Migration, Search and Skill Heterogeneity

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Abstract

Cross-border migration can act as an important adjustment mechanism to country-specific shocks. Yet, depending on who moves, it can have unintended consequences for business cycle stability. This paper argues that the skill composition of migration plays a critical role. When migration flows become more concentrated in skilled labour an important trade-off arises. On the one hand, migration releases unemployment pressures for the origin countries. On the other hand, it generates negative compositional effects (the so-called "brain drain" effects) and skill imbalances, which reduce supply capacity in origin countries. This paper analyses quantitatively the impact of cyclical migration in an open-economy DSGE model with endogenous migration flows, trade linkages, search and matching frictions, and skill heterogeneity. I apply this framework to the case of the Greek emigration wave following the European Debt Crisis. What I find is that emigration flows implied strong negative effects for capital formation, leading to a more than 15% drop in investment. Rather than stabilising the Greek business cycle, labour mobility led to a deeper and more protracted recession.

Keywords: Migration, Matching Frictions, Skill Heterogeneity.
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1 Introduction

The 2010 Sovereign Debt Crisis exposed the Euro Area to a severe asymmetric shock, leading to divergent macroeconomic behaviour between the European core and periphery country members. Against the backdrop of mounting borrowing costs, a severe deterioration of the labour market conditions and a steep drop in economic activity, the capacity of European periphery countries to employ countercyclical macroeconomic tools was limited. The absence of the option to devaluate national currencies removed an important adjustment mechanism. At the same time, the austerity measures imposed in several Southern European countries meant that national fiscal policy had limited space for manoeuvring. Against limited alternative adjustment mechanisms, cross-border emigration flows from the European periphery to core countries surged (Fig. 1, a).[1] However, contrary to previous migration waves, this one was characterised by a significant shift in the skill-content of labour flows (Fig. 1, b).

Can migration indeed stabilise the business cycle of origin countries? How does the skill composition of migration flows impact the shock–absorbing capacity of migration? This paper sets out to address these questions through the lens of a small open economy Dynamic Stochastic General-Equilibrium (DSGE) model. The main finding is that the nature of migration flows in terms of skills is important for the stabilising role of migration. Contrary to conventional wisdom, migration can have a destabilising impact on the business cycle due to adverse effects on the incentives for capital accumulation and on supply capacity.

Labour mobility has been identified as a key adjustment mechanism to asymmetric shocks in the context of currency unions, and it is one of the preconditions for an optimal currency area according to the seminal work of Mundell (1961). When the relative factor prices and the nominal exchange rate cannot adjust in response to idiosyncratic shocks, mobility of production factors offers an alternative. Cross-border labour mobility in particular can stabilise labour market conditions in the country hit

[1] For the case of Greece, the country that experienced the deepest and most protracted recession, emigration flows resulted in more than 7% of active population exiting the country between 2010 and 2015 (Bandeira et al., 2019). For Spain, emigration flows were unprecedented as well, amounting to outflows close to 1% of total population over 2010 - 2014 (Izquierdo et al., 2016).

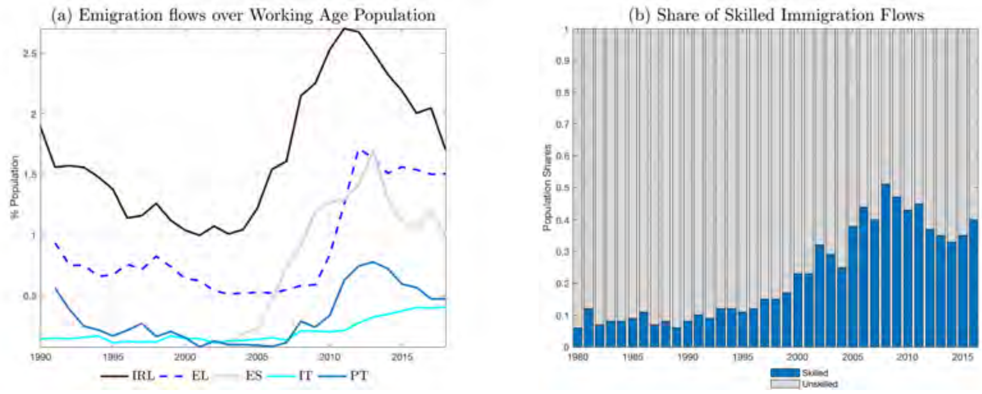
by the idiosyncratic shock. Emigration endogenously reduces the pool of unemployed thereby mitigating the increase in unemployment rates and the negative wage pressure in domestic labour markets. Additionally, cross-border migration allows consumption smoothing through remittances, which can act as a risk-sharing device.[2] In many ways, the increase in emigration from periphery countries during the Sovereign Debt crisis can be characterised as a Mundellian automatic stabiliser. Yet, this analysis of cyclical migration overlooks an important factor: skill heterogeneity. Gross migration flows from the Euro Area periphery to core countries mask important heterogeneity in terms of the educational profile of emigrants, which shifted in the recent migration wave.[3]

With heterogeneous labour flows, cross-country migration changes not only the size of the workforce in the origin country but also its skill composition. In this paper, I argue that the resulting skill imbalances can have a negative impact on firms' investment decisions leading to lower economic activity and reversing the cushioning effect of migration. To quantify the effects of cyclical migration, I build a DSGE model which features two types of household (high and low skilled), and explicitly accounts for the compositional ("brain drain") effects of migration. The model has three key frictions. Firstly, search and matching frictions which generate equilibrium unemployment and are asymmetric among the two types of workers. Secondly, a migration choice which endogenously changes over the business cycle depending on relative labour market conditions in origin and destination countries and mobility costs which differ across the two households. Thirdly, capital-skill complementarities in the production function, which introduce a link between capital demand and the skill content of the labour force.

[2]However, we should note that remittances are of minor quantitative significance for Southern European countries. Based on World Bank data, the average share of remittances over GDP for 2010-2015 was 0.82% for the European South. For comparison, the world average over the same period was 4.7%, as this insurance mechanism plays a much more prominent role for developing and frontier economies.

[3]For the case of Greece, Labrianidis and Pratsinakis (2016) report that approximately 65% of total migration outflows post 2010 were highly educated graduates. These findings are confirmed by own research. Based on LFS and population registry data from the German microcensus and the Danish statistical office, I find a shift in the skill content of both immigrant flows and stocks from the European periphery to Germany and Denmark respectively. While the rising educational attainment in origin countries can partially offset the negative compositional effects of emigration, the growth of high-skilled emigration outpaced dramatically the increase in tertiary educated domestic workforce (see appendix).

Figure 1: Emigration flows, evolution of size and skill composition



(a) Gross emigration flows from European periphery countries as a % share of total working age population (years 15-64). See appendix for net emigration flows. Source: Eurostat.
(b) Immigration flows from periphery (Ireland, Greece, Spain, Italy and Portugal) to Germany. Skill classification is via educational attainment (ISCED level 5 and above). The sample is controlled for working age at year of entry (years 25-64 to account for education-related migration). See appendix for alternative skill classifications. Source: German Microcensus.

I apply this framework to the case of Greece, focusing on the emigration wave during the Sovereign Debt crisis. I find that, for realistic degrees of capital skill complementarity in the production technology, skill-specific labour shortages due to migration outflows had a significant negative effect on capital accumulation and production. Comparing the baseline scenario to a counterfactual scenario of no migration, the output trough is lower by more than 7 percentage points, the investment trough by more than 15 percentage points, and consumption, despite an initially smaller drop (due to the risk-sharing effects of migration), exhibits a trough which is almost 5 percentage points lower.

The interaction between labour market externalities, due to search frictions, and production externalities, due to the capital-skill complementarity, is crucial for this result. The production externality reduces the incentive of firms to invest in capital when emigration flows are skewed towards the highly skilled. If capital is more productive when coupled with skilled labour, then a lower stock of skilled workers will reduce the returns on investment. The drop in capital demand is magnified due to search frictions and the heterogeneous mobility costs among the two skill types. Skilled households face lower mobility costs resulting in relatively more skilled unemployed directing their search abroad. As a result, market tightness for the skilled increases and the effective costs of skilled vacancies go up. Firms' incentive to post skilled vacancies are muted further amplifying the reduction in capital demand. The combined effect of lower total labour supply and lower relative share of skilled labour supply due to migration generates a sharp and persistent drop in output and exacerbates rather than dampens the recessionary shock.

This paper proceeds as follows. Section 2 briefly discusses the related literature. Section 3 presents the model and Section 4 presents the calibration strategy. Section 5 continues with the quantitative analysis of the model and section 6 concludes.

2 Related Literature

This paper relates to two strands of literature. Firstly, it contributes to the literature on cyclical migration. Following the increase of intra-Euro Area migration flows, there has been growing academic interest in studying how migration matters for the business cycle dynamics of Euro Area countries, as well as for monetary and fiscal policy. The paper that is the closest to my study is Bandeira et al. (2019). Similarly to the present paper, the authors look at Greek outflows in a small open economy model that combines search and matching frictions and endogenous labour mobility, but with a different focus. The authors examine the link between fiscal austerity and migration and uncover a novel bi-directional relationship. Fiscal consolidations, especially when conducted through labour tax hikes intensify emigration. In turn, emigration reduces the tax base at the origin country and leads to higher and more persistent consolidations in order to meet given fiscal targets. Even though the interaction between migration and fiscal policy is highly important, our study abstracts from this dimension. It introduces heterogeneity in migration flows and focuses on the compositional effects of migration due to "brain-drain".

This paper is also related to House et al. (2018). The authors provide empirical evidence that European net migration, in line with the predictions of Mundell's framework, responded strongly to the growing cross-country unemployment differentials during the Sovereign Debt crisis. The authors estimate a multi-country DSGE model that features frictional labour markets and internal migration. They find that labour mobility is effective in reducing cross-country unemployment and per capita GDP differentials and can substitute independent monetary policy in delivering the necessary adjustment.

In another related paper, Hauser and Seneca (2019) study the implications of labour mobility for the monetary authorities of a currency union. The authors build a two-region DSGE model with sticky prices and market inefficiencies. They find that migration by endogenously stabilising regional labour market conditions can ease the unemployment–inflation tradeoff of the monetary policy maker. They also study the implications of internal migration for optimal monetary policy and argue that in the presence of labour mobility, strict inflation targeting is suboptimal whereas a higher weight on labour market developments in the policy rule is welfare-improving.

Cyclical migration and its impact on destination countries has also gained increasing academic interest. Lozej (2019) study the effects of a positive migration shock in a DSGE model with frictional labour markets that is calibrated to the Irish economy. Similarly to this study, he finds that migration amplifies business cycle fluctuations to country-specific shocks. Smith and Thoenissen (2018) address a similar question focusing on the New Zealand economy. The authors estimate an open economy DSGE model with physical capital, human capital and housing. A key finding of their paper is that the differences in human capital levels between migrants and locals are critical for the business cycle impact of migration. This result is consistent with the findings of this paper. However, differently to Smith and Thoenissen (2018), this paper focuses on an origin country and explicitly accounts for the interplay between search frictions and the compositional effects of migration.

There have also been several empirical studies that assess the impact of migration shocks. Furlanetto and Robstad (2019) use Norwegian data in a structural VAR model, and find evidence that migration shocks are an important driver of unemployment dynamics, leading to lower unemployment rates for both the native and the total population. In a similar vein, Faccioli and Vella (2020) use recent data on net migration from Germany, and find that migration shocks had an expansionary effect on investment, output per capita, net exports and tax revenues. The authors also report differential impact of migration shocks on native and immigrant unemployment. They report that net migration shocks had a positive effect on job creation, driving down unemployment for natives but increasing competition for immigrant workers and subsequently causing their unemployment rate to increase.

The second strand of literature that our analysis relates to is research on capital-skill complementarities. Griliches (1969) stated the hypothesis that capital is less substitutable for skilled labour than for unskilled labour, and following his seminal work several studies have found supporting empirical evidence in favour of this hypothesis. Krusell et al. (2000) used U.S. data to estimate a more general production function that allowed for capital-skill complementarities, and found that capital equipment is more complementary with skilled labour than unskilled labour. They also showed that this hypothesis is critical in order to explain the pattern of skill premia in the US economy. In related work, Maliar et al. (2020) tested the capital-skill complementarity hypothesis extending the dataset in Krusell et al. (2000) to include more recent data (over 1993-2017) and confirmed the original findings.

Several studies have tested the capital-skill complementarity hypothesis for European countries as well. Lindquist (2005) uses Swedish data and finds that similarly to Krusell et al. (2000), skilled labour and capital equipment are complementary factor inputs, whereas unskilled labour and capital equipment are substitutes for one another. Batista (2007) tests this hypothesis for the case of the Portuguese economy and also finds evidence in favour of capital-skill complementarity in the aggregate production technology. Using a cross-sectional panel (that includes Greece and several other Euro Area countries) Duffy et al. (2004) also find some support in favour of the capital-skill complementarity hypothesis, although their evidence is weaker than country-specific studies and the required threshold for skilled labour is lower compared to Krusell et al. (2000).

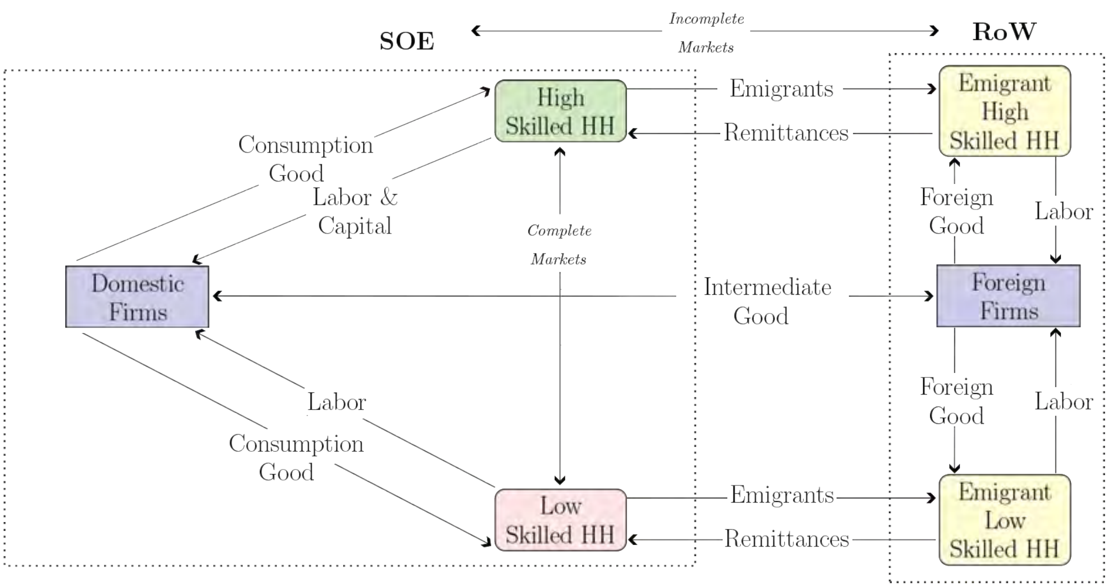
In a study that relates to this paper, Dolado et al. (2018) embed the capital-skill complementarity framework in a closed economy New Keynesian model with search and matching frictions, in order to study the distributional effects of monetary policy. This paper follows a similar modelling approach but in an open economy model that features changes in the skill composition of the domestic workforce due to heterogeneous migration flows.

3 The Model

3.1 Model Overview

I build a small open economy model which features two types of household (high and low skilled), search and matching frictions and endogenous migration. A combination of location preferences and a pecuniary cost to migrate micro-founds migration flows. The production technology is characterized by capital-skill complementarity, as in Krusell et al. (2000). The model also features a remittance channel, trade links, investment adjustment costs and real rigidities in order to capture empirically relevant features of the business cycle dynamics. These modelling choices allow me to study the aggregate and distributional impact of emigration in a unified way. Figure 1 illustrates the key features of the model.

Figure 1: Model Overview



3.2 Labour Markets

The small open economy (henceforth SOE) is populated by two household types. Type h, which supplies high–skilled labour, and type l, which supplies low–skilled labour. I assume that the mass of each household type stays constant and I denote with M_i the respective measure of household type i, for $i \in h, l$.[4] I also assume that the skill type of each household member is fixed (there is no transitioning across the different households) and that markets are segmented. The total population mass is normalised to one, i.e., $\sum_{i\in\{h,l\}} M_i = 1$. At any point in time, there are three different labour market status that a household member can occupy: employment at home $N^r_{i,t}$, employment abroad $N^e_{i,t}$, and unemployment $U_{i,t}$.

$$M_{i,t} = N^r_{i,t} + N^e_{i,t} + U_{i,t}\ , i \in \{h, l\}\ . \tag{1}$$

Unemployed workers can choose where to search. A share $\mu_{i,t}$ of the stock of unemployed, $U_{i,t}$, choose to search abroad, while the remaining search in the domestic market. A key assumption is that unemployed members "search from home" following empirical evidence in support of remote search (Redding and Rossi-Hansberg, 2017). The share of emigrant searchers, $\mu_{i,t}$, is an endogenous object of the model and differs across household types. Importantly, if separated from their job at Foreign, emigrant household members return to Home, thereby receiving the domestic unemployment benefits. This assumption will allow us to focus the analysis on work–related migration and implies that both emigrant and resident workers face the same outside option. The latter will play a role during the bargaining stage.

The matching process between workers and firms is costly in terms of time and resources due to matching frictions. These matching frictions generate positive involuntary unemployment in equilibrium, and give rise to a match surplus that agents divide among themselves based on a wage setting specification. The matching technology which captures search frictions, is modified to reflect the migration choice of household

[4]An alternative modelling choice would be to introduce population growth dynamics and assume that emigration changes the total mass of household types. However, given the emphasis of the paper on cyclical migration, I maintain the assumption of constant measure for both skill types.

members in the following way

$$m_{i,t} = \chi_i (V_{i,t})^{1-\epsilon_i}((1-\mu_{i,t})\,U_{i,t})^{\epsilon_i} \ , i \in \{h,l\} \ , \tag{2}$$

where $m_{i,t}$ denotes the new matches for each skill type i, χ_i is the matching efficiency, ϵ_i is the elasticity of new matches with respect to searching workers, and $V_{i,t}$ denotes the vacancies posted by firms.

The transition probabilities associated with the matching function are modified in a similar way. The job–finding probability, $f_{i,t}$, the job–filling probability, $q_{i,t}$ and labour market tightness, $\theta_{i,t}$, are defined as follows

$$f_{i,t} \equiv \frac{m_{i,t}}{((1-\mu_{i,t})U_{i,t})} \ , \tag{3}$$

$$q_{i,t} \equiv \frac{m_{i,t}}{V_{i,t}} \ , \tag{4}$$

$$\theta_{i,t} \equiv \frac{V_{i,t}}{((1-\mu_{i,t})U_{i,t})} \ , i \in \{h,l\} \ . \tag{5}$$

We follow the timing convention used in Sala et al. (2008) and assume that new matches become productive with a lag. Under this time–to–build assumption, the mass of resident and emigrant employed workers evolves according to the following laws of motion

$$N^r_{i,t+1} = (1-\rho_i)N^r_{i,t} + f_{i,t}(1-\mu_{i,t})U_{i,t} \ , \tag{6}$$

$$N^e_{i,t+1} = (1-\rho^\star_i)N^e_{i,t} + f^\star_{i,t}\mu_{i,t}U_{i,t} \ , i \in \{h,l\} \ , \tag{7}$$

where ρ_i is the exogenous separation probability of a match. The law of motion of emigrant workers depends on the foreign separation rate, $\rho^\star_i$, and the foreign job–finding rate, $f^\star_{i,t}$, which the SOE takes as given.[5]

[5]While the domestic job-finding rate, $f_{i,t}$, is determined in equilibrium, the SOE has no impact on foreign labour market conditions which are taken as exogenous processes. This is a reasonable assumption even in the presence of large migration outflows if their relative size compared to the destination country labour force is small (e.g., due to dispersed search across several destination

3.3 Households

The two household types share certain common features. Both type of agents derive utility from consumption and they incur a disutility cost when members of the household work abroad. I follow the large family framework of Andolfatto (1996) and subsequent literature, which allows me to abstract from heterogeneity due to changes in the employment status or location of work when deriving the intertemporal consumption–saving decisions of the household.[6]

The disutility cost that household members suffer is proportional to the size of the emigrant stock. This cost captures location preferences, which are a key building block in quantitative models of economic geography (Kennan and Walker, 2011; Redding and Rossi-Hansberg, 2017) and have become a common practice in business cycle models with labour mobility (Bandeira et al., 2019; House et al., 2018; Sterk, 2015). These preferences capture in a reduced form way the attachment of household members to the Home location due to higher utility from local amenities, the lack of language and cultural barriers or lower informational frictions regarding labour market conditions (Kaplan and Schulhofer-Wohl, 2017).

High–skilled Households

The representative high–skilled household maximises the expected lifetime utility function subject to the budget constraint, the law of motion of capital and the laws of motion of emigrant and resident employment. Given the assumption of perfect risk–sharing among household members and the constant household mass assumption, the

countries).

[6]The large family assumption is equivalent to the existence of complete markets at the household level, which allow for perfect risk–sharing among emigrants and residents, as well employed and unemployed members. This assumption adds tractability to the optimisation problem of the household as the relevant stochastic discount factor is the same for all household members. Under the alternative specification where the emigrant members cease to be part of the domestic household, they would also adopt the foreign stochastic discount factor.

optimisation problem of the household can be recast in per capita terms as follows

$$\underbrace{\max}_{c_{h,t},\mu_{h,t},k_{t+1},d^{\star}_{t+1}} \quad \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left(\ln(c_{h,t} - \chi \overline{c}_{h,t-1}) - \Omega_h n^e_{h,t} \right) \ , \tag{8}$$

where $c_{h,t}$ is the per capita consumption of the household members, (I will henceforth denote with small–case letters the variables in per–capita terms), χ governs habits, the term $\overline{c}_{h,t-1}$ captures aggregate last period consumption (which the household members take as given), $n^e_{h,t}$ is the relative measure of skilled emigrants and Ω_h governs the moving disutility. The flow budget constraint is given by

$$\begin{aligned} c_{h,t} + i_t + Q_t R_t d^{\star}_t + \frac{\mathit{\Gamma}_h}{2} \left(\frac{\mu_{h,t}\, u_{h,t}}{\mu_{h,t-1}\, u_{h,t-1}} - 1 \right)^2 \mu_{h,t}\, u_{h,t} \\ = R^k_t k_t + Q_t d^{\star}_{t+1} + w_{h,t} n^r_{h,t} + Q_t w^{\star}_{t,h}\, n^e_{h,t} + \phi_h u_{h,t} + t_{h,t} + div_t \end{aligned} \tag{9}$$

where i_t is investment, Q_t is the real exchange rate and $d^{\star}_t$ is the debt position of the household from trading an international non–state contingent bond. In each period, a share $\mu_{h,t} u_{h,t}$ of household members emigrates and the household pays additionally to the disutility cost, a pecuniary moving cost governed by parameter $\mathit{\Gamma}_h$. These pecuniary costs will be critical for matching the dynamics of emigration flows and differ by skill type. Household members can be employed at Home, $n^r_{h,t}$, earning labour income $w_{h,t}$, employed at Foreign, $n^e_{h,t}$, earning real-exchange-rate-adjusted foreign wage, $Q_t\, w^{\star}_{t,h}$, or unemployed earning unemployment benefit ϕ_h.[7] Apart from earning labour income, the household rents capital k_t to firms, issues debt $d^{\star}_{t+1}$, pays lump–sum taxes $t_{h,t}$ and receives dividend income from firm ownership div_t. R^k_t and R_t are the rental rate of capital and the gross returns on holding domestic debt. Finally, χ_t is the risk–premium which will be defined below.

[7]Emigrants workers receive the same wage as native foreign workers as I abstract from issues related to immigrant assimilation and/or labour misallocation. This assumption hinges on the degree of substitutability between migrant and native workers within skill type, which has been an object of controversy in the literature (e.g., see the debate between Ottaviano and Peri, 2012 and Borjas et al., 2008). However, in the context of intra–Euro Area migration, the assumption of perfect substitutability seems reasonable to maintain. The foreign wage $w^{\star}_{h,t}$ is taken as given by the household.

Capital stock evolves according to the following law of motion

$$k_t = (1-\delta)k_{t-1} + \left(1 - \frac{\Xi}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2\right) i_t \ , \tag{10}$$

where δ is the depreciation rate and parameter Ξ controls the investment adjustment costs.

Low–skilled Households

Low–skilled households face a similar problem to the high–skilled households (see appendix for remaining optimality conditions of both households). For tractability reasons only high–skilled households have firm and capital ownership and access to international financial markets. However, under the baseline model with complete domestic financial markets, the above assumptions have little effect for the per capita consumption of the low–skilled, which perfectly co–moves with the high–skilled per capita consumption based on the following risk–sharing condition

$$\Lambda^c_{l,t} = \tilde{\Theta}\Lambda^c_{h,t} \ , \tag{11}$$

where $\Lambda^c_{l,t}$ is the marginal utility of consumption for low–skilled households, $\Lambda^c_{h,t}$ is the marginal utility of consumption for high–skilled households and $\tilde{\Theta}$ captures the initial wealth distribution.

Moving Choice

While domestic and emigrant employment are determined by their respective laws of motion as the outcome of search and matching frictions, the share of unemployed who direct their search abroad, $\mu_{i,t}$, is determined by the optimality conditions of the household. The representative household manager compares the relative labour market conditions at Home and Foreign taking into account the utility and pecuniary moving costs. The moving costs are only worth paying if the wage and job–finding rate differentials between the two regions are large enough. In the model, this is captured by the following arbitrage condition

$$\underbrace{f^{\star}_{i,t}\,\Lambda^{e}_{i,t}-f_{i,t}\,\Lambda^{r}_{i,t}}_{\text{Net gain from search abroad}} = \Lambda^{c}_{i,t}\left(\frac{\mathit{\Gamma}_i}{2}\left(\frac{\mu_{i,t}u_{i,t}}{\mu_{i,t-1}u_{i,t-1}}-1\right)^2+\mathit{\Gamma}_i\left(\frac{\mu_{i,t}u_{i,t}}{\mu_{i,t-1}u_{i,t-1}}-1\right)\frac{\mu_{i,t}u_{i,t}}{\mu_{i,t-1}u_{i,t-1}}+\right.$$
$$\underbrace{\beta\mathbb{E}_t\Lambda^{c}_{i,t+1}\mathit{\Gamma}_i\left(\frac{\mu_{i,t+1}u_{i,t+1}}{\mu_{i,t}u_{i,t}}-1\right)\left(\frac{\mu_{i,t+1}u_{i,t+1}}{\mu_{i,t}u_{i,t}})^2\right)}_{\text{Moving costs}}, \tag{12}$$

where $\Lambda^{r}_{i,t}$ denotes the net marginal value of a domestically employed worker and $\Lambda^{e}_{i,t}$ is the net marginal value of an emigrant worker. $\Lambda^{r}_{i,t}$ comprises of two terms: the expected flow value that a job match generates net of foregone unemployment benefits and the capital gains of an additional worker conditional on the job match surviving. The associated Bellman equation is

$$\Lambda^{r}_{i,t}\equiv\frac{\partial\mathcal{L}_{i,t}}{\partial n^{r}_{i,t+1}}=\beta\mathbb{E}_t\Lambda^{c}_{i,t+1}\left(w_{i,t+1}-\phi_i\right)+(1-\varrho_i-f_{i,t+1})\Lambda^{r}_{i,t+1}\ i\in\{h,l\}\ . \tag{13}$$

$\Lambda^{e}_{i,t}$ is similar but there is an additional component which captures the utility costs associated with migration

$$\begin{aligned}\Lambda^{e}_{i,t}\equiv\frac{\partial\mathcal{L}_{i,t}}{\partial n^{e}_{i,t+1}}&=-\beta\Omega_i+\beta\mathbb{E}_t\Lambda^{c}_{i,t+1}\left(Q_{t+1}w^{\star}_{i,t+1}-\phi_i\right)\\&+\beta\mathbb{E}_t(1-\varrho^{\star}_i)\Lambda^{e}_{i,t+1}-\beta\mathbb{E}_tf_{i,t+1}\Lambda^{r}_{i,t+1}\ .\end{aligned} \tag{14}$$

3.4 Production

Production follows a layered structure. There are different firm types, which are all owned by the high–skilled household. In the first stage of production, a continuum of perfectly competitive firms hire high and low skilled labour and capital and produce a homogeneous tradeable intermediate good. This is the stage at which search and matching frictions occur and wage bargaining takes place. In the second stage, there a representative firm bundles the intermediate home and foreign tradeable goods into the final good X_t, which is then used for resident consumption, C^{r}_{t}, investment I_t, and government spending G_t.

3.4.1 Final Good Firms

The representative final good firm aggregates the domestic and foreign intermediate goods $X_{d,t}$ and $X_{f,t}$ according to the following CES technology

$$X_t = \left(\omega^{\frac{1}{\theta}} X_{d,t}^{\frac{\theta-1}{\theta}} + (1-\omega)^{\frac{1}{\theta}} X_{f,t}^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}} \ , \theta > 0 \ , \omega \in (0,1) \ , \tag{15}$$

where parameter ω captures the degree of home bias in the small open economy and θ the elasticity of substitution between domestic and foreign goods. The associated price index is

$$P_t = \left(\omega \, \varrho_{d,t}^{1-\theta} + (1-\omega) \ \varrho_{f,t}^{1-\theta}\right)^{\frac{1}{1-\theta}} \ , \tag{16}$$

where $\varrho_{d,t}$ and $\varrho_{f,t}$ are the relative prices of the domestic and foreign good. The representative firm takes prices as given and maximises profits $\Pi_t = X_t - \varrho_{d,t} \, X_{d,t} - \varrho_{f,t} \, X_{f,t}$, which yields the following optimal demand schedules

$$X_{d,t} = \omega \, \varrho_{d,t}^{-\theta} \, X_t \ , \tag{17}$$

$$X_{f,t} = (1-\omega) \ \varrho_{f,t}^{-\theta} X_t \ . \tag{18}$$

3.4.2 Intermediate Good Firm

The wholesale intermediate good firm combines labour inputs with capital and faces frictional labour markets. I adopt a more general two-layer CES technology that nests the standard Cobb–Douglas production function, following Krusell et al. (2000)

$$\begin{aligned} y_t^h &= A_t \left(s_s S_t^{\nu} + (1-s_s) {N_{l,t}^{r}}^{\nu}\right)^{\frac{1}{\nu}} \ , \\ S_t &= \left(s_k K_t^{\gamma} + (1-s_k)(N_{h,t}^r)^{\gamma}\right)^{\frac{1}{\gamma}} \ , \\ s_k &\ , s_s \in (0,1) \ , \gamma \ , \nu \in (-\infty, 1) \ \text{and} \ \gamma \ , \nu \neq 0 \ , \end{aligned} \tag{19}$$

where A_t is the exogenous neutral technology process, y_t^h is the domestic intermediate good production and S_t is the skilled composite input good. The parameters that govern the elasticity of substitution between input factors are γ and ν. The elasticity of substitution between high–skill labour and capital is equal to $1/(1-\gamma)$, whereas the elasticity of substitution between low–skill labour and capital (which is identical to the elasticity of substitution between the two labour types) is equal to $1/(1-\nu)$. The parameters s_s and s_k control the income share of low–skill labour and capital respectively. The key feature of this encompassing production technology is that for $\nu > \gamma$ capital–skill complementarities arise, whereas when either $\nu \to 0$ or $\gamma \to 0$ we can retrieve the Cobb–Douglas function.

Wholesale firms decide how many vacancies to post and how much capital to rent by solving the following dynamic cost minimization problem (note that they have the same stochastic discount factor as the high–skilled households)

$$\underbrace{\min}_{v_{h,t}, v_{l,t}, k_t} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\Lambda^c_{h,t+1}}{\Lambda^c_{h,t}} \left(p^w_t y^h_t - r^K_t K_t - w_{h,t} N^r_{h,t} - w_{l,t} N^r_{l,t} - \kappa_h v_{h,t} - \kappa_l v_{l,t} \right) \ , \tag{20}$$

subject to their production technology (19) and the laws of motion of employment

$$N^r_{i,t+1} = (1-\rho_i) N^r_{i,t} + q_{i,t} v_{i,t} \quad , i \in \{h, l\} \ , \tag{21}$$

where $q_{i,t}$ is the probability of filling a vacancy for skill type i, p^w_t is the relative price of the wholesale goods in terms of the final good and κ_i is the vacancy posting cost. The first–order condition for vacancies combined with the free entry condition of firms yield the job creation schedule

$$\frac{\kappa_i}{q_{i,t}} = \beta \mathbb{E}_t \frac{\Lambda^c_{h,t+1}}{\Lambda^c_{h,t}} \left(p^w_{t+1} F^n_{i,t+1} - w_{i,t+1} + (1-\varrho_i) \frac{\kappa_i}{q_{i,t+1}} \right) \ . \tag{22}$$

Firms post vacancies until the expected marginal cost of posting a vacancy, i.e., the real posting cost κ_i times the expected duration that the vacancy remains unfilled $1/q_{i,t}$, is equal to the expected marginal benefit, i.e., the net revenue created by an additional worker and the expected continuation value of the match which survives with probability $(1-\rho_i)$. The variable $F^n_{i,t}$ denotes the marginal product of labour of skill type i. The differences in the marginal labour productivity and in the search frictions that workers face will determine how skill premia evolve.

Wage Schedule

With frictional labour markets workers and firms hold monopoly power due to search costs, which include the vacancy posting costs, as well as foregone wages and production. As a result, each job match involves an economic rent which is split between workers and firms according to some surplus sharing rule.

Below I define the value functions that enter the surplus sharing rule. Let $\mathcal{J}_{i,t}$ denote the value of a filled vacancy of skill type i for the representative firm

$$\mathcal{J}_{i,t} = p_t^w F_{i,t}^n - w_{i,t} + (1 - \varrho_i)\mathbb{E}_t \beta \frac{\Lambda_{h,t+1}^c}{\Lambda_{h,t}^c} \mathcal{J}_{t+1} \ . \tag{23}$$

If the firm successfully fills a vacancy, it obtains the net flow profit of the match and the continuation value conditional on match survival. Let $\mathcal{V}_{i,t}^n$ denote the value of a match for a domestic worker in utility adjusted terms. The associated Bellman equation is

$$\mathcal{V}_{i,t}^n \equiv \frac{\Lambda_{i,t}^n}{\Lambda_{i,t}^c} = w_{i,t} - \phi_i + \beta \mathbb{E}_t \frac{\Lambda_{i,t+1}^c}{\Lambda_{i,t}^c} (1 - \varrho_i - f_{i,t}) \mathcal{V}_{i,t+1}^n \ . \tag{24}$$

Wages are determined as the outcome of a Nash bargaining problem that maximises the weighted product of firm and households' match surplus

$$\underbrace{\max,}_{w_{i,t}^n} = \left(\mathcal{V}_{i,t}^n\right)^{\psi_i} \left(\mathcal{J}_{i,t}\right)^{1-\psi_i} \ , \tag{25}$$

where $\psi_i \in (0, 1)$ is the worker's relative bargaining power. The Nash–bargained wage is defined as

$$w_{i,t}^n = (1 - \psi_i) \left(p_t^w F_{i,t}^n + \kappa_i \theta_{i,t}\right) + \psi_i \phi_i \ . \tag{26}$$

As in Hall (2005), I introduce real wage rigidities in the labour market by assuming the following adaptive rule [8]

$$w_{i,t} = (w_{i,t-1})^{\gamma_w} \left(w^n_{i,t}\right)^{1-\gamma_w} \ , \tag{27}$$

where γ_w denotes the degree of real wage rigidity.

Fiscal Policy

The government pays unemployment benefits and consumes G_t of final goods (which I assume to be a constant fraction g of GDP in every period) and levies lump–sum taxes. The period–by–period constraint of the government is described as follows

$$G_t + \sum_{i\in\{h,l\}} \phi_i U_{i,t} = \sum_{i\in\{h,l\}} M_i t_{i,t} \tag{28}$$

3.5 Market Clearing

Market clearing in the intermediate goods market requires production to equal total demand for domestic intermediate goods

$$y^h_t = X_{d,t} + X^\star_{d,t} \ , \tag{29}$$

where foreign aggregate demand $X^\star_{d,t}$ is given by the following schedule

$$X^\star_{d,t} = (1-\omega^\star)\left(\frac{\rho_{d,t}}{Q_t}\right)^{-\theta^\star} X^\star_t \ . \tag{30}$$

[8] The introduction of real wage rigidities is one way to address the well documented "Shimer's puzzle" i.e., the unrealistically high stability in the vacancy and unemployment rates generated in the canonical search and matching model (Shimer, 2005). With sticky wages, firms can extract a larger share of the match surplus. As a result, vacancy posting and unemployment rates become more sensitive to changes in the underlying shocks. These rigidities capture in a reduced form a range of imperfections related to institutional or legal frictions in the labour market.

The real exchange rate is defined as $Q_t = \frac{P_t^\star}{P_t}$. The parameters $\theta^\star$ and $\omega^\star$ are the foreign counterparties for the elasticity of substitution and home bias. The structure of the foreign economy is similar to the home economy but due to the small size of the latter, domestic developments have a negligible effect in foreign economy dynamics. As a result, $X_t^\star$, which denotes the foreign GDP which is exogenous.

For final good market clearing it is useful to rewrite the consolidated budget constraint (9) in terms of the budget constraint of the emigrants and residents. Starting with the constraint of residents (the budget constraint for the low–skilled, which is analogous, is presented in the appendix)

$$\begin{aligned}(u_{h,t} + n_{h,t}^r)c_{h,t}^r + i_t + Q_t R_t d_t^\star + \frac{\Gamma_h}{2}\left(\frac{\mu_{h,t}\, u_{h,t}}{\mu_{h,t-1}\, u_{h,t-1}} - 1\right)^2 \mu_{h,t}\, u_{h,t} \\ = R_t^k k_t + Q_t d_{t+1}^\star + w_{h,t} n_{h,t}^r + \underbrace{Q_t Z_{h,t} n_{h,t}^e}_{\text{remittances}} + \phi_h u_{h,t} + t_{h,t} + div_t\end{aligned} \tag{31}$$

where $c_{h,t}^r$ is consumption of the domestic final good and $Z_{h,t}$ are per capita remittances which are in terms of the foreign final good. Remittances are pinned down by the budget constraint of emigrants who send a constant fraction of their labour income back home, and allocate the remaining amount to foreign good consumption $c_{h,t}^e$[9]

$$c_{h,t}^e n_{h,t}^e = w_{h,t}^\star n_{h,t}^e - Z_{h,t} n_{h,t}^e = (1-\zeta) w_{h,t}^\star n_{h,t}^e \ . \tag{32}$$

Market clearing for final goods implies

$$X_t = \sum_{i\in\{h,l\}} (N_{i,t}^r + U_{i,t})c_{i,t}^r + \sum_{i\in\{h,l\}} \frac{\Gamma_i}{2}\left(\frac{\mu_{i,t}\, u_{i,t}}{\mu_{i,t-1}\, u_{i,t-1}} - 1\right)^2 \mu_{i,t}\, u_{i,t} + \sum_{i\in\{h,l\}} \kappa_i v_{i,t} + I_t + G_t \ . \tag{33}$$

Further, the trade balance is defined in units of the final good as follows

$$TB_t = \rho_{d,t} X_{d,t}^\star - \rho_{f,t} X_{f,t} \ , \tag{34}$$

[9]Note that total per capita consumption, which is the relevant optimisation object, is derived as the residual of (9) and (30). It is given by $c_{h,t} = (u_{h,t} + n_{h,t}^r)c_{h,t}^r + Q_t n_{h,t}^e c_{h,t}^e$.

and GDP is defined as

$$p_t^y Y_t = \sum_{i\in\{h,l\}} (N_{i,t}^r + U_{i,t}) c_{i,t}^r + I_t + G_t + TB_t \ , \tag{35}$$

where p_t^y is the real GDP deflator. Taking into account the market clearing conditions for the different markets and aggregating the budget constraint for both households we can obtain the law of motion of net foreign assets as

$$Q_t R_t D_t^\star = Q_t D_{t+1}^\star + TB_t + Q_t \left(Z_{h,t} N_{h,t}^e + Z_{l,t} N_{l,t}^e \right) \ , \tag{36}$$

where $D_t^\star = M_h d_t^\star$. The known issue of non–stationarity that arises in the SOE is addressed by assumming the following debt–elastic interest rate [10]

$$R_t = R_t^\star + \chi_t \ , \tag{37}$$

where $R_t^\star$ is the foreign interest rate which the SOE takes as given and χ_t is the risk–premium it pays

$$\chi_t = \Psi \left(\exp \left(\frac{Q_t D_{t+1}^\star}{gdp_t} - \frac{Q D^\star}{gdp} \right) - 1 \right) + \epsilon_t^{rp} \ , \tag{38}$$

where ϵ_t^{rp} denotes the risk premium shock.

4 Calibration

The model is calibrated to match salient features of the Greek economy prior to the Euro Area debt crisis. For conventional parameters I follow closely the Bank of Greece small open economy DSGE framework (Papageorgiou, 2014). For less conventional parameters, such as labour market institutional features, I target related moments of

[10] The steady state level of net foreign asset holdings is not pinned down by the equilibrium conditions in the small open economy. Instead there are multiple steady states depending on the initial conditions of net foreign assets. As a result, temporary shocks can have permanent effects on the level of variables creating a unit–root problem in equilibrium dynamics. Assuming debt–elastic interest rates is one way of circumventing the non–stationarity.

the Greek economy. Table 1 in the appendix summarizes the calibration strategy. The calibration is at an annual frequency.

Preferences The subjective discount factor is set to $\beta = 0.96$ so that the model is consistent with a long–run annual real interest rate of 4%. I set the parameter that controls habit formation χ to 0.6 following Papageorgiou (2014). The parameters Ω_i which control the disutility of moving are set to jointly match an implied steady state share of total emigrant stock equal to 8% and a relative share of skilled emigrants equal to 35%.[11] Turning to the pecuniary costs, Γ_i, which discipline the response of emigration flows to the recessionary shock, I jointly target the total cumulative outflows between 2010 and 2015, amounting to 7% of working age population according to (Bandeira et al., 2019), and an average skill to unskilled ratio of 2/3 over the same period. The latter is in line with survey data evidence from Labrianidis and Pratsinakis (2016) who report that more than 65% of Greek emigrants post 2010 were highly educated graduates (as measured by ISCED levels of 5 and above).

Production I set the parameters that govern the capital–labour complementarity following Krusell et al. (2000). Specifically, γ is set to match an elasticity of substitution between skilled labour and capital equal to $\rho_{k,h} = 0.67$, and ν is set to match an elasticity of substitution between unskilled labour and capital equal to $\rho_{k,l} = 1.67$. The income share parameters s_k and s_s are calibrated to match the Greek capital income share $r_t^k K_t/gdp_t = 0.36$ (based on Papageorgiou, 2014) and the skilled labour share $w_{h,t}N_{h,t}/gdp_t = 16\%$ based on EUKLEMS data. I follow Chodorow-Reich et al. (2019) and set the elasticity of substitution between foreign and domestic intermediate goods to $\theta = 1.65$. Home bias is equal to $\omega = 0.75$ as in Bandeira et al. (2019). Even though these values are targeted to Greek trade data they are very close to values used conventionally in the open economy literature (see for instance Backus et al., 1994). The depreciation rate is set to $\delta = 8\%$, in line with Chodorow-Reich et al. (2019) and the parameter governing the investment adjustment costs is set to $\Xi = 0.9$ following Papageorgiou (2014).

[11] This is the 2000–2009 average emigrant stock in Euro Area countries based on the International Migration Database of OECD. The targeted relative share of skilled emigrants is the 2000–2009 average share based on the German Microcensus data.

Labour Market and Demographics The relative mass of the high–skilled household is set to match the share of working age population with tertiary education as reported in ELSTAT. For the matching efficiency parameters I target the skill–specific unemployment rate for the period 2000–2009 (7% and 12% for high and low skilled respectively) based on Eurostat. The resulting values imply higher matching efficiency for skilled. Separation rates are set to $\rho_h = \rho_l = 8\%$ following Hobijn and Sahin (2009), who estimate transition rates for several OECD countries, including Greece.[12] I set the steady state job–filling probabilities equal to $q_h = 0.7$ and $q_l = 0.6$, which are comparable to the values in Pappa et al. (2015). This calibration strategy pins down the vacancy posting costs and yields total vacancy costs equal to 4% of the GDP. This number is on the high end but consistent with the literature (Trigari, 2009). Moreover, this calibration strategy implies that search frictions are relatively higher for the low–skilled who face lower job–finding probabilities and are characterized by lower matching efficiency. The combination of lower job–filling rates and higher vacancy posting costs for the low-skilled increases the effective hiring cost in that market segment. However, the low–skilled are relatively more abundant. As a result, there is more slack in their market, which puts downward pressure on their wages. This acts as a counterweight for firms which can extract a relatively larger share of the match surplus in the low–skill segment. The match elasticities with respect to searchers are set to $\epsilon_h = 0.6$ and $\epsilon_l = 0.4$. These values are within the range of plausible elasticities reported in the Pissarides and Petrongolo (2001) survey. Moreover, I assume that the decentralised equilibrium is socially efficient which equates the worker's bargaining power ψ_i to their respective match elasticities ϵ_i (see Hosios, 1990). The unemployment benefits for skilled and unskilled are set to match an average replacement rate of 65% based on the OECD "Benefits and Wages" data on Greece (Christoffel et al., 2009). The parameter that governs real wage rigidities is equal to $\gamma_w = 0.65$ following Papageorgiou (2014).

Foreign The labour market conditions at Foreign enter the optimal search decision of the households who compare regional differences on unemployment and job–finding rates.

[12] Even though data on skill–specific separation rates are not available our calibration does deliver different job–finding probabilities across households.

I calibrate the relevant foreign labour market variables to match German data given that Germany was the most popular Euro Area destination country for Greek emigrants. I target foreign unemployment rate of 4% for high-skilled and 8% for low–skilled based on Eurostat. I set the separation rate equal to $\rho^{\star} = 0.13$ following Hobijn and Sahin (2009). Wage differentials between Home and Foreign are based on EUKLEMS data prior to 2010. Finally, ζ which is controlling for remittances is calibrated to target a total share over GDP equal to 0.3%, based on World Bank data.

5 Quantitative Analysis

I first evaluate the quantitative implications of migration by studying the dynamic adjustment of the model economy to a negative risk–premium shock under two scenarios. The baseline scenario features an outflow of high and low–skilled labour in line with what we observed in the data. In the counterfactual scenario, the option to emigrate is shut down. The shock is calibrated to generate an initial drop in aggregate resident consumption consistent with the data (household consumption dropped by 6.8% y.o.y in 2010). An important takeaway from this exercise is that contrary to the conventional wisdom, migration amplified the effects of the recessionary shock. This experiment confirms previous findings in the cyclical migration literature (Bandeira et al., 2019, Lozej, 2019), and it provides novel insight into how amplification differs across skill–specific variables. The model is approximated to a first order around its deterministic steady state and the shock path is kept constant across the different scenarios.

The amplifying role of migration

As shown in Fig. 2, the initial response of consumption is similar under both model scenarios, in line with the calibration strategy. Facing higher risk–premia, households reduce debt issuance which leads to a compression in aggregate demand and a drop in consumption. For the first three years, when the rate of migration outflows is the highest, resident consumption performs marginally better in the presence of migration. This can be explained by the increase in remittances which help to relax the budget constraint of the residents. Despite a similar initial response, the consumption paths differ significantly in terms of dynamics, with consumption being more persistent under the baseline scenario. This can be traced to the deeper and more protracted contraction of production in the presence of migration.

Firms respond to lower aggregate demand by reducing vacancy postings, causing unemployment to increase and wages to fall. Because mobility costs are lower for the high–skilled, emigration flows are larger and peak earlier for skilled labour. This has severe negative effects for investment and capital accumulation. The contraction in investment is much more pronounced under migration because the shrinking relative stock of skilled labour implies that capital becomes less productive. Indeed, an important difference between the two scenarios is the different trajectory of the marginal productivity of capital.

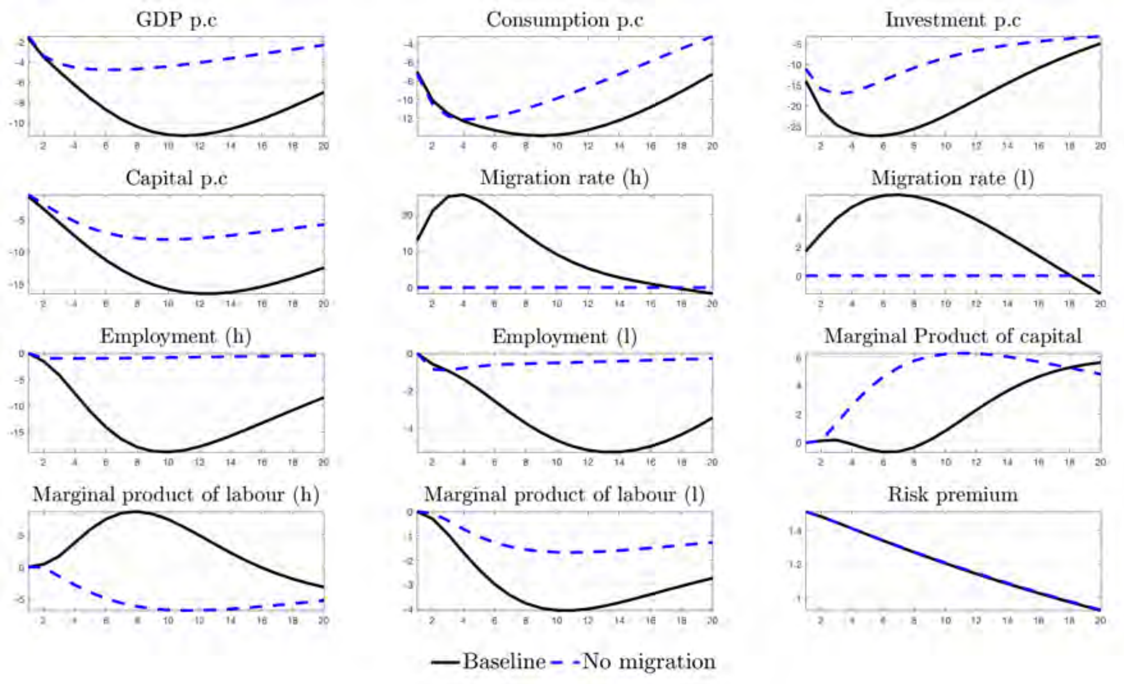


Figure 2: Impulse Response Functions to a negative risk-premium shock. IRFs are in terms of % deviations from steady state with the exception of migration rates which are in absolute deviations from the steady state. The parenthesis terms refer to skilled households (h) and unskilled households (l). The horizontal axis depicts years. First row variables are in per capita terms.

Migration does stabilise domestic unemployment as Fig. 3 shows. However, this cushioning effect is temporary and differs across skill types.[13] For the skilled households, that are more mobile and also face higher job–finding rates at Foreign, unemployment rate in fact drops. For the unskilled households, the cushioning effects of migration kick in with delay due to their higher adjustment costs, and are less sizeable. Once migration outflows reverse, the unemployment rate increases for both households.

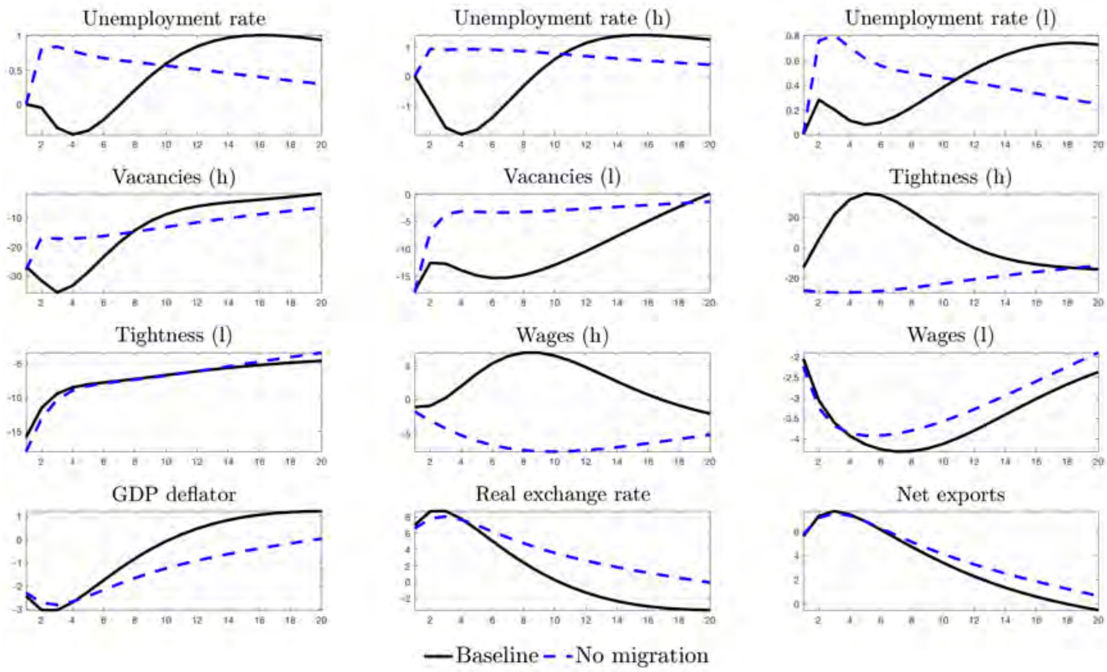


Figure 3: Impulse Response Functions to a negative risk-premium shock. IRFs are in terms of % deviations from steady state with the exception of unemployment rates and the real exchange rate which are in absolute deviations from steady state. The parenthesis terms refer to skilled households (h) and unskilled households (l). The horizontal axis depicts years.

The asymmetric emigration flows imply different responses of key labour market variables for the skilled and unskilled households. Firms face a higher effective cost of posting vacancies in the skilled segment because they compete over a smaller pool of domestic skilled searchers. As a result, emigration amplifies the reduction in vacancies

[13]Fig. 3 reports total unemployment rates, i.e., it includes unemployed searchers who are looking for jobs abroad. For the dynamics of unemployment that excludes search at Foreign see the appendix.

for the skilled. In contrast, the unskilled who are less mobile, face a reduction in vacancies that is closer to the no–migration scenario. The dynamics of tightness differ in an analogous way.

Wages also respond very differently for skilled and unskilled. For the skilled, wages increase in sharp contrast with the no–migration scenario. For the unskilled, wages experience an even steeper reduction compared to the no–migration scenario. This divergent behaviour of wages has two key drivers. Firstly, the asymmetric response of tightness. Secondly, the starkly different response of the marginal product of labour. The decrease in domestic labour supply is pushing the marginal product of labour up for both skill types. However, the reduction of capital has a countervailing effect.[14] Due to the relative scarcity of skilled labour, the former dominates for skilled whereas the latter is stronger for the unskilled, causing wages to diverge.

Interestingly, migration has a mitigating effect on the external adjustment of the economy. Under both scenarios, the real exchange rate depreciates in response to the risk premium shock due to the negative price pressures. This in turn induces an expenditure switching effect which drives up net exports as domestic tradeable goods become relatively cheaper. However, in the presence of migration the decrease in relative prices is less pronounced due to lower adjustment of high–skilled wages. Migration essentially implies that the origin economy cannot export its way out of the crisis to the same degree as in the no–migration case.

As Fig. 4 shows, heterogeneous migration outflows have aggregate as well as distributional effects. In the absence of migration, the risk–premium shock drives skill premia down because the skilled workers suffer a larger drop in their productivity as firms also reduce demand for the complementary capital. However, under the baseline scenario the mass exit of skilled workers drives skill premia to the opposite direction. This sharp increase in skill premia is sufficient to generate higher income inequality, compared to the no–migration scenario. Indeed, the response in the relative income share is muted under migration despite the fact that skilled employment contracted

[14] Under the baseline calibration, cross–partial derivatives $\frac{\partial MPL_i}{\partial K}$ are positive for both skill types.

significantly more.[15]

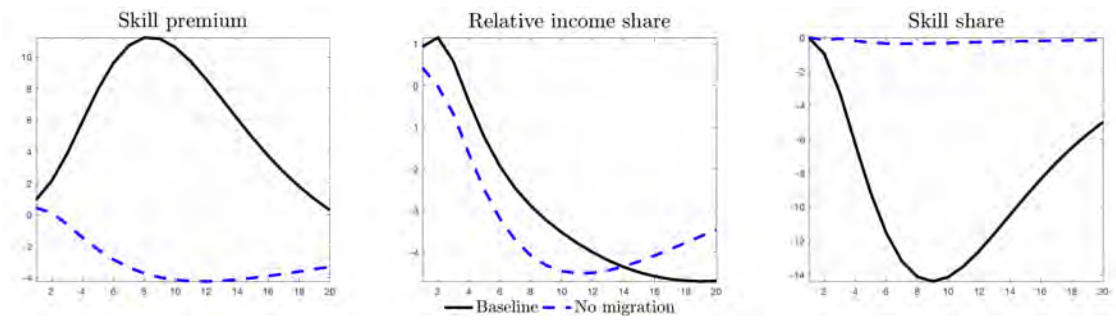


Figure 4: Impulse Response Functions to a negative risk–premium shock. IRFs are in terms of % deviations from steady state. Relative income share refers to the income share of skilled workers over unskilled workers. Skill share refers to the ratio of skilled to unskilled workforce. The horizontal axis depicts years.

Who leaves matters

In the previous experiment, the amplifying role of emigration can be traced to two underlying channels: changes in the size of the domestic workforce and changes in its skill composition. To better distil the role of heterogeneity in migration flows, I repeat this exercise but restricting the moving choice to one skill group for each scenario. Fig. 5 presents the responses of key macroeconomic variables to the same negative risk–premium shock when migration is shut down for both skill types, when it is an option for only skilled searchers and when only unskilled searchers can move. This allows us to separately identify the impact of migration outflows from each group. Fig. 5, compares the model responses (right column) to data (left column). The goal of this exercise is not to replicate exactly the historical path of the variables, but rather to uncover the relative importance of the compositional effects of migration. In the data series, consumption refers to total final consumption expenditure of households, investment to gross fixed capital formation and trade balance to net exports of goods. All variables are in aggregate terms.

[15]The income shares are defined as $\frac{w_i N_i^r}{gdp - \sum_{i \in \{h,l\}} \kappa_i V_i}$.

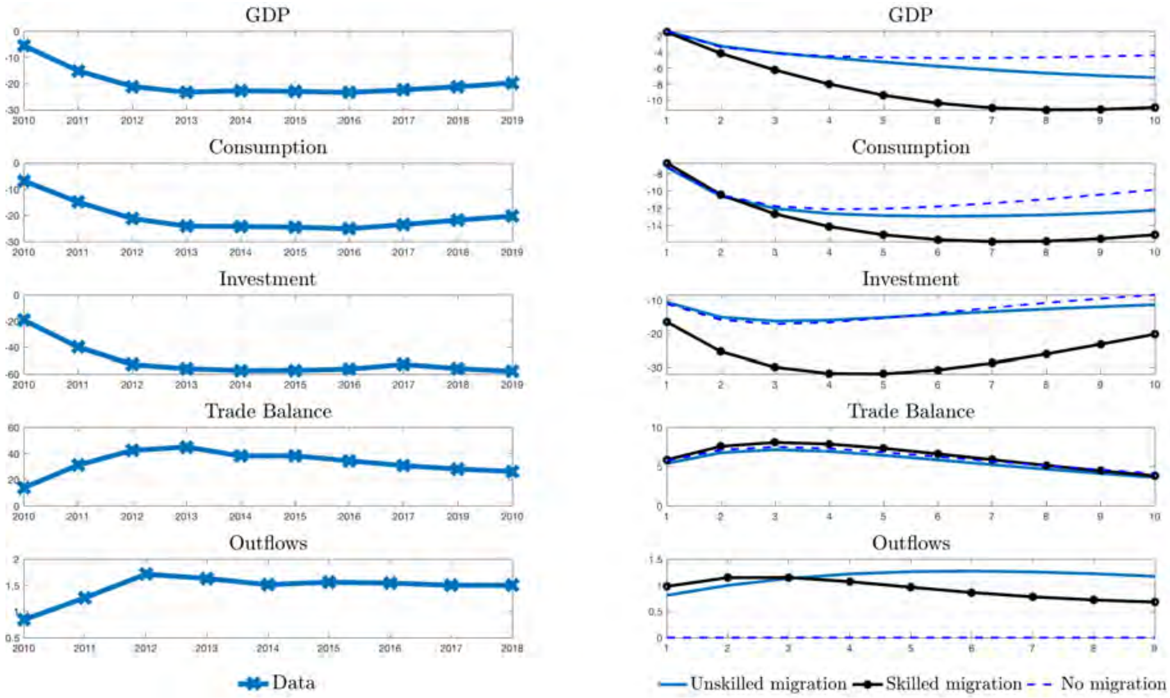


Figure 5: Impulse Response Functions to a negative risk-premium shock. The data series are in % deviations from their 2009 values apart from outflows. Measurements are in chain linked volumes (2010). Model responses are in % deviations from steady state apart from outflows. Outflows are in % of total working age population. Source: ELSTAT.

Despite outflows being comparable in terms of size under the two migration scenarios, the contraction of the GDP and its main components differs substantially in magnitude and persistence. The main driver of this result lies in the starkly different response of investment. When only the unskilled have the option to emigrate, the reduction in investment is muted, and tracks closely the investment response under the no–migration scenario. This is not the case under the skilled emigration scenario when investment suffers a much steeper drop. The trough–to–trough difference between the two migration scenarios is more than 20%.

To understand the differences in the response of investment, it is important to note the interplay between the two externalities that the model features. Firstly, the production externality implies that firms' demand for capital differs depending on who leaves.

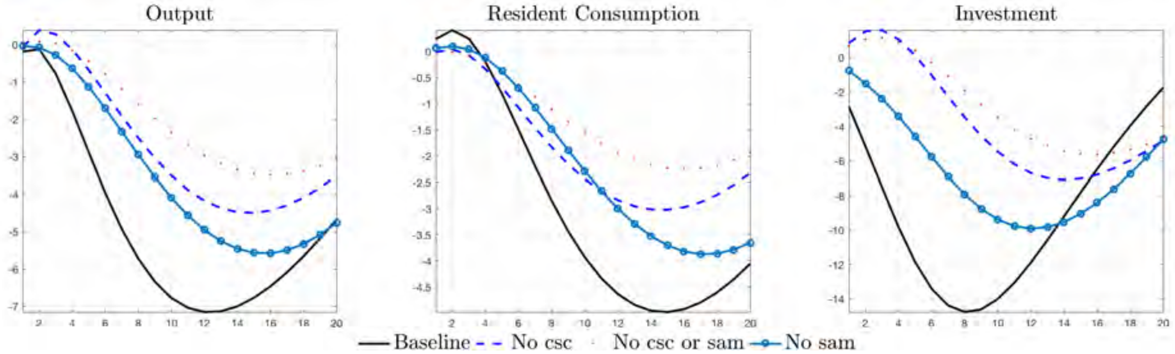


Figure 6: Differences in Impulse Response Functions to a negative risk-premium shock with and without migration. The respective IRFs are in % deviations from steady state. The horizontal axis depicts years. All variables are in aggregate terms.

When it is skilled labour who emigrates, the change in the skill ratio of the domestic workforce leads to a lower marginal productivity of capital due to capital skill complementarities, and dampens capital demand. This drop is further amplified due to the second externality in the model, which originates in the labour market. In the presence of search and matching frictions, asymmetric emigration will lead do different degrees of congestion in the skilled and unskilled market segments. When only skilled workers emigrate, the relatively higher competition among firms in the skilled segment mitigates their hiring incentives. Lower vacancy posting for skilled workers leads to further deterioration of the workforce composition and intensifies the reduction in capital demand.[16]

This is evident in Fig. 6, which compares the amplifying effect of migration under different model specifications. This figure plots the differences in impulse response functions to a negative risk premium shock with and without migration. I gradually turn off the key frictions of the model in order to investigate their relative importance and interactions. The different lines refer to the baseline model specification (black

[16]Note that in the decentralised equilibrium with emigration an important inefficiency arises. When household members decide where to direct their search they don't internalise the impact of their choice on aggregate labour market tightness (see Hosios (1990) for related discussion). As a result, they fail to fully account for how their choice impacts capital formation.

line), a model where capital–skill complementarity is shut down[17] (blue dashed line), a model with symmetric search frictions for skilled and unskilled (blue circled line) and a model where both capital skill complementarity and asymmetric frictions are turned off (red dotted line). When skilled labour is no longer complementary to capital, migration improves the performance of investment in the short run, as firms substitute the scarcer labour for the relatively cheaper capital. This response however is short–lived. With skilled labour being complementary to capital, investment immediately responds to the deteriorating skill composition of the labour force. Importantly, this response is magnified in the presence of search and matching asymmetries for the skilled and unskilled labour. The interplay between the production and the labour market externalities generates a strong amplification due to migration, and leads to a drop in investment which is almost 15% larger compared to the no migration–case.

6 Conclusion

This paper investigates the impact of cross-country migration for the business cycle of origin countries, bringing the compositional effects of labour mobility to the forefront of the debate. To do so, I build a small open economy DSGE model with heterogeneous households and three key features: search frictions in the labour market, endogenous mobility between countries and capital-skill complementarities in the production function. I find that the surge in migration outflows from Greece during the Sovereign Debt crisis amplified the recession. The skill composition of emigration flows, which disproportionately reflected the exodus of highly educated workers, played a key role for this result. The "brain drain" effect of migration had a particularly severe impact on capital demand. I find that migration led to a more than 15% drop in investment compared to the no-migration scenario, and that the interplay between the externalities in the production technology and the labour market was an important driver of this result.

This analysis suggests that cross-country mobility is an incomplete mechanism to achieve macroeconomic adjustment. In fact, this paper shows that depending on who

[17] I assume that $\gamma = \nu$ in the no csc specification.

leaves migration can significantly exacerbate internal imbalances. An interesting extension would be to investigate the impact of migration on the long-run level of productive capacity in origin countries. If high productivity growth sectors are disproportionately affected by emigration (e.g., because of lower R&D investment or lower intangible capital) then cyclical labour mobility can have a long-lasting impact on economic activity. Relatedly, if migration leads to higher misallocation of labour (e.g., due to lower returns on training) it may result in hysteresis and persistent scarring of the economic performance.

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A Appendix

A.1 Additional Figures

The following figure depicts the share of skilled immigration flows from European periphery to Germany. Skill groups are based on declared occupation. Specifically, following the ISCO occupations classification, I classify survey respondents as high–skilled if their occupation falls into groups 1–3 (Managers, Professionals, Technicians and associate professionals). The remaining are classified as low–skilled. As is evident from this plot, the shift in the skill content of migration is robust to different measures of skill.

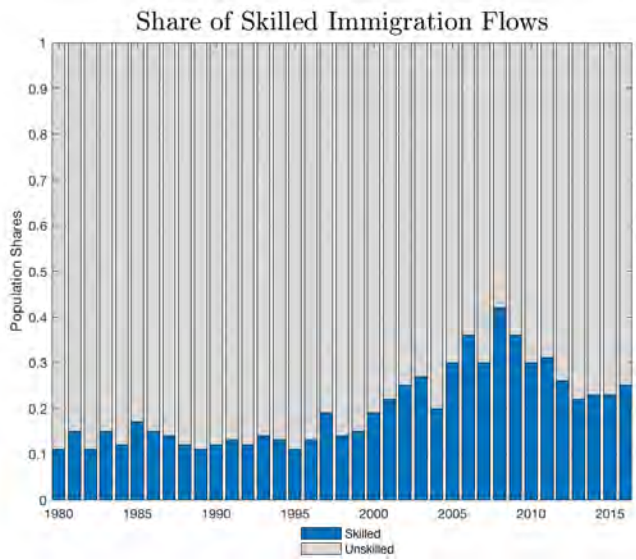

Figure A.1: Immigration flows from periphery (Ireland, Greece, Spain, Italy and Portugal) to Germany. Skill classification is via occupations. The sample is controlled for working age at year of entry (years 25-64 to account for education-related migration). Source: German Microcensus.

The following figures depict net emigration flows and the evolution of the skill share of the domestic working age population for European periphery countries. Emigration flows turned from being negative prior to the Sovereign Debt crisis to positive in line with the change in gross emigration flows. Turning to the evolution of the skill shares, it is interesting to note that despite their rapid increase over the past 25 years, they remained relatively stable during the crisis, when skilled-emigration increased.

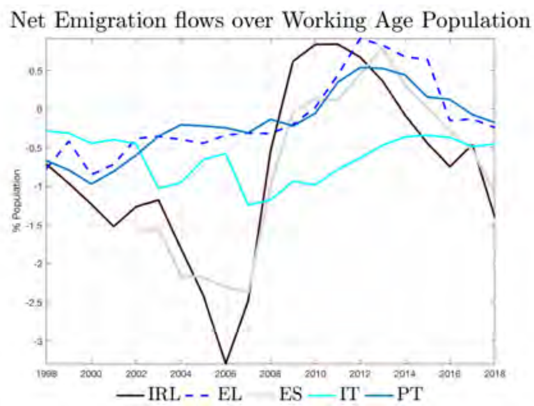

Figure A.2: Net emigration flows from European periphery (Ireland, Greece, Spain, Italy and Portugal) as a % of working age population (years 15-64). Source: Eurostat.

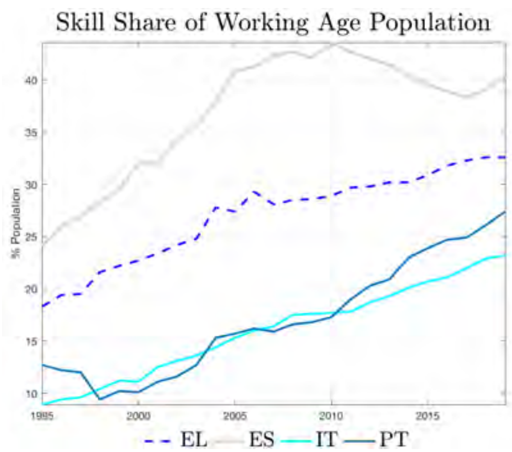

Figure A.3: Skill share as a % of working age population (years 15-64). Source: Eurostat.

A.2 Calibration

Table A.1: Calibration Strategy

Parameter	Description	Value	Rationale
β	subjective discount factor	0.96	4% annual real interest rate
χ	habits	0.6	Papageorgiou (2014)
θ	$X_d - X_f$ elasticity of substitution	1.65	Chodorow-Reich et al. (2019)
δ	depreciation rate	0.08	Chodorow-Reich et al. (2019)
ω	home bias	0.75	Chodorow-Reich et al. (2019)
$\rho_{k,l}$	$K - N_l$ elasticity of substitution	1.67	Krusell et al. (2000)
$\rho_{k,h}$	$K - N_h$ elasticity of substitution	0.67	Krusell et al. (2000)
s_s	skilled bundle share	0.47	skilled share–EUKLEMS
s_k	capital share	0.89	capital share–Papageorgiou (2014)
M_h	mass high-skilled	0.31	Eurostat
M_l	mass low-skilled	0.69	Eurostat
$\Omega_{h,l}$	disutility of moving	1.24, 0.22	8% emigrant stock, 35% skilled
$\mathit{\Gamma}_{h,l}$	pecuniary moving cost	0.98, 6.5	7% cumulative outflows, 65% skilled
μ_h	matching efficiency	0.86	7% unemployment rate of skilled
μ_l	Matching efficiency	0.61	12% unemployment rate of unskilled
$\rho_{h,l}$	separation rate	0.08	Hobijn and Sahin (2009)
κ_h	vacancy posting cost	0.1	job-filling rate 0.7 skilled
κ_l	vacancy posting cost	0.43	job-filling rate 0.6 low-skilled
ϵ_h ϵ_l	elasticity of matches to workers	0.6,0.4	Pissarides and Petrongolo (2001)
ψ_h ψ_l	bargaining power of workers	0.6,0.4	Hosios (1990)
γ_w	real wage rigidities	0.65	Papageorgiou (2014)
$w_h^\star$	foreign wage premia	$w_h^\star/w_h = 1.45$	EUKLEMS
$w_l^\star$	foreign wage premia	$w_l^\star/w_l = 1.05$	EUKLEMS
Ψ	Debt-elastic rate	0.001	Schmitt-Grohe and Uribe, 2003
Ξ	Investment adj. cost	0.9	Papageorgiou (2014)
Ξ	Foreign home bias	0.24	$y^{star} = 1$ normalisation
g	Government expenditure	0.15	$\frac{G^{ss}}{gdp^{ss}} = 0.18$, ELSTAT
ζ	Remittances share	0.47	$\frac{Rem}{gdp} = 0.3\%$, World Bank
ρ^{rp}	Risk premium shock persistence	0.98	Literature
σ^{rp}	Risk premium shock std	0.015	Literature

A.3 Model Equations

Exposition of low-skilled household's decision problem

$$\underbrace{\max}_{c_{l,t},\mu_{l,t}} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left(\ln(c_{l,t} - \chi \bar{c}_{l,t-1}) - \Omega_l n^e_{l,t} \right) \ , \text{s.t} \tag{A.1}$$

$$c_{l,t} + \frac{\Gamma_l}{2} \left(\frac{\mu_{l,t}\, u_{l,t}}{\mu_{l,t-1}\, u_{l,t-1}} - 1 \right)^2 \mu_{l,t}\, u_{l,t} = w_{l,t} n^r_{l,t} + Q_t w^\star_{l,t}\, n^e_{l,t} + \phi_l u_{l,t} + t_{l,t} \tag{A.2}$$

The household takes prices $\left\{ w_{l,t} \ , w^\star_{l,t} \ , Q_t \right\}$ as well as $t_{l,t} \ , n^r_{l,t} \ , n^e_{l,t}$ as given and solves the utility maximisation problem subject to the budget constraint well as the law of motion of emigrant and resident labour (6 and 7). The marginal utility of consumption is defined as

$$\Lambda^c_{l,t} = (c_{l,t} - \chi \bar{c}_{l,t-1})^{-1} \ . \tag{A.3}$$

Under complete domestic markets, it is pinned down by the risk-sharing condition (11)

$$\Lambda^c_{l,t} = \tilde{\Theta} \Lambda^c_{h,t} \tag{A.4}$$

The remaining equilibrium conditions are as follows

$$n^r_{l,t+1} = (1 - \rho_l) n^r_{l,t} + f_{l,t}(1 - \mu_{l,t}) u_{l,t} \tag{A.5}$$

$$n^e_{l,t+1} = (1 - \rho^\star_l) n^e_{l,t} + f^\star_{l,t} \mu_{l,t} u_{l,t} \tag{A.6}$$

$$\Lambda^r_{l,t} = \beta \mathbb{E}_t \Lambda^c_{l,t+1} \left(w_{l,t+1} - \phi_l \right) + (1 - \varrho_l - f_{l,t+1}) \Lambda^r_{l,t+1} \tag{A.7}$$

$$\begin{aligned} \Lambda^e_{l,t} = & -\beta \Omega_l + \beta \mathbb{E}_t \Lambda^c_{l,t+1} \left(Q_{t+1} w^\star_{l,t+1} - \phi_l \right) \\ & + \beta \mathbb{E}_t (1 - \varrho^\star_l) \Lambda^e_{l,t+1} - \beta \mathbb{E}_t f_{l,t+1} \Lambda^r_{l,t+1} \ . \end{aligned} \tag{A.8}$$

$$f^{\star}_{l,t}\,\Lambda^{e}_{l,t} - f_{l,t}\,\Lambda^{r}_{l,t} = \Lambda^{c}_{l,t}\left(\frac{\mathit{\Gamma}_l}{2}\left(\frac{\mu_{l,t}u_{l,t}}{\mu_{l,t-1}u_{l,t-1}} - 1\right)^2 + \mathit{\Gamma}_l\left(\frac{\mu_{l,t}u_{l,t}}{\mu_{l,t-1}u_{l,t-1}} - 1\right)\frac{\mu_{l,t}u_{l,t}}{\mu_{l,t-1}u_{l,t-1}} + \right.$$
$$\left. \beta\mathbb{E}_t\Lambda^{c}_{l,t+1}\mathit{\Gamma}_l\left(\frac{\mu_{l,t+1}u_{l,t+1}}{\mu_{l,t}u_{l,t}} - 1\right)\left(\frac{\mu_{l,t+1}u_{i,t+1}}{\mu_{l,t}u_{l,t}})^2\right)\right), \tag{A.9}$$

$$c^{e}_{l,t}n^{e}_{l,t} = w^{\star}_{l,t}n^{e}_{l,t} - Z_{l,t}n^{e}_{l,t} = (1-\zeta)w^{\star}_{l,t}n^{e}_{l,t}\,. \tag{A.10}$$

$$c_{l,t} = (u_{l,t} + n^{r}_{l,t})c^{r}_{l,t} + Q_t n^{e}_{l,t}c^{e}_{l,t} \tag{A.11}$$

Additional equilibrium equations for high-skilled household

$$\Lambda^{c}_{h,t} = (c_{h,t} - \chi c_{h,t-1})^1 \tag{A.12}$$

$$1 = \mathbb{E}_t\beta\frac{Q_{t+1}}{Q_t}\frac{\Lambda^{c}_{h,t+1}}{\Lambda^{c}_{h,t}}R^{\star}_{t+1} \tag{A.13}$$

$$T_t = \mathbb{E}_t\beta\frac{\Lambda^{c}_{h,t+1}}{\Lambda^{c}_{h,t}}\left(r^{K}_{t+1} + T_{t+1}(1-\delta)\right) \tag{A.14}$$

$$\frac{1}{T_t} = 1 - \frac{\Xi}{2}(\frac{i_t}{i_{t-1}} - 1)^2 - \Xi(\frac{i_t}{i_{t-1}} - 1)^2\frac{i_t}{i_{t-1}} + \mathbb{E}_t\beta\frac{\Lambda^{c}_{h,t+1}}{\Lambda^{c}_{h,t}}\frac{T_{t+1}}{T_t}\Xi\left(\frac{i_{t+1}}{i_t} - 1\right)\left(\frac{i_{t+1}}{i_t}\right)^2 \tag{A.15}$$

where T_t denotes the shadow value of capital.

A.4 Results

Additional experiment results

Labour market responses to a negative risk-premium shock. Unemployment rates refer to a narrower measure that excludes those who search at Foreign.

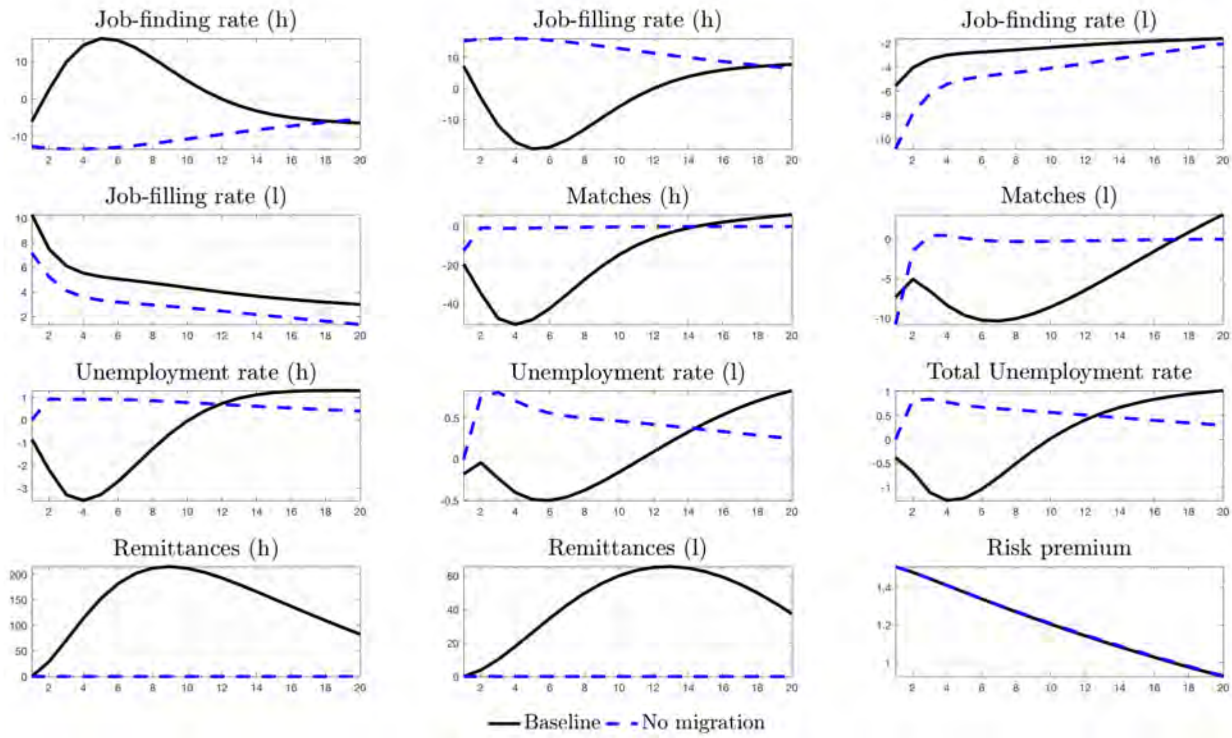

Figure A.4: Impulse Response Functions to a negative risk-premium shock. IRFs are in terms of % deviations from the steady state with the exception of the unemployment rates. The parenthesis terms refer to skilled households (h) and unskilled households (l). Horizontal line depicts years.

Responses of GDP and main components under migration of only skilled labour, migration of only unskilled labour and the baseline scenario (which features migration of both skill types). In the data series, consumption refers to total final consumption expenditure of households, investment to gross fixed capital formation and trade balance to net exports of goods. All variables are in aggregate terms.

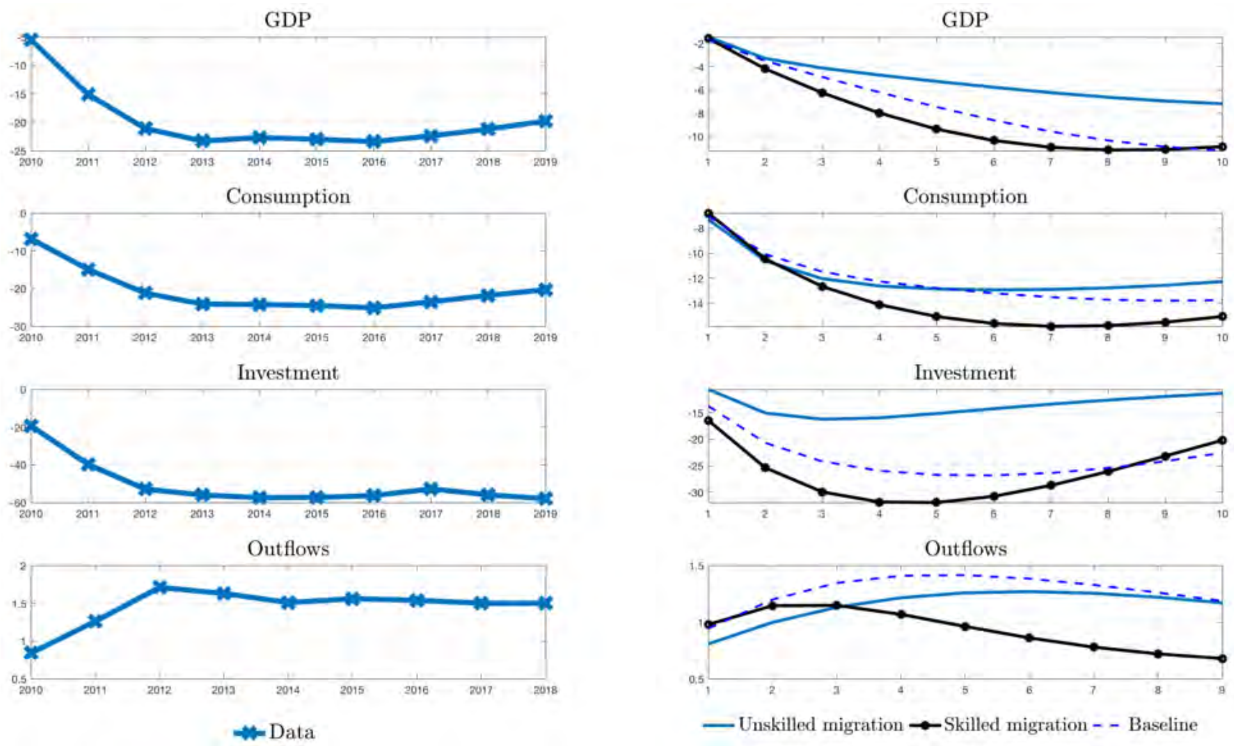

Figure A.5: Impulse Response Functions to a negative risk-premium shock. The data series are in % deviations from their 2009 values apart from outflows. Measurements are in chain linked volumes (2010). Model responses are in % deviations from steady state apart from outflows. Outflows are in % of total working age population. Source: ELSTAT.

Differences in impulse response functions to a negative risk premium shock with and without migration. The different lines refer to the baseline specification (black line), a specification where capital–skill complementarity is shut down (blue dashed line), a model with symmetric search frictions for skilled and unskilled (blue circled line) and a model where both capital skill complementarity and asymmetric frictions are turned off (red dotted line).

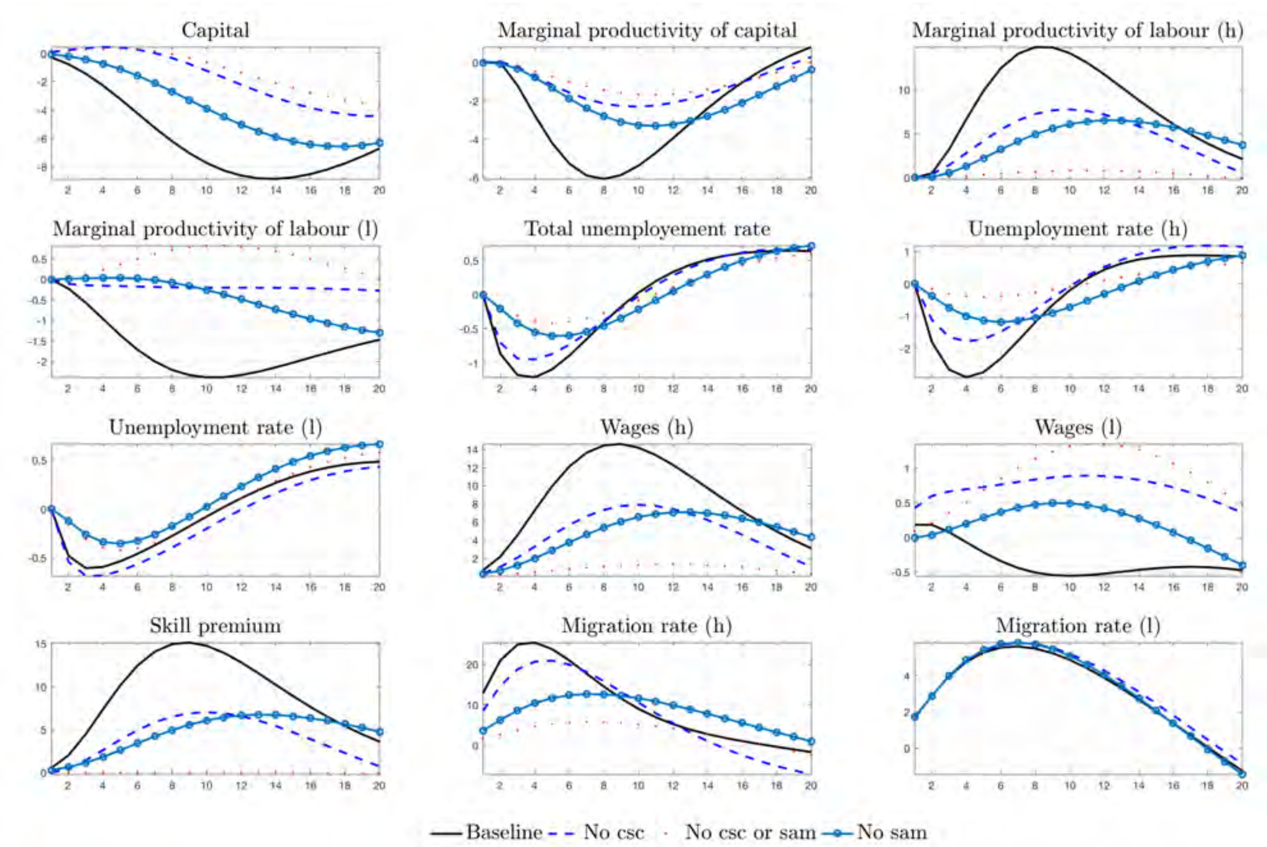

Figure A.6: Differences in Impulse Response Functions to a negative risk-premium shock with and without migration. The respective IRFs are in % deviations from steady state apart from the responses of migration and unemployment rates, which are in deviations from steady state. The horizontal axis depicts years.