

Migration, Unemployment and the Business Cycle - A Euro Area Perspective - ¹

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Abstract

In the recent European debt crisis, internal migration flows in the euro area reacted strongly to diverging labor market conditions. This experience points towards the prominent role of short-term business cycle migration in the euro area and the consequent need to understand the motives behind it. We start by an empirical investigation of the business cycle in 59 bilateral migration corridors in the Euro12 over the period 1980-2010 and find three noteworthy facts. Firstly, unemployment differentials seem to be an important driving force of internal migration. Secondly, in a majority of corridors the relationship between real wage differentials and intra-euro area net migration is puzzling. Thirdly, across migration corridors there is a considerable heterogeneity with respect to the correlation of net migration and the real wage respectively unemployment differential. 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 labor market frictions and rigidities in both countries. Our model is able to replicate all three empirical observations and explains the heterogeneity of migration corridors by differences in the type of shock that hits an economy and the relative price/wage rigidity. Our paper is related to the existing literature that quantifies the effects of migration and unemployment and bridges it to DSGE models with unemployment. Further, we contribute to the recently growing literature that investigates the causes and consequences of temporary migration.

Keywords: Labor Migration, International Business Cycles, Unemployment

JEL: E24, F22, F41

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1. Introduction

In a currency union of heterogeneous member countries migration is a potential adjustment mechanism to abate relative business cycle fluctuations under a common monetary policy. Starting with the work of Mundell (1961), labor mobility is an important criterion for an optimum currency area. Within the euro area, free movement of labor is legally guaranteed⁴ and reduces the migration cost of both, employed and unemployed workers. Despite the absence of migration restrictions, Beyer and Smets (2014) consider migration flows between euro area countries too little to act as a main stabilization tool and in this context refer to the cultural, language and institutional difference in Europe.⁵ On the contrary, Jauer et al. (2014) find that on average the absorption of one quarter of an asymmetric labor market shock can be attributed to migration in the European Union. This dissent notwithstanding, European policy makers highlight migration as a means to increase overall employment against the background of heterogeneous labor market conditions (ECB, 2014).⁶

At the same time, there is a lot of discussion about opening up national labor markets to immigrants from the free movement area. A prominent case is the United Kingdom where the government in 2010 formulated the ‘net migration target’ which aims at reducing net migration substantially (Wadsworth, 2015). Against the background of a continuing positive net immigration, there is a fear of downward pressure on wages and growing unemployment among natives. Clearly, this national policy is at odds with the European free movement policy, such that these two poles span the area of conflict of internal migration in the euro area and underline the need to understand its nature and determinants.

During the European financial and debt crisis migration flows changed markedly on the euro area and the country level. Therefore, the crisis incidence sheds light on the determinants of internal migration. It is particularly insightful in two interrelated respects. Firstly, the crisis relatively strongly affected the unemployment dispersion in the euro area while leaving the wage dispersion

⁴The free movement of persons endows EU citizens with the right to move freely for the purpose of living, working, studying and retiring. As one of the four economic freedoms, the freedom of movement of workers (Article 45 TFEU) allows EU citizens to work in any other EU destination and guarantees the absence of discrimination based on nationality. The legislation extends to unemployed workers who can receive unemployment benefits from the country where they became unemployed while searching for a job in another EU country for a limited time period. In the destination country they are entitled to receive equal treatment with respect to support from employment services and access to work.

⁵Additional reasons are seen in imperfections in the housing and rental market and liquidity constraints (Huber (2005), ECB (2012)). Burda (1993) and Burda (1995) provide another explanation of low mobility by arguing that due to uncertain future returns, postponing migration can have a positive option value.

⁶Policies to increase migration range from increasing the compatibility of school systems to improving the rental markets for housing (ECB, 2012).

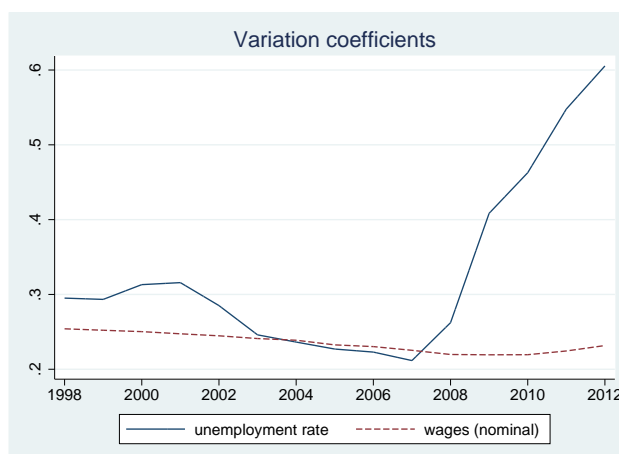


Figure 1: Dispersion of unemployment and wages in the euro18-area

Source: own figure, Eurostat data.

nearly unchanged. In Figure 1 we compare the dispersion of wages⁷ and unemployment measured by the coefficient of variation over the period 1998-2010. We find that unemployment rates are much more dispersed than wages⁸ since 2008. Secondly, the growing regional labor market disparities are mirrored by the crisis' heterogeneous impact⁹ on national migration flows. Since 2008 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 later.

Both observations indicate that the growing unemployment dispersion provides a potential explanation of the marked change in migration patterns in the euro area.¹⁰ Further, they point to the need to understand the impact of the business cycle and unemployment fluctuations on direction, size and composition of internal migration in the EMU. Therefore, we carry out a comprehensive analysis of the interrelation of wages, unemployment and migration patterns in the Euro12 over the business cycle for the period 1980 to 2010. Our analysis of 59 bilateral migration corridors reveals that while unemployment differentials are positively correlated with net migration in a majority of corridors, the relationship between real wage differentials and net migration is counter intuitively negative in many corridors. However, in both respects we find a considerable heterogeneity across

⁷We use compensation per employee as an indicator for wages. Regional dispersion of unemployment and wages is measured by the coefficient of variation that normalizes the standard deviation by the mean.

⁸This 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 (Solon et al., 1992).

⁹In section 2 these changes will be described in more detail.

¹⁰This 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.

corridors.

In line with these findings we build a theoretical business cycle model of migration and unemployment. Our interest is twofold: On the one hand, we want to assess the effect of migration on output fluctuations and thus the role of migration in abating asymmetric shocks. On the other hand, we want to identify how the business cycle and the fluctuation of wages and unemployment affect bilateral migration flows. While we find the effects in the first dimension to be relatively low, we identify significant effects in the second dimension. Our model is able to replicate our empirical observations and explains the heterogeneity of migration corridors by differences in the type of shock that hits an economy and the relative price/wage rigidity. Additionally, we find that the more inelastic the migrant labor supply and the more rigid migrant wages are, the lower are the fluctuations in migrant flows. This understanding allows us to analyze the effects of different immigration and labor market policies on migration patterns in the EMU migration corridor.

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), Stark and Fan (2011), Kemnitz (2006), Kemnitz (2009)) to the growing literature on unemployment in Dynamic Stochastic General Equilibrium (DSGE) models.

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

2. Literature Survey

The importance of internal migration in the EMU has grown over time, such that a substantial part of the migrant population in the euro area countries is related to the free movement of labor. In a panel of OECD countries over the period 1980-2010, Beine et al. (2013) find empirical evidence of the Schengen agreements and the introduction of the Euro to have increased internal migration in the members of the European Union. In many countries, the immigrant stock to a large part consists of migrants from other member countries. E.g. in 2014, 45% of all immigrants living in Germany originated from another EU28 country, within this group Spanish and Greek immigrants made up for the largest populations from another EMU country with 16% and 9% respectively

(Destatis (2015)). This corresponds to an immigrant share¹¹ of 4.5% (EU28), 0.7% (Spain) and 0.4% (Greece).

As a consequence of the free movement of workers, internal migration in the EMU is mainly motivated by work-related factors and often has a temporary nature (OECD (2014), Brücker et al. (2014)). The importance of work related factors is supported by the fact that in 2014 in the euro area the unemployment rate of citizens from the EU15 other than the reporting country was 2.3 percentage points lower than the average unemployment rate of 11.7%. With respect to temporary migration, Dustmann and Görlach (2015) point towards data limitations in assessing the size of return migration; however they provide evidence for a sizable amount of return migration. 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 higher in European countries than in the United States, Canada or New Zealand. The outmigration rate after five years was 60.4% in Ireland, 50.4% in Belgium and 28.2% in the Netherlands. A distinct pattern noted by Dustmann and Görlach (2015) is that the temporariness of migration increases with economic and cultural similarities between the destination and the source country. With respect to economic indicators, the group of EMU countries is more homogenous than the overall EU28.¹² Therefore, we expect temporary migration to be of high relevance in the euro area.

In order to assess the determinants of short-run migration in the euro area, it is of interest whether internal migration exhibits a cyclical pattern. For the United States Saks and Wozniak (2011) find internal migration to vary procyclically. In the group of OECD countries Beine et al. (2013) find current and future business cycle and employment dynamics to influence bilateral migration flows. Further, it is documented that the employment probabilities of migrants are closely related to the business cycle in the euro area. Dustmann et al. (2010) document that in Germany the unemployment response to labor market shocks is stronger for immigrants than for natives within the same skill group. Prean and Mayr (2012) show 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)).

The European financial and debt crisis sheds further light on the determinants of internal migration and the interrelation of business cycles and migration patterns. During the crisis, migration flows changed markedly on the euro area and the country level (OECD (2014)). Between 2007 and 2010 free movement immigration flows dropped by 35 % in Europe and rebounded with diverg-

¹¹Defined as immigrant stock divided by population size.

¹²The membership in the euro area is conditional on fulfillment of economic convergence criteria.

ing patterns thereafter. In countries with traditionally high immigration such as Ireland, Portugal, Spain, and Italy, total inflows declined strongly while they increased significantly in Finland, Austria and Germany. Consequently, as documented by Bertoli et al. (2013)¹³, Germany as the largest economy in the EMU transformed into the most important migration destination in the area.

In line with these empirical findings, there is a growing theoretical literature on short-term economic fluctuations and migration in a DSGE framework. Mandelman and Zlate (2012) introduce immigration of unskilled Mexicans to the U.S. to an RBC model. In a New-Keynesian (NK) model, Binyamini and Razin (2014) and in a similar vein Engler (2009) assess the effects of immigration respectively emigration on the Phillips curve and find it to be flatter in both cases. The flatter Phillips curve in presence of labor mobility is a key insight from integrating migration into the NK model. Because of the inflow of workers a lower wage increase is needed to increase the labor force compared to the case without labor mobility. However, this result relies on the assumption of a neoclassical international labor market that is characterized by fully flexible wages and the absence of real labor market frictions. Bentolila et al. (2008) partly overcome this weakness by including real wage rigidity in an *ad hoc* manner in their derivation of an empirically testable NK Phillips Curve. They find that immigration alters the slope and intercept of the Phillips Curve via a different labor supply elasticity and bargaining power of immigrants.

Common to all the above approaches is a unilateral focus on the effects of migration in either the source or the destination country. In contrast, Hauser (2014) shows that a technology shock spills-over from one location to another via its effect on the direction of the labor force movement. While her two-country model of internal U.S. labor migration incorporates bilateral migration flows it abstracts from unemployment and the underlying frictions. However, internal migration in the EMU is characterized by an interplay of migration and unemployment at business cycle frequencies. To this end, a model of internal migration in the EMU would need to incorporate both, the effect of migration on source and destination countries as well as unemployment and labor market frictions.

In this paper we develop a comprehensive model of bilateral migration flows with these distinct features. Thereby, we try to contribute to the literature on the causes and consequences of temporary migration by explicitly modeling the interaction of unemployment and migration. Our paper bridges the literature that quantifies the effects of migration and unemployment (Dustmann et al. (2008), Stark and Fan (2011), Kemnitz (2006), Kemnitz (2009)) to the growing literature on

¹³Bertoli et al. (2013) investigate bilateral migration flows to Germany in the years 2006 - 2012 and document a strong impact of the crisis on the size of migration flows. The authors empirically find that the immigration increase is grounded mainly in migration diversion of immigrants from one destination country to an alternative one. In contrast, migration creation only played a subordinate role.

unemployment in Dynamic Stochastic General Equilibrium (DSGE) models.

In the DSGE framework two different approaches to introduce unemployment can be distinguished. One approach (e.g. Gali (2010), Gali (2011)) reinterprets the DSGE model with staggered wage setting formulated by Erceg et al. (2000). The market power of differentiated types of labor 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 equilibrium level. Other sources of unemployment such as real labor market frictions are not accounted for. The other approach (e.g. Krause and Lubik (2007), Walsh (2003), Walsh (2005), Gertler et al. (2008), Faia and Rossi (2013), Christiano et al. (2013)) explicitly models real frictions from search and matching in line with Mortensen and Pissarides (1994). There exist versions with and without the assumption of rigid wages.¹⁴

We build a DSGE model with endogenous migration in the spirit of Hauser (2014) and include unemployment in order to match the empirical observations on the euro area. In contrast to a large part of the literature on migration in business cycle models but in line with empirical observations of the internal migration patterns in the EMU, 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.

Following Gali (2010), we allow for unemployment that occurs as a consequence of labor market frictions and rigidities in both countries. Our approach explains unemployment as result of time-varying country-specific mark-ups on competitive equilibrium wages that potentially differ for natives and immigrants. This set-up allows us to assess the effects of differing labor supply elasticities, wage persistence and bargaining powers of natives and migrants on cross-country migration flows and their combined influence on macroeconomic aggregates.

¹⁴Shimer (2005) and Hall (2009) 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.

3. Empirical observations and literature review

3.1. Compiling a data set

The preceding review of the literature and tentative investigation of the crisis incidence underlines the need to investigate a) whether migration patterns in the euro area vary systematically with the business cycles and b) how wages, unemployment and migration patterns are interrelated over the business cycle. In order to answer these questions we compile a large data set with bilateral migration and macroeconomic data¹⁵ in a similar vein as Beine et al. (2013) but with a focus on the euro area. The data set contains observations for the years 1980-2010 and covers 12 euro area countries¹⁶. Due to the lack of availability of quarterly¹⁷ bilateral migration data we rely on annual data from the United Nations and the OECD Migration database. Each pair of countries is referred to as a migration corridor and our set of countries gives rise to $12 \cdot 11/2 = 66$ potential migration corridors. Due to data limitations the number of actual corridors in the panel reduces to 59.¹⁸ For each bilateral migration corridor, we define the net migration as the difference of immigration and emigration between the two countries. It has to be noted that within the euro area the observed migration flows origin from an interplay of complex migration patterns. Basically, immigration to EMU countries can be distinguished according to the source country which can be located inside the EMU, inside the EU but outside the EMU or outside the EU. We want to focus on internal migration in the EMU, thereby we do not account for the nationality of a migrant only for the source country. For instance an increase in immigration from another EMU country can be either caused by migration creation or the diversion of immigrants from one destination to another.¹⁹

The data series for the macroeconomic variables real GDP, real consumption, unemployment rate, employment, labor force, real wages, price inflation, wage inflation, trade balance were drawn from the AMECO database. Real compensation per employee serves as a proxy for real wages.²⁰

In order to extract the cyclical component we take logs and apply the HP filter with a smoothing parameter of $\lambda = 400$, some variables are normalized by the population size.²¹

¹⁵See Appendix 6.5 for a description of the data.

¹⁶Austria, Belgium, Germany, Spain, Finland, France, Ireland, Italy, Luxemburg, Netherlands, Portugal and Greece

¹⁷The empirical investigation of short-run migration flows is limited by the fact, that data on a business cycle frequency is still very rare. There is new data set for Germany with monthly data. But most studies use data of annual basis from 1980 until now.

¹⁸There are still some missing years in that panel. For the period 1980-2010 there are no missing observations for 42 corridors, for 1990-2010 for 50 corridors and for 1996-2010 56 corridors.

¹⁹In our theoretical model we assume the population of both countries to be constant over time. However, due to data limitations we use data on all migrants from one EMU country to another and thus cannot keep the population of countries constant.

²⁰Gali (2010) 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.

²¹In order to check the robustness of our results with respect to the smoothing parameter we also use $\lambda = 100$ and

3.2. Business Cycle Statistics of the Euro Area

In the following we present business cycle facts on the euro area. Thereby our interest is twofold, as we want to describe the average migration corridor and want to point out heterogeneity across the different corridors. In the following analysis we will summarize our findings on the migration corridors in the euro area.

Variable x	$(\sigma(x)/\sigma(y))$	$\text{corr}(x,y)$	$\text{corr}(x,x^*)$
Output y	1	1	0.57
Consumption c	0.81	0.79	0.42
Employment n	0.76	0.69	0.41
Labor force l	0.39	0.43	0.14
Unemployment rate u	0.48	-0.68	0.39
Real wage w	0.68	0.17	0.52

Table 1: Empirical euro area business cycle - Key facts

Table 1 gives the standard deviations as a measure of the volatility of the macroeconomic variables of interest. The standard deviations are measured as the deviation from the trend and are averaged over all bilateral migration corridors. The left column expresses the standard deviation in relation to the output volatility. The typical results from national and international business cycle analysis are also valid for the EMU business cycle. Domestic consumption fluctuates less than domestic output and the national unemployment rate fluctuates less than national employment but more than the labor force.²²

The middle column shows the correlation with output. Domestic consumption and employment are highly correlated with output. While unemployment and output are negatively correlated, real wage and output are positively correlated. The correlation is stronger for unemployment than for wages.

The right column shows the correlation of variables across migration corridors. Overall, the positive correlation of domestic and foreign variables indicates a high level of integration within the euro area. The corridor consumption correlation is lower than the corridor output correlation.²³ Across corridors unemployment is less correlated than wages, indicating a higher labor market dispersion with respect to that variable.

Table 2 focuses on the stylized relationship of key variables for labor migration, in fact the relative fluctuation to the GDP, the cyclicality, the correlation of net migration with the real wage dw

$\lambda = 6.25$. See Table 7 in Appendix 6.6.

²²See Gali (2010).

²³See Backus et al. (1992) for the international consumption correlation puzzle.

x=Net migration rate	
Fluctuation ($\sigma(x)/\sigma(y)$)	1.55
Cyclical ($\rho(x, dy)$)	0.17
Real wage differential ($\rho(x, du)$)	-0.1
Unemployment differential ($\rho(x, d(w/p))$)	-0.31

Table 2: Empirical euro area business cycle - Net migration

and the unemployment differential du .²⁴ The net immigration displays a stronger volatility than real GDP and is positively correlated with output, thus internal migration seems to be procyclical. However, Hauser (2014) demonstrates for the U.S. labor market that while unconditional labor mobility is procyclical, the picture is less clear for conditional labor mobility.²⁵

Immigration and net migration are negative correlated with wage and unemployment differentials. As a first intuition, the negative correlation between unemployment differentials and net migration can be explained by assuming that unemployment is c.p. causal for the migration decision. In the euro area, an exogenous labor demand shocks increase the unemployment rate in one country such that native households decide to emigrate to another country with lower unemployment. Although the correlation between negative wage differential and net migration is small, its negative sign is not as intuitive. Instead of assuming employment conditions to be causal for the migration decision, we would rather think of the opposite direction. An exogenous shock to the migrant supply conditions within the corridor leads to an increase of immigration which may results finally in lower real wages.²⁶

Until now, our focus is the average corridor of the euro area. In a next step we look deeper into the euro area pattern for specific corridor relationships. The graph on the left hand of Figure 2 depicts the correlation between the cyclical component of net migration and the cyclical component of the real wage differential sorted by the 59 corridors. A similar picture can be drawn on the right hand side of Figure 2, which summarizes the correlation between the cyclical component of net migration and the cyclical component of the unemployment differential. Both graphs suggest to classify corridors into four types according to their correlation between net migration and wage or

²⁴The wage and the unemployment differentials are defined as difference between domestic and foreign variables. They act as empirical proxies for non observable time-varying migrants wage/unemployment differentials.

²⁵Her 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 EMU labor market.

²⁶This result only changes slightly by using different time periods and smoothing parameters. With lower λ and smaller time periods the negative correlation between net migration and both the unemployment as well as the wage differential becomes lower.

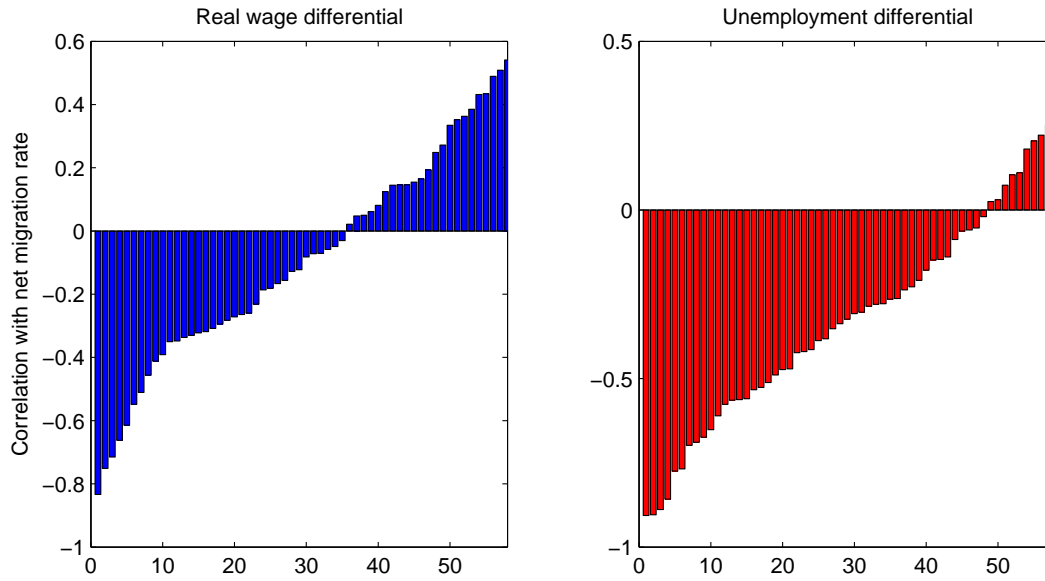


Figure 2: Correlation between the cyclical component of net migration and real wage/unemployment differential for 59 euro area corridors

Source: own figure, Eurostat data.

unemployment differential.

Overall, the business cycle facts underline that both, unemployment and wage differentials are important to understand cyclical migration patterns in the euro area. Summing up the empirical evidence, we interpret the previous findings as evidence for a) business cycle related fluctuations in migration patterns and b) the crucial role of unemployment in shaping intra-euro area migration patterns c) a puzzling relationship between wages and intra-euro area net migration d) cross-country heterogeneity with respect to the correlation of net migration and the wage respectively unemployment differential.

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 in order to find a comprehensive explanation for the euro area average and cross-country patterns.

4. A Model with Migration and Unemployment

The section introduces migration in a dynamic stochastic equilibrium model with unemployment. The general structure of the model is similar to Erceg et al. (2000) with the interpretation of Gali (2011). We apply this model to the two country case with bilateral trade in goods. Migration is closely related to unemployment in our model because workers set their wages subject to the national and international demand for their type of labor. Thereby, we implicitly model the decision either to work at home or abroad endogenously. By insuring the idiosyncratic unemployment risk of agents the framework preserves the representative household paradigm.

4.1. Households

Both countries $j \in [H, F]$ are populated by a large number of households normalized to one that face similar optimization problems. Each household has a continuum of members indexed by the type of labor $i \in [0, 1]$. Within one family all members are guaranteed the same level of the aggregate consumption bundle c_t^j irrespective of their labor type and employment status. In the home country, the representative household maximizes the welfare function

$$\max_{\{c_t, w_{h,t}, w_{h,t}^*, b_t, b_t^*\}} E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, n_{h,t}(i), n_{h,t}^*(i)), \quad (1)$$

subject to the budget constraint²⁷

$$\Theta_t b_t + \Theta_t^* b_t^* + p_t c_t = \int_0^1 w_{n,t}(i) n_{h,t}(i) di + \int_0^1 w_{e,t}^*(i) n_{h,t}^*(i) di + b_{t-1}^* + b_{t-1} + \Pi_t. \quad (2)$$

$w_{h,t}(i)$ denotes the domestic nominal wage of an domestic i -type employed worker and Π_t is the nominal firm revenue which is distributed over domestic households in a lump-sum fashion. b_t represents the demand for nominally risk-less bonds paying a monetary unit at price Θ_t . Initially, we assume complete financial markets such that households can buy domestic and foreign bonds. The household takes the labor demand as given. $n_{h,t}(i) \in [0, 1]$ is the fraction of members specialized in type i labor are demanded in domestic markets. $n_{h,t}^*(i) \in [0, 1]$ is the fraction of members specialized in type i labor who are demanded in foreign country.²⁸

²⁷The budget constraint in terms of c_t can be derived by aggregating the demand functions for domestic and foreign goods over all goods z and assuming local non-satiation.

²⁸The subscript denotes the place of supplier. Variables with a * are supposed to be foreign variables. Variables with a subscript h denote the country of origin. Therefore, domestic (foreign) household members that stay in their home country are called natives. They supply a fraction $n_{h,t}$ ($n_{f,t}^*$) to domestic (foreign) firms. The other members that move to the foreign (domestic) country supply $n_{h,t}^*$ ($n_{f,t}$) to foreign (domestic) firms. From perspective of the domestic country they are called emigrants. From perspective of the foreign country they are immigrants.

The period utility is given by the integral of the households members' period utilities

$$u(c_t, n_t(i)) = \left\{ \log c_t - \chi_{t+k} \left(\int_0^1 \frac{n_{h,t}(i)^{1+\psi}}{1+\psi} di - \int_0^1 \frac{n_{h,t}^*(i)^{1+\psi^*}}{1+\psi^*} di \right) \right\} d_t, \quad (3)$$

χ_{t+k} and χ_{t+k}^* are labor supply shocks that affects the total domestic labor supply.²⁹ The inverse Frisch elasticity of labor supply $\psi > 0$ determines the curvature for the disutility of labor of the domestic households. The optimality condition for the domestic household can be written as:

$$\Theta_t = \beta E_t \left\{ \frac{c_t}{c_{t+1}} \frac{p_t}{p_{t+1}} \right\} \quad \Theta_t^* = \beta E_t \left\{ \frac{c_t}{c_{t+1}} \frac{p_t}{p_{t+1}} \right\}. \quad (4)$$

Foreign households face exact the same program. Therefore, the optimality conditions for the foreign household are:

$$\Theta_t = \beta E_t \left\{ \frac{c_t^*}{c_{t+1}^*} \frac{p_t^*}{p_{t+1}^*} \right\}, \quad \Theta_t^* = \beta E_t \left\{ \frac{c_t^*}{c_{t+1}^*} \frac{p_t^*}{p_{t+1}^*} \right\}. \quad (5)$$

According to these conditions, households in both countries smooth consumption over time and diversify between countries:

$$c_t = c_t^* q_t. \quad (6)$$

The latter describes the international portfolio condition in case of perfect financial markets. q_t is the real exchange rate defined as the quotient between foreign and domestic consumption price level.

The domestic consumption aggregate is composed of the domestic consumption good $c_{h,t}$ and the imported consumption good $c_{f,t}$:

$$c_t = \left((1 - \omega)^{\frac{1}{\mu}} (c_{h,t})^{\frac{\mu-1}{\mu}} + \omega^{\frac{1}{\mu}} (c_{f,t})^{\frac{\mu-1}{\mu}} \right)^{\frac{\mu}{\mu-1}}. \quad (7)$$

where μ is the share of domestic goods in a household's consumption expenditures. The home produced and import good baskets are defined as CES composites of differentiated home and

²⁹A positive domestic labor supply shock can be interpreted as an increase of external immigration into the domestic economy. Because of free labor mobility within the corridor the share of domestic workers that move to the foreign country increases.

foreign produced varieties:

$$c_{h,t} \equiv \left(\int_0^1 c_{h,t}(z)^{\frac{\varepsilon_p-1}{\varepsilon_p}} dz \right)^{\frac{\varepsilon_p}{\varepsilon_p-1}}, \quad c_{f,t} \equiv \left(\int_0^1 c_{f,t}(z)^{\frac{\varepsilon_p-1}{\varepsilon_p}} dz \right)^{\frac{\varepsilon_p}{\varepsilon_p-1}},$$

where ε_p denotes the elasticity of substitution between different consumption varieties in home and foreign. Expenditure minimizing subject to the consumption indexes gives the demand functions for domestic and foreign goods:

$$c_{h,t}(z) = \left(\frac{p_{h,t}(z)}{p_{h,t}} \right)^{-\varepsilon_p} c_{h,t}, \quad c_{f,t}(z) = \left(\frac{p_{f,t}(z)}{p_{f,t}} \right)^{-\varepsilon_p} c_{f,t}, \quad (8)$$

where

$$p_{h,t} \equiv \left(\int_0^1 p_{h,t}(z)^{1-\varepsilon_p} dz \right)^{\frac{1}{1-\varepsilon_p}}, \quad p_{f,t} \equiv \left(\int_0^1 p_{f,t}(z)^{1-\varepsilon_p} dz \right)^{\frac{1}{1-\varepsilon_p}}. \quad (9)$$

$p_{h,t}(z)$ is the price for the domestic produced variety and $p_{h,t}$ is the price for the domestic produced good basket. Similarly, $p_{f,t}(z)$ is the price for the domestically produced varieties and $p_{f,t}$ is the price for the foreign produced good basket.

The demand for the domestic and imported consumption bundle are

$$c_{h,t} = (1 - \omega) \left(\frac{p_{h,t}}{p_t} \right)^{-\mu} c_t, \quad c_{f,t} = \omega \left(\frac{p_{f,t}}{p_t} \right)^{-\mu} c_t, \quad (10)$$

with the aggregate consumption price:

$$p_t = \left((1 - \omega) p_{h,t}^{1-\mu} + \omega p_{f,t}^{1-\mu} \right)^{\frac{1}{1-\mu}}. \quad (11)$$

4.2. Wage Setting and Migration

Each type of worker from country j determines its wage subject to the demand from firms in the domestic and foreign economy. We allow for labour mobility in the firm production production as in Ottaviano and Peri (2012). Thus, composite labor employed by each firm z in each country j is a CES index of native and migrant workers:

$$n_t(z) = \left((1 - \gamma)^{\frac{1}{\theta}} (n_{h,t}(z))^{\frac{\theta-1}{\theta}} + \gamma^{\frac{1}{\theta}} (n_{f,t}(z))^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}. \quad (12)$$

The parameters $0 < \gamma < 1$ and $\theta > 0$ are the share of foreign workers in the production and the substitution elasticity between native and migrant worker. The native and immigrant labor are defined as CES composites of differentiated types of native and immigrant labor:

$$n_{h,t}(z) \equiv \left(\int_0^1 n_{h,t}(i,z) \frac{\varepsilon_w - 1}{\varepsilon_w} di \right)^{\frac{\varepsilon_w}{\varepsilon_w - 1}}, \quad n_{f,t} \equiv \left(\int_0^1 n_{f,t}(i,z) \frac{\varepsilon_w - 1}{\varepsilon_w} di \right)^{\frac{\varepsilon_w}{\varepsilon_w - 1}},$$

where ε_w denotes the elasticity of substitution between different types of native and immigrant labor. The demand for the native and immigrant composite labor are:

$$n_{h,t}(z) = (1 - \gamma) \left(\frac{w_{h,t}}{w_t} \right)^{-\theta} n_t(z), \quad n_{f,t}(z) = \gamma \left(\frac{w_{f,t}}{w_t} \right)^{-\theta} n_t(z), \quad (13)$$

with the aggregate wage index:

$$w_t = \left((1 - \gamma) w_{h,t}^{1-\theta} + \gamma w_{f,t}^{1-\theta} \right)^{\frac{1}{1-\theta}}. \quad (14)$$

Aggregating over all firms z gives the aggregate demand for native and immigrant labor:

$$n_{h,t}(i) = \int_0^1 n_{h,t}(i,z) dz, \quad n_{h,t} = \int_0^1 N_{h,t}(z) dz. \quad (15)$$

The differentiated types of workers in each country j possess market power and set their domestic and foreign wage with a positive markup. As formalized by Calvo (1983), workers specialized in type i labor can reset their wages with a constant probability $1 - \xi_w$ each period. ξ_w is independent across time and labor types but differs between emigrants and natives. According to the empirical evidence migrant workers have a more flexible wage, $\xi_{wh} > \xi_{wf}$ and $\xi_{wh}^* < \xi_{wf}^*$. Domestic workers of a type i that are able to reset their nominal wage, choose their optimal wage $w_{h,t}^O$ in period t with respect to their disutility from work subject to the flow budget constraint 2 and the aggregate domestic and foreign firm labor demand for native labor type i as derived above in equations 13 and 15: The first order condition of the wage setting problem for households living in country $j \in [h, f]$ who implicitly supply their labor in country $m \in [f, h]$ is given by:

$$\left(\frac{w_{m,t}^{j,O}}{w_{m,t}^j} \right)^{1+\varepsilon_w \psi} = \mu_w \frac{E_t \sum_{k=0}^{\infty} (\beta \xi_{wj})^k \left\{ \left(\frac{w_{m,t+k}^j}{w_{m,t}^j} \right)^{\varepsilon_w(1+\psi)} \frac{n_{m,t+k}^j}{c_{t+k}^j} mrs_{m,t+k}^j \right\}}{E_t \sum_{k=0}^{\infty} (\beta \xi_{wj})^k \left\{ \left(\frac{w_{m,t+k}^j}{w_{m,t}^j} \right)^{\varepsilon_w - 1} \frac{w_{m,t+k}^j}{P_{t+k}^j} \frac{n_{m,t+k}^j}{c_{t+k}^j} \right\}}. \quad (16)$$

with a constant wage mark-up $\mu_w = \frac{\varepsilon_w}{\varepsilon_w - 1}$ that is assumed to be equal in both countries. The main difference of native and immigrants is that they ground their wage setting decisions on different marginal rate of substitutions $mrs_{m,t+k}^j = \chi_{t+k}^j (n_{m,t+k}^j)^\psi c_{t+k}^j$. While emigrant and native workers both evaluate their wage to their home consumption, differences arise due to labor demand and the expected future wage and unemployment paths of domestic and foreign country.

The aggregate wage in both countries is a weighted average of optimized and non-optimized native wage profiles:

$$(w_{m,t}^j)^{1-\varepsilon_w} = (1 - \xi_{wj})(w_{m,t}^{jO})^{1-\varepsilon_w} + \xi_{wj}(w_{m,t-1}^j)^{1-\varepsilon_w}. \quad (17)$$

Finally, the equations (16) and (17) result in the wage inflation rate:

$$\Pi_{m,t}^{jW} = \left(\frac{1}{\xi_{wj}} \right)^{\frac{1}{\varepsilon_w}} \left(1 - (1 - \xi_{wj}) \left(\frac{f_{1,m,t}^j}{f_{2,m,t}^j} \right)^{\frac{1-\varepsilon_w}{1+\varepsilon_w\psi}} \right)^{\frac{1}{\varepsilon_w}}, \quad (18)$$

with

$$f_{1,m,t}^j = \frac{n_{m,t}^j}{c_t^j} mrs_{m,t}^j + \beta \xi_w E_t \{ (\Pi_{m,t+1}^{jW})^{\varepsilon_w(1+\psi)} f_{1,m,t+1}^j \},$$

$$f_{2,m,t}^j = \frac{w_{m,t}^j}{p_t^j} \frac{n_{m,t}^j}{c_t^j} + \beta \xi_{wj} E_t \{ (\Pi_{m,t+1}^{jW})^{\varepsilon_w - 1} f_{2,m,t+1}^j \}.$$

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

$$\Pi_t^W = (1 - \gamma)\Pi_{h,t}^W + \gamma\Pi_{f,t}^W, \quad (19)$$

$$\Pi_t^{*W} = (1 - \gamma)\Pi_{f,t}^{*W} + \gamma\Pi_{h,t}^{*W}. \quad (20)$$

4.3. Firms

In each country j we assume a continuum of competitive price setting firms which produce a differentiated good $z \in [0, 1]$. The producing firm z in country j uses composite labor $n_t(z)$ to produce its final good:

$$y_t(z) = a_t n_t(z)^{1-\alpha}. \quad (21)$$

a_t is the country specific exogenous aggregate technology and its logarithm follows an AR(1) process with persistence parameter $0 < \rho_A^j < 1$ and a white noise process with zero mean and constant variance σ_A^2 . Each firm resets the price $p_{h,t}(z)$ of its produced good in any given period

with a constant probability $1 - \xi_p$. A firm z that is allowed to change its price in period t , sets its optimal price $p_{j,t}^O(z)$ to maximize its real lifetime value consistent with the households optimality condition

$$E_t \sum_{k=0}^{\infty} (\xi_p)^k \Theta_{t+k} \left\{ \frac{p_{h,t}^O}{p_{h,t+k}} y(z)_{h,t+k} - mc(z)_{h,t+k} y(z)_{h,t+k} \right\}$$

given the sequence of demand constraints from domestic and foreign households for the specific good of firm z in country j derived by combining equations 8 and 10:

$$c_{h,t+k}(z) = (1 - \omega) \left(\frac{p_{h,t}^O(z)}{p_{h,t+k}} \right)^{-\varepsilon_p} \left(\frac{p_{h,t+k}}{p_{t+k}} \right)^{-\mu_p} c_{t+k}, \quad (22)$$

$$c_{h,t+k}^*(z) = \omega \left(\frac{p_{h,t}^{*O}(z)}{p_{h,t+k}^*} \right)^{-\varepsilon_p} \left(\frac{p_{h,t+k}^*}{p_{t+k}^*} \right)^{-\mu_p} c_{t+k}^*. \quad (23)$$

Since all differentiated firms produce with the same production technology the optimal price would be chosen by all resetting firms. The first order condition is given by:

$$\frac{p_{h,t+k}^O(z)}{p_{h,t+k}} = \mu_p \frac{\sum_{k=0}^{\infty} (\xi_p \beta)^k E_t \left\{ c_{t+k}^{-1} y_{t+k} mc_{t+k}(z) \left(\frac{p_{h,t+k}}{p_{h,t}} \right)^{\varepsilon_p} \right\}}{\sum_{k=0}^{\infty} (\xi_p \beta)^k E_t \left\{ c_{t+k}^{-1} y_{t+k} \left(\frac{p_{h,t+k}}{p_{h,t}} \right)^{\varepsilon_p - 1} \right\}}, \quad (24)$$

with $\mu^P = \frac{\varepsilon_p}{\varepsilon_p - 1}$.

The aggregate producer price level evolves according to the following difference equation:

$$p_{h,t}^{1-\varepsilon_p} = (1 - \xi_p) (p_{h,t}^O)^{1-\varepsilon_p} + \xi_p p_{h,t-1}^{1-\varepsilon_p}. \quad (25)$$

Finally, the equations (24) and (25) give the non-linear price inflation rate:

$$\Pi_{h,t}^P = \left(\frac{1}{\xi_p} \right)^{\frac{1}{\varepsilon_p}} \left(1 - (1 - \xi_p) \left(\frac{g_{1,h,t}}{g_{2,h,t}} \right)^{\frac{1-\varepsilon_p}{1+\varepsilon_p\phi}} \right)^{\frac{1}{\varepsilon_p}}, \quad (26)$$

with

$$g_{1,h,t} = \mu^P y_{h,t} (c_{h,t})^{-1} mc_t(z) + \beta \xi_p E_t \left\{ (\Pi_{h,t+1}^P)^{\frac{\varepsilon_p}{1-\alpha}} g_{1,h,t+1} \right\},$$

$$g_{2,h,t} = y_{h,t} (c_{h,t})^{-1} + \beta \xi_w E_t \left\{ (\Pi_{h,t+1}^P)^{\varepsilon_p - 1} g_{2,h,t+1} \right\}.$$

The firm specific real marginal costs results from solving the cost minimization problem of the firm j :

$$mc_t(z) = \frac{w_t/p_{h,t}}{(1-\alpha)a_t n_t(z)^{-\alpha}}, \quad (27)$$

where w_t denotes the aggregate wage index in country j .

From the labor market clearing condition $n_{h,t+k} \equiv \int_0^1 n_{h,t+k}(j) dj$ and the production function (21) firm specific labor demand results as a function of the aggregate production, total factor productivity and price dispersion:

$$n_t = \left(\frac{y_t}{a_t}\right)^{\frac{1}{1-\alpha}} \Delta_t^P \Delta_t^W, \quad (28)$$

with $\Delta_t^W = \left(\frac{w_t(i)}{w_t}\right)^{-\varepsilon_w} di$ and $\Delta_t^P = \left(\frac{p_{h,t}(j)}{p_{h,t}}\right)^{-\frac{\varepsilon_p}{1-\alpha}} di$.

The wage and price dispersion paths can be summarized as:

$$\Delta_t^P = (1 - \xi_p) \left(\frac{1 - \xi_p (\Pi_t^P)^{\varepsilon_p - 1}}{1 - \xi_p}\right)^{\frac{\varepsilon_p}{(1-\alpha)(\varepsilon_p-1)}} + \xi_p \Delta_{t-1}^P (\Pi_t^P)^{\frac{\varepsilon_p}{1-\alpha}}, \quad (29)$$

$$\Delta_t^W = (1 - \xi_w) \left(\frac{1 - \xi_w (\Pi_t^W)^{\varepsilon_w - 1}}{1 - \xi_w}\right)^{\frac{\varepsilon_w}{(1-\alpha)(\varepsilon_w-1)}} + \xi_w \Delta_{t-1}^W (\Pi_t^W)^{\varepsilon_w}. \quad (30)$$

4.3.1. Terms of trade, nominal and real exchange rates

The nominal exchange rate is assumed to be constant and is normalized to one for the corridor.³⁰ We assume that the law of one price holds for each individual good such that the price of a good z produced in country j is the same in country j and k , i.e. $p_h(z) = p_h^*(z)$ and $p_f^*(z) = p_f(z)$. The real exchange rate is equal to the quotient between the foreign and domestic consumption price level

$$q_t = \frac{p_t^*}{p_t}. \quad (31)$$

The terms of trade between countries is defined as:

$$s_t = \frac{p_{f,t}}{p_{h,t}}. \quad (32)$$

³⁰In the sample period from 1980 to 2010 the corridors changed their monetary system from mostly pegged exchange rates to a monetary union. Although this regime change may also influence the relationship between net migration and its main determinants it is of minor interest in this paper. For most corridors there has been a relatively stable nominal exchange rate between 1980 and 2010. In an extended approach we separate the total period in two subperiods before and after the Euro introduction. The first subperiod is modelled with a pegged exchange rate system, in the second subperiod we assume a common monetary policy. This does not change our results according to the average relationship between the bilateral migration flows and its main determinants. However, by simulating the transitory regime shift, we are able to explain time-varying migration cycle correlations.

Introducing the domestic and foreign consumption price level (11) in equation (31) yields:

$$q_t = \frac{[(1 - \omega^*)(s_t)^{1-\mu} + \omega^*]^{\frac{1}{1-\mu}}}{[(1 - \omega) + \omega(s_t)^{1-\mu}]^{\frac{1}{1-\mu}}}. \quad (33)$$

The country specific production basket is used both domestically and offshore:

$$y_t = c_{h,t} + c_{h,t}^*, \quad (34)$$

with

$$c_{h,t} = (1 - \omega) \left(\frac{p_{h,t}}{p_t} \right)^{-\mu_p} c_t, \quad (35)$$

$$c_{h,t}^* = \omega \left(\frac{p_{h,t}^*}{p_t^*} \right)^{-\mu_p} c_t^*. \quad (36)$$

Combining the aggregate resource constraint with the portfolio diversification condition links aggregate domestic consumption to the output:

$$y_t = \left[(1 - \omega) + \omega \left(\frac{s_t}{q_t} \right)^{-\mu_p} \left(\frac{p_{h,t}}{p_t} \right)^{-\mu_p} q_t^{-1} \right] c_t. \quad (37)$$

The central bank supplies a monetary asset.³¹ Due to its systemic position, the central bank can influence the nominal interest rate in order to stabilize the price inflation and the output to their target rates:

$$i_t = d_t \left[\left(\frac{\Pi_{h,t}^P}{\bar{\Pi}_h^P} \right)^{\varphi_\pi} \left(\frac{y_{h,t}}{y_{h,t}^n} \right)^{\varphi_y} \right]. \quad (38)$$

where d_t is country-specific aggregate money demand shock that follows an AR(1) process with persistence parameter $0 < \rho_M^j < 1$ and a white noise process with zero mean and constant variance σ_D^2 .³² where $\bar{\Pi}_h^P$ and $y_{H,t}^n$ are the target variables.³³ The target weights φ_π and φ_y are set exogenously by empirically observed parameters for the Euro area.³⁴

³¹The 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.

³²We use the money supply shock as a proxy for an aggregate country-specific demand shock.

³³The target variables are the steady state values. Therefore, the target price inflation is equal to zero and the target output is steady state output.

³⁴See Taylor (1993), Woodford (2001), Taylor and Williams (2010).

4.4. Definition of the Equilibrium

Imposing that domestic and foreign bonds are in zero net supply $b_t + b_t^* = 0$, we define an equilibrium as a sequence of domestic and foreign quantities:

$$\begin{aligned} \{\mathcal{X}\}_{t=0}^\infty &= \{c_t, y_t, n_t, n_{h,t}, n_{f,t}, l_t, l_{h,t}, l_{f,t}, u_t, u_{h,t}, u_{f,t}\}, \\ \{\mathcal{X}^*\}_{t=0}^\infty &= \{c_t^*, y_t^*, n_t^*, n_{h,t}^*, n_{f,t}^*, l_t^*, l_{h,t}^*, l_{f,t}^*, u_t^*, u_{h,t}^*, u_{f,t}^*\} \end{aligned}$$

a sequence of domestic, foreign and international prices, wages and inflation rates:

$$\begin{aligned} \{\mathcal{P}\}_{t=0}^\infty &= \{p_t, p_{h,t}, p_{f,t}, w_t, w_{h,t}, w_{f,t}, \pi_t^P, \pi_{h,t}^P, \pi_{f,t}^P, \pi_t^W, \pi_{h,t}^W, \pi_{f,t}^W\}, \\ \{\mathcal{P}^*\}_{t=0}^\infty &= \{p_t^*, p_{h,t}^*, p_{f,t}^*, w_t^*, w_{h,t}^*, w_{f,t}^*, \pi_t^{*P}, \pi_{h,t}^{*P}, \pi_{f,t}^{*P}, \pi_t^{*W}, \pi_{h,t}^{*W}, \pi_{f,t}^{*W}\}, \\ \{\mathcal{Q}\}_{t=0}^\infty &= \{q_t, s_t\} \text{ such that} \end{aligned}$$

(1) for a given price and wage sequence $\{\mathcal{P}\}_{t=0}^\infty, \{\mathcal{P}^*\}_{t=0}^\infty, \{\mathcal{Q}\}_{t=0}^\infty$ a given realization of shocks $\{\mathcal{S}\}_{t=0}^\infty$ and a monetary policy $\{\mathcal{M}\}_{t=0}^\infty$ the sequence $\{\mathcal{X}\}_{t=0}^\infty, \{\mathcal{X}^*\}_{t=0}^\infty$ satisfies first order conditions for domestic and foreign households and firms.

(2) for a given sequence of quantities $\{\mathcal{X}\}_{t=0}^\infty, \{\mathcal{X}^*\}_{t=0}^\infty$ a given realization of shocks $\{\mathcal{S}\}_{t=0}^\infty$ and a monetary policy $\{\mathcal{M}\}_{t=0}^\infty$ the price sequence $\{\mathcal{P}\}_{t=0}^\infty, \{\mathcal{P}^*\}_{t=0}^\infty, \{\mathcal{Q}\}_{t=0}^\infty$ guarantees international labor, goods and financial market equilibrium conditions.³⁵

4.5. Analysis of the Phillips Curve

To understand the macroeconomic effects of immigration we analyze the price Phillips curve relation. This is a common approach in the literature on migration and output fluctuations (Bentolila et al. (2008), Engler (2009), Hauser (2014)). However, most contributions assume a competitive labor market.³⁶ However, in contrast to the existing literature our model features an endogenous wage decision of natives and migrants. The wage decision gives rise to unemployment of both groups of workers and implicitly models the decision to either work at home or abroad endogenously. This allows us to assess the effects of migration and its key parameters on the Phillips curve. The nested Phillips curve expression is:³⁷

$$\begin{aligned} \hat{\pi}_{h,t}^P &= \frac{2\beta}{1+2\beta+\lambda_p} E_t \hat{\pi}_{h,t+1}^P - \frac{\beta^2}{1+2\beta+\lambda_p} E_t \hat{\pi}_{h,t+2}^P + \frac{1}{1+2\beta+\lambda_p} \hat{\pi}_{h,t-1}^P \\ &\quad + \frac{(1-\beta L^{-1})(1-L)\lambda_p}{1+2\beta+\lambda_p} \left(\frac{\alpha}{1-\alpha} \hat{y}_t - \frac{1}{1-\alpha} \hat{a}_t + \bar{\omega} \hat{s}_t \right) \\ &\quad - \frac{\lambda_p \lambda_w}{1+2\beta+\lambda_p} \left(\psi \hat{u}_t + \bar{\gamma} \left(\frac{\lambda_w^*}{\lambda_w} \psi^* - \psi \right) \hat{u}_{f,t} + \bar{\gamma} \psi \left(1 - \frac{1-\bar{\gamma}}{1-\bar{\gamma}_L} \right) \hat{im}_{l,t} \right), \quad (39) \end{aligned}$$

³⁵The deterministic symmetric zero inflation steady state is denoted in the Appendix 5.

³⁶Engler (2009) and Hauser (2014) assume a competitive labor market. In a partial equilibrium model Bentolila et al. (2008) introduce unemployment and real wage rigidity in an *ad hoc* manner.

³⁷See Appendix 6.3 for the derivation.

with $\lambda_p = \frac{(1-\xi_{p,j})(1-\beta\xi_{pj})(1-\alpha)}{\xi_{pj}(1-\alpha-\alpha\varepsilon_{pj})}$ and $\lambda_w = \frac{(1-\xi_{w,j})(1-\beta\xi_{wj})}{\xi_{wj}(1+\varepsilon_{wj}\psi^j)}$.

In the benchmark case, defined by the absence of international trade and migration,³⁸ the price Phillips curve is isomorphic to the one of Galí (2010). In this case, nominal wage rigidity causes future and past expectations about wage setting to additionally influence the marginal cost function of firms. Depending on what is more flexible - nominal wages or prices - the real wage income can either increase or decrease in reaction to a positive labor productivity shock. If prices are more sluggish than nominal wages, the real wage income increases and fosters households to consume more and enlarge their labor supply correspondingly. Firms who cannot set an optimized price cannot pass through their reduced marginal cost to consumers and face a decreasing demand and reduce their labor demand. Thus, in a closed economy where household do not have the possibility to decide to work home or abroad, additional supply of households becomes unemployed.³⁹

Next, we allow for migration and trade. In general, migrant and native wages can differ due to different bargaining power ε_w^j , labor supply elasticity ψ^j and wage flexibility ξ_w^j . In a symmetric setting, immigrants and natives react in a similar manner to shocks. Therefore, the Phillips curve in this case corresponds to the benchmark case. In contrast, differences in these parameters lead to an unemployment and nominal wage difference in both countries and give rise to a non-zero net migration in the steady state. We start by relaxing the assumption of symmetry with respect to the inverse labor supply elasticity in order to introduce a difference between migrants and natives.⁴⁰ Compared to the benchmark case, migration affects the Phillips curve via the term $\frac{\lambda_p\lambda_w}{1+2\beta+\lambda_p}\bar{\gamma}\left(\frac{\lambda_w^*}{\lambda_w}\psi^* - \psi\right)\hat{u}_{f,t}$. The effect of heterogeneity in the inverse labor supply elasticity is twofold. We discuss it for $\psi^* > \psi$, denoting the fact that the labor supply elasticity of migrants is lower than of natives. On the one hand the term $\psi^* - \psi$ turns positive, on the other hand a higher ψ^* implies a lower λ_w^* which acts as a scaling factor in front of ψ^* and thus lowers the difference. The first effect arises because migrants have higher preference to reduce wages in order to stay employed in case firms reduce their labor demand. Although only some migrants can adjust their wages, the adjustment is higher than the wage reduction of native workers and lowers the firms' pressure to reduce labor demand. The second effect measures the strategic complementarity between specific labor-types. If ε_w stays equal across migrant and native labor type, a higher labor supply elasticity increases the strategic complementarity of the migrant worker in relation to the native worker. The overall effect is positive $\left(\frac{\lambda_w^*}{\lambda_w}\psi^* - \psi > 0\right)$, since the direct effect on ψ^* is stronger than on its scaling parameter λ_w^*/λ_w . Consequently, the Phillips curve is flatter with

³⁸In this case we assume μ^j and γ^j to be zero.

³⁹Although family households expect a fraction of members to become unemployed, they set wages above competitive wage in order to maximize their wage income.

⁴⁰In this case we assume $\varepsilon_w^* = \varepsilon_w$, $\xi_w^* = \xi_w$ and $\psi^* \neq \psi$. See Bentolila et al. (2008).

respect to the unemployment rate if migrants have a higher labor supply elasticities.⁴¹

Finally, we additionally allow for differences of migrants and natives with respect to ε_W^j and ξ_w^j .⁴² Compared to the benchmark case, the difference of the price Phillips curve with and without migration becomes:

$$\bar{\gamma} \left(\frac{\lambda_w^*}{\lambda_w} \psi^* - \lambda_w \psi \right) \hat{u}_f - \bar{\gamma} \psi \left(1 - \frac{1 - \bar{\gamma}}{1 - \bar{\gamma}_L} \right) (\hat{l}_h - \hat{l}). \quad (40)$$

For analytical clarification we assume migrants to set wages more flexibly than native workers $\xi_w^* < \xi_w$ and to have a lower market power $\varepsilon_W^* < \varepsilon_w$. The parameter choice can be justified by the insider-outsider theory which predicts migrants have a lower market power to influence the wage setting process. Additionally, it is likely that firms offer shorter contract periods to migrants which results in a smaller Calvo parameter value.⁴³ Both parameters increase λ_w^* and thereby decrease the slope coefficient of the wage Phillips curve.

⁴¹See Appendix 6.3 for the derivation.

⁴²We consider as before $\psi^* \neq \psi$.

⁴³It is worth mentioning that the empirical evidence of this theory is discussed controversially. In contrast, the shirking theory would suggest that migrants are often younger such that they have a higher incentive to shirk or quit.

5. Impulse Response Functions and Discussion of Results

5.1. Calibration

The proposed model follows the literature on open economy DSGE models with migration and empirical labor market facts.⁴⁴ In order to analyze the theoretical effects, we calibrate⁴⁵ the model to annual data. In order to isolate the effects of migration, all firm and trade parameters are assumed to be symmetric across countries.

For the theoretical analysis of a symmetric corridor we set the discount factor to $\beta = 0.98$ consistent with an annualized interest rate of $\rho = 0.02$ percent.⁴⁶ According to Gali (2010) and DiCecio and Nelson (2010) we set the inverse of the Frisch elasticity of labor supply to $\psi = 5$ and the elasticity of substitution between different types of workers from one country $\varepsilon_w = 4.5$ in order to match the average steady state unemployment rate of $\bar{u} \approx 5\%$. The intra-industrial elasticity of substitution is set to $\varepsilon_p = 6$ which corresponds to a constant price markup of firms of $\mu_p = 1.2$ and implies that on average firms increase their prices relative to their marginal costs by 20 percent. The price adjustment parameter is set to $\xi_p = 0.2$. Döpke et al. (2009) report empirical estimates of the annual price adjustment parameter to range from 0.03 and 0.67. Based on ECB (2012) results, we assume the labor markets to be more rigid than goods market in the euro area. Therefore, in terms of the annual model we set the wage rigidity to $\xi_w = 0.3$. According to the EMU average we set the degree of openness to $\omega = 0.25$ and the trade elasticity to $\mu = 1.5$. The central bank's policy function is not derived as optimal monetary policy. Instead we use common interest rate target coefficients of $\phi_\pi = 1.5$ and $\phi_y = 0.125$. We proceed in a similar way to extract the stochastic shock parameters. For a better visualization of the impulse response functions we use a standard deviation of unity. But in order to match the moments the empirical shocks and persistence parameters are extracted from an AR-1 estimation of labor productivity, labor supply functions and the interest rate spread in two euro area corridors between 1970 and 2010. Thus, average annual standard deviation of labor productivity, aggregate demand and labor supply shocks between 1970 and 2010 were 0.0195, 0.0201 and 0.1011. The annual average persistence parameter of labor productivity, aggregate demand and labor supply was 0.92, 0.98 and 0.98 respectively.

⁴⁴See e.g. Gali (2010), Mandelman and Zlate (2008) Mandelman and Zlate (2012), Hauser (2014), Dustmann and Görlach (2015).

⁴⁵Calibration is a starting point in order to investigate the joint behavior of migration, wages and unemployment. The next step would be to calibrate the model for particular migration corridors. Finally, we aim at using Bayesian estimation techniques to estimate the parameters of the model and compare the model with 'true' (conditional) standard deviations.

⁴⁶See Table 6 in Appendix 6.2 for the model parametrization.

In both countries the share of euro area migrants in total employment is set to be $\gamma = 0.07$ which is the unweighted EMU average without Germany.⁴⁷ For the substitution elasticity of a migrant worker we choose a higher value $\theta = 3$ than Mandelman and Zlate (2008) who assumed the substitution elasticity between Mexican and U.S. American workers to be 1.55.⁴⁸ We distinguish between two scenarios which we refer to as the symmetric (SYM) and the asymmetric corridor (ASYM). The symmetric corridor assumes the same parameter value for migrants and natives. The asymmetric corridor distinguishes between native and migrant workers according the labor mobility parameters and the steady state unemployment rates.

According to the literature migrant and native workers differ with respect to their labor supply elasticity ψ , their wage rigidity ξ_w and the wage setting power μ_w which is strongly influenced by the substitution elasticity between migrant labor types ε_w . Bentolila et al. (2008) argue that the labor supply elasticity of immigrants is lower than of natives, which corresponds to a higher migrant $\psi^* = 6$. Additionally, it can be argued that the bargaining power of migrants is lower than for natives, such that $\varepsilon_{w,f} = 5.52$ and the consequent markup are lower. Finally, migrants can be expected to adjust their wage more quickly than natives such that annual $\xi_{w,f} = 0.2$ is lower in the case of migrants.⁴⁹

5.2. Dynamic responses to shocks

In this section we describe the effects of migration on the business cycle dynamics from the perspective of the domestic economy. The guiding questions for the analysis relate to our empirical findings. First, we want to explain why both, the unemployment and the wage differential are negatively correlated with migration in the average euro area corridor, where the second is counter intuitive. Secondly, we aim at identifying factors that provide explanations for the observed heterogeneity across corridors.

Initially, we choose parameter values as defined in Table 6 in order to mimic a hypothetical (average) euro area migration corridor and simulate the impulse response functions of domestic aggregate variables to both, a positive productivity shock and a positive labor supply shock, that occur in the domestic economy. Subsequently, we further investigate the dynamic responses to a domestic productivity shock by varying the relative price/wage rigidity and introducing asymmetries between the corridors. Figures 3 – 5 in the Appendix 6.4 summarize the corresponding reactions

⁴⁷See ECB (2014).

⁴⁸Because of the relatively high education level in all countries of the EMU we expect migrants to be relatively similar with respect to the skill level.

⁴⁹Countries could also differ with respect to their migrant share γ and their average elasticity of substitution in production between migrant and native worker θ . While the effects of an increasing share of migrant share is trivial, the elasticity of substitution is very neglectable as long as migrants and natives are substitutes, $\theta > 1$.

of domestic macroeconomic aggregates including wage and unemployment differentials as well as the corridor-wide labor mobility.

Domestic productivity shock

As can be seen in Figure 3, a positive domestic productivity shock (represented by the blue line) leads to decreasing marginal costs and aggregate producer prices.⁵⁰ 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 that cannot adjust their wages. Because the wages are calibrated to be more rigid than prices, the decrease in price inflation is more pronounced than in wage inflation and the real wage and structural unemployment rise temporarily. As a consequence of the higher domestic productivity, foreign goods become relatively more expensive and are demanded less via the terms of trade channel. The reduced output incentivizes 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 temporarily. 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 differential between home and foreign to be positive.

If labor is free to move between both countries and migrant workers are substitutable to domestic workers and are demanded by a fraction γ , the labor immigration decision depends on the wage setting decision of the foreign household.⁵¹ In case of the positive domestic productivity shock, 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 wage in the domestic market and shift a higher fraction of labor supply to the foreign labor market. Consequently, the immigration rate in the domestic economy decreases as can be seen in Figure 3. At the same time, domestic households expect future wage and unemployment differences between domestic and foreign labor markets to be more favorable in the foreign country. Therefore, the net migration turns negative from the perspective of the domestic country. Overall, a positive

⁵⁰It is well known from the business cycle literature that in case of sluggish prices and wages, productivity shocks lead to a temporary decrease of employment. See Erceg et al. (2000), Gali (1999) and Gali (2010).

⁵¹In fact, by setting the native and migrant wage schedule given the home and foreign demand, a family household makes an indirect decision about the migrant labor supply. Finally, the firm decides the effective demand after the productivity shock occurs.

domestic demand shock thus can explain the negative correlation of net migration with both, the unemployment and the wage differential.

Labor supply shock

For the same set of parameters we also investigate a positive labor supply shock in Figure 3 (represented by the red line). A positive domestic labor supply shock increases both, the supply of natives in the home economy and the supply of immigrant workers in the foreign economy via migration diversion⁵². As a consequence the net migration rate is negative. The increase in the labor force incentivizes 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 the output via lower wages that reduce the marginal cost of firms and the producer prices in firms that can readjust their price and thus increase employment. However, the nominal wage decrease is stronger than the price decrease and overall the real wage decreases. In the foreign economy we observe the same effects, but because the share of the immigrant population is relatively low, the effects are quantitatively smaller. Consequently, in presence of a positive labor supply shock we observe a negative net migration in combination with both, a negative real wage differential and a positive unemployment differential.

Relative price/wage rigidity

As a next step, we want to assess the effect of the relative price/wage rigidity on the observed correlation of the real wage differential and net migration in Figure 4. Therefore we assume two scenarios, one with a very low price rigidity (represented by the blue line) in which the prices are more flexible than the wages and one with a very high price rigidity (represented by the red line) in which the prices are less flexible than the wages. As pointed out above, a positive domestic technology shock goes along with a negative net migration rate by decreasing domestic producer prices and nominal wages. The overall reaction of the real wage depends on the relative change of both variables. In the scenario with low price rigidity the reduction in the price level overcompensates the nominal wage reduction and the real wage increases. In the scenario with high price rigidity the relative strength of the reductions are reversed and the real wage decreases. Thus, for one type of shock we can either observe a negative or a positive correlation of real wage differential and net migration rate depending on the relative price/wage rigidity.

⁵²Migration diversion denotes the fact that external migrants can change locations between different euro area countries

Asymmetric migration corridor

Finally, we investigate a positive domestic productivity shock in an asymmetric migration corridor. Although, in principle a broader range of parameter values could be analyzed, we concentrate on differences in the labor supply elasticity and the wage rigidity between home and foreign. If the migrant households supply labor more elastically than native households, they principally have a lower willingness to change their wage in reaction to aggregate employment fluctuations (red line in Figure 5). In presence of decreasing employment, immigrants reduce their wage less but at the same time relatively strongly decrease their labor supply. As a consequence of the lower wage decrease, the firms reduce demand for immigrants relatively strong. Therefore, we observe a larger increase in the unemployment differential than in the case of immigrants with a low labor supply elasticity (black line). It appears noteworthy, that the reaction of the real wage differential is hardly affected by the parameter choice. The dynamic responses to a positive domestic technology shock vary quantitatively but not qualitatively.

If immigrants can adjust their wages more flexibly than natives, they can react faster to an economy-wide shock (red line in Figure 5). In case of a positive domestic technology shock they can reduce their nominal wage stronger than natives, such that the aggregate wage inflation is lower. Consequently, a stronger labor supply reduction coincides with a weaker employment decline. Overall, the unemployment increase is lower than in the case of very rigid migrant wages (black line). The wage decrease goes along with a stronger decline in the wage differential and weaker increase in the unemployment differential. Thus, it translates into a larger decline in immigration and net migration. Again, the dynamic responses to a positive domestic technology shock vary quantitatively but not qualitatively.

5.3. Discussion of Results

The investigation of impulse response functions sheds light on several transmission channels and parameters that affect the observed migration patterns in the euro area. For the average euro area corridor a domestic labor productivity shock provides an explanation for the observed negative correlation of net migration and the real wage respectively unemployment differential. The shock increases real wages and unemployment and causes a negative net migration in the country where it originates. With respect to the heterogeneity across corridors we investigated different types of shocks, the relative price/wage rigidity and asymmetries between corridors as potential explanations. Domestic labor productivity and labor supply shock increase the unemployment differential and cause a negative net migration rate. However, they have differential effects on the real wage differential. Therefore, different types of shocks that hit an economy provide an explanation for the observed heterogeneity across corridors. The relative price/wage rigidity affects

the impact of one type of shock on the real wage differential. Depending on what is more rigid, wages or prices, one can observe either a positive or a negative correlation of net migration and the real wage differential. Thus, heterogeneity with respect to the relative price/wage rigidity can account for the observed differences between euro area migration corridors. The third potential explanation, asymmetries between corridors with respect to the labor supply elasticity and the wage rigidity is unable to account for the observed heterogeneity. Unless the immigrant share is very (unrealistically) high, the asymmetry only has qualitative but not quantitative effects.

Finally, we assess 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 domestic and foreign productivity and demand shocks from their distributions and simulate 1000 periods to extract the standard deviations conditional on all shocks and the correlations from the structural model.⁵³ The results are summarized in Table 3 and 4. Table 3 depicts the empirical

Variable x	$(\sigma(x)/\sigma(y))$	SYM*	corr(x, y)	SYM*
Output y	1	1	1	1
Consumption c	0.81	0.67	0.76	0.82
Employment n	0.76	0.69	0.69	0.78
Labor force l	0.39	0.50	0.43	0.29
Unemployment rate u	0.48	0.59	-0.68	-0.66
Real wage w	0.68	0.50	0.17	0.59

*SYM: Symmetric model

Table 3: Theoretical vs. Empirical Moments of the EMU countries business cycle 1980-2010 - The symmetric case and simulated relative standard deviations and correlations of the average EMU business cycle for the period 1980-2010. The first column of Table 3 depicts the empirical standard deviations. The second contains the standard deviations that our model would predict. In the third and fourth column of Table 3 we compare the theoretical correlations with the empirical ones. The symmetric model matches the empirical fluctuation relations and correlations quite well.⁵⁴ Although the business cycle volatility of consumption, employment and labor force in relation to output are too low, the cross relations are similar. The model overstates the fluctuations of unemployment and to understate the fluctuations of real wages.

⁵³In order to compare the theoretical model with the empirical unconditional standard deviations we simulate the time series including all shocks. Therefore, the reactions of macroeconomic variables are not conditional on a specific shock. To compare the true conditional reactions, we have to compare the extracted theoretical standard deviations in case of a single shock with the empirical counterparts resulting from a structural VAR.

⁵⁴In Table 8 of Appendix 6.6 we also simulate the asymmetric model but do not find significantly different results.

Table 4 summarizes the empirical and simulated relative standard deviations and correlations of the average EMU migration cycle for the period 1980-2010. The comparison reveals three notable results: First, the symmetric and the asymmetric model predict the relative fluctuations and correlation of net migration and the GDP quite well. Second, the model overstates the fluctuations of wage differentials and understates the fluctuations of unemployment differentials over the business cycle. Thus, it seems that the overestimation compensates for the underestimation of the other in determining the migration fluctuation. Third, the model predicts the negative sign of the correlation between net migration and its main and foremost determinants.⁵⁵

Intuitively, both shortcomings of the model - the relatively high wage differential fluctuation and the relatively high wage correlation - indicate that at least one additional channel exists that reduces the volatility of unemployment and increases the volatility of wages and thus has a significant impact on net migration fluctuations and correlations within the EMU. Summarizing our

x=Net migration rate	Empirical values	SYM*	ASYM**
Fluctuation ($\sigma(x)/\sigma(y)$)	1.55	1.56	1.55
Cyclicalitly ($\rho(x, dy)$)	0.17	0.11	0.11
Real wage differential ($\rho(x, du)$)	-0.1	-0.75	-0.75
Unemployment differential ($\rho(x, d(w/p))$)	-0.31	-0.26	-0.27

*SYM: Symmetric model **ASYM: Asymmetric Model

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

results, we find that our model fits suitable well to describe migration flows over the business cycle in the euro area. However, both, standard deviations and correlations, point towards the need to improve the wage and unemployment specification in our model. In line with this finding, introducing search and matching appears as a valuable extension. Search and matching frictions as modeled by Mortensen and Pissarides (1994) reduce the volatility of unemployment because a worker-firm match has a value that exceed the contemporaneous marginal product by taking into account the cost of forming a match. At the same time, the standard formulation of the model generates very high wage fluctuations.

Other arguments point towards a similar direction of further research. Our results show that allowing for migration does not significantly change the dynamic pattern of the output and inflation

⁵⁵Although it overstates the negative correlation between the cyclical component of net migration and the real wage differential for this average EMU corridor calibration, it is principally able to explain the negative sign of the main determinants.

gap. In our model, two reasons for the relatively low impact of migration flows on the aggregate fluctuation of output stand out. One reason lies in the similarity of labor market characteristics of migrants and natives as modeled in the scenario of a symmetric corridor. Another reason is the relatively low migrant share.

Nevertheless, an increased mobility might not abate relative business cycle fluctuations because there is a growing structural mismatch between labor demand and supply in the European labor market with respect to the skills of workers (ECB, 2012). In line with this finding, introducing search and matching appears as valuable extension of our model. Search and matching frictions account for skill heterogeneity of workers and the resulting information asymmetry between workers and firms when forming a match. Incorporating these features, would reduce the flexibility of labor market adjustments to shocks and thereby provide a more realistic description of labor markets in the EMU. Additionally, a model with search and matching would allow us to account for some key facts in the empirical migration literature such as the higher separation rate of migrant jobs in an economic downturn (Dustmann et al. (2010), Prean and Mayr (2012)).

6. Conclusions

This paper proposes a new approach to model the fluctuation of migration and unemployment over the business cycle in a two-country setting. In particular, we focus on the bargaining power of workers and nominal wage rigidity as sources of unemployment.

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.

Our subsequent empirical analysis of bilateral migration and macroeconomic data over the years 1980-2010 supports this notion. We present several key migration related business cycle facts for the Euro12 that provide evidence for business cycle related fluctuations in migration patterns and a) the crucial role of unemployment differentials in shaping intra-euro area migration patterns, b) a puzzling relationship between real wage differentials and intra-euro area net migration and c) a considerable cross-country heterogeneity with respect to the correlation of net migration and the wage respectively unemployment differential.

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 labor market frictions and rigidities in both countries. Our calibrated model is able to replicate all three empirical observations. With respect to the average euro area migration corridor, we show that a positive technology shock in one country of a migration corridor gives rise to a positive real wage and unemployment differential and a negative net migration. Consequently, the dynamic behavior subsequent a productivity shock can explain the empirically observed correlations. With respect to the heterogeneity across corridors, we identify differences in the type of shock that hits an economy and the relative price/wage rigidity as valid explanations. Further our model gives rise to a flatter Phillips curve in presence of immigration and thus replicates a key finding of the migration literature. Relating the wage and the unemployment rate of migrants to the structural parameters underlying their wage setting behavior enables us to show that the more inelastic the migrant labor supply and the more rigid the migrant wages are, the lower are the fluctuations in migrant flows.

Even though insightful, the model has some shortcomings that will guide our further direction of research. Emphasis in further work will be placed on the fact that our model overestimates the

fluctuation of unemployment at the expense of a lower wage fluctuation that is not in line with our empirical observations. This points towards the need to include search and matching frictions into the model. Empirical observations such as the growing skill-mismatch in the EMU labor market and the higher separation rate of migrants in an economic downturn further support the need of a search and matching model of euro area labor migration. Such a model would introduce the labor market tightness as another channel via which migration can affect the firms' marginal cost and thus the price dynamics in an economy.

6.1. Symmetric zero-Inflation Steady State

Variable	Domestic country	Foreign country
Technology	$a = 1$	$a^* = 1$
Inflation	$\pi^P, \pi_h^P, \pi_f^P, \pi^W, \pi_h^W, \pi_f^W = 1$	$-\pi^{*P}, \pi_h^{*P}, \pi_f^{*P}, \pi^{*W}, \pi_h^{*W}, \pi_f^{*W} = 1$
Marginal costs	$mc = \frac{1}{\mu_p}$	$mc^* = \frac{1}{\mu_p}$
Prices	$p, p_h, p_f = 1$	$p^*, p_h^*, p_f^* = 1$
Exchange rates	$q, s = 1$	$q, s = 1$
Trade balance	$tb = 0$	$tb = 0$
Consumption	$y = c$	$y^* = c^*$
MRS	$mrs = \frac{1}{\mu_w}$	$mrs^* = \frac{1}{\mu_w}$
Nominal wages	$w, w_h, w_f = 1$	$w^*, w_h^*, w_f^* = 1$
Unemployment	$u, u_h, u_f = 1 - \left(\frac{1}{\mu^W}\right)^\psi$	$u^*, u_h^*, u_f^* = 1 - \left(\frac{1}{\mu^W}\right)^\psi$
Employment	$n = \left(\frac{1}{\mu}\right)^{\frac{1}{1+\psi-\alpha}}$	$n^* = \left(\frac{1}{\mu}\right)^{\frac{1}{1+\psi-\alpha}}$
Labor force	$l = \left(\frac{1}{\mu}\right)^{\frac{\alpha-1}{(1+\psi-\alpha)\phi}}$	$l^* = \left(\frac{1}{\mu}\right)^{\frac{\alpha-1}{(1+\psi-\alpha)\phi}}$
Production	$y = \left(\frac{1}{\mu}\right)^{\frac{1-\alpha}{1+\psi-\alpha}}$	$y^* = \left(\frac{1}{\mu}\right)^{\frac{1-\alpha}{1+\psi-\alpha}}$

Table 5: Steady state: Symmetric equilibrium

6.2. Basic parametrization

Structural parameter	Value	Target
Time preference	$\beta = 0.98$	$\bar{i} = 2\%$ p.a.
Intraindustrial SE	$\varepsilon_P = 6$	$\mu_p = 1.2$
Production elasticity	$\alpha = 0.25$	Gali (2011)
Price adjustment	$\xi_P = 0.2$	Döpke et al. (2009)
Openness	$\omega = 0.25$	EMU average
Trade elasticity	$\mu = 1.5$	EMU average
Labor mobility parameter	Value	Target
Native labor supply elasticity	$\psi = 5$	DiCecio and Nelson (2010)
Share of migrant worker	$\gamma = 0.07$	EMU average
Wage adjustment	$\xi_W = 0.3$	
SE of migrant work	$\theta = 3$	
SE of native labor type	$\varepsilon_W = 4.5$	$\bar{u} = 5\%$
Shock parameter	Value	Target
SD Labor productivity	$\zeta_{A,t} = 0.0195$	EMU average
SD Labor supply shock	$\zeta_{A,t} = 0.1011$	EMU average
SD monetary policy shock	$\zeta_{M,t} = 0.0207$	EMU average
Persistence labor productivity	$\rho_A = 0.92$	EMU average
Persistence labor supply	$\rho_A = 0.98$	EMU average
Persistence monetary policy	$\rho_M = 0.9$	EMU average
Policy parameters	Value	Target
Price inflation target	$\phi_\pi = 1.5$	
Output target	$\phi_y = 0.125$	

Table 6: Calibration

6.3. Deriving the Slope of the price Phillips curve

Case 1: Model with price and wage stickiness but without migration

$$\hat{\pi}^P(1 - \beta L^{-1}) = \lambda^P \hat{m}c, \quad (41)$$

$$\hat{\pi}^W(1 - \beta L^{-1}) = \lambda^W (m\hat{r}s - \hat{w} + \hat{p}), \quad (42)$$

where L describes the lag parameter.

The marginal cost function is

$$\hat{m}c = \hat{w} - \hat{p} + \frac{\alpha}{1 - \alpha} \hat{y} - \frac{1}{1 - \alpha} \hat{a} + \bar{\omega} \hat{s}_t. \quad (43)$$

The marginal rate of substitution is

$$m\hat{r}s = \hat{c} + \psi \hat{n}. \quad (44)$$

The real wage in terms of the labor supply is

$$\hat{w} - \hat{p} = \hat{c} + \psi \hat{l}. \quad (45)$$

The real wage changes according to:

$$\hat{w} - \hat{p} = \frac{\hat{\pi}^W - \hat{\pi}^P}{1 - L}. \quad (46)$$

The unemployment rate is defined as $\hat{u} = \hat{l} - \hat{n}$. Thus, we get:

$$\hat{\pi}^W = -\frac{\lambda^W}{1 - \beta L^{-1}} \psi \hat{u}. \quad (47)$$

Inserting into MPL, MC and finally into the price Phillips curve gives:

$$\begin{aligned} \hat{\pi}_t^P = & \frac{2\beta}{1 + 2\beta + \lambda_p} E_t \hat{\pi}_{t+1}^P - \frac{\beta^2}{1 + 2\beta + \lambda_p} E_t \hat{\pi}_{t+2}^P + \frac{1}{1 + 2\beta + \lambda_p} \hat{\pi}_{t-1}^P \\ & + \frac{(1 - \beta L^{-1})(1 - L)\lambda^P}{1 + 2\beta + \lambda_p} \left(\frac{\alpha}{1 - \alpha} \hat{y} - \frac{1}{1 - \alpha} \hat{a} + \bar{\omega} \hat{s}_t \right) - \frac{\lambda^P \lambda^W}{1 + 2\beta + \lambda_p} \psi \hat{u}. \end{aligned} \quad (48)$$

Case 2: Model with price and wage stickiness and migration

For simplicity we assume that steady state unemployment rates and the Calvo parameters are symmetric between countries. Thus migrant and native worker differ with respect to their inverse labor elasticity $\psi \neq \psi^*$:

With symmetric steady state unemployment rates the countrywide wage Phillips curve is:

$$\hat{\pi}^W(1 - \beta L^{-1}) = -\lambda^W([(1 - \bar{\gamma})\psi + \bar{\gamma}\psi^*]\hat{u} + \bar{\gamma}(\psi^* - \psi)(\hat{u}_{im} - \hat{u})), \quad (49)$$

$$\hat{\pi}^W(1 - \beta L^{-1}) = -\lambda^W(\psi\hat{u} + \bar{\gamma}(\psi^* - \psi)\hat{u}_{im}). \quad (50)$$

with $\bar{\gamma} = \gamma^\theta \left(\frac{\bar{N}_j}{\bar{N}}\right)^{1-\theta}$ and $\hat{u}_{im} - \hat{u} = \hat{im}_n - \hat{im}_l = (\hat{n}_f - \hat{n}) - (\hat{l}_f - \hat{l})$.

Considering the difference in native and migrant worker and $\hat{w} = (1 - \bar{\gamma})\hat{m}rs_f + \bar{\gamma}\hat{m}rs_h$ in the marginal cost equation gives

$$\hat{m}c = -\frac{\lambda^W}{(1 - \beta L^{-1})(1 - L)}(\psi\hat{u} + \bar{\gamma}(\psi^* - \psi)\hat{u}_{im}) + \frac{\hat{\pi}^P}{1 - L} + \frac{\alpha}{1 - \alpha}\hat{y} - \frac{1}{1 - \alpha}\hat{a} + \bar{\omega}\hat{s}_t. \quad (51)$$

The price Phillips curve is finally:

$$\begin{aligned} \hat{\pi}_t^P &= \frac{2\beta}{1 + 2\beta + \lambda_p} E_t \hat{\pi}_{t+1}^P - \frac{\beta^2}{1 + 2\beta + \lambda_p} E_t \hat{\pi}_{t+2}^P + \frac{1}{1 + 2\beta + \lambda_p} \hat{\pi}_{t-1}^P \\ &+ \frac{(1 - \beta L^{-1})(1 - L)\lambda^P}{1 + 2\beta + \lambda_p} \left(\frac{\alpha}{1 - \alpha}\hat{y} - \frac{1}{1 - \alpha}\hat{a} + \bar{\omega}\hat{s}_t \right) - \frac{\lambda^P \lambda^W}{1 + 2\beta + \lambda_p} (\psi\hat{u} + \bar{\gamma}(\psi^* - \psi)\hat{u}_{im}) \end{aligned} \quad (52)$$

To compare both slopes we subtract the Phillips curve without migration:

$$\Delta \hat{\pi}_t^P = -\bar{\gamma}(\psi^* - \psi)\hat{u}_{im}. \quad (53)$$

As we can easily see, if $\psi^* > \psi$ the price Phillips curve becomes flatter.

Case 3: Model with price and wage stickiness and asymmetric migration

Now finally, we loose the restrictions on the other parameter values to compare the slopes under fully asymmetric migrant behavior. Therefore we let nominal wage rigidities and steady state unemployment differ across countries.

The countrywide wage Phillips curve is now

$$\hat{\pi}^W(1 - \beta L^{-1}) = (1 - \bar{\gamma})\lambda_W(\hat{c} + \psi\hat{n}_h - \hat{w}_h + \hat{p}) + \bar{\gamma}\lambda_W^*(\hat{c} - \hat{q} + \psi^*\hat{n}_f - \hat{w}_f + \hat{p}). \quad (54)$$

Rearranging and considering the definition of the immigration rate $\hat{im}_n = \hat{n}_f - \hat{n}$, the aggregate

employment $\hat{n} = (1 - \bar{\gamma})\hat{n}_h + \bar{\gamma}\hat{n}_f$ gives:

$$\begin{aligned} \hat{\pi}^W(1 - \beta L^{-1}) = & [(1 - \bar{\gamma})\lambda_W + \bar{\gamma}\lambda_W^*](\hat{c}) + [(1 - \bar{\gamma})\lambda_W\psi + \bar{\gamma}\lambda_W^*\psi^*]\hat{n}_h + \bar{\gamma}(\lambda_W^*\psi^* - \lambda_W\psi)\hat{im}_{n,t} \\ & - (1 - \bar{\gamma})\lambda_W(\hat{w}_h - \hat{p}) - \bar{\gamma}\lambda_W^*(\hat{w}_f - \hat{p}) - \bar{\gamma}\lambda_W^*(1 - 2\bar{\omega})\hat{s}. \end{aligned} \quad (55)$$

Inserting the specific labor supply $\hat{w}_h - \hat{p}_h = \hat{c} + \psi\hat{l}_h$ and $\hat{w}_f - \hat{p}_f = \hat{c} - \hat{q} + \psi^*\hat{l}_f$ and the unemployment definition yields $\hat{u} = \hat{l} - \hat{n}$ the price Phillips curve:

$$\begin{aligned} \hat{\pi}_t^P = & \frac{2\beta}{1 + 2\beta + \lambda_p} E_t \hat{\pi}_{t+1}^P - \frac{\beta^2}{1 + 2\beta + \lambda_p} E_t \hat{\pi}_{t+2}^P + \frac{1}{1 + 2\beta + \lambda_p} \hat{\pi}_{t-1}^P \\ & + \frac{(1 - \beta L^{-1})(1 - L)\lambda^P}{1 + 2\beta + \lambda_p} \left(\frac{\alpha}{1 - \alpha} \hat{y} - \frac{1}{1 - \alpha} \hat{a} + \bar{\omega} \hat{s}_t \right) \\ & - \frac{\lambda^P \lambda^W}{1 + 2\beta + \lambda_p} \left(\psi \hat{u} + \bar{\gamma} \left(\frac{\lambda_W^*}{\lambda_W} \psi^* - \lambda_W \psi \right) \hat{u}_f + \bar{\gamma} \psi \left(1 - \frac{1 - \bar{\gamma}}{1 - \bar{\gamma}_L} \right) (\hat{l}_h - \hat{l}) \right). \end{aligned} \quad (56)$$

In comparison to the Phillips curve without migration we get:

$$\Delta \hat{\pi}_t^P = -\bar{\gamma} \left(\frac{\lambda_W^*}{\lambda_W} \psi^* + \lambda_W \psi \right) \hat{u}_f + \bar{\gamma} \psi \left(1 - \frac{1 - \bar{\gamma}}{1 - \bar{\gamma}_L} \right) (\hat{l}_h - \hat{l}), \quad (57)$$

with $\bar{\gamma}_L = \gamma^\theta \left(\frac{L_j}{L} \right)^{1-\theta}$.

6.4. Impulse response functions

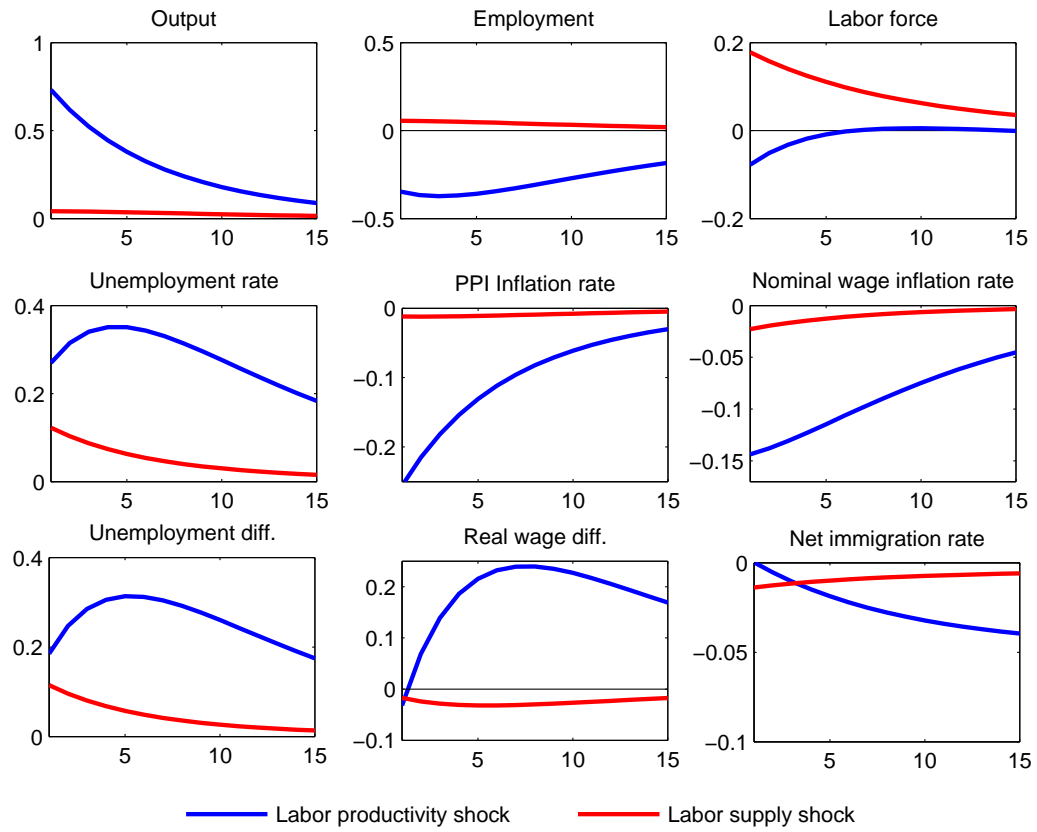


Figure 3: Domestic positive labor productivity vs. labor supply shock

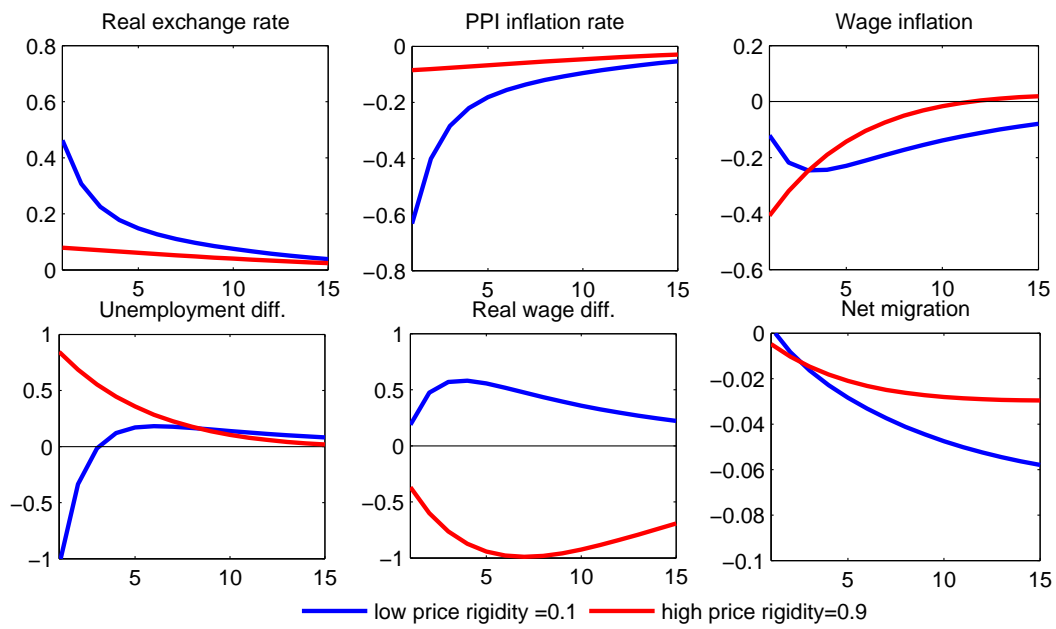


Figure 4: Domestic positive productivity shock and relative price/wage stickiness

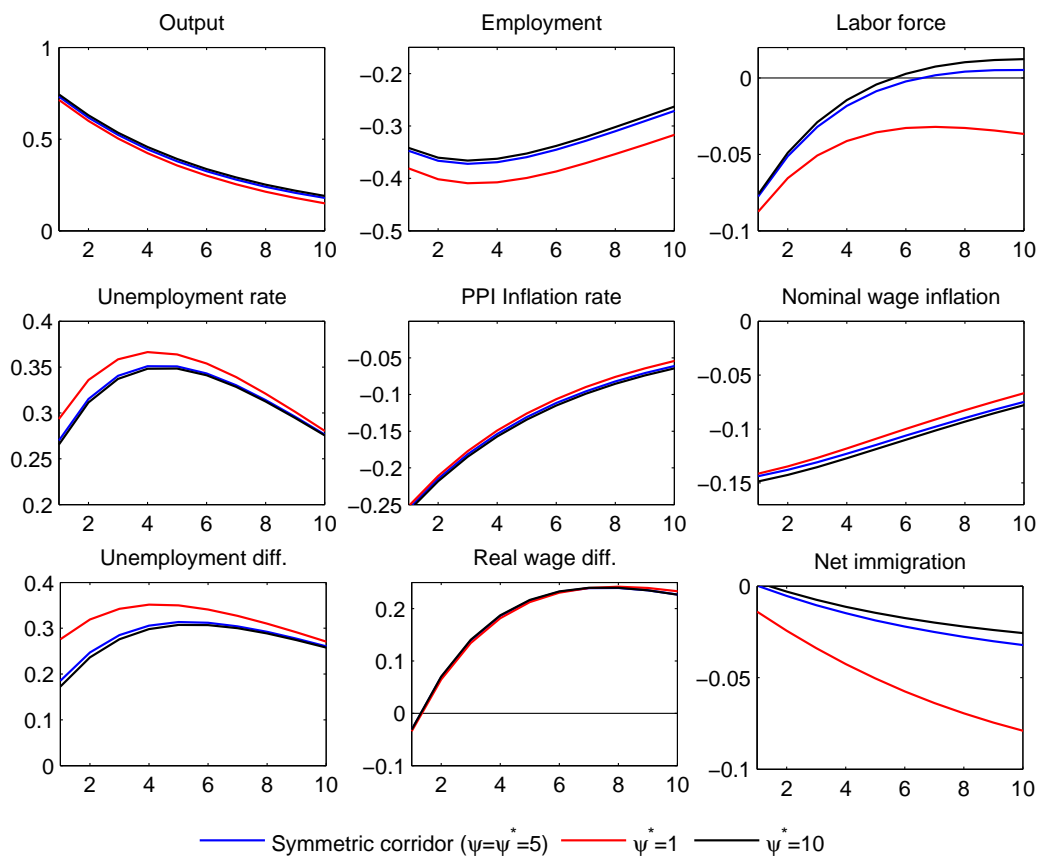


Figure 5: Domestic positive productivity shock and differences between native and migrant workers

6.5. Data description

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

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

Employment: Employment, persons: total economy (National accounts) (NETN) (1000 Persons), AMECO database, 2015.

Labor force: Total labour force (Labour force statistics) (NLTN) (1000 Persons), AMECO database, 2015.

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

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

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

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

Immigration: Bilateral immigration flows, "International Migration Flows to and from Selected Countries: The 2008 Revision", United Nations, 2008. Missing values for the periods after 2008 are estimated by OECD Migration database, OECD, 2015.

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

Net migration: Difference of immigration as a share of total domestic population and emigration as a share of foreign population. We do so in order to match the steady state share in the model.

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. We do so in order to match the steady state share in the model.

6.6. Robustness

x=Net migration rate	1980-2010	1999-2010	1980-2010	1980-2010
λ	400	400	6.25	100
Fluctuation ($\sigma(x)/\sigma(y)$)	1.55	1.35	2.00	1.64
Cyclicalilty ($corr(x, dy)$)	0.18*	0.19*	0.13*	0.13*
Unemployment differential ($corr(x, d(w/p))$)	-0.31*	-0.16*	-0.13*	-0.21*
Real wage differential ($corr(x, du)$)	-0.08*	-0.03	0.04	-0.006

Table 7: Empirical euro area business cycle robustness - Net migration

Variable x	$(\sigma(x)/\sigma(y))$	Model	$corr(x, y)$	Model
Output y	1	1	1	1
Consumption c	0.81	0.67	0.76	0.8
Employment n	0.76	0.70	0.69	0.73
Labor force l	0.39	0.53	0.43	0.32
Unemployment rate u	0.48	0.59	-0.68	-0.63
Real wage w	0.68	0.49	0.17	0.59

Table 8: Theoretical vs. empirical moments of the euro area business cycle 1980-2010 - Asymmetric model

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