A search and matching approach to business-cycle migration in the euro area

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Abstract

Recently migration patterns in the euro area changed markedly in response to increasing unemployment disparities. This reinforced the interest in labor mobility as stabilization tool against the background of heterogeneous labor market conditions. In a data set of 55 bilateral migration corridors in the euro area over the period 1980-2010 we find evidence for business-cycle related fluctuations in net migration flows and the crucial role of unemployment and vacancies in shaping migration patterns. We propose a two-country DSGE model with migration that is able to replicate the empirical facts on business-cycle migration. In this model unemployment arises from search and matching frictions. We start by modeling migration as a proportional outflow from unemployed workers and in a second step endogenize migration via the unemployed workers choice on which labor market to search for a job. The framework allows to account for wage and unemployment gaps between natives and immigrants over the cycle as well as for factors such as language barriers that hinder the labor market integration of foreigners.

We find that the impact of migration on country-specific average wages and unemployment depends crucially on the characteristics of immigrants and natives as well as the institutional characteristics of the total corridor, i.e. search efficiency.

Keywords: Labor Migration, Unemployment, Search and Matching

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1. Introduction

European policy makers continue to highlight migration as a means to increase overall employment against the background of heterogeneous labor market conditions. The legal framework of the European Union guarantees free movement of persons and lays the foundation for a potentially high mobility in the euro area. The interest in labor mobility was reinforced during the recent European crisis episode where migration patterns in the euro area changed markedly in response to increasing unemployment disparities. Therefore, understanding the drivers of internal migration in the euro area is crucial in order to assess this important adjustment mechanism.

Against this background three stylized facts about internal migration in the euro area stand out from the empirical literature. First, even though the importance of internal migration has increased over time, cross-country migration flows are smaller than interstate migration flows in the United States. Second, migration has a temporary and often circular nature. Third, migration flows react to relative business cycle fluctuations in the euro area and are mainly motivated by employment probabilities and wages.

To gain more insights into the impact of the business cycle on the direction and size of migration flows, we carry out a comprehensive empirical analysis of the interrelation of wages, unemployment and vacancies with migration patterns in the euro area over the business cycle for the period 1980 to 2010. Our analysis of 55 bilateral migration corridors reveals that on average wage and unemployment differentials are negatively correlated with net migration. The correlation of net migration and vacancies is positive. In combination with the unemployment pattern this points towards the important role of relative labor market tightness for migration decisions.

A theoretical model of internal migration and the business cycle in the euro area has to be able to replicate these empirical findings. We propose a two-country dynamic stochastic general equilibrium (DSGE) model with migration that features unemployment arising from search and matching frictions. We start by modeling migration as a proportional outflow from the stock of unemployed workers such that net migration solely reacts to changes in employment probabilities. In a second step we endogenize migration via the unemployed workers choice on which labor market to search for a job. Thereby, migrants take into account all relevant information on relative labor market conditions (wages, employment and separation probabilities).

The inclusion of labor market frictions crucially shapes the migration patterns in this model. Immigrant workers face uncertainty to become unemployed and by modeling
an outflow of unemployed migrants we are able to capture the temporary nature of migration. Furthermore our approach lowers the migration flows compared to the case of a frictionless labor market for two interrelated reasons. By modeling a distinct matching process for migrants we are able to account for language barriers and other factors that hinder the labor market integration of foreigners. This feeds back to the migration decision in which agents take into account that it might take time to form a match abroad. Additionally, we can show that migration affects the relative business cycle fluctuations via a wage bargaining channel. As an outside option the possibility to migrate changes the workers’ negotiation position in the wage bargaining process. If the labor market situation in the foreign economy improves relative to the home economy then the value of the outside option and the native workers’ wages increase.

The calibrated version of our model is able to replicate key facts about the migration cycle in the euro area. It matches the empirically observed wage and unemployment gaps between native and immigrant workers and reproduces aggregate macro and labor market facts in the steady state and over the cycle. Simulations of our model show the interaction of emigration and return migration flows with labor market variables in response to a productivity shock. We find that a higher labor mobility decreases the unemployment fluctuation while it increases the output and employment fluctuation. A shock that improves the wage bargaining position of native workers via a higher emigration value at the same time decreases the negotiation position of emigrant workers. Therefore we observe opposing wage effects of a higher emigration and return migration rate. Overall, we find that the impact of migration on country-specific average wages and unemployment depends crucially on the characteristics of immigrants and natives and their interaction as well as the institutional characteristics of the total corridor, i.e. search efficiency. The model bridges the literature on migration in the search and matching framework to the literature on two-country DSGE models.

The paper is structured as follows: Section 2 reviews the literature on migration patterns in the euro area, on unemployment and migration in DSGE models, and on migration in search and matching models, Section 3 presents business cycle statistics on migration in the euro area with respect to unemployment, vacancies and wages, Section 4 describes the theoretical model, Section 5 discusses the parametrization and the model results with respect to the impact of parameters, the dynamic responses and the correspondence with business cycle facts and Section 6 concludes.
2. Literature overview

A theoretical model of internal cross-country migration in the euro area has to be able to replicate three empirical findings that stand out from the empirical literature. Firstly, even though the importance of internal migration has increased over time migration flows are smaller than the inter-state flows in the United States. In a panel of OECD countries over the period 1980-2010, Beine et al. (2013) find empirical evidence of the Schengen agreement and the introduction of the euro to have increased internal migration in the European Union (EU). Beyer and Smets (2015) employ a multilevel factor model to document that in the EU the contribution of cross-country mobility to a national labor demand shock has increased over time to approximately one third of the adjustment which is lower than the benchmarks of regional mobility in the EU or inter-state mobility in the United States. Reasons are seen in the cultural, language and institutional difference in Europe as well as in imperfections in the housing and rental market and liquidity constraints (Bartz and Fuchs-Schündeln, 2012; ECB, 2012; Huber, 2007).

Secondly, migration has a temporary and often circular nature (Brücker et al., 2014; OECD, 2014). The term temporary migration refers to a variety of phenomena whose documentation is limited by data availability (Constant et al., 2013; Dustmann and Görlach, 2016). A report by the OECD (2008) finds that in the 1990s the share of migrants that leave their host country within the first five years after arrival was on average higher in European countries than in the United States, Canada or New Zealand. A distinct pattern noted by Dustmann and Görlach (2016) is that the temporariness of migration increases with economic and cultural similarities between the destination and the source country. With respect to economic indicators, the group of euro members is more homogenous than the EU-28 as a whole. For Germany, the high relevance of temporary migration from other EU countries is documented by Brücker et al. (2014) and Constant and Zimmermann (2011), who explain the shorter migration periods by the lack of legal migration restrictions and low migration cost.

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1Constant and Zimmermann (2011)[p. 498] distinguish return, repeat and circular migration. While return migration is defined as a final return to the migrant home country, repeat migration refers to migrants who “frequently and repeatedly move to foreign countries” and circular migration “describes the systematic and regular movement of migrants between their homelands and foreign countries typically seeking work”.

2The reported outmigration rate after five years is 60.4 percent in Ireland, 50.4 percent in Belgium and 28.2 percent in the Netherlands.

3The membership in the euro area is conditional on the fulfillment of economic convergence criteria.
Thirdly and closely connected to the temporariness of migration patterns, migration flows react to relative business cycle fluctuations in the euro area and are mainly motivated by employment probabilities and wages (Brücker et al., 2014; OECD, 2014).\textsuperscript{4} Beine et al. (2013) find current and future business cycle and employment dynamics to influence bilateral migration flows.\textsuperscript{5} Additionally, during the recent European financial and debt crisis growing labor market disparities among the members of the euro area were mirrored by a marked change in the size and direction of migration flows (Bertoli et al., 2013; OECD, 2014).

In the growing theoretical literature on business cycle migration many contributions abstract from unemployment and rely on the assumption of a frictionless international labor market that is characterized by fully flexible wages. Mandelman and Zlate (2012) model immigration of unskilled Mexicans to the U.S. in a RBC model. In a New-Keynesian (NK) model, Binyamini and Razin (2008) and in a similar vein Engler (2009) assess the effects of immigration respectively emigration on the Phillips curve and find it to be flatter in both cases. The flatter Phillips curve in presence of labor mobility is a key insight from integrating migration into the NK model. Because of the inflow of workers a lower wage increase is needed to raise the labor force compared to the case without labor mobility. In a two-country model of internal U.S. labor migration Hauser (2014) shows that a technology shock spills-over from one location to another via its effect on the direction of the labor force movement. However, this result

Another group of business cycle migration models accounts for the role of labor market frictions. In the DSGE framework two approaches to introduce unemployment can be distinguished. One approach (e.g. Galí, 2011) reinterprets the DSGE model with staggered wage setting formulated by Erceg et al. (2000) where the market power of differentiated types of labor gives rise to a positive average wage markup and unemployment. Bentolila et al. (2008) include real wage rigidity in an ad hoc manner in their derivation of an empirically testable NK Phillips curve. They find that immigration alters the slope and intercept of the Phillips curve via a different labor supply elasticity and bargaining power of immigrants. In Clemens and Hart (2015) we model migration by allowing agents to set a native and a migrant wage. Even though this model is able to match aggregate business cycles suitably well, it gives a rather implicit description

\textsuperscript{4}For Germany Brücker et al. (2014) finds that in the group of repeated migrants and of migrants from other EU countries the dominant migration motive is taking up a job or searching for a job.

\textsuperscript{5}According to their panel estimation a 1% rise in the ratio of employment rates between destination and origin country in a migration corridor increases the bilateral migration rate by 5%. 

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of how migrants respond to relative labor market fluctuations. The more common approach to introduce unemployment into the DSGE framework is to model real frictions from search and matching in line with Diamond (1982), Mortensen (1982), Pissarides (1985), Mortensen and Pissarides (1994) (e.g. Christiano et al., 2016; Faia and Rossi, 2013; Gertler et al., 2008; Krause and Lubik, 2007; Walsh, 2005). In the migration literature Ortega (2000) uses a dynamic two-country labor matching model where workers can choose to search at home or abroad with information asymmetries to show that this set-up gives rise to multiple Pareto-ranked steady-states with and without immigration. Chassamboulli and Palivos (2013, 2014) analyze skill-biased immigration inflows in a model with search and matching and skill heterogeneity and the contribution by Battisti et al. (2014) investigates the welfare effect of immigration of workers who are perfect substitutes within skill classes. Braun and Weber (2016) use a dynamic search and matching model of two regions to analyze the historical episode of massive expellees inflow to post-war Germany.

The advantage of the search and matching approach is that it delivers a detailed description of the labor market processes over the business cycle. This is particularly helpful in the context of migration, because it allows us to explicitly model the migration flows in response to relative employment probability and wage fluctuations. Further, it allows to take into account different employment dynamics (e.g. separation rate) for migrants and natives over the cycle. We differ from these set-ups by modeling the interaction of two economies over the business cycle and by allowing for migration in both directions in response to relative business cycle fluctuations and differences in employment probabilities. Thereby, we bridge the literature on unemployment in two-country DSGE models to the literature on migration in a search and matching framework. Including unemployment in the analysis has nontrivial consequences because unemployment rates exhibit a different dynamic pattern than wages.

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6There exist versions with and without the assumption of rigid wages. Shimer (2005) and Hall (2005) propose wage rigidity as one way to introduce the empirically observed negative correlation of unemployment and vacancies (‘Beveridge curve’) into the search and matching model.

7While the wage patterns for migrants and natives follow similar patterns over the cycle they differ with respect to employment probabilities. Dustmann et al. (2010) find that in Germany the unemployment response to labor market shocks is stronger for immigrants than for natives within the same skill group. Prean and Mayr (2016) obtain a similar result for Austria that even holds after controlling for industry and job characteristics. This is in line with the general finding, that immigrants tend to be hit hard and immediately in an economic downturn (OECD, 2013).
3. Empirical observations

3.1. Compiling the data set

To investigate the migration business cycle in the euro area we compile a large data set with bilateral migration and macroeconomic variables\(^8\) in a similar vein as Beine et al. (2013) but with a focus on the euro area. The data set contains observations for the years 1980-2010 and covers 12 euro area countries (EA-12\(^9\)). Due to the lack of availability of quarterly\(^10\) bilateral migration data we rely on annual data from the United Nations and the OECD Migration database. Each pair of countries is referred to as a migration corridor and our set of countries gives rise to 12 \(\cdot 11/2 = 66\) potential migration corridors. Due to data limitations the number of actual corridors in the panel reduces to 55.\(^11\) For each bilateral migration corridor we define the net migration as the difference of immigration and emigration between the two countries and normalize it by the average labor force in the migration corridor.

The data series for the macroeconomic variables real GDP, real consumption, unemployment rate, employment, labor force, real wage, price inflation, wage inflation, and trade balance were drawn from the AMECO database. Real compensation per employee serves as a proxy for real wages.\(^12\) Vacancy data for the euro area can be obtained from Eurostat for the years 2001 onwards. However, this data is neither seasonally adjusted nor harmonized and lacks observations for France and Italy. As an indicator for vacancies that overcomes these shortcomings\(^13\) we use the series of employers’ perception of labour shortages in manufacturing data from the European Commissions’ Surveys of Business Confidence. This data is widely used and has been shown to be highly correlated with official vacancy series (e.g. Bonthuis et al. (2013)).

For the migration business cycle relative fluctuations of variables in source and destination countries matter. Therefore, we construct differentials of output, real wage,

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\(^8\)See Appendix 7.1 for a description of the data.
\(^9\)The EA-12 refers to Austria, Belgium, Germany, Spain, Finland, France, Ireland, Italy, Luxembourg, Netherlands, Portugal and Greece.
\(^10\)The empirical investigation of short-run migration flows is limited by the fact, that data on a business cycle frequency is still very rare. Therefore, most studies use data on an annual basis from 1980 until now. For Germany there is a new data set with monthly data.
\(^11\)There are still some missing years in that panel. In the period 1980-2010 there are 42 corridors without missing observations, in 1990-2010 the number increases to 50 corridors and in 1996-2010 to 55 corridors.
\(^12\)Galí (2011) points out, that compensation per employee is a wage concept that comprises other employment-related cost to the employer than wages and exhibits stronger volatility than earnings-based concepts.
\(^13\)Because this indicator bases on a percentage share of firms it is not affected by country size. However, the series does not provide data for Ireland and might be subject to a memory effect ECB (2002).
unemployment rate and vacancies for each migration corridor. The differentials are defined as the difference in a variable, normalized by its corridor average. The wage and the unemployment differentials act as empirical proxies for non observable time-varying migrants wage/unemployment differentials.\footnote{While comparable data in source and destination countries is available for average wages, there is a lack of data on skill-specific wage differentials. Grogger and Hanson (2011) provide an approach to construct such a measure. We justify our approach by findings of Dustmann et al. (2010) who find little evidence for differential wage patterns of skilled and unskilled native workers and migrants. Thus the average real wage measures is an indicator for the wage dynamics of all four groups.} All variables are in real terms and in terms of the cyclical component, i.e. the deviation of the variable from its trend. In order to extract the cyclical component we take logs of all level variables and apply the HP filter with a smoothing parameter of $\lambda = 400$.\footnote{Thereby we follow Beine et al. (2013) who also use a value of $\lambda = 400$ for the analysis of business cycle migration with annual data. We check the robustness of our results with respect to the smoothing parameter and find that our results do not change fundamentally with $\lambda = 100$ and $\lambda = 6.25$.} EA-12 averages are obtained as unweighted averages of all corridors.

3.2. Business cycle statistics for the euro area

In the following we present business cycle facts for the euro area that help to assess whether internal migration patterns vary systematically with the business cycles and how wages, unemployment, vacancies and migration patterns are interrelated over the business cycle. Because the empirical literature points towards the importance of employment dynamics for net migration we include vacancies in our analysis. Our interest is twofold, we want to identify characteristic patterns of the average EA-12 migration corridor and consider heterogeneity across corridors.

There is evidence for a migration cycle in the EA-12 because the net migration rate displays a relatively strong volatility. According to Table 1 (column four) net migration is positively correlated with the output differential, thus internal migration seems to be procyclical.\footnote{However, Hauser (2014) demonstrates for the U.S. labor market that while unconditional labor mobility is procyclical, the picture is less clear for conditional labor mobility. Her SVAR analysis of all migration corridors in the U.S. reveals that subsequent a technology shock some states face a net inflow of workers while others face an outflow. A similar SVAR exercise should be carried out for the EA-12 labor markets.} Over the cycle the net migration rate displays a strong negative correlation with the unemployment rate differential that is mirrored by a positive correlation with the employment differential. Additionally, net migration is positively correlated with the indicator of vacancies over the cycle, while vacancies on average exhibit a negative correlation with the unemployment rate of 0.54, i.e. the Beveridge curve is downward sloping. Combined, vacancies and unemployment point towards the importance of
labor market tightness for the net migration patterns. As we would expect from the literature review, the correlation of net migration with real wages is lower than with the unemployment rate. Surprisingly, the correlation of real wage and net migration is negative.

To further investigate the dynamic behavior of net migration and the differentials of real output, unemployment rate, vacancies and real wage, Table 1 displays the dynamic correlations up to the third lag and lead. The net migration rate is positively correlated with output and negatively correlated with unemployment at various lags and leads. In both cases the contemporaneous is the peak correlation. As a first intuition, the negative correlation between the unemployment differential and net migration can be explained by assuming that unemployment is c.p. causal for the migration decision. In the euro area, an exogenous negative labor demand shock decreases output and increases unemployment in one country and consequently native households decide to emigrate to another country with higher output and lower unemployment. This view is supported by the fact that the vacancy differential has the maximum correlation 0.11 at the first and second lag and thus leads the net migration. The negative correlation between the real wage differential and the net migration rate can be observed for the third lag up to the first lead.\textsuperscript{17} The maximum correlation $-0.13$ at the first lag indicates that the wage differential leads the net migration rate by one to two periods. Instead of assuming the wage conditions to be causal for the migration decision, a shock that increases wages and decreases net migration e.g. via an increased unemployment can

\begin{table}[h]
\centering
\begin{tabular}{lcccccc}
\hline
 & \multicolumn{6}{c}{$\tau$} \\
Statistic & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
\hline
$\rho(dy_{t+\tau}, nm_t)$ & 0.010 & 0.058 & 0.113 & 0.167 & 0.100 & 0.041 & -0.019 \\
$\rho(du_{t+\tau}, nm_t)$ & -0.012 & -0.138 & -0.274 & -0.307 & -0.199 & -0.054 & 0.093 \\
$\rho(dv_{t+\tau}, nm_t)$ & 0.032 & 0.111 & 0.110 & 0.089 & -0.011 & -0.033 & -0.049 \\
$\rho(dw_{t+\tau}, nm_t)$ & -0.072 & -0.118 & -0.131 & -0.099 & -0.071 & 0.008 & 0.087 \\
\hline
\end{tabular}
$\rho(dx_{t+\tau}, nm_t)$ denotes the correlation of net migration and the $\tau$th lag (lead) of the differential of variable $x$ if $\tau$ is negative (positive). $y$ denotes output, $u$ denotes the unemployment rate, $v$ denote vacancies and $w$ the real wage.

\textsuperscript{17}This result only changes slightly by using different time periods and smoothing parameters. The correlation of net migration with the unemployment and the wage differential decreases with a lower $\lambda$ and a shorter time period.

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explain the observed pattern. The observation that the wage differential is negatively correlated with net migration at three lags and positive starting with the second lead speaks against the hypothesis, that the average negative correlation of net migration and wages stems from the negative effect of immigration on wages.

Figure 1: Correlation between the cyclical component of net migration and real wage, vacancy and unemployment differential for 55 euro area corridors

Figure 1 highlights the heterogeneity across migration corridors. The 55 migration corridors are sorted by sign and size of the contemporaneous correlation of the net migration rate and the differential of the real wage (left), unemployment (middle), vacancies (right). With respect to wages the heterogeneity across corridors is highest with approximately two thirds of all corridors exhibit a negative correlation and some corridors displaying a positively correlation of up to 0.5. With respect to wages the picture more clear with a majority of corridors displaying a negative correlation. For vacancies we again find more heterogeneity and the lowest maximum correlations compared to the other variables. The signs of net migration correlation with wages and vacancies can act as dimensions to classify migration corridors into four types and we observe that in a majority of corridors migration flows are directed towards a high labor market tightness (see Figure 3 in the appendix).

Overall, the business cycle facts underline that the analysis of wages alone is not sufficient to understand the cyclical migration patterns in the euro area. Our results
points towards the importance of relative unemployment and labor market tightness fluctuations. In line with these findings we develop a two-country dynamic stochastic general equilibrium model of internal business cycle migration in the euro area and allow for unemployment that arises from search and matching frictions.

4. A two-country business cycle model with unemployment and migration

4.1. Model system

In discrete time we construct a two-country dynamic general equilibrium model with search and matching and cross-country labor mobility. Both economies are symmetric\(^{18}\) and consist of identical households, two types of firms and a government. Households consume an final good that is a composite of home and foreign intermediate goods. Each household consists of a continuum of workers which can either be employed or be unemployed in the home or the foreign country. Employed workers supply their labor to the intermediate good firms and earn a wage determined in bilateral Nash bargaining. Unemployed workers can either search in the domestic or the foreign labor market. Thus, we can distinguish between the native and migrant stock, the stock of employed and unemployed immigrants from foreign, and the net migrant flow which is the difference in the population between two subsequent periods. Intermediate goods producing firms in both countries hire native and immigrant workers by posting vacancies with linear costs in segmented frictional labor markets. Matches are resolved at an exogenous rate. The government collects a lump sum tax which is used to finance the unemployment benefits. We introduce financial integration by assuming that asset markets are incomplete and households in each country issue risk-free bonds denominated in their national currency.

4.1.1. Emigration and return migration

Since both countries have a symmetric structure we introduce a circular migration schedule. The native working-age population of each country consists of employed and job-seeking natives and emigrants and its size is equal to \(1 = u_{h,t} + u^*_h + n_{h,t} + n^*_h\). The national labour force deviate from the native working-age population and is defined as sum of native and immigrant workers and job-seekers, \(l_t = u_{h,t} + u_{f,t} + n_{h,t} + n_{f,t}\). With-

\(^{18}\)Due to the symmetry assumption all equations are derived for the home economy. They analogously apply to the foreign economy.
out loss of generality we abstract from migration of employed workers. Consequently, at any point in time migration flows comprise a share of unemployed workers $\mu_t$ who move to the foreign labor market and a share of unemployed emigrants $\gamma_t$ who return home.

The time pattern for a foreign searcher who want to participate in the domestic labour market is depicted in figure 2. At the beginning of each period a fraction $\mu$ of native and foreign job-seekers $u_{h,t}$ decide to either search in Home or Foreign. Once she decided to move to the foreign country at the end of the period she belongs to the beginning of next-period’s stock of job-seeking (unemployed) migrants in the foreign country. In the next period she will find a job at the foreign labour market with the same probability as the foreign native job-seeker who staid in his country. Given the fact that most EU migrants do not leave their home country forever, we assume that with probability $\gamma$ a migrant will return to its country. Emigrant workers who return reduce the unemployed migrant stock in the foreign country but increase the unemployed native stock in the domestic country. Furthermore, the job finding probability decreases and the job separation rate increases the next-period unemployment stocks. Thus, the native and emigrant unemployment stocks evolve according to the following functions

\[
\begin{align*}
    u_{h,t+1} &= (1 - \mu_t)[u_{h,t} - f_{h,t}u_{h,t} + \rho n_{h,t}] + \gamma_t[u^*_{h,t} - f^*_{h,t}u^*_{h,t} + \rho^* n^*_{h,t}], \\
    u^*_{h,t+1} &= (1 - \gamma_t)[u^*_{h,t} - f^*_{h,t}u^*_{h,t} + \rho^* n^*_{h,t}] + \mu_t[u_{h,t} - f_{h,t}u_{h,t} + \rho n_{h,t}].
\end{align*}
\]

19It is a common approach in the migration literature with search and matching to not consider job-to-job migration (e.g. Braun and Weber, 2016; Chassamboulli and Palivos, 2014).

20Analogously, the emigration and return migration rate for foreign workers are denoted by $\mu^*_t$ and $\gamma^*_t$. 

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Figure 2: Timing of migration
Equation (1) and the foreign emigrant counterpart of equation (2) determine total domestic unemployment \( u_t = u_{h,t} + u_{f,t} \).

4.1.2. Household decision

Households are distributed along the unit interval and consist of a continuum of workers of measure one. The optimization problem of a representative household is:

\[
\max \left\{ c_t, k_{t+1}, a_{t+1}, a^*_{t+1} \right\} E_0 \sum_{t=0}^{\infty} \beta^t \log(c_t)
\]

subject to the intra-temporal budget constraint:

\[
c_t + k_{t+1} + a_{t+1} + \frac{\Delta}{2} a_{t+1}^2 + q_t a^*_t + q_t \frac{\Delta^*}{2} a^*_{t+1}^2 =
(1 + i_t) a_t + (1 + i^*_t) q_t a^*_t + (1 + r^K_t - \delta) k_t + b (1 - n_{h,t} - n^*_{h,t}) + w_{h,t} n_{h,t} + q_t w^*_h n^*_{h,t} - T_t,
\]

where \( c_t \) is consumption in units of the domestic aggregate good, \( k_t \) is capital rented to firms at the real rate \( r^K_t \) and \( q_t \) denotes the real exchange rate. The risk-free interest rate \( i_t \) equals the net capital rate \( r^K_t - \delta \). \( a_t \) and \( a^*_t \) denote holdings of domestic and foreign bonds that are traded internationally and each pay the risk-free rate \( i_t \) and \( i^*_t \). We assume international quadratic transaction cost on domestic and foreign assets which can occur due to a structural international financial market taxation.\(^{21}\)

The household income consists of the real labor income of native and emigrant workers\(^{22}\) \( w_{h,t} n_{h,t} \) and \( q_t w^*_h n^*_{h,t} \). We assume that natives and emigrants from one household pool their labor income in order to insure each other and consume the same average consumption level (Andolfatto, 1996; Merz, 1995). The labor income of emigrant workers has to be multiplied by the real exchange rate in order to measure it in units of the domestic composite good. Besides their labor income representative households receive interest earnings from international bond and capital holdings and the benefits \( b \) for unemployed members. The unemployment benefit is paid according to the nationality of the worker such that agents receive the same payment when being unemployed in

\(^{21}\)\(\Delta \) and \( \Delta^* \) are positive to avoid non-stationarity of the model but are set close to zero in order to minimize the influence on the dynamic pattern. See Melitz and Ghironi (2005).

\(^{22}\)Superscript * denotes foreign variables. Subscripts \( h, f \) refer to nationality of a worker or the origin of a goods variety.
the domestic and the foreign economy.\textsuperscript{23}

The first order conditions with respect to consumption, bonds and capital accumulation imply the following Euler equations for capital, domestic and foreign bonds:

\begin{align}
1 = & \beta E_t \left\{ \frac{c_t}{c_{t+1}} \left( 1 + r_{t+1}^k - \delta \right) \right\}, \\
1 + \Delta a_{t+1} = & \left( 1 + i_{t+1} \right) \beta E_t \left\{ \frac{c_t}{c_{t+1}} \right\}, \\
1 + \Delta^* a^*_{t+1} = & \left( 1 + i^*_{t+1} \right) \beta E_t \left\{ \frac{c_t}{c_{t+1}} \frac{q_{t+1}}{q_t} \right\}.
\end{align}

In equilibrium those conditions pin down the stochastic discount factor in both countries. There is no labor supply decision of households and workers supply a fixed number of hours. Therefore \( n_t \) and \( u_t \) are defined as employment and unemployment per average working hour.

\subsection{Labor market and immigration}

The domestic labor market is subject to search and matching frictions. In order to form a new employment relationship, unemployed workers can search either in the domestic or the foreign labor market \((u_{h,t}, u^*_{h,t})\). Firms post separate vacancies \( v_{h,t} \) and \( v_{f,t} \) for natives and immigrants. In line with key findings from the empirical literature on migration patterns in the euro area we consider job market differences of both groups. The segmented labor market between native and immigrant workers is captured by separate Cobb-Douglas matching functions:

\begin{align}
m_{h,t} = & N(u_{h,t})^\delta (v_{h,t})^{1-\delta}, \\
m_{f,t} = & I(u_{f,t})^\delta (v_{f,t})^{1-\delta}.
\end{align}

\( N \) and \( I \) are measures for the matching efficiency of both worker types. They capture structural factors, e.g. relocation costs and language, that lead to significantly different job creation and job finding rates for migrants. \( 0 < \delta < 1 \) is the match elasticity with respect to unemployment and does not vary between natives and immigrants.\textsuperscript{24} It is

\textsuperscript{23}This assumption is justified by EU legislation that allows workers to search abroad while receiving the domestic unemployment benefit. Further this assumption helps to abstract from the role of unemployment benefits for the migration decision and to focus on the effect of employment probabilities instead.

\textsuperscript{24}This is our starting point, later we will consider differences in the match elasticity between natives and immigrants.
time consuming to form a match and therefore new matches become productive in the next period. The evolution of domestic aggregate native and immigrant employment is:

\[ n_{h,t+1} = (1 - \rho)n_{h,t} + M_t m_{h,t}, \quad (10) \]
\[ n_{f,t+1} = (1 - \rho)n_{f,t} + M_t m_{f,t}. \quad (11) \]

The job separation rate \( \rho \) is exogenous and identical for natives and immigrants.\(^{25}\) \( M_t \) is the time-varying matching technology.\(^{26}\) The matching technology is country-specific and does neither reduce the geographic skill mismatch between native and immigrant workers \( N_{h} \), nor the skill mismatch between native and immigrant workers \( \Theta \). It therefore points towards a more efficient matching process due to better technology. The logarithm of the country-specific matching technology follows an AR(1) process \( \log(M_t) = \rho_M \log(M_{t-1}) + \epsilon_M, t \) with persistence parameter \( 0 < \rho_M < 1 \) and a white noise shock \( \epsilon_M, t \) with zero mean and constant variance \( \sigma^2_M \). The labor market tightness for natives and immigrants is defined as \( \theta_{h,t} \equiv \frac{v_{h,t}}{u_{h,t}} \) and \( \theta_{f,t} \equiv \frac{v_{f,t}}{u_{f,t}} \). The characteristics of the Cobb-Douglas matching function imply that firms fill their posted vacancies for natives with a probability \( q_{h,t} \equiv \frac{m_{h,t}}{v_{h,t}} = N\theta_{h,t}^{-\delta} \) and for immigrants with a probability \( q_{f,t} \equiv \frac{m_{f,t}}{v_{f,t}} = I\theta_{f,t}^{-\delta} \). Similarly, native and immigrant workers find a job with the probabilities \( f_{h,t} \equiv \frac{m_{h,t}}{u_{h,t}} = N\theta_{h,t}^{1-\delta} \theta_{h,t} \) and \( f_{f,t} \equiv \frac{m_{f,t}}{u_{f,t}} = I\theta_{f,t}^{1-\delta} \theta_{f,t} \).

### 4.1.4. Intermediate firms and immigrants

We assume two sectors. All firms in the intermediate goods sector produce intermediate goods with capital and labor as input factors under perfect competition. In the retail sector firms use domestic and foreign intermediate goods in order to produce the final good. The final good can be consumed, invested into the physical capital stock and used to cover the migration cost. The representative firm of the intermediate sector uses the following production technology:

\[ y_t = Z_t k_t^\alpha n_t^{1-\alpha}, \quad (12) \]

where \( 0 < \alpha < 1 \) is the partial production elasticity of capital. \( Z_t \) is the country specific exogenous aggregate technology and its logarithm follows an AR(1) process \( \log(Z_t) = \rho_Z \log(Z_{t-1}) + \epsilon_Z, t \) with persistence parameter \( 0 < \rho_Z < 1 \) and a white noise shock \( \epsilon_Z, t \) with zero mean and constant variance \( \sigma^2_Z \). The labor market tightness for natives and immigrants is defined as \( \theta_{h,t} \equiv \frac{v_{h,t}}{u_{h,t}} \) and \( \theta_{f,t} \equiv \frac{v_{f,t}}{u_{f,t}} \). The characteristics of the Cobb-Douglas matching function imply that firms fill their posted vacancies for natives with a probability \( q_{h,t} \equiv \frac{m_{h,t}}{v_{h,t}} = N\theta_{h,t}^{-\delta} \) and for immigrants with a probability \( q_{f,t} \equiv \frac{m_{f,t}}{v_{f,t}} = I\theta_{f,t}^{-\delta} \). Similarly, native and immigrant workers find a job with the probabilities \( f_{h,t} \equiv \frac{m_{h,t}}{u_{h,t}} = N\theta_{h,t}^{1-\delta} \theta_{h,t} \) and \( f_{f,t} \equiv \frac{m_{f,t}}{u_{f,t}} = I\theta_{f,t}^{1-\delta} \theta_{f,t} \).

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\(^{25}\) We start with this simplifying assumption. Later we want to introduce an immigrant separation rate that is anti-cyclical in line with findings by Dustmann et al. (2010) and Prean and Mayr (2016).

\(^{26}\) See Christoffel et al. (2009) and Furlanetto and Groshenny (2012).
\( \rho Z \log(Z_{t-1}) + \epsilon_{Z,t} \) with persistence parameter \( 0 < \rho < 1 \) and a white noise process \( \epsilon_{Z,t} \) with zero mean and constant variance \( \sigma^2_{Z,t} \). The aggregate labor composite is the sum of native and immigrant employment adjusted with the relative productivity parameter \( \Theta \) which measures the skill mismatch according to country specific capital such as language skills:

\[
n_t = n_{ht,t} + \Theta n_{ft,t}.
\]

The evolution of native and immigrant employment at firm level corresponds to that of aggregate employment. Since firms can decide about the vacancies for a given vacancy filling rate, the laws of motion of native and immigrant employment can be written as

\[
n_{ht,t+1} = (1 - \rho)n_{ht,t} + v_{ht,t} q_{ht,t},
\]

\[
n_{ft,t+1} = (1 - \rho)n_{ft,t} + v_{ft,t} q_{ft,t}.
\]

For every posted vacancy the firm pays a time-invariant cost \( \kappa \) that is equal for native and immigrant workers and linear with respect to the number of vacancies posted.

The representative firm in the intermediate sector maximizes its present value of discounted profit flows:

\[
J(n_{ht,t}, n_{ft,t}) = E_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left[ p_{ht,t} y_t - w_{ht,t} n_{ht,t} - w_{ft,t} n_{ft,t} - r^k_t k_t - \kappa v_{ht,t} - \kappa v_{ft,t} \right],
\]

subject to the the production function (12), the labor composite (13) and the law of motion for natives (14) and immigrants (15). The capital demand of the firm satisfies \( r^k_t = (1 - \alpha) \frac{y_{ht,t}}{k_t} \). Under the assumption of the free entrance condition\(^{27} \) the first-order conditions with respect to vacancies and employment are:

\[
\frac{\kappa}{q_{ht,t}} = E_t \beta_{t+1} \frac{\partial J_{t+1}}{\partial n_{ht,t+1}},
\]

\[
\frac{\kappa}{q_{ft,t}} = E_t \beta_{t+1} \frac{\partial J_{t+1}}{\partial n_{ft,t+1}},
\]

\[
\frac{\partial J_t}{\partial n_{ht,t}} = p_{ht,t} \alpha \frac{y_t}{n_t} - w_{ht,t} + (1 - \rho) E_t \beta_{t+1} \frac{\partial J_{t+1}}{\partial n_{ht,t+1}},
\]

\[
\frac{\partial J_t}{\partial n_{ft,t}} = p_{ht,t} \alpha \frac{\Theta y_t}{n_t} - w_{ft,t} + (1 - \rho) E_t \beta_{t+1} \frac{\partial J_{t+1}}{\partial n_{ft,t+1}},
\]

\(^{27}\)The value of a vacancy is \( \frac{\partial h_t}{\partial v_{ht,t}} = \frac{\partial h_t}{\partial v_{ft,t}} = 0 \ \forall t. \)
where the stochastic discount factor is $\beta_{t+1} \equiv \beta_{t+1}$. Combining equations (17), (19) and (18), (20) gives the job creation conditions for native and immigrant jobs

$$\frac{K}{q_{h,t}} = E_t \beta_{t+1} \left\{ p_{h,t+1} \alpha \frac{y_{t+1}}{n_{t+1}} - w_{h,t+1} + (1 - \rho) \frac{K}{q_{h,t+1}} \right\}, \quad (21)$$

$$\frac{K}{q_{f,t}} = E_t \beta_{t+1} \left\{ p_{f,t+1} \Theta \frac{y_{t+1}}{n_{t+1}} - w_{f,t+1} + (1 - \rho) \frac{K}{q_{f,t+1}} \right\}. \quad (22)$$

The job creation condition states that firms increase vacancies until the benefit from employing an additional worker is equal to the cost of posting a vacancy.

4.1.5. Nash bargaining

The firm and the newly hired native and immigrant workers determine the wage rates $w_{h,t}$ and $w_{f,t}$ according the Nash bargaining solution. The Nash bargaining solution splits the overall surplus of the match in order to maximize the Nash product which for the native worker is given by

$$\max_{w_{h,t}} (ms_{N_{h,t}})^\eta (g_{h,t})^\eta, \quad (23)$$

where $0 < \eta < 1$ represents the bargaining power of the native worker on the domestic labor market. Thus the first order condition is

$$ms_{N_{h,t}} = \frac{\eta}{1 - \eta} g_{h,t}, \quad (24)$$

where the marginal firm surplus of an additional filled vacancy $g_{h,t} \equiv \frac{\partial J_t}{\lambda_t \partial n_{h,t}}$ is given by equation (19) and (17). The marginal surplus of working net of the marginal surplus of being unemployed $ms_{N_{h,t}} \equiv \frac{\partial V_t}{\lambda_t \partial n_{h,t}} - \frac{\partial V_t}{\lambda_t \partial u_{h,t}}$ is

$$ms_{N_{h,t}} = w_{h,t} - b + (1 - \rho - f_{h,t}) E_t \beta_{t+1} ms_{h,t+1} - \mu_t (1 - \rho - f_{h,t}) E_t \beta_{t+1} ms_{h,t+1} \quad (25)$$

The first and second term on the left hand side of the equation are standard in the search and matching literature. The marginal surplus of workers measured in consumption units is the difference of the wage and the unemployment benefit and the future value of having the job. The option to migrate when unemployed gives rise to a third

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28 In the beginning we assume the same bargaining power for natives in immigrants. Later we will consider differences.
term $ms_{E}^{h,t}$ that describes the marginal surplus of emigration. It is as an additional outside option for the native worker in the wage bargaining process and is defined as the value of searching a job as immigrant in the foreign country net of the value of searching a job as a native in the home country:

$$ms_{E}^{h,t} \equiv \frac{\partial V_{t}}{\lambda_{t} \partial u_{h,t}^{*}} - \frac{\partial V_{t}}{\lambda_{t} \partial u_{h,t}}$$

with

$$\frac{\partial V_{t}}{\lambda_{t} \partial u_{h,t}^{*}} = b + E_{t} \beta_{t+1} \left[ f_{h,t}^{*} \frac{\partial V_{t+1}}{\lambda_{t+1} \partial n_{h,t+1}^{*}} + (1 - f_{h,t}^{*}) \left( (1 - \gamma_{t}) \frac{\partial V_{t+1}}{\lambda_{t+1} \partial u_{h,t+1}^{*}} + \gamma_{t} \frac{\partial V_{t+1}}{\lambda_{t+1} \partial u_{h,t+1}} \right) \right],$$

$$\frac{\partial V_{t}}{\lambda_{t} \partial u_{h,t}} = b + E_{t} \beta_{t+1} \left[ f_{h,t} \frac{\partial V_{t+1}}{\lambda_{t+1} \partial n_{h,t+1}} + (1 - f_{h,t}) \left( (1 - \mu_{t}) \frac{\partial V_{t+1}}{\lambda_{t+1} \partial u_{h,t+1}} + \mu_{t} \frac{\partial V_{t+1}}{\lambda_{t+1} \partial u_{h,t+1}^{*}} \right) \right].$$

The value of being a native unemployed comprises the unemployment benefit and the discounted values of being employed in the domestic labor market and the values of being unemployed in the domestic or the foreign labor market in the next period, each weighted by their probability of occurrence. The expected value of searching as native or as emigrant are weighted by the migration probability. The value of being unemployed as a migrant in foreign is defined correspondingly but the weighting factor for future values of unemployment is the return migration rate. By inserting equations (28) and (27), the surplus sharing rule (24) and the the marginal surplus of a filled vacancy (17) into equation (26) we obtain an expression for the marginal surplus of emigration:

$$ms_{E}^{h,t} = \left( \frac{\eta^{*} \kappa^{*}}{1 - \eta^{*}} \theta_{h,t}^{*} - \frac{\eta \kappa}{1 - \eta} \theta_{h,t} \right) + (1 - \mu_{t}(1 - f_{h,t}) - \gamma_{t}(1 - f_{h,t}^{*})) E_{t} \beta_{t+1} \frac{\partial V_{t}}{\lambda_{t} \partial u_{h,t+1}} - \frac{\partial V_{t}}{\lambda_{t} \partial u_{h,t}}.$$  \hspace{1cm} (29)

The marginal surplus of emigration increases in the bargaining power abroad and decreases with the bargaining power at home. Additionally, a higher job market tightness in foreign increases the value of emigration because it goes along with a high job finding rate abroad. Higher cost of posting vacancies in foreign stabilize the match, because it increases the value of a filled vacancy in foreign. The future value of emigrate is irrelevant for workers who emigrate and those who will return in the next period. With a

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29 The model set up and our calibration ensure that $\frac{1 - \mu_{t}(1 - f_{h,t}) - \gamma_{t}(1 - f_{h,t}^{*})}{1 + \eta} > 1$ and that expectations on future surplus converges to a unique steady state.
higher return migration rate the share of unemployed emigrants who return increases. Similarly, with higher migration rates a higher share of native unemployed will emigrate in future periods. Therefore, the future marginal surplus of emigration has a lower influence on the current emigrant value if the migration and return migration rates are high. The expected domestic and foreign job finding rates influence the future marginal surplus. The higher the job finding rate is, the lower is c.p. the measure of native and emigrant unemployment. Therefore, the absolute expected marginal surplus will be small.

By inserting the value of a job (19), the marginal surplus of an employed worker (25) and the marginal surplus of emigration (29) into the wage bargaining rule (23) and using equation (17) we finally get the wage equation

$$w_{h,t} = \eta \left[ \rho h, t \frac{y_t}{h_t} + \kappa \theta h, t \right] + (1 - \eta) \left[ b + \mu (1 - \rho - f h, t) E_t \beta_{t+1} m s_{h,t+1}^E \right].$$

Similarly, the emigrant wage is derived as

$$w_{h^*, t} = \eta^* \left[ \rho f, t \frac{\Theta^* y^*}{h^* t} + \kappa^* \theta h^*, t \right] + (1 - \eta^*) \left[ b - \gamma (1 - \rho^* - f h^*, t) E_t \beta_{t+1} m s_{h^*, t+1}^E \right].$$

The intuition behind the wage equation is straightforward. Migration poses an additional outside option in our model. If the employment probabilities in the foreign economy improve relative to the domestic economy, the value of emigration (the outside option) increases. Similar to the case of a higher unemployment benefit this strengthens the worker’s negotiation position and leads to higher wages. While with or without labor mobility domestic workers participate from improvements in the production process and the labor market situation in the domestic economy with a weight $\eta$, labor mobility connects the domestic wages to the relative foreign economy labor market situation. For emigrants from home the argument holds with a reverse direction of causality. An increase in the relative labor market situation in foreign reduces their outside option to return home and thus lowers their wage negotiation position.

4.1.6. Endogenous migration decision

So far we treated migration as exogenous with $\mu_t = \mu$ and $\gamma_t = \gamma$. In this section of the paper we extend the model and endogenize both migration rates by modeling a migration decision. Our approach is close to the motivation of the net migration rate in Braun and Weber (2016). In this set up workers choose the location of being unemployed
and searching for a job by comparing the expected value of being unemployed abroad and at home. Workers pay idiosyncratic migration cost when changing their location. The better the relative labor prospects in the foreign economy the more workers can afford to migrate because the surplus of emigration exceeds their cost of migration.

To guarantee the coexistence of a positive emigration and remigration flow of home workers we assume that each migrant receives a constant transfer when switching borders that is higher for emigrants than for return migrants \( f^\mu_{h,t} > f^\gamma_{h,t} \). One can think of \( f^\mu_{h,t} \) denoting a transfer that is paid in the context of government policies to increase mobility and \( f^\gamma_{h,t} \) measuring the home bias of emigrants in consumption units. At the end of the period before the migration decision is taken an unemployed worker in home receives a signal about his individual emigration cost as a fraction of the unemployment benefit \( c^\mu_{h,t} b \). The migration cost are draws from a time-invariant distribution with support \( c_{h,t} \in [0,1] \), c.d.f. \( F(c^\mu_{h,t}) \) and uniform density \( f(c^\mu_{h,t}) \). The difference in the transfers for emigrants and return migrants allows to derive two different migration thresholds up to which it is beneficial for a worker to change his location. The emigration cost threshold \( \tilde{c}^\mu_{h,t} \) is determined as follows:

\[
\tilde{c}^\mu_{h,t} b - f^\mu_{h,t} = E_t \beta_t + \frac{1}{ms_{t+1}} E_t + \frac{1}{ms_{t+1}}. \tag{32}
\]

All workers with idiosyncratic migration cost below the threshold value have an incentive to migrate and since we assume a uniform distribution the threshold equals the emigration rate \( \mu_t \). The return migration cost threshold \( \tilde{c}^\gamma_{h,t} \) is determined analogously:

\[
\tilde{c}^\gamma_{h,t} b - f^\gamma_{h,t} = -E_t \beta_t + \frac{1}{ms_{t+1}}, \tag{33}
\]

\[
= - (\tilde{c}^\mu_{h,t} b - f^\mu_{h,t}), \tag{34}
\]

where \( \tilde{c}^\gamma_{h,t} = \gamma_t \) under the assumption of a uniform distribution. Using these relations the marginal surplus of emigration can be rewritten:

\[
ms^E_{h,t} = \frac{\eta^* \kappa^*}{1 - \eta^*} \theta_{h,t} + \frac{\eta \kappa}{1 - \eta} \theta_{h,t} + E_t \beta_{t+1} ms^E_{h,t+1} + (1 - f^*_{h,t}) b (\gamma_t)^2 - (1 - f^*_{h,t}) b (\mu_t)^2, \tag{35}
\]
where we use the fact that for a given migration threshold the expected migration cost of agents who migrate can be expressed as:

\[ \bar{c}_h^\mu = E[c_h^\mu | c_h^\mu < \bar{c}_h^\mu], \]  
\[ = \frac{1}{2} \bar{c}_h^\mu, \]  
\[ \bar{c}_h^\gamma = E[c_h^\gamma | c_h^\gamma < \bar{c}_h^\gamma], \]  
\[ = \frac{1}{2} \bar{c}_h^\gamma. \]  

Inserting equation (35) in the wage equations (30) and (31) gives the native and emigrant wage that are bargained under endogenous migration rates:

\[ \omega_{h,t} = \eta \left( \frac{\alpha y_t + \theta_{h,t} \kappa}{n_t} \right) + (1 - \eta)b \left( 1 + (1 - \rho - f_{h,t}) \frac{\mu_t^2}{2} \right), \]  
\[ \omega_{h,t}^* = \eta^* \left( \frac{\alpha^* y_t^* + \theta_{h,t}^* \kappa^*}{n_t^*} \right) + (1 - \eta^*)b \left( 1 + (1 - \rho^* - f_{h,t}^*) \frac{\gamma_t^2}{2} \right). \]  

4.1.7. Final good sector and international trade

The country-specific intermediate good can be either used domestically or exported to the foreign economy:

\[ y_t = y_{h,t} + y_{f,t}^*. \]  

The final domestic good \( x_t \) is a CES aggregate of the foreign-specific and the home-specific intermediate good:

\[ x_t = \left( (1 - \omega) \frac{1}{\psi} y_{h,t}^{\frac{\psi-1}{\psi}} + \omega \frac{1}{\psi} y_{f,t}^{\frac{\psi-1}{\psi}} \right)^{\frac{\psi}{\psi-1}}, \]  

where \( \omega \) is the degree of openness in the domestic economy and \( \psi \) is the elasticity of substitution between the home- and the foreign-specific intermediate good. By solving the profit-maximization problem of the representative final good producer we can write the demand functions for the home and the import demand function for the foreign-specific good as follows:

\[ y_{h,t} = (1 - \omega)(p_{h,t})^{-\psi} x_t, \]  
\[ y_{f,t} = \omega(q_t p_{f,t}^*)^{-\psi} x_t, \]  

21
where \( p_{h,t} \equiv \frac{P_{h,t}}{P_{h,t}} \) is the price of the domestic produced good in units of the domestic composite good. \( p_{f,t}^* \equiv \frac{P_{f,t}^*}{P_{f,t}^*} \) is the price of the foreign produced good in units of the foreign composite good. The real exchange rate is defined as \( q_t \equiv \frac{P_{f,t}^*}{P_{h,t}} \) and the bilateral terms of trade between home and foreign are given by \( s_t \equiv \frac{P_{f,t}}{P_{h,t}} \). The trade balance in units of the domestic composite good is defined as the difference between exports and imports:

\[
\text{tb}_t \equiv p_{h,t}^* y_{h,t} - p_{f,t}^* q_t y_{f,t}.
\]

The current account balance in units of the domestic composite good is defined as the sum of the trade balance and the factor income balance:

\[
\text{ca}_t = i_t a_t + i_t^* q_t^* - q_t^* y_{f,t} + \text{tb}_t + \text{ib}_t,
\]

where the latter is given by the difference between the factor incomes of home and foreign emigrants \( \text{ib}_t = w_{h,t}^* q_t^* n_{h,t} - w_{f,t}^* n_{f,t} \). The balance of payments is equal to zero and can be expressed as:

\[
\text{bop}_t \equiv 0 = q_{t+1} a_{t+1}^* - q_t^* a_t^* + a_{t+1} - a_t - \text{ca}_t,
\]

which shows that the financial account must be equal to the inverse current account balance.

**4.1.8. Equilibrium**

Finally, we close the model by assuming that government unemployment benefits are financed by the lump sum tax \( T_t \). Additionally, the government collects the cost of financial market transactions and transfers it in a lump-sum fashion

\[
T_t = g_t \bar{g} + b(u_{h,t} + u_{h,t}^*) - \left( \frac{\Delta}{2} (a_{t+1})^2 + \Delta^* (a_{t+1}^*)^2 q_{t+1} \right).
\]

We assume that the government has a constant spending \( \bar{g} \) that could change over time due to random government spending shocks \( g_t \). The government spending shock follows an AR(1) process. Combining the government balanced budget with the households’ resource constraint and the definition of the external balances we can write the aggregate resource constraint as:

\[
p_{h,t} y_t = c_t + j_t + \kappa (v_{h,t} + v_{f,t}) + g_t \bar{g} + \text{tb}_t.
\]
The substitution elasticity of matching is equal to the wage bargaining power in order
\[ \omega \]
and the labor share of output is close to the empirical observed value for the EA-

Imposing that domestic and foreign bonds are in zero net supply \( a_t + a_t^* = 0 \), we define
an equilibrium as a sequence of domestic and foreign quantities:
\[ \{X\}_t = \{x_t, y_t, y_h_t, y_f_t, c_{t-1}, j_t, k_t, v_{t-1}, v_{f,t}, n_t, n_{h,t}, n_{f,t}, u_t, u_{h,t}, u_{f,t}, f_h_t, f_f_t, \theta_h_t, \theta_f_t, q_{f,t}, q_{h,t}, q_{f,t}, \eta_{h,t}, \eta_{f,t}, m_{h,t}, m_{f,t}\}, \]
\[ \{X^*\}_t = \{x_t, y_t, y_h_t, y_f_t, c_{t-1}, j_t, k_t, v_{t-1}, v_{f,t}, n_t, n_{h,t}, n_{f,t}, u_t, u_{h,t}, u_{f,t}, f_h_t, f_f_t, \theta_h_t, \theta_f_t, q_{f,t}, q_{h,t}, q_{f,t}, \eta_{h,t}, \eta_{f,t}, m_{h,t}, m_{f,t}\}, \]

a sequence of domestic, foreign and international prices and wages:
\[ \{P\}_t = \{p_{h,t}, p_{f,t}, \omega_{h,t}, \omega_{f,t}\}, \]
\[ \{P^*\}_t = \{p_{h,t}^*, p_{f,t}^*, \omega_{h,t}^*, \omega_{f,t}^*\}, \]
\[ \{Q\}_t = \{q_t, s_t\} \]

such that

1. for a given price and wage sequence \( \{P\}_t, \{P^*\}_t, \{Q\}_t \) a given realization of
shocks \( \{S\}_t \) the sequence \( \{X\}_t, \{X^*\}_t \) satisfies first order conditions for domes-
tic and foreign households and firms,

2. for a given sequence of quantities \( \{X\}_t, \{X^*\}_t \) a given realization of shocks
\( \{S\}_t \) the price sequence \( \{P\}_t, \{P^*\}_t, \{Q\}_t \) guarantees international labor,
goods and financial market equilibrium conditions.

5. Impulse Response Functions and Discussion of Results

5.1. Calibration

The proposed model follows the literature on open economy DSGE models with
either search and matching or migration.\(^{30}\) In order to analyze the theoretical effects,
we calibrate the model to annual data of a average euro area corridor. The effects of
migration are isolated by assuming all firm and trade parameters to be symmetric across
countries. For the theoretical analysis of a symmetric corridor we set the discount factor
to \( \beta = 0.955 \) consistent with an annualized interest rate of \( \rho = 0.045 \) percent.\(^{31}\) The partial
production elasticity of capital \( \alpha \) is set to the conventional value of \( \frac{1}{3} \). Therefore, the
labor share of output is close to the empirical observed value for the EA-12 countries of
\[ \frac{\omega}{\eta} = 0.6. \] The annual depreciation rate of physical capital is set to \( d = 0.059 \). According
to the EA average we set the degree of openness to \( \omega = 0.25 \) and the trade elasticity to
\[ \psi = 1.5. \]

The marginal surplus of a match is split equally between worker and firms \( \eta = 0.5. \)
The substitution elasticity of matching is equal to the wage bargaining power in order

\(^{30}\) See e.g. Christoffel et al. (2009), Mandelman and Zlate (2012), Hauser (2014), Dustmann and Görlach
(2016), Chassambouli and Palivos (2014) and Battisti et al. (2014).

\(^{31}\) See Table 2 in Appendix 7.2 for the model parametrization.
to meet the Hosios condition.\textsuperscript{32} The separation rate $\rho$ measures the transition probability between the employment and the unemployment status. Shimer (2005) reports a monthly rate of 3.6\% for the United States. Christoffel et al. (2009) find quarterly fitted values of 3\% for the euro area countries. We use the quarterly data to obtain annual separation rate $\rho = 0.11$ with the formula described by Kudlyak (2014). The unemployment benefit $b$ is set by targeting the steady state replacement rate of $b_{\text{sw}} = 0.65$ which is proposed by Christoffel et al. (2009). We set the migration rate and the return migration rate to $\mu = 0.015$ and $\gamma = 0.2$. The former is set according to annual average internal emigration rate of the EA-12. The latter reflects the observation that close to 50\% of migrants return to their country of origin after five years.\textsuperscript{33}

We further target three key characteristics of the relation between net migration and labor market variables in the EA-12 countries. First, we set the vacancy posting costs to $\kappa = 0.09$. This implies a steady state job finding of 0.9 which is close to the empirical observations for annual values.\textsuperscript{34} Second, a labor productivity parameter of $\Theta = 0.985$ replicates a steady state wage gap between native and immigrant workers of $\frac{\pi_h}{\pi_f} = 1.032$ which is similar to EA-12 specific studies.\textsuperscript{35} Third, we target the EA-12 native immigrant unemployment gap of $\frac{\pi_f}{\pi_f + \pi_f} = 1.17$ by setting the native matching efficiency to 0.47 and the immigrant matching efficiency to 0.41.\textsuperscript{36}

In order to match the moments, the empirical shocks and persistence parameters are extracted from an AR(1) estimation of TFP, government spending and the matching technology in the euro area corridors between 1980 and 2010. The average annual standard deviation of all four shock are identified by our model assumptions and directly observable in the underlying data set. In order to get the characteristics of the technology shock, we calculated the cyclical component of the Solow residual from the production function. We than estimated the autoregressive parameter by applying the underlying AR(1) process. The characteristics of the government spending shock are directly calculated by estimating an AR(1) process with data from the AMECO database. Finally, we model the country-specific match technology as an AR(1) process by using a country average matching function similar to the equations (8) and (9). Thus, between 1980 and 2010 we get average annual standard deviation of country-specific TFP, gov-

\textsuperscript{32}The Hosios condition sets the firms share of the surplus equal to the elasticity of the matching function with respect to posting a vacancy. See Hosios (1990).

\textsuperscript{33}See OECD (2008).

\textsuperscript{34}See Wang and Xie (2013), Hobijn and abin (2009).

\textsuperscript{35}See Dustmann et al. (2010), Jean/Causa.2010.

\textsuperscript{36}See Table 8 in the Appendix.
ernment spending and match efficiency shocks of 0.0195, 0.004 and 0.03. The annual average persistence parameter are 0.9, 0.81 and 0.62 respectively.

5.2. Steady state

We document the steady state calibration in Table 2. We explicitly model physical capital investment and government expenditures which account for 18% and 20% of the GDP. Therefore, the consumption share of GDP is equal to 60%. The consideration of trade in goods and bonds as well as free labor mobility has no impact, because the intra-EA-12 net migration and trade balance must be equal to zero in an EU-12 average country. The remainder of 2% arises from the vacancy cost share for migrants and natives. Turning to the structural characteristics of the EA-12 average labor market we find

<table>
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<th>Macroeconomic variables</th>
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<td>Consumption share</td>
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<td>Investment share</td>
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<td>Government spending share</td>
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<tr>
<td>Vacancy cost share</td>
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<tr>
<td>Labor share in total output</td>
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<td>Capital-output ratio</td>
<td>0.62</td>
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<table>
<thead>
<tr>
<th>Labor market variables</th>
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<td>Average domestic unemployment rate</td>
<td>$\frac{\bar{n}_h+\bar{n}_f}{\bar{n}_h+\bar{n}_f+\bar{n}_f+\bar{n}_f}U_h + \frac{\bar{n}_f+\bar{n}_f}{\bar{n}_h+\bar{n}_f+\bar{n}_f+\bar{n}_f}U_f$</td>
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<tr>
<td>Average domestic job finding rate</td>
<td>$\frac{\bar{f}_h}{\bar{f}_h+\bar{f}_f+\bar{f}_f}f_h + \frac{\bar{f}_f}{\bar{f}_h+\bar{f}_f+\bar{f}_f}f_f$</td>
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<tr>
<td>Unemployment benefit</td>
<td>$\frac{\bar{b}}{\bar{f}_h+\bar{f}_f}$</td>
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<tr>
<td>Unemployment gap between immigrant and native</td>
<td>$\frac{\bar{n}_f+\bar{n}_h}{\bar{n}_f+\bar{n}_f}$</td>
</tr>
<tr>
<td>Wage gap between native and immigrant</td>
<td>$\frac{\bar{w}_h}{\bar{w}_f+\bar{w}_f}$</td>
</tr>
<tr>
<td>Migrant worker share of total work force</td>
<td>$\frac{\bar{n}_f+\bar{n}_f}{\bar{n}_h+\bar{n}_f+\bar{n}_f+\bar{n}_f}$</td>
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</table>

Table 2: Calibration

a 62% labor share in GDP which is slightly above the empirical observed values. The steady state unemployment rate is 9.3% which is a weighted average of the native unemployment rate (9.2%) and the immigrant unemployment rate of (10.8%). Additionally, there the native wage is 3.2% higher than the immigrant wage and the annual native job finding rate is 15% percent higher than the immigrant job finding rate. Finally, our
calibration matches the unweighted average share of the EA-12 foreign-born workers to the total labor force in the country of residence \( \frac{\pi_f + \pi_f}{n_f + n_f + n_f + n_f} = 0.03 \).

5.3. Migration and the business cycle

In this section we describe the effects of three different shocks on migration and the business cycle dynamics from the perspective of the home economy. Initially, we choose parameter values as defined in Table 7 in order to mimic a hypothetical (average) euro area migration corridor and simulate the impulse response functions of domestic aggregate variables (Table 2). We distinguish between three scenarios. A baseline scenario where the emigration and return migration rate correspond to the empirically observed values \( \mu = 0.015 \) and \( \gamma = 0.2 \). This scenario is depicted by a blue line. The second scenario is characterized by very low return migration rates of \( \gamma = 0.02 \) and a green line. In this scenario migration becomes more persistent. The last scenario characterizes a high corridor labor mobility of \( \mu = 0.2 \) per year and could be understand as a political target scenario in which labor is very mobile between member states of the EA-12. We analyze the impulse response functions with respect to these three scenarios. First, we are interested in the effects of business-cycle shocks on migration and the macroeconomic variables. Second, we investigate the effects of migration and return migration on the business cycle by comparing the two alternative scenarios with the baseline prediction. Third, we analyze the dynamic effect of migration on the Beveridge curve.

Domestic productivity shock

As can be seen in Figure 4, in the baseline scenario (blue line) a positive domestic productivity shock reduces the cost of production and leads to an increase in output, consumption and wages.\(^{38}\) As a consequence of lower production costs firms post vacancies while workers can claim a higher wage depending on their bargaining power and employment increases, respectively unemployment decrease. In the baseline scenario the increase in domestic wages and vacancies raises the actual and future surplus of emigration for foreign workers. Therefore, the net migration flow is positive in case of a domestic productivity shock. Additionally, the net migration flow is negatively correlated with the unemployment differential and positively correlated with the wage

\(^{37}\)The unweighted average does not contain Luxembourg which has a share of almost 30%.

\(^{38}\)It is well known from the business cycle literature that in case of sluggish prices and wages, productivity shocks can lead to a temporary decrease of employment. See Erceg et al. (2000), Gali (1999) and Gali (2010). We do not consider rigidities in this analysis, although we know that sticky wages and prices have an important impact on the relation between net migration.
differential over the cycle. In the second scenario (green line) immigrants stay for long-term because the annual return migration rate is low. The effect of a productivity shock on output wages and employment is lower. Thus, a long-term stay tend to reduce the fluctuation of output and wages but to increases the unemployment fluctuations. This can be explained by focusing on the dynamics of the marginal surplus of emigration. In the initial period the actual marginal surplus is higher because foreign immigrants expect to stay for a longer time-period in the home economy. But the marginal surplus converges more rapidly to its steady state value because a lower return migration rate increases the migrant stock which pushes the wage differential and the unemployment differential faster to the steady state. In the third scenario (red line) the annual emigration rate is high.\textsuperscript{39} In case of a productivity shock the employment increase is higher than in the baseline scenario. This is due to the increase of the job finding rate in the domestic relative to the foreign labor market. Combined with expected migrant wage surpluses the unemployed foreigners have an total surplus of searching jobs in the domestic country over the cycle. The dynamics of the job filling rate are similar to the baseline case because of the equally sized productivity increase. This leads to lower average wages during the wage bargaining process and lower unemployment for natives and migrants.

The short-term fluctuations of the Beveridge curve relationship can be analyzed by the correlation between vacancy and unemployment fluctuations.\textsuperscript{40} The domestic productivity shock creates an inverse reaction of unemployment and vacancies which turns into the empirically downward sloping Beveridge curve. A higher migration reduces the correlation but does not lead to a sign switching.

\textit{Demand shocks}

A positive demand shock by an increase of government spending will increase the output and employment. The corresponding impulse response functions can be found in Figure 5. In contrast to the productivity shock the increase of output and employment is U-shaped because the higher demand will affect the vacancy posting of the firm more gradually. This translates into the dynamic pattern of net migration flows. The demand shock changes the inter-temporal consumption pattern of the household in favor of current consumption. Therefore, the initial effect on the marginal surplus of emigration

\textsuperscript{39}Since both countries are symmetric, the emigration rate of the domestic country is the immigration rate of the foreign economy and vice versa.

\textsuperscript{40}See Benati and Lubik (2014) and Furlanetto and Groshenny (2012).
is larger and its dynamic path becomes steeper. Both, foreigners and natives searching on the foreign labor market have an incentive to migrate, respectively come back to the country of origin. Therefore, the unemployment rate increase is higher than in the baseline case. The effect of migration on the Beveridge curve in case of demand shocks is very small. The higher migration leads to a lower unemployment rate as mentioned above. This goes hand in hand with a reduction of vacancy posting of the firm.

**Matching technology shock**

We also investigate a positive shock on the matching efficiency in Figure 6. An increase in the matching efficiency is related to a more efficient matching technology in the domestic labor market e.g. via an improved public job finding assistance. Several other factors mentioned in the literature\textsuperscript{41}, i.e. skill mismatch and geographical mismatch are considered to be time-invariant in our model. An increase in the matching technology implies that the domestic labor market more efficiently matches native and foreign workers with domestic firms. Thus, the probability of finding a job in the domestic country increases as well as the domestic firms’ probability of filling a vacancy. This leads to a higher production and lower unemployment.\textsuperscript{42} At the same time the number of vacancies increases shortly because of the expansion of expected production but soon after decreases due to the better matching process. The effects of migration and return migration on the business cycle are similar to the case of the productivity shock and do not change the Beverdige curve relationship over the cycle.

**5.4. Model fit**

Finally, we assess the quality of the model by comparing the theoretical business cycle statistics of the calibrated model with the empirical facts presented in section 3.2. To that end, we draw country-specific shocks from their distributions and simulate 1000 periods to extract the standard deviations conditional on all shocks and the correlations from the structural model.\textsuperscript{43} The results are summarized in Table 3 and 4.

\textsuperscript{41}See Furlanetto and Groshenny (2012).

\textsuperscript{42}The effect arises because hiring costs are formed before the match occurs as Furlanetto and Groshenny (2012) show.

\textsuperscript{43}In order to compare the theoretical model with the empirical unconditional standard deviations we simulate the time series including all shocks. Therefore, the reactions of macroeconomic variables are not conditional on a specific shock. To compare the true conditional reactions, we would have to compare the extracted theoretical standard deviations in case of a single shock with the empirical counterparts resulting from a structural VAR.
Variable \((x)\) | \(\frac{\sigma(x)}{\sigma(y)}\) EA-12 data | Model | \(\rho(x,y)\) EA-12 data | Model
--- | --- | --- | --- | ---
Real output \((y)\) | 1 | 1 | 1 | 1
Real consumption \((c)\) | 0.81 | 0.6 | 0.76 | 0.7
Employment \((n)\) | 0.76 | 0.11 | 0.69 | 0.53
Unemployment rate \((u)\) | 0.48 | 0.11 | -0.68 | -0.53
Vacancies \((v)\) | 0.80 | 0.56 | -0.54 | -0.63
Real wage \((w)\) | 0.68 | 0.62 | 0.17 | 0.98

For notation see Table 1. Model refers to the symmetric calibration of the model.

Table 3: Theoretical vs. Empirical Moments of the EA-12 countries business cycle 1980-2010 - The symmetric case

Table 3 depicts the empirical and simulated relative standard deviations (column one and two) and correlations (columns three and four) of the average EA-12 business cycle for the period 1980-2010. The model matches the empirical fluctuation relations and correlations quite well. Although the business cycle volatility of consumption, employment and unemployment in relation to output are too low, the cross relations are similar. The former results from not considering the marginal rate of substitution between consumption and hours in the household decision. Additionally, nominal and real rigidities would increase the fluctuation of quantities rather than prices and wages. This would also lower the correlation of the real wage and output over the cycle.

Variable \((x)\) | \(\frac{\sigma(x)}{\sigma(y)}\) EA-12 data | Model | \(\rho(x,y)\) EA-12 data | Model
--- | --- | --- | --- | ---
Output \((y)\) | 1.55 | 0.19 | 0.17 | 0.21
Unemployment \((u)\) | - | - | -0.31 | -0.34
Vacancies \((v)\) | - | - | -0.08 | 0.56
Real wage \((w)\) | - | - | -0.10 | 0.23

For notation see Table 1. Model refers to the symmetric calibration of the model.

Table 4: Theoretical vs. Empirical Moments of the EA-12 countries cyclical migration from 1980-2010

Table 4 summarizes the empirical and simulated relative standard deviations and correlations of the average EA-12 migration cycle for the period 1980-2010. The comparison reveals three notable results: First, the model predicts the relative fluctuations and correlation of net migration and the GDP quite well. Second, the model understates the fluctuations of net migration over the cycle. Furthermore, it does not predict the negative
correlation with respect to the wage differential. Third, the model predicts the negative sign of the correlation between net migration and the unemployment differential.

Intuitively, both shortcomings of the model - the relatively high wage correlation and the relatively low unemployment fluctuation - indicate the existence of at least one additional channel that increases the volatility of unemployment and decreases the volatility of wages and thus has a significant impact on net migration fluctuations and correlations within the euro area. Summarizing our results, we find that our model fits suitable to describe migration flows over the business cycle in the euro area. However, both, standard deviations and correlations, point towards the need to improve the wage and unemployment specification in our model. In line with this finding, introducing nominal or real rigidities appears as a valuable extension. Rigidities as modeled by Gertler et al. (2008), Krause et al. (2008) and Gali (2010) generate a lower wage fluctuation due to price and wage adjustment costs. With time-varying mark-up wages, unemployment fluctuates over time and leads to a higher variation of employment over the cycle.

6. Conclusions

This paper proposes a new approach to model the fluctuation of migration and unemployment over the business cycle in a two-country setting. In particular, we focus on search and matching frictions as sources of unemployment. By starting with a summary of the empirical evidence on euro area migration patterns, we find internal migration to have increased over time, and be mostly work-related and of temporary nature. Our subsequent empirical analysis of bilateral migration and macroeconomic data over the years 1980-2010 supports this notion. We present several key business cycle facts for the EA-12 that provide evidence for business cycle related fluctuations in net migration flows and the crucial role of unemployment differentials in shaping intra-euro area migration patterns. On average, we find a negative correlation of the net migration rate with both, the unemployment and the wage differential, at various lags and leads. Additionally, we find a positive correlation with respect to vacancies which lead net migration over the cycle. We interpret this as evidence for the importance of the relative labor market tightness for net migration flows.

In line with these findings we develop a two-country dynamic stochastic general equilibrium model of internal business-cycle migration in the euro area and allow for unemployment that occurs as a consequence of search and matching frictions in both countries. Calibrated to the EA-12 average corridor the model is able to replicate key
facts about the migration cycle in the euro area. It matches the empirically observed wage and unemployment gaps between native and immigrant workers and reproduces aggregate macro and labor market facts in the steady state and over the cycle.

The investigation of impulse response functions sheds light on several transmission channels and parameters that affect the observed migration patterns in the euro area. The model provides three different shocks that give rise to the negative relationship between unemployment differentials and net migration. It also explains the positive correlation between net migration flows and the vacancy differentials over the cycle. Additionally, we investigate the effects of emigration and return migration on the business cycle and the Beveridge curve. With respect to the business-cycle fluctuations we find three noteworthy facts. First, a higher emigration rate increases the cyclical behavior of output and employment, but decreases the fluctuations of unemployment. Second, a lower return migration reduces the circularity of migration and the business cycle fluctuations of output and employment, but it increase the fluctuations of unemployment. With a low return migration rate there is a lower probability that emigrants move back to their country of origin in case of labor market changes. This loss in geographical flexibility is paid by higher unemployment fluctuations over the cycle. Third, we observe opposing wage effects of a higher emigration and return migration rate because the wage bargaining positions of native and emigrant workers are inversely related to the emigration value.

The strength of our model is its ability to incorporate empirical observations such as the higher separation rate of migrants in an economic downturn. Even though insightful, the model has some shortcomings that will guide our further direction of research. Emphasize in future work will be placed on the fact that our model slightly understates the fluctuation of unemployment at the expense of a higher wage fluctuation. This points towards the need to include price and wage rigidity into the model. This would allow us to highlight the role of the labor market tightness as another channel via which migration can affect the firms’ marginal cost and thus the price dynamics in an economy.
7. Appendix

7.1. Data description

**Output:** Gross domestic product at 2010 market prices per head of population (RVGDP) \((2010=100)\) multiplied by total population (National accounts) (NPTD) \((1000\ \text{Persons})\), AMECO database, 2015.

**Consumption:** Total consumption at 2010 prices (OCNT) (in national currency \(2010=100\)), AMECO database, 2015.

**Employment:** Employment, persons: total economy (National accounts) (NETN) \((1000\ \text{Persons})\), AMECO database, 2015.

**Labor force:** Total labour force (Labour force statistics) (NLTN) \((1000\ \text{Persons})\), AMECO database, 2015.

**Unemployment rate:** Unemployment rate: total :- Member States: definition EURO-STAT (ZUTN), AMECO database, 2015.

**Vacancies:** Employer perception of labour shortages (total manufacturing), European Commission’s Surveys of Business Confidence, Quarterly questionnaire, 2016

**Real wages:** Real compensation per employee, deflator GDP: total economy (RWCDV) \((2010=100)\), AMECO database, 2015.

**CPI inflation:** Percentage change of national consumer price index (All-items) (ZCPIN) \((2010=100)\), AMECO database, 2015.

**Wage inflation:** Percentage change of Compensation of employees: total economy (UWCD), AMECO database, 2015.

**Output differential:** Difference of domestic output and foreign output normalized by the average corridor output.

**Unemployment differential:** Difference between the domestic unemployment rate and the foreign unemployment rate.

**Vacancy differential:** Difference of domestic vacancies and foreign vacancies.

**Wage differential:** Difference of domestic real wage and foreign real wage normalized by the domestic real wage normalized by the average corridor real wage.

**Immigration/Emigration:** Bilateral immigration/emigration flows, “International Migration Flows to and from Selected Countries: The 2008 Revision”, United Nations, 2008. Missing values for the periods after 2008 are estimated by OECD Migration database, OECD, 2015. Additionally, we use the immigration data as proxy for missing emigration data in between of periods.

**Net migration:** Difference of immigration and emigration normalized by the average corridor as a share of foreign population.
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Row: sending country; column: receiving country
Corridors in parenthesis [] are not considered in the baseline estimation due to limited time periods. They are considered within the robustness check.
X: No data available
Corridors with xx are dropped because of the missing net migration value.
80 denotes the initial year of data availability: 1980
* estimated with immigration/emigration statistics from the receiving country
(F): Only foreign citizens
(B): Both, foreign and domestic country citizens
Austria (AT), Belgium (BE), Germany (DE), Greece (EL), Spain (ES), Finland (FI), France (FR), Ireland (IE), Italy (IT), Luxembourg (LU), Netherlands (NL), Portugal (PT)

Table 5: List of all corridors
Figure 3: Four types of migration corridors

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<td>EL IT</td>
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<td>PT ES</td>
</tr>
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<td>12</td>
<td>BE IE</td>
<td>27</td>
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<td>42</td>
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<td>43</td>
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</tr>
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<td>14</td>
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<td>29</td>
<td>FR LU</td>
<td>44</td>
<td>IE NL</td>
<td></td>
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<td>FR NL</td>
<td>45</td>
<td>IE ES</td>
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</tr>
</tbody>
</table>

Table 6: List of all corridors

Belgium (BE), Germany (DE), Ireland (IE), Greece (EL), Spain (ES), France (FR), Italy (IT), Luxembourg (LU), Netherlands (NL), Austria (AT), Portugal (PT), Finland (FI)
7.2. Basic parametrization

<table>
<thead>
<tr>
<th>Structural parameter</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time preference</td>
<td>$\beta = 0.955$</td>
<td>$i \approx 4.5%$ p.a.</td>
</tr>
<tr>
<td>Production elasticity</td>
<td>$\alpha = 1/3$</td>
<td>Labor share</td>
</tr>
<tr>
<td>Wage bargaining power</td>
<td>$\eta = 0.5$</td>
<td>Hosios condition</td>
</tr>
<tr>
<td>Substitution elasticity of matching</td>
<td>$\delta = 0.5$</td>
<td>Hosios condition</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Measured from data</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separation rate</td>
<td>$\rho = 0.11$</td>
<td>Kudlyak (2014)</td>
</tr>
<tr>
<td>Migration rate</td>
<td>$\mu = 0.015$</td>
<td>EA average</td>
</tr>
<tr>
<td>Return migration rate</td>
<td>$\gamma = 0.2$</td>
<td>OECD (2008)</td>
</tr>
<tr>
<td>Depreciation rate</td>
<td>$d = 0.058$</td>
<td>Capital-output ratio</td>
</tr>
<tr>
<td>Openness</td>
<td>$\omega = 0.25$</td>
<td>EA average</td>
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</table>

<table>
<thead>
<tr>
<th>Calibrate to Match</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade elasticity</td>
<td>$\psi = 1.5$</td>
<td>Import share $\frac{\overline{y}_f}{\overline{y}}$</td>
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<tr>
<td>Native match efficiency</td>
<td>$N = 0.47$</td>
<td>Country-specific unemployment rate $\overline{u}$</td>
</tr>
<tr>
<td>Immigrant match efficiency</td>
<td>$I = 0.41$</td>
<td>Native-immigrant unemployment gap $\frac{\pi_f (\pi_h + \pi_f)}{(\pi_f + \pi_h)} \pi_f$</td>
</tr>
<tr>
<td>Immigrant relative productivity</td>
<td>$\Theta = 0.985$</td>
<td>Native-immigrant wage gap $\frac{\pi_h}{\pi_f}$</td>
</tr>
<tr>
<td>Unemployment benefit</td>
<td>$b = 0.62$</td>
<td>Unemployment benefit $\frac{b}{\overline{u}}$</td>
</tr>
<tr>
<td>Vacancy costs</td>
<td>$\kappa = 0.09$</td>
<td>Average vacancy costs $\frac{x(\overline{v}_h + \overline{v}_f)}{\overline{v}}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Shock parameter</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD TFP shock</td>
<td>$\xi_Z = 0.0195$</td>
<td>EA average</td>
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<tr>
<td>SD government spending shock</td>
<td>$\xi_G = 0.004$</td>
<td>EA average</td>
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<tr>
<td>SD match technology shock</td>
<td>$\xi_L = 0.03$</td>
<td>EA average</td>
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<tr>
<td>Persistence TFP</td>
<td>$\rho_Z = 0.9$</td>
<td>EA average</td>
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<tr>
<td>Persistence government spending</td>
<td>$\rho_G = 0.81$</td>
<td>EA average</td>
</tr>
<tr>
<td>Persistence match technology</td>
<td>$\rho_L = 0.62$</td>
<td>EA average</td>
</tr>
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</table>

Table 7: Calibration
<table>
<thead>
<tr>
<th>Country</th>
<th>Native UR</th>
<th>Immigrant UR</th>
<th>Unemployment ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>5.6</td>
<td>6.68</td>
<td>1.20</td>
</tr>
<tr>
<td>Belgium</td>
<td>9.5</td>
<td>14</td>
<td>1.47</td>
</tr>
<tr>
<td>Finland</td>
<td>12.1</td>
<td>12.3</td>
<td>1.01</td>
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<tr>
<td>France</td>
<td>11.9</td>
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<td>Germany</td>
<td>7.7</td>
<td>9.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Greece</td>
<td>11.1</td>
<td>14.9</td>
<td>1.34</td>
</tr>
<tr>
<td>Ireland</td>
<td>8.5</td>
<td>7.6</td>
<td>0.9</td>
</tr>
<tr>
<td>Italy</td>
<td>11.5</td>
<td>16.5</td>
<td>1.4</td>
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<tr>
<td>Luxembourg</td>
<td>2.4</td>
<td>3.2</td>
<td>1.29</td>
</tr>
<tr>
<td>Portugal</td>
<td>6.7</td>
<td>7.8</td>
<td>1.16</td>
</tr>
<tr>
<td>Spain</td>
<td>13.9</td>
<td>15.1</td>
<td>1.09</td>
</tr>
<tr>
<td>Euro average</td>
<td>9.9</td>
<td>10.8</td>
<td>1.17</td>
</tr>
</tbody>
</table>

Table 8: Intra EA-12 Native vs. immigrante unemployment rate  
* Source: OECD Migration Database. OCED Data are extracted from the labour force surveys, provided by Eurostat and averaged over the period 1998-2002. ** Data for Intra-EA-12 immimmigrant unemployment are not available for the Netherlands.
7.3. Impulse response functions

Figure 4: Productivity shock home
Figure 5: Government spending shock home
Figure 6: Matching technology shock home
References


Bonthuis, B., Jarvis, V., Vanhala, J., 2013. What’s going on behind the euro area Beveridge curve(s)? Tech. Rep. 15, ECB.


