*0.047*	*0.215*	*0.292*	*4.652*	*0.540*
FR	0.011	1.092	1.462	0.156	1.173	0	0.038	0.214	0.296	7.416	0.287
	0.024	*1.081*	*1.423*	*0.142*	*1.122*	*0*	*0.042*	*0.210*	*0.296*	*7.413*	*0.295*
IT	0.059	0.061	0.617	0.111	0.444	2.132	0	0.000	0.082	0.162	0.001
	0.057	*0.050*	*0.642*	*0.105*	*0.472*	*2.324*	*0*	*0.011*	*0.101*	*0.158*	*0*
NL	0.046	0.315	1.398	0.155	0.021	0.367	0.032	0	0.223	0.000	0.001
	0.050	*0.302*	*1.377*	*0.141*	*0.035*	*0.375*	*0.029*	*0*	*0.224*	*0*	*0*
PT	0.001	0.004	0.186	0.004	0.273	0.001	0.036	0.002	0	0.555	0.028
	0	*0*	*0.171*	*0*	*0.270*	*0*	*0.020*	*0.007*	*0*	*0.561*	*0.033*
Rich	0.090	0.379	2.873	0.285	2.157	2.198	0.754	0.608	0.634	0	0.239
	0.097	*0.371*	*2.825*	*0.271*	*2.091*	*2.210*	*0.715*	*0.618*	*0.628*	*0*	*0.250*
Poor	0.355	0.605	1.793	0.009	0.253	0.567	0.358	0.664	0.112	4.449	0
	0.339	*0.591*	*1.753*	*0.007*	*0.256*	*0.568*	*0.334*	*0.653*	*0.121*	*4.448*	*0*

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

	Target (%)	Model (%)
AT	5.10	5.10
BE	8.55	8.56
DE	5.07	5.12
DK	6.59	6.63
ES	26.34	26.39
FR	11.51	11.52
IT	12.37	12.38
NL	6.96	6.96
PT	13.57	13.57
Rich	7.36	7.36
Poor	8.27	8.28

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

	Target (%)	Model (%)
AT	2.55	2.56
BE	3.32	3.32
DE	1.88	1.89
DK	4.03	4.08
ES	12.48	12.25
FR	5.41	5.44
IT	6.49	6.49
NL	3.20	3.22
PT	9.52	9.52
Rich	3.09	3.08
Poor	3.87	3.89

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

	Target	Model
AT	0.640	0.028
BE	0.766	0.035
DE	3.469	4.246
DK	0.230	0.036
ES	1.753	1.030
FR	1.982	3.360
IT	1.979	0.031
NL	0.422	0.266
PT	0.195	0.490
Rich	4.796	6.551
Poor	0.337	0.099

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 indicates the average price level in the EU28)

	Target	Model
AT	0.807	0.808
BE	0.871	0.870
DE	0.933	0.938
DK	0.943	0.939
ES	0.728	0.729
FR	0.921	0.922
IT	0.753	0.755
NL	0.945	0.943
PT	1.047	1.037
Rich	0.997	0.996
Poor	0.991	0.985

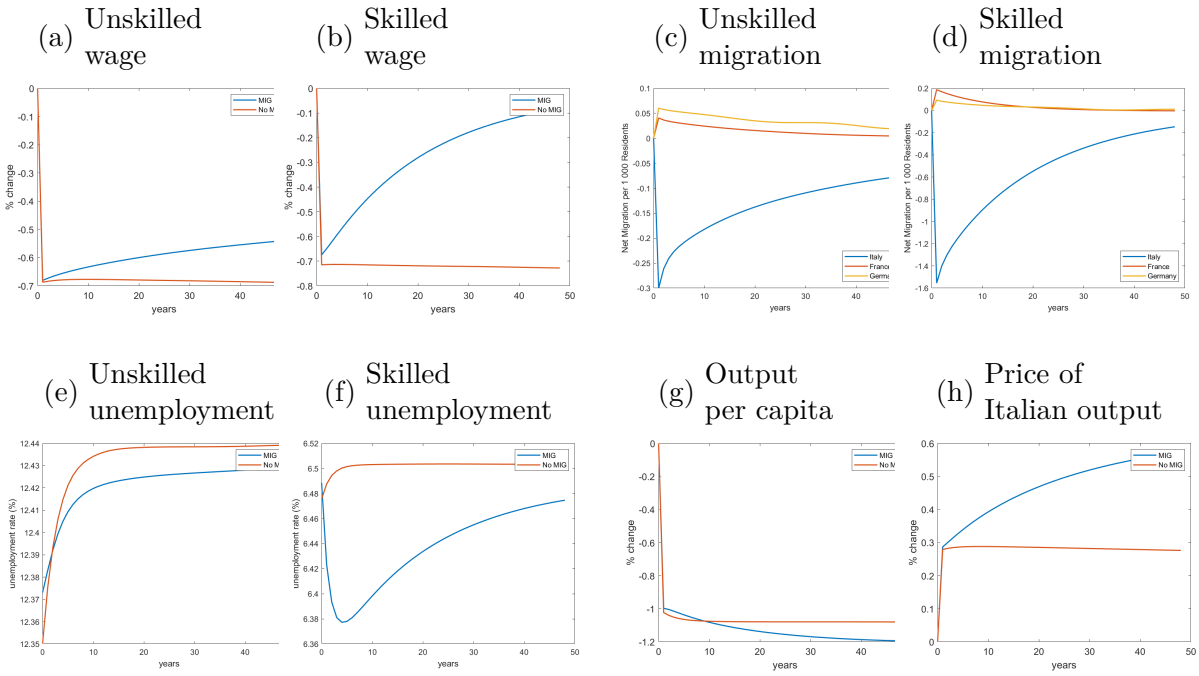
Table A9: Model fit: Migration Wage Discount (Non-Natives wages divided by Natives Wages)

Appendix C: Additional Results and Robustness Checks

In this appendix we report the results that we obtained by varying single parameters of the model that we borrowed from the literature. We focused on the baseline scenario of a permanent negative shock of 1% to Italian total factor productivity, and show transition paths between steady states as in the figures shown in the paper.

B.3 Flexible Wages

Figure A2: Effects of a permanent reduction in Italian total factor productivity by 1 percent in a model with flexible wages



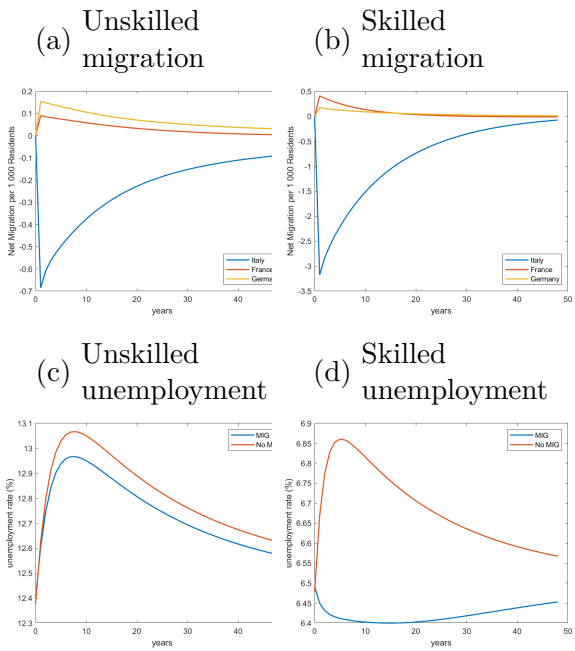
Note: The figure shows transitions between steady states for outcomes following a permanent reduction in Italian total factor productivity by 1 percent. Wage persistence is set to $\omega = 0$.

B.4 Elasticity of Substitution across Skills

TBD

B.5 Elasticity of Substitution across Goods

Figure A3: Effects of a permanent reduction in Italian total factor productivity by 1 percent in a model with higher goods elasticity



Note: The figure shows transitions between steady states for outcomes following a permanent reduction in Italian total factor productivity by 1 percent. Elasticity between Final National Goods is raised to 6

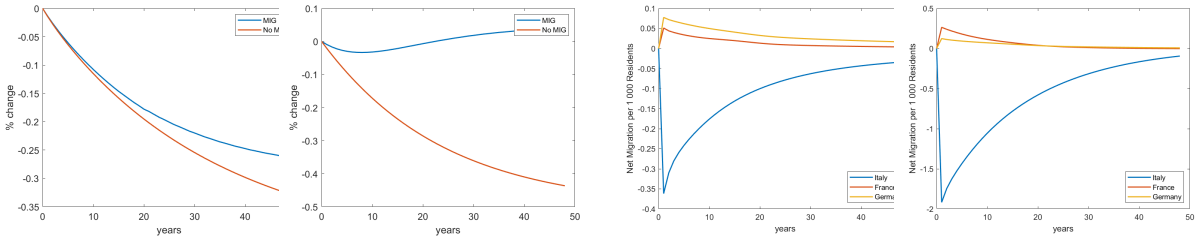
B.6 Discount Factor

We also examine the robustness of our results to the use of different discount rates. Our baseline in the main text assumes that future outcomes are discounted at a rate of 5 percent. Figure A4 shows the effect of integrated labor markets under alternative discount rates of 1 percent (in panels (a)-(d)) and 10 percent (panels (e)-(h)), respectively.

Figure A4: Effects of a permanent reduction in Italian total factor productivity by 1 percent in a model with higher discount factor

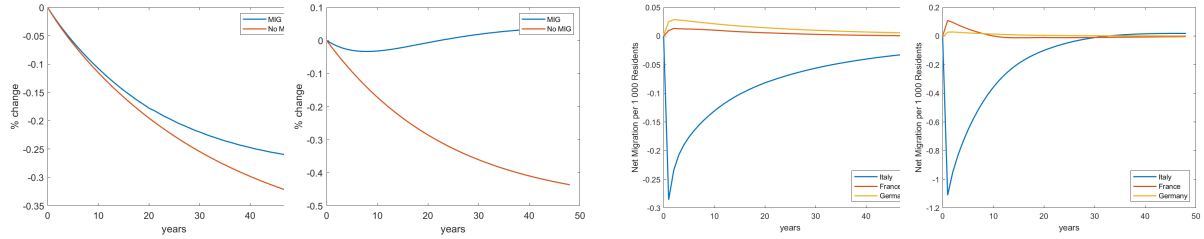
$r = 1\%$

(a) Low skilled wage (b) High skilled wage (c) Low skilled migration (d) High skilled migration



$r = 10\%$

(e) Low skilled wage (f) High skilled wage (g) Low skilled migration (h) High skilled migration



Note: The figure shows transitions between steady states for outcomes following a permanent reduction in Italian total factor productivity by 1 percent. Panels (a)-(d) show transitions under a discount rate of 1 percent; panels (e)-(h) assume a discount rate of 10 percent.