Migration, Unemployment and the Business Cycle: A Euro Area Perspective

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Abstract

We investigate the business cycle in 55 bilateral migration corridors in the euro area over the period 1980-2010 and find evidence for business cycle related fluctuations in net migration flows and the crucial role of unemployment in shaping migration patterns. While on average wage and unemployment differentials are negatively correlated with net migration, across migration corridors we document a considerable heterogeneity in the wage dimension. In line with these findings, we build a two-country dynamic stochastic general equilibrium (DSGE) model of internal business-cycle migration in the euro area and allow for unemployment that occurs as a consequence of imperfect labor market and rigidities in both countries.

Our model features an endogenous migration decision separate from the labour supply decision. It contributes to the literature on the causes and consequences of temporary migration by bridging it to DSGE models with unemployment. We find that in case of typical business cycle fluctuations, i.e. supply and demand shocks, the net migration rate is positively correlated with the wage differential and negatively correlated with the unemployment differential. Labour market shocks are responsible for more distinct patterns with respect to wages, unemployment and thus migration flows. A migration specific shock that affects the costs of immigration and a wage markup shocks can account for the negative correlation of net migration and the real wage differential over the cycle.

Keywords: Labour Migration, International Business Cycles, Unemployment

\textsuperscript{JEL: E24, F22, F41}
1. Introduction

The legal framework of the European Union guarantees free movement of persons\(^1\) and lays the foundation for a potentially high labour mobility in the euro area. Two poles span the area of conflict of internal migration in the euro area and underline the need to understand its nature and determinants: while many European policy makers promote internal migration as a means to increase overall employment against the background of heterogeneous labour market conditions, opening up national labour markets to immigrants from the free movement area also raises concerns. A prominent case is the United Kingdom where the Brexit votum in 2016 is argued to reflect fear of the consequences of high positive net migration rates from the rest of the union (Wadsworth et al., 2016).

The euro crisis episode, that was characterised by a marked change in migration flows on the euro area level and the country level, reinforced the interest in labour mobility as a potential adjustment mechanism to abate relative business cycle fluctuations under a common monetary policy.\(^2\) Between 2007 and 2010 free movement immigration flows dropped by 35% in Europe and rebounded with diverging patterns thereafter (OECD, 2014). This incidence sheds light on the determinants of internal migration and the interrelation of business cycles and migration patterns.

Figure 1 underlines that since 2007 across EA-12\(^3\) countries the unemployment dispersion increased relatively strongly while the wage dispersion remained nearly unchanged.\(^4\) The growing cross-country labour market disparities are mirrored by the crisis’ heterogeneous impact on national migration flows. Unemployment increased in countries such as Spain and Italy while it sank in others such as Germany, at the same time intra-euro migration flows diverted from the former to the latter. Between 2009 and 2011 the net migration rate in Germany increased from 0.27 to 1.61 persons per 1000 population, while in Spain it changed from 13.82 before the crisis to -0.38. Spain, which was the largest immigration country in 2009 has turned to a net emigration country during the crisis.\(^5\) This observation indicates that the growing unemployment dispersion provides a potential explanation for the marked change in euro area migration patterns.\(^6\) Even though the crisis episode provides new insights in migration patterns in the euro

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\(^1\)By endowing EU citizens with the right to move freely for the purpose of living, working, studying and retiring, the free movement of persons reduces the migration cost of both, employed and unemployed workers (Article 45 TFEU).

\(^2\)Starting with the work of Mundell (1961), labour mobility is an important criterion for an optimal currency area.

\(^3\)The EA-12 refers to Austria, Belgium, Germany, Spain, Finland, France, Ireland, Italy, Luxembourg, Netherlands, Portugal and Greece.

\(^4\)This result should be interpreted with caution as aggregate wages might not reflect the cyclical pattern of wages properly e.g. because of long-term wage contracts or a composition bias (Verdugo, 2016; Solon et al., 1994).

\(^5\)See Table A.3 in Appendix.

\(^6\)This would be in line with Dao et al. (2014) who find that the decline of internal migration in the United States coincides with a reduced regional unemployment dispersion.
area, it can not substitute for a thorough analysis of the general impact of the business cycle on direction, size and composition of internal migration in the euro area that is needed in order to assess this important adjustment mechanism.

Figure 1: Dispersion of unemployment and wages in the EA-12. Dispersion is measured by the coefficient of variation that normalises the standard deviation by the mean (both in unweighted terms). The data sources and definitions are described in Section 3.1.

To this end, we carry out a comprehensive empirical analysis of the interrelation of wages, unemployment and migration patterns in the euro area over the business cycle for the period 1980 to 2010. We focus on this period for reasons of data availability, but also to exclude effects from the Syrian crisis that onset in 2011 and initiated a strong inflow of refugees to the euro area as well as from monetary policy that was characterized by nominal interest rates at the zero lower bound and non-standard policy measures in recent years. Our analysis of 55 bilateral migration corridors reveals that on average net migration is negatively correlated with wage and unemployment differentials. However, across corridors we find a considerable heterogeneity in the wage dimension.

In line with these findings we build a two-country dynamic stochastic general equilibrium (DGSE) model with migration and unemployment. Other than the majority of contributions in the field of DSGE models with migration, we separate the migration and the labour supply decision which allows us to model native and migrant unemployment in both countries. This approach circumvents the difficulty that little is know about the strength of the short term wealth effect on migrant labour supply. Our interest is twofold: We aim at identifying how the business cycle and the fluctuation of wages and unemployment affect bilateral migration flows. At the same time we want to assess the effect of migration on output fluctuations and thus the role of migration in abating asymmetric shocks. While we identify significant effects that differ with the extent of rigidities and for different types of shocks in the first dimension, we find the effects in the second dimension to be relatively low. We interpret our results as follows: In most corridors net (im-)migration is procyclical. Thus, it is used as insurance against country-specific business-cycle risk. However, in a smaller part net migration is coun-
tercyclical. However, if migration is used as insurance motive or not depends on the type of the shock and the relative price/wage rigidity. The model is able to replicate our empirical observations on average and explains the heterogeneity of the relation of net migration and wage differentials across migration corridors by differences in the type of shock that hits an economy. By explicitly modeling the interaction of unemployment and migration, we contribute to the growing literature on the causes and consequences of temporary migration. Our paper bridges the literature that quantifies the effects of migration and unemployment (Dustmann et al., 2008; Kemnitz, 2009; Stark and Fan, 2011) to the growing literature on unemployment in open economy DGSE models.

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

2. Literature Survey

The empirical literature documents that the importance of internal cross-border migration in the euro area has grown over time. 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. In many member countries the immigrant stock to a large part consists of migrants from another EU country. Correspondingly, the importance of migration as a stabilisation tool has increased over time. Beyer and Smets (2015) employ a multilevel factor model and show that in the EU the contribution of international and regional migration has increased from the periods 1977-1999 to 1990-2013. In a similar vein Jauer et al. (2014) document an increase in regional labour mobility in the EU and attribute on average up to one quarter of the asymmetric labour market shock absorption within a year to regional migration.

Despite data limitations there is evidence of the high importance of temporary migration in the euro area (Constant et al., 2013; Dustmann and Görlach, 2016; Dustmann and Weiss, 2007) as a consequence of the free movement of workers (Brücker et al., 2014b; OECD, 2014). E.g. 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.\footnote{E.g. in 2014, 45% of all immigrants living in Germany originated from another EU-28 country, within this group Italian and Greek immigrants made up for the largest populations from another euro country with 16% and 9% respectively (Destatis, 2015). This corresponds to an immigrant share, i.e. immigrant stock divided by population size, of 4.5% (EU-28), 0.7% (Italy) and 0.4% (Greece).}

\footnote{The reported outmigration rate after five years is 60.4% in Ireland, 50.4% in Belgium and 28.2% in the Netherlands.}
Additionally, there is evidence that short-run migration fluctuates with the business cycle. In the group of OECD countries Beine et al. (2013) find current and future business cycle and employment dynamics to influence bilateral migration flows. 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%. Combined, these observations point towards the important role of the employment rate and its counterpart the unemployment rate for migration over the business cycle. Dustmann et al. (2010a) find that in Germany the unemployment response to labour 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).

A theoretical model of internal migration in the euro area has to be able to incorporate and replicate these empirical findings. The recently growing literature on business-cycle migration in a DSGE framework provides a valuable starting point. Mandelman and Zlate (2012) model immigration of unskilled Mexicans to the U.S. in a two-country RBC model. In a model with bilateral migration Hauser (2014) shows that a technology shock spills-over from one location to another via its effect on the direction of the labour force movement. Other contributions focus on the effect of introducing migration in a New-Keynesian (NK) model of a single economy. They find the Phillips curve to be flatter in both, immigration (Binyamini and Razin, 2008) and emigration countries (Engler, 2009), because with labour mobility a lower wage increase is needed to raise the labour force. However, this result relies on the assumption of a neoclassical international labour market that is characterised by fully flexible wages and the absence of real labour market frictions. Bentolila et al. (2008) overcome this weakness by including real wage rigidity and unemployment and find that immigration alters the slope and intercept of the Phillips curve via a different labour supply elasticity and bargaining power of immigrants. In the DSGE framework different approaches to introduce unemployment can be distinguished. One approach (e.g. Galí, 2011a,b) reinterprets the DSGE model with staggered wage setting formulated by Erceg et al. (2000). The market power of differentiated types of labour gives rise to a positive average wage markup that in presence of nominal frictions varies over the business cycle. In this approach, structural unemployment arises because wages exceed their efficient equilibrium level. Other sources of unemployment such as real labour market frictions are not accounted for. The other approach (e.g. Christiano et al., 2016; Faia and Rossi, 2013; Gertler et al., 2008; Krause and Lubik, 2007) explicitly models real frictions from search and matching in line with Mortensen and Pissarides (1994). Chassamboulis and Palivos (2013, 2014) follow this approach to analyse the equilibrium effects of an exogenous migrant inflow on natives’

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9 For inter-state migration in the United States Saks and Wozniak (2011) and Hauser (2014) document a procyclical pattern.

10 More precisely, one should speak about underemployment because the wage markup is derived from the workers’ optimisation problem and thus the employment below the efficient level is a desired outcome.

11 There exist versions with and without the assumption of rigid wages. Shimer (2005) and Hall (2005)
labor market outcomes. Braun and Weber (2016) study the labour market adjustment subsequent to an exogenous expellee inflow in a two-region search and matching model with migration.

Internal migration in the euro area is characterised by an interplay of migration and unemployment at business cycle frequencies. To this end, a model of internal migration in the euro area needs to incorporate both, the effect of migration on source and destination countries as well as unemployment and labour market frictions. In this paper we develop a comprehensive model of bilateral migration flows with these distinct features. We build a DSGE model with endogenous migration and include unemployment in order to match the empirical observations on the euro area. In line with the empirical observations on internal migration patterns in the euro area, we consider differences in employment probabilities as a key migration trigger additional to wages. Including unemployment in the analysis has nontrivial consequences because unemployment rates exhibit a different dynamic pattern than wages. It is a well-known fact that in the euro area nominal wages are above equilibrium and rigid (e.g. Schmitt-Grohé and Uribe, 2013; Smets and Wouters, 2003). Therefore, we follow Galí (2011b) and allow for unemployment that occurs as a consequence of labour market frictions and rigidities in both countries. This approach explains unemployment as result of time-varying country-specific markups on competitive equilibrium wages, that in our framework potentially differs for natives and migrants. This set-up enables us to assess the effects of differing labour supply elasticities, wage persistence and bargaining powers of natives and migrants on cross-country migration flows and their combined influence on macroeconomic aggregates.

3. Empirical observations

3.1. Compiling the data set

To investigate the characteristics of migration in the euro area over the business cycle we compile a large data set with bilateral migration and macroeconomic variables in a similar vein as Beine et al. (2013) but with a focus on the euro area. The empirical investigation of European business cycle migration flows is limited by the fact, that migration data on a business cycle frequency is still very rare. Therefore, most studies use data on an annual basis or at least quarterly data for a small time period. Despite those difficulties, we are able to use a novel quarterly migration data set which contains immigration and emigration of the working-age population between Austria, Belgium, Germany, Finland, Netherlands and Spain over large time horizons in order to test our model results. Nevertheless, in our empirical motivation we want to analyse a common time horizon and also include other EA countries where quarterly migration data are not made.

proposed wage rigidity as one way to introduce the empirically observed negative correlation of unemployment and vacancies ('Beveridge curve') into the search and matching model.

12See Appendix A.2 for a description of the data.
available yet. Therefore, we use annual data for the years 1980-2010 for 12 euro area countries (EA-12) 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 $12 \cdot \frac{11}{2} = 66$ potential migration corridors. Due to data limitations in some corridors even on an annual basis the number of actual corridors in the panel reduces to 55.\textsuperscript{13} For each bilateral migration corridor we define the net migration as the difference of immigration and emigration between the two countries and normalise it by the average labour force in the migration corridor. We focus on internal migration in the EA-12, thereby we do not account for the nationality of a migrant only for the source country. For instance an increase in immigration from another EA-12 country can be either caused by migration creation or the diversion of immigrants from one destination to another.\textsuperscript{14}

The data series for the macroeconomic variables real GDP, real consumption, unemployment rate, employment, labour force, real wage, price inflation and wage inflation were drawn as annual data from the AMECO database and in quarterly frequency from the OECD National Accounts database. Real compensation per employee serves as a proxy for real wages.\textsuperscript{15} For the migration business cycle relative fluctuations of variables in source and destination countries matter (Beine et al., 2013). Therefore, we construct differentials of main potential determinants such as output, real wage, and unemployment rate for each migration corridor. The differentials are defined as the difference in a variable, normalised by its corridor average in case of variables that depend on country size e.g. output and employment. The wage and the unemployment differentials act as empirical proxies for non observable time-varying migrant wage and unemployment differentials.\textsuperscript{16} 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 $\lambda = 400$.\textsuperscript{17} EA-12 averages are obtained as unweighted averages of all corridors.

\textsuperscript{13}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.

\textsuperscript{14}A refugee inflow to the EU, as observed recently, does not have a direct impact on our data because we focus on data by nationality and in addition asylum laws prohibit this group of migrants to relocate between different countries.

\textsuperscript{15}Galí (2011a) 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.

\textsuperscript{16}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.

\textsuperscript{17}Thereby we follow Beine et al. (2013) who use a value of $\lambda = 400$ for the analysis of business cycle migration with annual data. Table A.7 in the appendix displays the robustness of our results with respect to the smoothing parameter and the time period considered.
3.2. Migration Cycle Statistics of the Euro Area

In the following we present facts on internal migration patterns the euro area that help to assess whether they vary systematically with the business cycle and how wages, unemployment and migration patterns are interrelated over the business cycle. Thereby our interest is twofold, we want to identify characteristic patterns of the average EA-12 migration corridor and consider heterogeneity across corridors. Table 1 provides key facts for the migration cycle in the average EA-12 corridor with respect to correlations as measure for cyclicality. 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. labour market that while unconditional labour mobility is procyclical, the picture is less clear for conditional labour 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 labour market.}

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclicality ($\rho(dy, nm)$)</td>
<td>0.17</td>
</tr>
<tr>
<td>Unemployment rate differential ($\rho(du, nm)$)</td>
<td>-0.31</td>
</tr>
<tr>
<td>Real wage differential ($\rho(dw, nm)$)</td>
<td>-0.10</td>
</tr>
</tbody>
</table>

$p(dx, nm)$ denotes the contemporaneous correlation of the corridor differential of variable $x$ and net migration.

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. The net migration rate is negatively correlated with the real wage but to a lower degree than (un-)employment. One potential explanation could be the fact that across corridors unemployment is less correlated than wages which indicates a higher labour market dispersion with respect to unemployment.\footnote{See Table A.6 in Appendix A.3 that provides details on the EA-12 business cycle.}

Figure 2 displays the dynamic behavior of net migration and the differentials of real output, unemployment rate and real wage 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 and the lag correlations exceed the lead correlations. Combined, this is an indication for unemployment to be c.p. causal for the migration decision. The intuition is straightforward: in case of a shock that decreases output and increases unemployment and household income, agents from native households decide to emigrate to another country with higher output and lower unemployment.\footnote{Output does not directly affect the behavior of households, but agents react to fluctuations in unemployment or wages that are related to output.}

Although smaller in size, the negative correlation between the net migration rate and the real wage differential can
be observed for the third lag up to the first lead. The maximum correlation $-0.13$ at the first lag indicates that the wage differential leads the net migration rate by one to two periods. The negative sign of the correlation between wages and net migration makes the intuition puzzling, because it would mean that people tend to move in the direction where real wages are relatively lower. 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 explain the observed pattern.

Figure 3 highlights the heterogeneity across migration corridors. The left hand graph sorts the 55 migration corridors by sign and size of the contemporaneous correlation of the net migration rate and the real wage differential. While approximately two thirds of all corridors exhibit a negative correlation (e.g. Spain and the Netherlands or France),
in some corridors both variables are positively correlated with up to 0.5 (e.g., Italy and Greece or Finland). The right hand side depicts the corridor correlations for net migration and the unemployment differential. With a majority of corridors displaying a negative correlation the picture is less heterogeneous. Only one out of six corridors has a positive but small correlation. The signs of the two correlations can act as dimensions to classify migration corridors into four types (see Figure A.4 in Appendix A.3).

Overall, the business cycle facts underline that both, unemployment and wage differentials are important to understand cyclical migration patterns in the euro area. We interpret the previous empirical findings as evidence for business cycle related fluctuations in net migration flows and the crucial role of unemployment in shaping intra-euro area migration patterns. In line with these findings we develop a two-country DSGE model of internal business cycle migration in the euro area and allow for unemployment in order to find a comprehensive explanation for the euro area average and cross-country patterns.

4. A Model with Migration and Unemployment

This section introduces endogenous migration in a New Keynesian model with unemployment. We formulate a migration decision in the spirit of the labor force participation formulation in Erceg and Levin (2014). A representative household observes country specific unemployment and wages and allocates families between the home and the foreign labor market. Thereby, the existence of adjustment cost of moving labour cross borders accounts for the fact that large business cycle shocks such as during the Great Recession trigger stronger migration movements than small shocks.

Traditionally, the migration literature models the migration decision in terms of an explicit destination specific labour supply decision by the agents. In general, the labour supply decision hinges critically on the formulation of the preferences in the utility function. With the conventional preferences of King et al. (1988) type business cycle shocks lead to a counter cyclical labour supply response that is not in line with empirical observations. Galí et al. (2012a) overcome this by introducing a shifting parameter that limits the short run wealth effect on the labour supply. Against this background defining the migration rate on the basis of a labor supply decision seems arbitrary. We circumvent this by sequentially separating a migration decision and a subsequent labour supply decision.

The general structure of the model is similar to Galí et al. (2012a) which extends the wage-setting set-up in Erceg et al. (2000) to the case of indivisible labour as introduced by Galí (2011b). In this specification structural unemployment arises, because the market power of differentiated types of labour gives rise wages above their equilibrium level. Other sources of unemployment such as labour market frictions are not accounted for. In presence of nominal frictions, the positive average wage markup varies over the business cycle. By insuring the idiosyncratic unemployment risk of agents the framework preserves the representative household paradigm (Andolfatto, 1996; Merz, 1995).
We apply this model to two symmetric countries that form a migration corridor and have bilateral trade in goods with zero external balances in the steady state. The trade block of the model is a simplified version of de Walque et al. (2017).

4.1. Households

The home economy is populated by a representative household with a large number of identical families indexed by \( k \in 0, 1 \]. The household maximises the utility of all families and determines a fraction \( \gamma_t \) of families to move to the foreign labour market, and \( 1 - \gamma_t \) of families to remain in the home country. Consequently, \( \gamma_t \) denotes the emigrant share from the perspective of the home economy.

4.1.1. Preferences, budget and optimisation behavior

Each family has a continuum of infinitely lived members represented by the unit square and indexed by a pair \((i, j) \in 0, 1 \times 0, 1\) where the first dimension \( i \) describes the type of labour service in which a member is specialised and the second dimension \( j \) measures her disutility of working. Due to perfect insurance within one family, all members consume the same level of the aggregate consumption bundle irrespective of their labor type and employment status.\(^{22}\)

The representative household maximizes the following intertemporal utility that is derived by integrating over all families’ and their members’ utilities:

\[
U_t = E_0 \sum \limits_1^{\infty} \beta^t \left( \log \tilde{C}_t - \chi_t \Xi_t \left( (1 - \gamma_t) \int_0^1 (L_{h,t}(i)e_{h,t}(i))^{1+\psi_m} di \right. \right. \\
\left. \left. + \gamma_t \int_0^1 (L_{h,t}^*(i)e_{h,t}^*(i))^{1+\psi_m} di \right) - \chi \gamma_t \gamma_t^{1+\psi_t} \gamma_t^{1+\psi_t} - \phi \gamma_t \left( \frac{\gamma_t}{\gamma_{t-1}} \right), \right)
\]

with \( \tilde{C}_t = C_t - hC_{t-1} \), where \( C_t \) denotes the consumption aggregate, \( h \in 0, 1 \) is a parameter that represents external habit formation, \( L_{h,t}(i) \) is the labour force participation rate of family members specialised in type \( i \) labour in the home economy and \( e_{h,t}(i) = 1 - u_{h,t}(i) \) is the corresponding employment rate, thus \( L_{h,t}(i)e_{h,t}(i) \) refers to the native type \( i \) workers of family \( k \). Accordingly, \( L_{h,t}^*(i)e_{h,t}^*(i) \) with \( e_{h,t}^*(i) = 1 - u_{h,t}^*(i) \) refers to the emigrant workers of type \( i \) from the perspective of the home country and

\(^{21}\)Due to the symmetry assumption households and firms in both countries face uniform optimisation problems. All equations are derived for the home economy and analogously apply to the foreign economy. In general, home variables do not have a superscript and foreign variables are denoted by a * superscript. In case of variables where country of supply and origin differ, the superscript denotes the location of the supply and the subscript (h or f) denotes the location of the origin or birth in case of agents.

\(^{22}\)As pointed out by Galí et al. (2012a) an unavoidable feature of the risk-sharing assumption is that ex-post unemployed workers have a higher utility than employed workers. Assuming that workers internalize the contribution of their employment to their household’s benefit guarantees a positive participation rate of all types.
immigrant workers from the perspective of the foreign country. \( \chi_t \) is an exogenous preference shifter that affects the labour supply of all labor types equally and that in logs follows an AR(1) process with an i.i.d.-normal error structure. Following (Gaš et al., 2012a), \( \Xi_t \) is an endogenous preference shifter defined as \( \Xi_t = \frac{Z_t}{\Theta_t} \) with: \( Z_t = Z_{t-1}^c \tilde{C}_t^v \) that allows to reduce the short-term wealth effect on labour supply whose influence is governed by parameter \( \nu \in (0, 1] \). In line with empirical observations, for low values of \( \nu \) the short-term wealth effect is weak and the labour supply response is procyclical. \( \psi_n, \psi_m \) denote the inverse Frisch elasticities of native and migrant labour supply. To capture the relative preference of living in the home country, we introduce a disutility of living abroad that is increasing in the share of emigrant families. \( \chi_\gamma \) is a scaling parameter and \( \psi_\gamma \) is a parameter determining the shape of the distribution of living abroad disutilities across families. The model accounts for the fact that it is costly to adjust the share of labour abroad and the quadratic cost function is \( \phi_{\gamma} \left( \gamma_t / \gamma_{t-1} \right) = 0.5 \phi_\gamma \phi_{\gamma,t} \left( \gamma_t / \gamma_{t-1} - 1 \right)^2 \) where \( \phi_{\gamma,t} \) is an adjustment cost shock that in logs follows an AR(1) process with an i.i.d.-normal error structure.

The household’s intratemporal budget constraint is:

\[
P_{c,t}(C_t + I_t) + B_{h,t} + \frac{\Theta_{t}}{\Phi_{b,t}} B_{f,t} \leq \int_0^1 W_{h,t}(i) L_{h,t}(i) e_{h,t}(i) e_{h,t}(i) di + \int_0^1 W_{h,t}^s(i) L_{h,t}^s(i) e_{h,t}^s(i) e_{h,t}^s(i) di + B_{f,t-1} + B_{h,t-1} + \left( R^K_t u_t - \phi_k(u_t) \right) K^p_{t-1} + \int_0^1 \Pi_t(z) dz, \tag{2}
\]

The household uses total income to purchase units of the consumption bundle and investment good at price \( P_{c,t} \), to pay a lump-sum tax \( T_t \) and to invest in nominal riskless domestic and foreign bonds \( B_{h,t} \) and \( B_{f,t} \) that pay a monetary unit at price \( \Theta_t \) and \( \Theta^*_t \). In order to avoid nonstationarity of net foreign assets, foreign bonds holdings are subject to real cost \( \phi_{b,t} \). The home household’s labour income is generated by native workers, who receive the type-specific nominal wage \( W_{h,t}(i) \), and by emigrant workers, who receive the type-specific nominal wage \( W_{h,t}^s(i) \). The household’s capital income equals the return \( R^K_t \) on the effective capital stock \( K_t = u_t K_{f,t}^p \) rented to the firms net of cost that arise from changing the capital utilisation \( \phi_k(u_t) \). Additionally, the household receives payments from bond holdings and nominal profits \( \int \Pi_t(z) dz \) from owning the intermediate firms in the home economy. The household’s capital stock evolves according to:

\[
K^p_t = (1 - \delta) K^p_{t-1} + \eta^f_t \left[ 1 - S \left( \frac{L_t}{I_{t-1}} \right) I_t \right], \tag{3}
\]

where \( \delta \in (0, 1) \) is the depreciation rate, \( \eta^f_t \) is an investment price specific shoke that in logs follows an AR(1) process with an i.i.d.-normal error structure and \( S(I_t/I_{t-1}) \) denotes the investment adjustment cost function with standard properties.
The consumption good and the investment goods are composites of the domestic good bundle $y_{ht}$ and the imported good bundle $y_{ft}$:

\[
C_t = \left( (1 - \omega) \frac{1}{\varphi} \left( C_{ht} \right)^{\frac{\lambda - 1}{\varphi}} + \omega \frac{1}{\varphi} (1 - \phi_{ct}) (C_{ft})^{\frac{\lambda - 1}{\varphi}} \right)^{\frac{\varphi}{\lambda}}, \tag{4}
\]

\[
I_t = \left( (1 - \omega) \frac{1}{\varphi} \left( I_{ht} \right)^{\frac{\lambda - 1}{\varphi}} + \omega \frac{1}{\varphi} (1 - \phi_{it}) (I_{ft})^{\frac{\lambda - 1}{\varphi}} \right)^{\frac{\varphi}{\lambda}}, \tag{5}
\]

where $\omega \in (0, 1)$ denotes the share of the foreign good in the aggregate good and $\lambda$ denotes the elasticity of substitution between domestic and foreign goods. As in de Walque et al. (2017) $\phi_{ct}$ and $\phi_{it}$ denote cost that occur in the adjustment of imported consumption and investment goods with standard quadratic form. For given prices $p_{ht}$ and $p_{ft}$ of the home and foreign produced composite good, expenditure minimising subject to the CES-aggregate gives the consumption and investment demand functions for domestic and foreign composite goods:

\[
C_{ht} = (1 - \omega) \left( \frac{P_{ht}}{P_{ct}} \right)^{-\lambda} C_t, \quad C_{ft} = \omega \left( \frac{P_{ft}}{P_{ct}} \right)^{-\lambda} C_t, \tag{6}
\]

\[
I_{ht} = (1 - \omega) \left( \frac{P_{ht}}{P_{ct}} \right)^{-\lambda} I_t, \quad I_{ft} = \omega \left( \frac{P_{ft}}{P_{ct}} \right)^{-\lambda} I_t, \tag{7}
\]

and the aggregate consumption price is $P_{ct} = \left( (1 - \omega) P_{ht}^{1-\lambda} + \omega P_{ft}^{1-\lambda} \right)^{1/(1-\lambda)}$.

Maximizing the welfare function (1) subject to the budget constraint (2) and the law of motion of the capital stock (3) gives the standard first-order conditions for consumption, capital utilisation, the real value of capital (Tobin’s q) and investment as in Smets and Wouters (2007). Optimal bond holdings are described by the Euler equations where $\Lambda_t = (C_t - hC_{t-1})^{-1}$ denotes the marginal utility of consumption:

\[
\Theta_t = \beta E_t \left\{ \frac{\Lambda_t}{\Lambda_{t+1}} \cdot \frac{P_{ct}}{P_{ct+1}} \right\}, \quad \Theta_t^* = \beta E_t \left\{ \frac{\Lambda_t}{\Lambda_{t+1}} \cdot \frac{P_{ct}}{P_{ct+1}} \right\}, \tag{8}
\]

4.2. Migration decision and labor supply

The model features a time-varying emigration rate $\gamma_t$ of families that is determined by the household. We assume that the household cannot observe type specific wages and unemployment rates, but only averages for native and migrant workers.\(^{23}\) Therefore, the emigration rate is the same for all types of workers $i$.

Introducing this assumption into the welfare function and maximizing it subject to the budget constraint gives the first-order condition for the emigrant share:

\[
\Lambda_t W_{ht} L_{ht} e_{ht} - \chi_t \Xi_t \frac{(L_{ht} e_{ht}^e)^{1+\psi_n}}{1+\psi_n} = \Lambda_t W_{ht}^* L_{ht}^* e_{ht}^* \chi_t \Xi_t \frac{(L_{ht}^* e_{ht}^e)^{1+\psi_n}}{1+\psi_n} - (\cdot), \tag{9}
\]

\(^{23}\)This assumption can be justified by the timing convention, where the household determines $\gamma_t$ before agents of each type $i$ learn about their ability to reset their wage in a given period. Since each type can reset their wage with the same probability irrespective of location and duration of the current wage contract. Consequently, if the number of agents is large enough they earn the average migrant wage.
with \((.) = \chi_{\gamma}^{\psi} + \phi_{\gamma,t} \left( \frac{\gamma_t}{\gamma_{t-1}} \right) + \phi'_{\gamma,t} \left( \frac{\gamma_t}{\gamma_{t-1}} \right) \frac{\gamma_t}{\gamma_{t-1}} - \beta \phi'_{\gamma,t} \left( \frac{\gamma_{t+1}}{\gamma_t} \right) \left( \frac{\gamma_{t+1}}{\gamma_t} \right)^2\). When determining the emigration share, the household takes into account that migrating agents face a risk to become unemployed. Since our model does not feature unemployment support or other social benefits the migration decision is directly influenced by the employment probability per family and the real wage. Additionally, native and migrant nominal wages react to the labor market conditions at home and abroad and a rise in the unemployment rate reduces the wage that the labour union determines. The optimality condition implies, that the household allocates families to the foreign labor market up to the point at which the marginal return of working in the home economy equals the marginal return of working in the foreign economy net of the disutility of living abroad and the migrant adjustment cost. Families are ordered sequentially based on their disutility of living abroad, with family \(k\) experiencing a disutility of \(I_{\gamma,t} \chi_{\gamma}^{\psi} \) with indicator function \(I_{\gamma,t}\) being one if the family lives abroad and zero otherwise.\(^{24}\) Integrating over all families gives the disutility term in the household welfare function\(\int_{0}^{\gamma} \chi_{\gamma}^{\psi} d\gamma = \chi_{\gamma}^{\psi} \gamma_t / (1 + \psi_t)\). Under the described incomplete information of the household\(^{25}\), the first-order conditions for the per family native and emigrant employment are given by:

\[
\begin{align*}
\chi_t \Xi_t (L_{h,t} e_{h,t})^{\psi_n} &= \lambda_t W_{h,t} \\
\chi_t \Xi_t (L_{h,t}^{*} e_{h,t}^{*})^{\psi_n} &= \lambda_t W_{h,t}^{*}
\end{align*}
\]  

Inserting (10) and (11) in (9) results in the following expression

\[
\frac{\psi_n}{1 + \psi_n} \chi_t \Xi_t (L_{h,t} e_{h,t})^{1+\psi_n} = \frac{\psi_m}{1 + \psi_m} \chi_t \Xi_t (L_{h,t}^{*} e_{h,t}^{*})^{1+\psi_m} - (.)
\]  

It underlines that the emigrant share varies directly with the employment rate – and thus the unemployment rate– and via the labor supply with the real wage.

The net migrant stock equals the share of immigrants net of the share of emigrants. Thus, the net migration from the perspective of the home country is defined as the change in the net migrant stock the over time:

\[
NM_t = (\gamma_t^* - \gamma_t) - (\gamma_{t-1}^* - \gamma_{t-1}) = -NM_t^*,
\]  

which is the negative of the net migration rate from the perspective of foreign. Inserting (9) and its foreign country counterpart gives an expression for the net migration rate in terms of the unemployment and wage differential. We calibrate the model such that the response to unemployment differentials is stronger than for the real wage differential.

\(^{24}\)Due to the risk-sharing assumption, migrating families have ex post a lower utility than families who remain in the home economy. Assuming that families internalize the contribution of their emigration to their household’s benefit guaranties labour mobility in the model.

\(^{25}\)Note, that this expression does not describe the actual labour supply, but is an expression that the household takes into account when determining the optimal share of emigrants.
Or: It becomes evident that the net migration reacts to unemployment differential more strongly. As a consequence of labour mobility, the model features an income balance which is defined as \( IB_t = W_{h,t}^* N_{h,t} - W_{f,t} N_{f,t} \).

Subsequent the migration decision, unions representing workers of each labour type \( i \) determine the native and emigrant wage as in Erceg et al. (2000). The native labour composite is defined as CES aggregat of differentiated worker types

\[
N_{h,t} = \left( \int_0^1 N_{h,t}(i)^{e_{wm,t} - 1/e_{wm,t}} di \right)^{e_{wm,t} / e_{wm,t} - 1}
\]

with elasticity of substitution \( e_{wm,t} \). Similarly, the emigrant labour composite is defined as

\[
N_{h,t}^* = \left( \int_0^1 N_{h,t}^*(i)^{e_{wm,t} - 1/e_{wm,t}} di \right)^{e_{wm,t} / e_{wm,t} - 1}
\]

with migrant elasticity of substitution \( e_{wm,t} \). Since different types of native and emigrant workers are imperfect substitutes the labour unions determine their nominal wages with a positive markup. As formalised by Calvo (1983), workers specialised in type \( i \) labour can reset their wages with a constant probability \( 1 - \xi_w \) each period. \( \xi_w \) is independent across time, location and labour types. As in Galí et al. (2012a), non-optimized wages are indexed to productivity growth and the price inflation rate according to \( W_{t+k|t} = W_{t+k-1|t} \Pi^t \Pi^{P|t-1} \gamma_w \) where \( \Pi^x \) denotes the steady-state (gross) growth rate of productivity, \( \Pi^{P|t-1} \) is the previous period’s (gross) rate of price inflation, \( \Pi^P \) is the steady state price inflation and \( \gamma_w \in 0,1 ] \) denotes the degree of price indexation.

Workers from home of a type \( i \) who are able to reset their native nominal wage in period \( t \) choose their optimal wage \( W_i^O \) and \( W_i^O * \) in order to maximise their household utility subject to the flow budget constraint (2) and the aggregate domestic and foreign firm labour demand for their labour type \( N_{h,t}(i) \) (equation 30) and \( N_{h,t}^*(i) \) (foreign firm counterpart of equation 31) as derived below.26 All types of labour \( i \) from home that reset their native wage in period \( t \) set the same wage level. The first-order condition associated with the native and emigrant wage setting problems are:

\[
\sum_{k=0}^{\infty} (\beta \xi_{wm})^k E_t \left\{ \frac{N_{h,t+k}}{(1 - \gamma_{t+k}) Z_{t+k}} \left( \frac{W_{h,t+k|t}}{P_{c,t+k}} - \mathcal{M}_{n,t+k} W_{h,t+k|t} \right) \right\} = 0 \quad (14)
\]

\[
\sum_{k=0}^{\infty} (\beta \xi_{wm})^k E_t \left\{ \frac{N_{h,t+k}^*}{\gamma_{t+k} Z_{t+k}} \left( \frac{W_{h,t+k|t}^*}{P_{c,t+k}} - \mathcal{M}_{m,t+k} W_{h,t+k|t}^* \right) \right\} = 0 \quad (15)
\]

with time varying native and immigrant wage markups \( \mathcal{M}_{n,t}^W = \frac{e_{wm,t}}{e_{wm,t} - 1} > \mathcal{M}_{m,t}^W = \frac{e_{wm,t}}{e_{wm,t} - 1} \), where we assume that native worker types have higher wages due to a lower

\[26\text{To transfer the aggregate native labour demand } N_{h,t}(i) \text{ in per family terms that are used in the household welfare function use the relation } N_{h,t}(i)/(1 - \gamma_t) = L_{h,t}(i)e_{h,t}(i), \text{ and similarly for emigrants } N_{h,t}^*(i)/(1 - \gamma_t) = L_{h,t}^*(i)e_{h,t}^*(i).\]
elasticity of substitution (i.e. a higher market power). Natives and emigrants who set wages in \( t \) ground their wage setting decision on different rates of substitution

\[
MRS_{h,t+k|1} = \lambda_{t+k}(1 - \gamma_{t+k})(L_{h,t+k|t}e_{h,t+k|1})^{\psi_h}Z_{t+k}
\]

and

\[
MRS_{h,t+k} = \chi_{t+k}\gamma_{t+1}(L_{h,t+k|t}^*e_{h,t+k|t})^{\psi_m}Z_{t+k}.
\]

While emigrant and native workers both evaluate their wage to their home consumption, differences arise due to varying labour demand across countries and the expected future wage and unemployment paths of the domestic and foreign country. In our formulation of the household welfare function the labour disutility is expressed in per family terms and the share of emigrating families acts as a scaling factor. Therefore, when further developing the first-order expressions the \( \gamma \) terms cancel out. Nevertheless, the emigration rate has an effect on the wage setting via the unemployment rate. The relation derives from the fact that the employment (and thus the employment rate) enters the marginal rate of substitution. The aggregate native wage in home is a weighted average of optimised and non-optimised native wage profiles:

\[
(W_{h,t})^{1-\epsilon_{wn,t}} = (1 - \hat{\epsilon}_{wn})(W_{h,t}^o)^{1-\epsilon_{wn,t}} + \hat{\epsilon}_{wn}(W_{h,t|-1})^{1-\epsilon_{wn,t}}.
\]

Combining equation (16) with the recursive formulation of the optimal wage expression (14) and log-linearising gives the native wage inflation rate\(^{27}\) in home:

\[
\hat{\pi}_{h,t}^w = \gamma_w \hat{\pi}_{t-1}^p + \beta \left( E_t \hat{\pi}_{h,t}^w - \gamma_w \hat{\pi}_{t}^p \right) - \lambda_{wn}\psi_n \frac{1}{1 - u_h}(\bar{u}_{h,t} - \bar{u}_{h,t}^{nat}),
\]

with \( \lambda_{wn} = \frac{(1-\hat{\epsilon}_{wn})(1-\beta\hat{\epsilon}_{wn})}{\hat{\epsilon}_{wn}(1+\epsilon_{wn}\psi_n)} \). Combined with the equation for the native unemployment rate (equation 21 below) this expression makes the relation between wages and the emigrant share explicit. An increase in the emigrant share reduces the unemployment rate and the improved labour market position of natives translates into a higher wage inflation rate. For emigrants combining equation (15) with an expression similar to (16) yields an expression for the emigrant wage inflation rate:

\[
\hat{\pi}_{h,t}^w = \gamma_w \hat{\pi}_{t-1}^p + \beta \left( E_t \hat{\pi}_{h,t}^w - \gamma_w \hat{\pi}_{t}^p \right) - \lambda_{wm}\psi_m \frac{1}{1 - u_h}(\bar{u}_{h,t} - \bar{u}_{h,t}^{nat}),
\]

with \( \lambda_{wm} = \frac{(1-\hat{\epsilon}_{wn})(1-\beta\hat{\epsilon}_{wn})}{\hat{\epsilon}_{wn}(1+\epsilon_{wn}\psi_m)} \). For emigrants an increase in the emigrant share raises emigrants’ unemployment and lowers their wage inflation rate. According to the aggregate

\(^{27}\)The wage inflation rate is defined as \( \hat{\pi}^w_{h,t} \equiv w_{h,t} - w_{h,t-1} \) where small letters denote detrended variables in logs, a hat denotes the log-deviation from the steady-state value, a tilde denotes the absolute deviation from the steady state and the superscript \( nat \) denotes the natural level in the absence of nominal rigidities.

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wage index the aggregate wage Phillips curve of the home country is a weighted average of native and immigrant wage inflation:

$$\Pi^W_t = (1 - \gamma)\Pi^W_{ht,t} + \gamma\Pi^W_{ft,t}. \quad (19)$$

Workers are only willing to participate in the labour market if the real wage exceeds their disutility of labour measured in units of the aggregate consumption good. The per family native and emigrant labour supply of type \(i\) from home is determined by the marginal supplier of native and emigrant labour \(i\):

$$L_{ht,t}(i) = \left( \frac{W_{ht,t}(i)}{P_t} \right) \frac{1}{P_n} \chi_1 Z_t,$$  \(L_{ht,t}^*(i) = \left( \frac{W_{ht,t}^*(i)}{P_t} \chi_1 Z_t \right) \frac{1}{P_n} \psi_n. \quad (20)$$

Note, that the individual labour supply does not depend on the emigration rate because the emigration rate has a proportional effect on the wage and the disutility and thus cancels out. The aggregate native labour supply equals the per family labour supply times the number of native families \(L_{ht,t} = (1 - \gamma_t) L_{ht,t}\) with \(L_{ht,t} \equiv \int_0^1 L_{ht,t}(i)di\) and similarly for the emigrant labour supply \(L_{ht,t}^* = \gamma_t L_{ht,t}^*\) with: \(L_{ht,t}^* \equiv \int_0^1 L_{ht,t}^*(i)di\).

When supplying their labour, workers of all types take the nominal wage and the labour demand as given. The labour demand is pinned down in section (4.3.2) by the optimal capital labour ratio and the relative wages of natives and immigrants. The resulting native and migrant unemployment rates are defined as:

$$u_{ht,t} = 1 - \frac{N_{ht,t}}{(1 - \gamma_t)L_{ht,t}},$$

$$u_{ht,t}^* = 1 - \frac{N_{ht,t}^*}{\gamma_t L_{ht,t}^*}, \quad (21),(22)$$

and encompass all agents who are not employed but would prefer to work taking into account the benefit of working to their household.

4.3. Firms
4.3.1. Homogenous good assemblers

The homogenous good assemblers operate in a perfectly competitive environment and demand a continuum of domestic and foreign intermediate inputs to produce a domestic \(Y_{ht,t}^d\) and a foreign \(Y_{ft,t}^d\) good. While the domestic bundle is demanded by final users in home for all types of expenditures, the foreign bundle is used for consumption and investment only:

$$Y_{ht,t}^d = C_{ht,t} + I_{ht,t} + G_t + \phi_k(u_t)K_t^p, \quad (23)$$

$$Y_{ft,t}^d = C_{ft,t} + I_{ft,t}. \quad (24)$$
Government spending follows an exogenous AR(1) process with For given prices of the home and foreign produced varieties, cost minimization subject to the Kimball (1995) aggregators\(^{28}\) \(\int_0^1 G \left( \frac{y_{h,t}^d(z)}{y_{h,t}^d}, \epsilon_{p,t} \right) = 1\) and \(\int_0^1 G \left( \frac{y_{f,t}^d(h)}{y_{f,t}^d}, \epsilon_{p,t} \right) = 1\) gives the demand functions:

\[
\begin{align*}
Y_{h,t}^d(z) &= Y_{h,t}^d G^{-1} \left( \frac{P_{h,t}(z)}{P_{h,t}} \tau_{h,t} \right) \quad \text{where: } \tau_{h,t} = \int_0^1 G' \left( \frac{Y_{h,t}^d(z)}{Y_{h,t}} \right) \frac{Y_{h,t}^d(z)}{Y_{h,t}} dz, \\
Y_{f,t}^d(h) &= Y_{f,t}^d G^{-1} \left( \frac{P_{f,t}(h)}{P_{f,t}} \tau_{f,t} \right) \quad \text{where: } \tau_{f,t} = \int_0^1 G' \left( \frac{Y_{f,t}^d(h)}{Y_{f,t}} \right) \frac{Y_{f,t}^d(h)}{Y_{f,t}} dh,
\end{align*}
\]

\(\epsilon_{p,t}\) is a nonnegative variable that in logs follows an exogenous ARMA(1) process and affects the frictionless price markup via changes in the elasticity of demand.

4.3.2. Intermediate good firms

There is a continuum of monopolistically competitive firms which produce a differentiated good \(z \in [0,1]\) and face a uniform price setting decision. In home, the firm \(z\) uses capital \(K_t\) rented out by the household at rental rate \(R_t^h\) and composite labour \(N_t(z)\) at the aggregate wage rate \(W_t\) to produce its final good:

\[
Y_{h,t}(z) = \epsilon_{a,t}(K_t)^{\alpha} \left( \gamma_N N_t(z) \right)^{1-\alpha} - \gamma_N \phi_p,
\]

where \(\epsilon_{a,t}\) is the country specific exogenous technology parameter that in logs follows an AR(1) process, \(\gamma_N\) is a labour-augmenting deterministic growth trend and \(\phi_p\) is a fixed cost parameter. Cost minimization gives the optimal capital-labor ratio that is equal across all firms:

\[
K_t = \frac{\alpha}{1 - \alpha} \frac{W_t}{R_t^h} N_t.
\]

We allow for labour mobility in the firm production production as in Ottaviano and Peri (2012). Thus, the composite labour employed by each firm \(z\) in the production function (27) is a CES index of native and immigrant workers:

\[
N_t(z) = \left( (1 - \gamma)^{\frac{1}{\theta}} (N_{h,t}(z))^{\frac{1}{\theta}} + \gamma^{\frac{1}{\theta}} (N_{f,t}(z))^{\frac{1}{\theta}} \right)^{\frac{\theta}{\theta-1}}.
\]

The parameter \(\gamma \in (0,1)^{29}\) denotes the share of immigrant workers in the production and governs their income share. \(\theta \in (0, \infty)\) is the aggregate elasticity of substitution between native and immigrant workers.\(^{30}\) For given type-specific wages \(W_{h,t}(i)\) and \(W_{f,t}(i)\) of

\(^{28}\)G is strictly increasing and concave with \(G(1) = 1\)

\(^{29}\)We calibrate the model such that the state state of the endogenous emigrant share equals the this parameter.

\(^{30}\)If \(\theta > 1\) native and immigrant workers are gross substitutes.
natives and immigrants, expenditure minimising subject to the labour indexes gives the home firms’ demand functions for native and immigrant labour types and labour composites:

\[ N_{h,t}(i, z) = \left( \frac{W_{h,t}(i)}{W_{h,t}} \right)^{-\varepsilon_{wn,t}} N_{h,t}(z), \quad N_{h,t}(z) = (1 - \gamma) \left( \frac{W_{h,t}}{W_t} \right)^{-\theta} N_t(z), \quad (30) \]

\[ N_{f,t}(i, z) = \left( \frac{W_{f,t}(i)}{W_{f,t}} \right)^{-\varepsilon_{wm,t}} N_{f,t}(z), \quad N_{f,t}(z) = \gamma \left( \frac{W_{f,t}}{W_t} \right)^{-\theta} N_t(z), \quad (31) \]

where the aggregate wage index is \( W_t = \left( (1 - \gamma)W_{h,t}^{1-\theta} + \gamma W_{f,t}^{1-\theta} \right)^{1/(1-\theta)} \) with the wage indices of the native (equation 16) and the immigrant labour composite. Aggregating over all firms \( z \) in home gives the demand for native and immigrant labour types and composites.

As in de Walque et al. (2017) intermediate good firms set separate prices for their good in the home market \( P_{h,t}(z) \) and for exported goods \( P_{h,t}^o(z) \). According to the Calvo (1983) mechanism, each firm resets the price of its produced variety in any given period with a constant probability \( 1 - \xi_p \) at home and \( 1 - \xi_p \) abroad. As in Smets and Wouters (2007) prices of firms who are not able to re-optimize in a given period are partially indexed to the previous period’s inflation and the steady state inflation \( P_{h,t}^{k+1|t} = P_{t+1}^{1-p} \Pi^{1-p} \) where \( p \in [0,1] \) denotes the degree of price indexation. A firm \( z \) that is allowed to change its price in the home market in period \( t \), chooses an optimal price \( P_{h,t}^o(z) \) to maximise its real life time value subject to the production function (27) and a sequence of demand constraints from domestic final goods firms for its variety \( Y_{h,t+k}(z) = Y_{h,t+k}^d(z) \) \( \forall k = 0, 1, \ldots \) that are defined by (25). The average real marginal cost of production are independent of the level of production:

\[ MC_{h,t} = \frac{R_+^{k\alpha} W_t^{1-\alpha}}{\epsilon_{a,t} a^{a} (1 - a)^{-a}} \]

and the problem simplifies to:

\[ \max E_t \left\{ \sum_{k=0}^{\infty} (\xi_p)^k \Theta_{t+k} \left[ \frac{P_{h,t+k|t}^o(z)}{P_t} - MC_{h,t} \right] Y_{h,t+k}(z) \right\} . \quad (33) \]

Since all differentiated firms produce with the same production technology, the optimal price would be chosen by all firms resetting their price in \( t \) and the aggregate producer price level for the home economy evolves according to the following difference equation:

\[ P_{h,t} = (1 - \xi_p)(P_{h,t}^o)G_{t-1}^{-1} \left( \frac{P_{h,t}^{o,t} \tau_{h,t}}{P_{h,t}^o} \right) + \xi_p P_{h,t|t-1}G_{t-1}^{-1} \left( \frac{P_{h,t|t-1}^{o,t} \tau_{h,t}}{P_{h,t}^o} \right). \quad (34) \]
Combining equation 34 with the first order condition associated with the problem (33) gives the standard non-linear price inflation rate of the home good:

\[ \hat{\pi}_P^h = \gamma_p \hat{\pi}_t^P + \beta \left( E_t \hat{\pi}_t^P - \gamma_p \hat{\pi}_t^P \right) - \lambda_p (\hat{m}c_t - \hat{\mu}_{ph,t}^nat), \]

with \( \lambda_p = \frac{(1-\beta_p)(1-\beta\sigma_p)}{\beta_p(1+(M^p-1)c_p)}, \) where \( M^p = \frac{c_p}{\epsilon_p-1} \) and \( \mu_{ph,t} \) respectively denote the price markup and the logarithm of the average price markup and \( \sigma_p \) is the curvature of the Kimball aggregator.

The price setting problem for the export price is set up analogously and an expression similar to (34) holds for the export price level.

4.3.3. International trade and financial markets

As in de Walque et al. (2017) international trade is modeled with an ad hoc assumption on the goods demand from the Rest of the world and transit goods. To bring the model in accordance with trade data, exports of the home economy correspond to a share of the foreign import demand and to changes in the demand from the Rest of the World

\[ X_t = M_t^* \beta_m \epsilon_{nt,t}, \]

with sensitivity parameter \( \beta_m \) and exogenous shock process \( \epsilon_{nt,t} \). Introducing a transit good \( X_t^* \) with a share \( \omega_m \) in the home imports, allows to account for the comovement between home and foreign exports:

\[ M_t = \left( 1 - \omega_m \right)^{1/\lambda_m} (Y_{f,t})^{\lambda_m^{-1}/\lambda_m} + \omega_m^{1/\lambda_m} (X_t^*)^{\lambda_m^{-1}/\lambda_m}, \]

where \( \mu_m \) denotes the elasticity of substitution between both import goods. Correspondingly, the export aggregator is:

\[ X_t = \left( 1 - \omega_x \right)^{1/\lambda_x} (Y_{h,t})^{\lambda_x^{-1}/\lambda_x} + \omega_x^{1/\lambda_x} (X_t^*)^{\lambda_x^{-1}/\lambda_x}, \]

where \( \omega_x \) denotes the share of transit goods in exports and \( \lambda_x \) the corresponding elasticity of substitution. The price of the transit good is assumed to equal the price of foreign consumption goods, thus \( P_{f,t} \) denotes the price of the import aggregate and the price for the export aggregate is:

\[ P_{x,t} = \left( (1 - \omega_x)(P_{h,t}^*)^{1-\lambda_x} + \omega_x (P_{f,t})^{1-\lambda_x} \right)^{1/\lambda_x}. \]

The trade balance is given by \( TB_t = P_{x,t}X_t - P_{f,t}M_t \) and the terms of trade are defined as \( S_t = \frac{P_{nat}}{P_{x,t}}. \) The nominal exchange rate is assumed to be constant and is normalised to
Optimal bond holdings are described by the Euler equations where $\Lambda_t = (C_t - hC_{t-1})^{-1}$ denotes the marginal utility of consumption:

$$\Theta_t = \frac{\Theta^*_t}{\phi_{b,t}}.$$  \hspace{1cm} (40)

Combining the optimal bond holding conditions for home and foreign bonds yields the uncovered interest rate parity which is used to pin down the nominal interest rate.

The nominal resource constraint is derived by inserting the firm profits into the aggregate budget constraint. It pins down the net foreign assets in relation to the trade and the income balance:

$$\Theta^*_t B_{f,t} = TB_t + IB_t + B_{f,t-1}. \hspace{1cm} (41)$$

4.4. Equilibrium

According to the real resource constraint, production equals demand. It is derived by assuming market clearing for each home produced good varieties $z \in [0, 1]$ and using equations (25) and the foreign country counterpart of equation (26):

$$Y_{h,t} = \int Y_{h,t}(z)dz = s_{h,t}Y^d_{h,t} + s^*_hY^*d_{h,t}, \hspace{1cm} (42)$$

where $\Delta^P_t \equiv \int G^{-1}\left(\frac{P_{xt}(z)}{P_{x,t}}, \tau_{x,t}\right)$ is a price dispersion measure and $Y^d_{h,t}$ and $Y^*d_{h,t}$ are defined by equations (23) and (24).

Native and immigrant labour market clearing $N_{h,t} = \int_0^1 \int N_{h,t}(i,z)dz$ and $N_{f,t} = \int_0^1 N_{f,t}(i,z)dz$ implies:

$$N_{h,t} = \Delta^W_{h,t} \int_0^1 N_{h,t}(z)dz, \quad N_{f,t} = \Delta^W_{f,t} \int_0^1 N_{f,t}(z)dz, \hspace{1cm} (43)$$

with native and immigrant wage dispersion terms $\Delta^W_{h,t} = (W_{h,t}(i) / W_{h,t})^{-\epsilon_{wm,t}}$ and $\Delta^W_{f,t} = (W_{f,t}(i) / W_{f,t})^{-\epsilon_{wm,t}}$. Considering the first order approximation of the labor composite $N_t(z) =$
\[(1 - \gamma)N_{h,t}(z) + \gamma N_{f,t}(z)\] and the fact that the first order approximation of the wage dispersion terms is one, it follows that up to the first order \(N_t = \int_0^1 N_t(z)dz\) holds. Combined with the production function (27) and the demand for the firm specific variety (25) the aggregate relation between aggregate employment and output is

\[N_t = \left(\frac{Y_t}{\epsilon_{a,t}}\right)^{1-\alpha} \Delta_P^t, \quad (44)\]

with price dispersion term \(\Delta_P^t = \int \left(\frac{P_{h,t}(z)}{P_{h,t}}\right)^{-1-\alpha} dz\) that is one up to first order such in a linearized version of the model the relation between employment and output is the same on the firm and the aggregate level.\(^{32}\)

The model is closed by assuming that the central bank supplies a monetary asset\(^{33}\) and that due to its systemic position, the central bank can influence the nominal interest rate in order to stabilise the price inflation and the output to their target rates:

\[
\frac{1 + i_t}{1 + \tilde{i}} = \left(\frac{1 + i_{t-1}}{1 + i}\right)^{\rho_I} \frac{\Pi^t \phi_1 y_t \psi_2}{\Pi} \left(1 - \frac{y_t / y_{t-1}}{y_{nat} / y_{nat}^{t-1}}\right) \epsilon_{m,t}, \quad (45)
\]

where \(\Pi\) is the consumer price inflation rate, \(\epsilon_{m,t}\) is a country-specific aggregate money supply shock that follows an AR(1) process in logs, \(\rho_I\) denotes the degree of interest rate smoothing. The target variables are the steady state values. The target weights are set exogenously by empirically observed parameters for the Euro area.\(^{34}\)

5. Impulse response functions - a calibrated version of the model

5.1. Euro area calibration and model fit

The proposed model follows the literature on open economy DSGE models with migration and empirical labor market facts.\(^{35}\) Before applying Bayesian estimation techniques to particular migration corridors in the next section, we calibrate\(^{36}\) the model to quarterly data and a hypothetical (average) euro area migration corridor in order to analyse the theoretical shock responses.\(^{37}\) In order to isolate the effects of migration,\(^{38}\)

\(^{32}\)For a derivation of the first order approximation of \(\Delta_W^t, \Delta_W^{f,t}\) and \(\Delta_P^t\) please refer to Galí (2011b, Appendix A).

\(^{33}\)The monetary asset can be understood as contract between the central bank and the agents of the economy. Everyone is legally obligated to hold one unit of that good on which the central bank pays an interest.

\(^{34}\)See Taylor (1993), Woodford (2001), Taylor and Williams (2010).

\(^{35}\)See e.g. Mandelman and Zlate (2012), Hauser (2014), Dustmann et al. (2010b).

\(^{36}\)See Tables A.8, A.9 and A.10 in Appendix A.4 for the model calibration.

\(^{37}\)We compute the moments for annual and quarterly frequencies for all variables except net migration and find that relative fluctuations and correlations for the key variables are almost equal. See Kim and Loungani (1992).
all firm and trade parameters are assumed to be symmetric across the two countries. We use similar parameter values as in Smets et al. (2014) who estimate a benchmark closed economy DSGE model without migration for the the euro area over the period 1984Q1–2009Q4. We also use the same interest rate targets for the central bank’s policy function, which is not derived as optimal monetary policy. Open economy parameters are similar to the mode of the estimates of the two country model by de Walque et al. (2017). Migration parameters are calibrated in line with the relevant literature and observed empirical facts.

In both countries the share of euro area migrants in total employment is set to $\gamma = 0.07$, which is the unweighted EA average without Germany. For the substitution elasticity of a migrant worker Empirical estimates of the elasticity of substitution underline that in the euro area natives and immigrants within the same skill group are imperfect substitutes. E.g. for Germany Brücker et al. (2014a) estimate the elasticity to be 6.7, which is slightly lower than the value of 7.0 obtained by Brücker and Jahn (2011) and 7.4 by Felbermayr et al. (2010). We choose a higher value $\theta = 7$ than Mandelman and Zlate (2012) who assume the substitution elasticity between Mexican and U.S. American workers to be 1.55. The labour market parameter for natives capture an average native unemployment rate of $u_h = 1 - \frac{N_h}{(1-\gamma)L_h} \approx 1 - \frac{1}{\psi_n} \approx 9.2\%$. Modeling differences between native and migrant workers within one country with respect to their preferences and labor mobility parameters allows us to replicate empirically observed wage, unemployment and participation gaps between both groups of workers.

We calibrate the average wage markup of migrants $\mu_{wm} = 1.40$ to be lower than for natives in order to match the empirically observed average native-migrant wage gap of 3.2%. It can be argued that the bargaining power of migrants is lower than for natives. In order to additionally capture the higher average migrant-native unemployment gap of 17%, we set the inverse Frisch elasticity of migrant labor supply lower than for natives to $\psi_m = 4.32$. Therefore the steady state unemployment rate is 9.3% which is a workforce-weighted average of the native unemployment rate (9.2%) and the immigrant unemployment rate of (10.8%). We assume that migrants adjust their wages at the same frequency than natives.

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 the relied shocks from their distributions and simulate 15000 periods to extract the standard deviations conditional on all shocks and the correlations from the structural model. The results are summarised in Table 2 and A.11.

Table 2 compares key statistics for the migration cycle in the EA-12 for the period

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38See ECB (2014).
39Because of the relatively high education level in all countries of the euro area we expect migrants to be relatively similar with respect to the skill level.
40See table A.4. In the long-run one can argue that these differences may - in case of full assimilation - diminish over time. However, in our model even in steady state workers move in both directions such that the gaps will persist.
41See Dustmann et al. (2010b),Jean et al. (2010).
Table 2: Empirical vs. theoretical moments – Migration cycle

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclicality ($\rho(dy, nm)$)</td>
<td>0.17</td>
<td>0.10</td>
</tr>
<tr>
<td>Unemployment rate differential ($\rho(du, nm)$)</td>
<td>-0.31</td>
<td>-0.29</td>
</tr>
<tr>
<td>Real wage differential ($\rho(dw, nm)$)</td>
<td>-0.10</td>
<td>-0.13</td>
</tr>
</tbody>
</table>

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

1Q1980–4Q2010 in the data and the simulated model. The correlation of the net migration rate and the differentials of output, unemployment and real wage show the right sign and in case of the former two are very close in magnitude. Table A.11 underlines that the calibration of our model is able to match the average euro area business cycle for the respective period. Summarising our results, we find that our model fits suitable well to describe migration flows over the business cycle in the euro area.

5.2. Dynamic responses to shocks

In this section we describe the interrelation of migration patterns and business cycle dynamics from the perspective of the domestic economy. Our results show that for a relatively low migrant share allowing for migration does not significantly change the dynamic pattern of the output and inflation gap. In Figure A.6 in Appendix A.5 this becomes evident for the TFP shock. Therefore the guiding questions for the analysis relate to our empirical findings. Firstly, we want to explain the finding that in the average euro area corridor both, the unemployment and the wage differential, are negatively correlated with net migration. Secondly, we aim at identifying factors that provide explanations for the observed heterogeneity across corridors.

We simulate the behaviour domestic aggregate variables to seven shocks in the domestic economy, that are subsumed under the categories supply, demand and labour market. Figures A.6 - A.8 in Appendix A.5 show the impulse responses of output, employment, real wage, labour supply, unemployment, real wages, net migration, emigration share, immigration share and net migrant stock. It is evident that within each category shocks have quite similar effects on the net migration dynamics. The price mark-up shock and the TFP shock, referred to as supply shocks (Figure A.6), drive output and inflation in opposite directions and lead to an immediate decrease in the net migration rate. The discount factor shock, the government spending shock and the investment affect the demand side of the economy (Figure A.7). Increasing output and prices are typically the result of a positive demand shock that also increase the inflow of migrants relative to the outflow of native workers. Thus, both categories of shocks have in common that they drive real wages and employment in the same direction. In contrast, labor market shocks (Figure A.8) drive real wages and employment in different direction. We analyse a labor supply shock, a wage mark-up shock as in Galí et al. (2012b) and by by adding

\[42\] All shocks are uniquely identified.
a migration-cost shock we are able to identify a third labour market shock. While a decreasing labour supply due to a lower labour force participation pushes wages but reduces unemployment, a wage-markup shock shifts both variables in the same direction. The migration-cost shock adversely affects migrants’ and natives’ labour market outcomes.

In the next section we use a neutral technology shock, a discount factor shock as prototype of the business cycle shock category to explain the observed relationship between net migration and its main determinants in more detail. To account for the distinctness of the labour market shocks, we investigate them separately.

**TFP shock**

As can be seen in Figure A.6, a positive domestic neutral technology shock (represented by the solid line) leads to decreasing marginal costs and aggregate producer prices.43

Because of price rigidities, some producers cannot reset their prices immediately but instead reduce their labor demand. Consequently, workers want to reduce their wage in order to remain employed. The extent to which adjusting workers are willing to reduce their wage depends on the inverse Frisch elasticity. Similarly to the firm side, not all types of workers can react to the shrinking demand by reducing their nominal wage such that the fraction of unemployed workers is higher for types than cannot adjust their wages. The decrease in price inflation is more pronounced than in wage inflation and the real wage and structural unemployment rise temporary. As a consequence of the higher domestic neutral technology, foreign goods become relatively more expensive and are demanded less via the terms of trade channel. The reduced output incentivises foreign firms and workers to cut prices and wages. Again, the interplay of staggered prices and nominal wage rigidity causes real wages to rise and thus, structural unemployment rises temporary. However, the overall effect on real wages and unemployment is stronger in the domestic economy where the shock originated. Therefore, we observe the real wage and the unemployment rate differential between home and foreign to be positive. While the positive real wage differential will be persistent, the unemployment differential vanishes after some periods, because price reduction and real wage gains will lead to a positive demand reaction.

If labor is free to move between both countries and migrant workers are substitutable to domestic workers and are demanded by a fraction $\gamma$, workers in home and foreign readjust the share of emigrating families as described by equation (9). Home and foreign households expect labor demand to decrease relatively stronger in home which goes in hand with a positive unemployment differential. Therefore, they reduce their nominal

---

43It is well known from the business cycle literature that in case of sluggish prices and wages, neutral technology shocks can lead to a temporary decrease of employment. See Erceg et al. (2000), Gali (1999), and Gali et al. (2012b). This is in contrast to the results of conventional real business cycle or search and matching models. The explanation for the difference is that with sluggish prices, neutral technology shocks increase the potential (flexible price) output level above the actual (rigid price) output level. Thus, the resulting output gap is negative, leading to a reduction in prices and quantities, i.e. employment.
wage in the domestic market and shift a higher fraction of labor supply to the foreign labor market. Consequently, the emigration rate increased and the immigration rate in decreases initially in the domestic economy as can be seen in Figure A.6. At the same time, domestic households expect future wage and unemployment differences between home and foreign labor markets to be more favorable in the home country. Because, they expect prices and unemployment to fall while real wages still increase. Therefore, the net migration turns positive from the perspective of the domestic country after some periods. Overall, the time pattern of the positive domestic demand shock thus can explain the negative relationships between net migration and the unemployment differential. However, in case of the negative correlation with the real wage differential it stays ambiguous.

Discount factor shock

An increase of the domestic discount factor in Figure A.7 (represented by the solid line) leads to a preference shift from consumption tomorrow to consumption today which increases the demand for domestically and foreign produced goods from the perspective of the home country. This leads to higher domestic production, employment and wages which transmits into higher price and wage inflation rates. To stabilize the price inflation, interest rates will go up which dampens the initial demand effect on output and employment. Because of higher employment demand the unemployment rate decreases but higher real wages will lead to a convergence back to the natural rate after around one year. A similar pattern can be observed for the foreign economy but here decreasing unemployment goes along with lower nominal wage increases. Thus, the domestic real wage rate increases by more while the domestic unemployment decreases by smaller rate than its foreign counterpart. There are two channels that drive the migration reaction on discount factor shocks. First, the simultaneous relative decrease in the unemployment rate and increase in the real wage provides an incentive to locate labour to the home labour market. Consequently, the emigration rate is reduced and the immigration rate increased. Second, it is assumed that migrant workers consume at home. Therefore, its their home country discount factor that is important for the migration decision. If the preference shock for consuming today affects emigration, migrants will move out of the country even if wages increase and unemployment decrease. In other words, a discount factor shock and more generally demand shocks explain the positive cyclical correlation of migration and wages as well as the observed negative correlation with unemployment.

Labor market shocks

For the same set of parameters we also investigate a positive labor supply shock in Figure A.8 (represented by the solid line). A positive domestic labor supply shock increases the labour force participation of native and immigrant workers in the home economy. The increase in the labor force incentivises workers to lower their wage, however due to the nominal wage rigidity the nominal wage deflation is lower than desired in order to keep unemployment at its steady state level. The shock affects output via
lower wages that reduce the marginal cost of firms and an increased employment in firms that can readjust their price. However, the nominal wage decrease is stronger than the price decrease and overall the real wage decreases.

In the foreign economy we observe only a negligible increase in both, real wages and unemployment which comes from the changes in relative prices. All together we observe a negative real wage differential and a positive unemployment differential. Consequently, in presence of a positive labor supply shock we observe a negative net migration.

In comparison to other labour market shocks, a wage-mark-up shock differs from an increase in labour supply due to its affect on unemployment.\(^{44}\) While an increase in labour supply leads to an oppositional effect on real wages and unemployment, a wage-mark-up shock drives both variables in the same direction. On the other hand it can distinguished from TFP shocks - which are characterized with a similar labour market reaction scheme - because of its negative output reaction. The migration reaction depends on the relative importance of the wage vs. unemployment differential in the endogenous migration decision (9). For our benchmark calibration the effect of the unemployment differential dominates and we observe an increase in the emigration rate and a decrease in the immigration. Thus the wage markup shock, that according to Smets et al. (2014) accounts for up to 27 per cent of the unemployment movement in the euro area, can explain the negative correlation of the real wage differential and net migration in the data. The last shock we want to analyze is an increase of migration costs. We can imagine that migration costs are either specific preferences for working at home (home bias) or some real institutional burden which arise exogenously in the model. A negative migration cost shock can thus be a reduction of the home bias, due to some exogenous event in the home country that affects utility, i.e. war, crisis. It could also be the reason of reducing real costs, i.e. by improving the process of admission of external degrees. A decrease of such costs in home goes clearly hand in hand with an increasing net immigration rate. The labour market effects can now be clearly disentangled. In contrast, to the labour supply shock with a migration shock we observe a positive correlation between labour supply and net migration, that is mainly driven by the assumption of purely labour-market related migration. Furthermore, it increases unemployment up to one year but reduces wages over the whole observation period. However, because of the imperfect financial markets migration is also used as additional vehicel to stabilise cross-country business cycle fluctuations. A reduction of its costs will increase consumption directly after some periods. Additional output can be produced at lower labour costs than without migrants, leading to a reduction of unemployment after the first year. Thus, the initial labour market effect is similar as in case of the labour supply shock, but after one year unemployment becomes negative. This second feature is also what migration cost shock distinguished from wage-mark-up shock.

\(^{44}\)Wage-mark-up shock can be further distinguished by using a search and matching framework. In principal it is most comparable to a wage bargaining shock.
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 with imperfect international labour and financial markets. In particular, we focus on the wage markup and nominal wage rigidity as sources of unemployment fluctuations.

By starting with a summary of the empirical evidence on euro area migration patterns, we find internal migration to be mostly work-related and of temporary nature. With respect to the determinants of migration, the recent crisis experience is insightful because it involved a strong increase in unemployment dispersion and a redirection of migration flows towards countries with lower unemployment (e.g. Germany). This observation points towards the importance of a theoretical migration model that includes both, wages and unemployment differences, as key driving forces of migration fluctuations over the business cycle.

Our subsequent empirical analysis of bilateral migration and macroeconomic data over the years 1Q1980-4Q2010 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. In case of unemployment the correlation is stronger and peaks at the contemporaneous correlation, while the wage differential leads the net migration rate by one to two periods. Across corridors we find a considerable heterogeneity in both dimensions that is more pronounced in the case of wage differentials.

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 labour market frictions and rigidities in both countries. Our model features a novel approach to implement an endogenous migration decision which is separated from the labour supply decision. Our calibrated model is able to replicate all three empirical observations. We calibrate the model to the euro area and show that it is able to replicate the business and migration cycle in the euro area.

Regarding the empirical findings with supply and demand shocks real wage differentials are positively and unemployment differential are negatively correlated with net migration. Consequently, the heterogeneous cross-corridor migration patterns we find in case of typical supply and demand shocks, the net migration rate is positively correlated with the wage differential and negatively correlated with the unemployment differential. Thus, dynamic behavior subsequent typical business shocks can not fully explain the empirically observed correlations. In contrast, labour market shocks can explain more distinct patterns shaping the relationship between wages, unemployment and thus migration flows during the business cycle. A wage markup shock, i.e. increasing wage-setting power of labour unions, can account for the negative correlation of net migration and the real wage differential over the cycle. Furthermore, we
implement a migration specific shock that affects the costs of immigration. A temporary reduction of immigration costs, i.e. due to integration policies, fosters labour mobility. It reduces the average wage and average unemployment and increases the output in the domestic country.

6.1. Acknowledgments

The authors are grateful for helpful comments and suggestions from Michael Burda, Maik Heinemann, Lutz Weinke, Julien Albertini and the participants of the Conference of Computational Economics and Finance 2016, the 11th Dynare Conference, Verein fr Socialpolitik and Research Seminars at the University of Potsdam, HU Berlin.
Appendix A. Empirical part

Appendix A.1. Euro area migration statistics

Table A.3: Net migration in the euro area between 2009 and 2012

<table>
<thead>
<tr>
<th>Period</th>
<th>Average net migration rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005-08</td>
</tr>
<tr>
<td>Austria</td>
<td>4.15</td>
</tr>
<tr>
<td>Belgium</td>
<td>5.10</td>
</tr>
<tr>
<td>Finland</td>
<td>2.18</td>
</tr>
<tr>
<td>France</td>
<td>1.42</td>
</tr>
<tr>
<td>Germany</td>
<td>0.27</td>
</tr>
<tr>
<td>Greece</td>
<td>3.48</td>
</tr>
<tr>
<td>Ireland</td>
<td>10.94</td>
</tr>
<tr>
<td>Italy</td>
<td>5.79</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>13.20</td>
</tr>
<tr>
<td>Netherlands</td>
<td>-0.60</td>
</tr>
<tr>
<td>Portugal</td>
<td>1.50</td>
</tr>
<tr>
<td>Spain</td>
<td>13.82</td>
</tr>
</tbody>
</table>

The net migration rate is defined as immigration minus emigration divided by 1000 population.
– denotes missing data.
Source: OECD (2014).
Table A.4: Intra EA-12 Native vs. immigrant unemployment rate

<table>
<thead>
<tr>
<th>Country</th>
<th>natives</th>
<th>immigrants</th>
<th>immigrant-native 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>
</tr>
<tr>
<td>France</td>
<td>11.9</td>
<td>11.25</td>
<td>0.94</td>
</tr>
<tr>
<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>
</tr>
<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>

Data for Intra-EA-12 immigrant unemployment is not available for the Netherlands.
Source: OECD Migration Database. OCED Data are extracted from the labour force surveys, provided by Eurostat and averaged over the period 1998-2002.
Appendix A.2. Data description

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

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


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


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

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

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


Emigration: Bilateral immigration flows, International Migration Flows to and from Selected Countries: The 2008 Revision, UN, 2008. Missing values for the periods after 2008 are estimated with data from the 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.
Table A.5: List of all corridors

<table>
<thead>
<tr>
<th>Sending country</th>
<th>AT</th>
<th>BE</th>
<th>DE</th>
<th>EL</th>
<th>ES</th>
<th>FI</th>
<th>FR</th>
<th>IE</th>
<th>IT</th>
<th>LU</th>
<th>NL</th>
<th>PT</th>
<th>Σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>–</td>
<td>80(B)</td>
<td>80(F)</td>
<td>[96(F)]</td>
<td>83(F)</td>
<td>80(B)</td>
<td>[96(F)]</td>
<td>86(F)</td>
<td>[96(F)]</td>
<td>80(B)</td>
<td>80(B)</td>
<td>[96(F)]</td>
<td>7(11)</td>
</tr>
<tr>
<td>BE</td>
<td>80*(F)</td>
<td>–</td>
<td>80(F)</td>
<td>80*(B)</td>
<td>80*(F)</td>
<td>80(B)</td>
<td>80*(F)</td>
<td>80(F)</td>
<td>80*(F)</td>
<td>80(F)</td>
<td>80*(F)</td>
<td>80(B)</td>
<td>11(11)</td>
</tr>
<tr>
<td>DE</td>
<td>80*(F)</td>
<td>80(B)</td>
<td>–</td>
<td>80*(F)</td>
<td>80*(F)</td>
<td>80(B)</td>
<td>80*(F)</td>
<td>80(F)</td>
<td>80*(F)</td>
<td>80(F)</td>
<td>80*(F)</td>
<td>80(B)</td>
<td>11(11)</td>
</tr>
<tr>
<td>EL</td>
<td>[96(F)]</td>
<td>80(B)</td>
<td>80(F)</td>
<td>–</td>
<td>83(F)</td>
<td>80(B)</td>
<td>85*(F)d</td>
<td>85(F)xx</td>
<td>86(F)</td>
<td>x</td>
<td>80(B)</td>
<td>85*(F)xx</td>
<td>6(10)</td>
</tr>
<tr>
<td>ES</td>
<td>85*(F)</td>
<td>80(B)</td>
<td>80(F)</td>
<td>85*(F)</td>
<td>–</td>
<td>80(B)</td>
<td>85*(F)</td>
<td>88(F)</td>
<td>86(F)</td>
<td>80(F)</td>
<td>80(B)</td>
<td>85*(F)</td>
<td>11(11)</td>
</tr>
<tr>
<td>FI</td>
<td>80*(F)</td>
<td>80(B)</td>
<td>80(F)</td>
<td>80*(F)</td>
<td>80*(F)</td>
<td>–</td>
<td>80*(F)</td>
<td>80(F)</td>
<td>80*(F)</td>
<td>80(F)</td>
<td>80*(F)</td>
<td>80(B)</td>
<td>11(11)</td>
</tr>
<tr>
<td>FR</td>
<td>[96(F)]</td>
<td>80(B)</td>
<td>80(F)</td>
<td>x</td>
<td>83(F)</td>
<td>80(B)</td>
<td>–</td>
<td>x</td>
<td>86(F)</td>
<td>80(F)</td>
<td>80(B)</td>
<td>92*(F)</td>
<td>8(9)</td>
</tr>
<tr>
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<td>80(B)</td>
<td>80(F)</td>
<td>x</td>
<td>83(F)</td>
<td>80(B)</td>
<td>92(F)xx</td>
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<td>86(F)</td>
<td>x</td>
<td>80(B)</td>
<td>x</td>
<td>6(8)</td>
</tr>
<tr>
<td>IT</td>
<td>86*(F)</td>
<td>80(B)</td>
<td>80(F)</td>
<td>86*(F)</td>
<td>83(F)</td>
<td>80(B)</td>
<td>86*(F)</td>
<td>86(F)</td>
<td>–</td>
<td>80(F)</td>
<td>80(B)</td>
<td>86*(F)</td>
<td>11(11)</td>
</tr>
<tr>
<td>LU</td>
<td>80*(F)</td>
<td>80(B)</td>
<td>80(F)</td>
<td>80*(F)xx</td>
<td>80*(F)</td>
<td>80(B)</td>
<td>80*(F)</td>
<td>80(F)xx</td>
<td>80*(F)</td>
<td>–</td>
<td>80(B)</td>
<td>80*(F)</td>
<td>9(11)</td>
</tr>
<tr>
<td>NL</td>
<td>80*(F)</td>
<td>80(B)</td>
<td>80(F)</td>
<td>80*(B)</td>
<td>80*(F)</td>
<td>80(B)</td>
<td>80*(F)</td>
<td>80(F)</td>
<td>80*(F)</td>
<td>80(F)</td>
<td>–</td>
<td>80*(B)</td>
<td>11(11)</td>
</tr>
<tr>
<td>PT</td>
<td>[96(F)]</td>
<td>80(B)</td>
<td>80(F)</td>
<td>x</td>
<td>83(F)</td>
<td>80(B)</td>
<td>92(F)</td>
<td>x</td>
<td>86(F)</td>
<td>80(F)</td>
<td>80(B)</td>
<td>–</td>
<td>8(9)</td>
</tr>
</tbody>
</table>

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

Corridor is not considered in the baseline estimation due to limited available time periods. Corridor is considered within the robustness check.

x No data available.
xx Corridors dropped because of the missing data on net migration.
* Initial year of data availability is 1980.
* Estimated with immigration/emigration statistics from the receiving country.
(F): Foreign citizens only.
(B): Both, foreign and domestic country citizens.
Appendix A.3. Euro area business and migration cycle facts

Table A.6: Empirical euro area business cycle

<table>
<thead>
<tr>
<th>Variable (x)</th>
<th>$\sigma(x)/\sigma(y)$</th>
<th>$\rho(x,y)$</th>
<th>$\rho(x,x^*)$</th>
<th>$\rho(dx,nm)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real output (y)</td>
<td>1</td>
<td>1</td>
<td>0.57</td>
<td>0.17</td>
</tr>
<tr>
<td>Real consumption (c)</td>
<td>0.81</td>
<td>0.79</td>
<td>0.42</td>
<td>0.12</td>
</tr>
<tr>
<td>Labour force (l)</td>
<td>0.39</td>
<td>0.43</td>
<td>0.14</td>
<td>0.12</td>
</tr>
<tr>
<td>Employment (n)</td>
<td>0.76</td>
<td>0.69</td>
<td>0.41</td>
<td>0.25</td>
</tr>
<tr>
<td>Unemployment rate (u)</td>
<td>0.48</td>
<td>-0.68</td>
<td>0.39</td>
<td>-0.31</td>
</tr>
<tr>
<td>Real wage (w)</td>
<td>0.68</td>
<td>0.17</td>
<td>0.52</td>
<td>-0.10</td>
</tr>
<tr>
<td>Net migration rate (nm)</td>
<td>1.55</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

$\sigma(x)/\sigma(y)$ denotes the ratio of the standard deviation of variable $x$ and the standard deviation of output, $\rho(x,z)$ denotes the contemporaneous correlation of variable $x$ and variable $z$, $^*$ denotes values for the other country in a corridor and $dx$ denotes the corridor differential of a variable $x$.

Table A.7: Empirical euro area business cycle robustness - Net migration (nm)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\lambda$ 400</td>
<td>400</td>
<td>6.25</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Fluctuation ($\sigma(nm)/\sigma(y)$)</td>
<td></td>
<td>1.55</td>
<td>1.35</td>
<td>2.00</td>
<td>1.64</td>
</tr>
<tr>
<td>Cyclicality ($\rho(dy,nm)$)</td>
<td></td>
<td>0.17*</td>
<td>0.19*</td>
<td>0.13*</td>
<td>0.13*</td>
</tr>
<tr>
<td>Unemployment rate diff. ($\rho(du,nm)$)</td>
<td></td>
<td>-0.31*</td>
<td>-0.16*</td>
<td>-0.13*</td>
<td>-0.21*</td>
</tr>
<tr>
<td>Real wage diff. ($\rho(dw,nm)$)</td>
<td></td>
<td>-0.10*</td>
<td>-0.03</td>
<td>0.04</td>
<td>-0.006</td>
</tr>
</tbody>
</table>

For notation see Table 1. $^*$ denotes 95%-Significance over all corridors.
Figure A.4: Four types of migration corridors

<table>
<thead>
<tr>
<th>id</th>
<th>Countries</th>
<th>id</th>
<th>Countries</th>
<th>id</th>
<th>Countries</th>
<th>id</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AT BE</td>
<td>16</td>
<td>BE PT</td>
<td>31</td>
<td>FR PT</td>
<td>46</td>
<td>IT LU</td>
</tr>
<tr>
<td>2</td>
<td>AT FI</td>
<td>17</td>
<td>BE ES</td>
<td>32</td>
<td>FR ES</td>
<td>47</td>
<td>IT NL</td>
</tr>
<tr>
<td>3</td>
<td>AT DE</td>
<td>18</td>
<td>FI FR</td>
<td>33</td>
<td>DE EL</td>
<td>48</td>
<td>IT PT</td>
</tr>
<tr>
<td>4</td>
<td>AT IT</td>
<td>19</td>
<td>FI DE</td>
<td>34</td>
<td>DE IE</td>
<td>49</td>
<td>IT ES</td>
</tr>
<tr>
<td>5</td>
<td>AT LU</td>
<td>20</td>
<td>FI EL</td>
<td>35</td>
<td>DE IT</td>
<td>50</td>
<td>LU NL</td>
</tr>
<tr>
<td>6</td>
<td>AT NL</td>
<td>21</td>
<td>FI IE</td>
<td>36</td>
<td>DE LU</td>
<td>51</td>
<td>LU PT</td>
</tr>
<tr>
<td>7</td>
<td>AT ES</td>
<td>22</td>
<td>FI IT</td>
<td>37</td>
<td>DE NL</td>
<td>52</td>
<td>LU ES</td>
</tr>
<tr>
<td>8</td>
<td>BE FI</td>
<td>23</td>
<td>FI LU</td>
<td>38</td>
<td>DE PT</td>
<td>53</td>
<td>NL PT</td>
</tr>
<tr>
<td>9</td>
<td>BE FR</td>
<td>24</td>
<td>FI NL</td>
<td>39</td>
<td>DE ES</td>
<td>54</td>
<td>NL ES</td>
</tr>
<tr>
<td>10</td>
<td>BE DE</td>
<td>25</td>
<td>FI PT</td>
<td>40</td>
<td>EL IT</td>
<td>55</td>
<td>PT ES</td>
</tr>
<tr>
<td>11</td>
<td>BE EL</td>
<td>26</td>
<td>FI ES</td>
<td>41</td>
<td>EL NL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>BE IE</td>
<td>27</td>
<td>FR DE</td>
<td>42</td>
<td>EL ES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>BE IT</td>
<td>28</td>
<td>FR IT</td>
<td>43</td>
<td>IE IT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>BE LU</td>
<td>29</td>
<td>FR LU</td>
<td>44</td>
<td>IE NL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>BE NL</td>
<td>30</td>
<td>FR NL</td>
<td>45</td>
<td>IE ES</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Austria (AT), Belgium (BE), Germany (DE), Spain (ES), Greece (EL), Finland (FI), France (FR), Ireland (IE), Italy (IT), Luxembourg (LU), Netherlands (NL), Portugal (PT).
### Appendix A.4. Calibration and model fit

Table A.8: Calibration - Parameters

<table>
<thead>
<tr>
<th>Structural parameters</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production elasticity</td>
<td>( \alpha = 0.22 )</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Time preference rate</td>
<td>( \rho = 0.24 )</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Depreciation rate</td>
<td>( \delta = 0.025 )</td>
<td>calibration SWW2014</td>
</tr>
<tr>
<td>External habit persistence</td>
<td>( h = 0.65 )</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Consumption smoothing</td>
<td>( \nu = 0.06 )</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Price Mark-up</td>
<td>( \mu_p = 1.48 )</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Curvature Kimball aggregator</td>
<td>( \sigma_p = 10 )</td>
<td>calibration SWW2014</td>
</tr>
<tr>
<td>Price adjustment</td>
<td>( \tilde{\xi}_p = 0.85 )</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Price indexation</td>
<td>( \gamma_p = 0.22 )</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Wage indexation</td>
<td>( \gamma_w = 0.22 )</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Capital utilization costs</td>
<td>( k^K = 4.65 )</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Capital utilization cost elast.</td>
<td>( \phi = 0.46 )</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Government share</td>
<td>( g = 0.18 )</td>
<td>calibration SWW2014</td>
</tr>
<tr>
<td>Trend growth</td>
<td>( \tau = 0.34 )</td>
<td>EA average</td>
</tr>
<tr>
<td>Trend inflation</td>
<td>( \pi = 0.45 )</td>
<td>EA average</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trade parameters</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Openness</td>
<td>( \omega = 0.34 )</td>
<td>( \bar{q} = 1 )</td>
</tr>
<tr>
<td>Trade elasticity</td>
<td>( \mu = 3.9 )</td>
<td>Corbo&amp;Osbat(2013)</td>
</tr>
<tr>
<td>Share transfer good in imports</td>
<td>( \omega_m = 0.35 )</td>
<td>mode of estimates De Walque et al(2017)</td>
</tr>
<tr>
<td>Elasticity of substitution imports</td>
<td>( \lambda_m = 1.5 )</td>
<td>mode of estimates De Walque et al(2017)</td>
</tr>
<tr>
<td>Share transfer good in exports</td>
<td>( \omega_x = 0.3 )</td>
<td>mode of estimates De Walque et al(2017)</td>
</tr>
<tr>
<td>Elasticity of substitution exports</td>
<td>( \lambda_x = 1.5 )</td>
<td>mode of estimates De Walque et al(2017)</td>
</tr>
<tr>
<td>Export sensitivity to foreign imports</td>
<td>( \beta_m = 0.15 )</td>
<td>EA average</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Policy parameters</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest rate smoothing</td>
<td>( \rho_i = 0.86 )</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Price inflation target</td>
<td>( \phi_{\pi} = 1.25 )</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Output gap target</td>
<td>( \phi_y = 0.19 )</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Growth target</td>
<td>( \phi_{\Delta y} = 0.02 )</td>
<td>mode of estimates SWW2014</td>
</tr>
</tbody>
</table>
Table A.9: Calibration - Parameters

<table>
<thead>
<tr>
<th>Migration parameters</th>
<th>Value</th>
<th>Target</th>
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</thead>
<tbody>
<tr>
<td>Share of migrant worker</td>
<td>$\gamma = 0.07$</td>
<td>EA average</td>
</tr>
<tr>
<td>SE of migrant work</td>
<td>$\theta = 7$</td>
<td>Brücker and Jahn (2011)</td>
</tr>
<tr>
<td>Native LS elasticity</td>
<td>$\psi_n = 5.57$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Migrant LS elasticity</td>
<td>$\psi_{m} = 4.3279$</td>
<td>$u^*_h / u_h = 1.17$</td>
</tr>
<tr>
<td>Native wage adjustment</td>
<td>$\xi_{wn} = 0.84$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Migrant wage adjustment</td>
<td>$\xi_{wm} = 0.84$</td>
<td>equals native wage adjustment</td>
</tr>
<tr>
<td>Native wage mark-up</td>
<td>$\mu_{wn} = 1.44$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Migrant wage mark-up</td>
<td>$\mu_{wm} = 1.40$</td>
<td>$w_h / w^*_h = 1.032$</td>
</tr>
<tr>
<td>Scaling parameter migration disutility</td>
<td>$\chi_{\gamma} = 0.04$</td>
<td>$\gamma = 0.07$</td>
</tr>
<tr>
<td>Elasticity of living abroad</td>
<td>$\psi_{\gamma} = 1$</td>
<td>linear realationship</td>
</tr>
<tr>
<td>Curvature migration adjustment cost</td>
<td>$\phi_{\gamma} = 10$</td>
<td>$&gt; k^K$</td>
</tr>
</tbody>
</table>

$\xi_{WN}$ and $\Pi$ denote the country averages over native and immigrant workers.

Table A.10: Calibration - Shocks

<table>
<thead>
<tr>
<th>Persistence</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistence neutral technology</td>
<td>$\rho_A = 0.98$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Persistence government spending</td>
<td>$\rho_G = 0.99$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Persistence discount factor</td>
<td>$\rho_D = 0.93$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Persistence investment</td>
<td>$\rho_I = 0.36$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Persistence monetary policy</td>
<td>$\rho_M = 0.30$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Persistence labour supply</td>
<td>$\rho_L = 0.8$</td>
<td>mode of estimates SWWW2014</td>
</tr>
<tr>
<td>Persistence price mark-up</td>
<td>$\rho_P = 0.44$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Persistence wage mark-up</td>
<td>$\rho_W = 0.91$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>MA price mark-up</td>
<td>$\rho_{MA} = 0.1$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>MA wage mark-up</td>
<td>$\rho_{WM} = 0.68$</td>
<td>mode of estimates SWW2014</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government spending &amp; technology</td>
<td>$\rho_{GA} = 0.18$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>Cross country technology</td>
<td>$\rho_{AA^*} = 0.2$</td>
<td>mode of estimates SWW2014</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard deviation</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD neutral technology</td>
<td>$\varsigma_A = 0.58$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>SD government</td>
<td>$\varsigma_G = 0.31$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>SD discount factor</td>
<td>$\varsigma_D = 0.24$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>SD investment</td>
<td>$\varsigma_I = 0.49$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>SD monetary policy</td>
<td>$\varsigma_M = 0.11$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>SD labour supply</td>
<td>$\varsigma_L = 1.14$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>SD price mark-up</td>
<td>$\varsigma_P = 0.12$</td>
<td>mode of estimates SWW2014</td>
</tr>
<tr>
<td>SD wage mark-up</td>
<td>$\varsigma_W = 0.30$</td>
<td>mode of estimates SWW2014</td>
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Table A.11: Empirical vs. theoretical moments – Business cycle

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\sigma(x)/\sigma(y)$</th>
<th>$\rho(x, y)$</th>
</tr>
</thead>
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<tr>
<td></td>
<td>EA-12 data</td>
<td>Model</td>
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<tr>
<td>Real output ($y$)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Real consumption ($c$)</td>
<td>0.81 0.79</td>
<td>0.76 0.82</td>
</tr>
<tr>
<td>Labour force ($l$)</td>
<td>0.39 0.31</td>
<td>0.43 0.29</td>
</tr>
<tr>
<td>Employment ($n$)</td>
<td>0.76 0.72</td>
<td>0.69 0.93</td>
</tr>
<tr>
<td>Unemployment rate ($u$)</td>
<td>0.48 0.68</td>
<td>-0.68 -0.71</td>
</tr>
<tr>
<td>Real wage ($w$)</td>
<td>0.68 0.60</td>
<td>0.17 0.37</td>
</tr>
</tbody>
</table>

For notation see Table 1. Model refers to the symmetric calibration of the model.
Appendix A.5. Impulse response functions

Figure A.5: Labour mobility vs. immobile labour
Figure A.6: Supply Shocks
Figure A.7: Demand shocks
Figure A.8: Labor market shocks
References

URL www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/Bevoelkerung


URL http://dx.doi.org/10.1111/jmcb.12151


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