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

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# Migration, Unemployment and the Business Cycle

## - A Euro Area Perspective -

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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. Investigating the business cycle in 55 bilateral migration corridors in the euro area over the period 1980-2010, we find evidence for business cycle related fluctuations in net migration flows and the crucial role of unemployment in shaping migration patterns. While on average wage and unemployment differentials are negatively correlated with net migration, across migration corridors we document a considerable heterogeneity in both dimensions that is more pronounced for wages. In line with these findings, we built a two-country dynamic stochastic general equilibrium (DSGE) model of internal business cycle migration in the euro area and allow for unemployment that occurs as a consequence of labor market frictions and rigidities in both countries. Our model is able to replicate the 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. We contribute to the literature on the causes and consequences of temporary migration and bridge it to DSGE models with unemployment.

*Keywords:* Labor Migration, International Business Cycles, Unemployment

*JEL:* E24, F22, F41

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## 1. Introduction

Two poles span the area of conflict of internal migration in the euro area (EA) and underline the need to understand its nature and determinants. On the one hand, 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 guaranteed<sup>1</sup> and reduces the migration cost of both, employed and unemployed workers. Against the background of heterogeneous labor market conditions European policy makers highlight migration as a means to increase overall employment (ECB, 2014). Even though migrations flows in the euro area are lower<sup>2</sup> than inter-state migration flows in the United States there is evidence for the importance of migration as an adjustment mechanism. According to Jauer et al. (2014) in the European Union on average one quarter of the asymmetric labor market shock absorption can be attributed to migration. In a similar vein, Beyer and Smets (2015) find that the contribution of migration to the adjustment to country-specific labor demand shocks has increased from 30% in the period 1977-1999 to 35% in the period 1990-2013. On the other hand, 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.

The European financial and debt crisis sheds 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 level and the country level (OECD, 2014). Between 2007 and 2010 free movement immigration flows dropped by 35 percent in Europe and rebounded with diverging patterns thereafter. In countries with traditionally high immigration such as Ireland, Portugal, Spain, and Italy, total inflows declined strongly while they increased significantly in Fin-

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<sup>1</sup>The 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.

<sup>2</sup>Reasons are seen in the cultural, language and institutional difference in Europe as well as imperfections in the housing and rental market and liquidity constraints (Bartz and Fuchs-Schuendeln (2013), Huber (2005), ECB (2012))

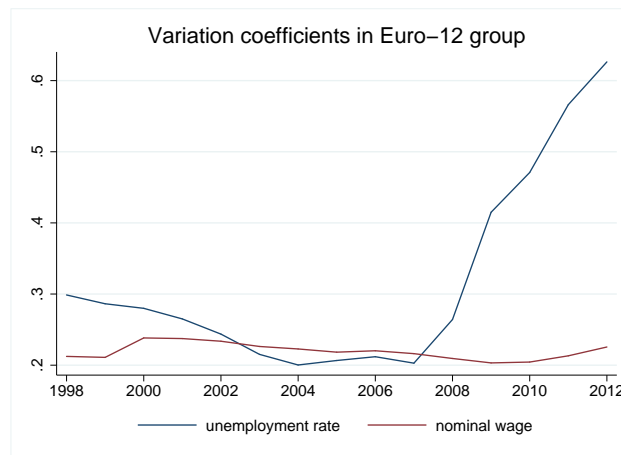


Figure 1: Dispersion of unemployment and wages in the euro area

Source: own figure, Eurostat data.

land, Austria and Germany. Consequently, as documented by Bertoli et al. (2013)<sup>3</sup>, Germany as the largest economy in the euro area transformed into the most important migration destination in the area. The crisis incidence 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 nearly unchanged. In Figure 1 we compare the dispersion<sup>4</sup> of unemployment and wages measured by the coefficient of variation in the EA-12 over the period 1998-2012. We find that unemployment rates are much more dispersed than nominal wages since 2008.<sup>5</sup> Secondly, the growing regional labor market disparities are mirrored by the crisis' heterogeneous impact 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 euro area migration patterns.<sup>6</sup> Further, they point to the need to understand the impact of the business cycle via wage and unemployment

<sup>3</sup>Bertoli et al. (2013) investigate data on 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 find that the immigration increase is grounded mainly in migration diversion from one destination country to an alternative one, while migration creation only plays a subordinate role.

<sup>4</sup>Regional dispersion of unemployment and wages is measured by the coefficient of variation that normalizes the standard deviation by the mean (both in unweighted terms). The data sources and definitions are described in Section 3.1.

<sup>5</sup>This result should be interpreted with caution as aggregate wages might not reflect the cyclical pattern of wages properly e.g. because of long-term wage contracts or a composition bias (Solon et al., 1992).

<sup>6</sup>This would be in line with Dao et al. (2014) who find that the decline of internal migration in the United States coincides with a reduced regional unemployment dispersion.

fluctuations on direction, size and composition of internal migration in the euro area.

To this end, we carry out a comprehensive empirical analysis of the interrelation of wages, unemployment and migration patterns in the euro area over the business cycle for the period 1980 to 2010. Our analysis of 55 bilateral migration corridors reveals that on average wage and unemployment differentials are negatively correlated with net migration. However, across corridors we find a considerable heterogeneity in both dimensions that is more pronounced in the case of wage differentials. In line with these findings we build a theoretical business cycle model of migration and unemployment. Our interest is twofold: We aim at identifying how the business cycle and the fluctuation of wages and unemployment affect bilateral migration flows. At the same time, we want to assess the effect of migration on output fluctuations and thus the role of migration in abating asymmetric shocks. While we identify significant effects in the first dimension, we find the effects in the second dimension to be relatively low. The 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 fluctuation in migrant flows. 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, 2009)) to the growing literature on unemployment in dynamic stochastic general equilibrium (DGSE) models.

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

## **2. Literature Survey**

The importance of internal migration in the euro area has grown over time and a substantial part of the migrant population in the member 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 agreement and the introduction of the euro to have increased internal migration in the European Union (EU). In many EU countries the immigrant stock to a large part consists of migrants from another member country. E.g. in 2014, 45 percent of all immigrants living in

Germany originated from another EU-28 country, within this group Italian and Greek immigrants made up for the largest populations from another euro country with 16 percent and 9 percent respectively (Destatis, 2015). This corresponds to an immigrant share<sup>7</sup> of 4.5 percent (EU-28), 0.7 percent (Italy) and 0.4 percent (Greece).<sup>8</sup>

As a consequence of the free movement of workers, internal migration in the euro area is mainly motivated by work-related factors and often has a temporary nature (OECD (2014), Brücker et al. (2014)). 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 on average higher in European countries than in the United States, Canada or New Zealand. The outmigration rate after five years was 60.4 percent in Ireland, 50.4 percent in Belgium and 28.2 percent 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 euro members is more homogenous than the EU-28 as a whole.<sup>9</sup> 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) and Hauser (2014) document a procyclical pattern of internal migration. 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, there is evidence 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 corresponds to the general finding that immigrants tend to be hit hard and immediately in an economic downturn (OECD, 2013).

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) model

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<sup>7</sup>Defined as immigrant stock divided by population size.

<sup>8</sup>In our analysis we abstract from the current refugee stream to the EU and namely Germany. However, the inflow is substantial. E.g. an inflow of 800,000 refugees to Germany in 2015 increases the immigrant stock by 9.8 percent and corresponds to a refugee immigrant share of 0.99 percent.

<sup>9</sup>The membership in the euro area is conditional on the fulfillment of economic convergence criteria.

immigration of unskilled Mexicans to the U.S. in a 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 raise 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 euro area is characterized by an interplay of migration and unemployment at business cycle frequencies. To this end, a model of internal migration in the euro area needs to incorporate both, the effect of migration on source and destination countries as well as unemployment and labor market frictions. In this paper we develop a comprehensive model of bilateral migration flows with these distinct features.

In the DSGE framework two different approaches to introduce unemployment can be distinguished. One approach (e.g. Gali (2011a,b)) 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.<sup>10</sup> 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.<sup>11</sup>

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<sup>10</sup>More precisely, one should speak about underemployment because the wage markup is derived from the workers' optimization problem and thus the employment below the efficient level is a desired outcome.

<sup>11</sup>Shimer (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.

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 euro area, we consider differences in employment probabilities as a key migration trigger additional to wages. Including unemployment in the analysis has nontrivial consequences because unemployment rates exhibit a different dynamic pattern than wages. It is a well-known fact that in the euro area nominal wages are above equilibrium and rigid. Therefore, we follow Gali (2011b) and allow for unemployment that occurs as a consequence of labor market frictions and rigidities in both countries. This approach explains unemployment as result of time-varying country-specific markups on competitive equilibrium wages, that in our framework potentially differs for natives and migrants. This set-up 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.

### 3. Empirical observations

#### 3.1. *Compiling the data set*

To investigate the migration business cycle in the euro area we compile a large data set with bilateral migration and macroeconomic variables<sup>12</sup> in a similar vein as Beine et al. (2013) but with a focus on the euro area. The data set contains observations for the years 1980-2010 and covers 12 euro area countries (EA-12<sup>13</sup>). Due to the lack of availability of quarterly<sup>14</sup> bilateral migration data we rely on annual data from the United Nations and the OECD Migration database. Each pair of countries is referred to as a migration corridor and our set of countries gives rise to  $12 \cdot 11/2 = 66$  potential migration corridors. Due to data limitations the number of actual corridors in the panel reduces to 55.<sup>15</sup> For each bilateral migration corridor we define the net migration as the difference of immigration and emigration between the two countries and normalize it by the average labor force in the migration corridor. It has to be noted that within the euro area the observed migration

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<sup>12</sup>See Appendix 7.1 for a description of the data.

<sup>13</sup>The EA-12 refers to Austria, Belgium, Germany, Spain, Finland, France, Ireland, Italy, Luxembourg, Netherlands, Portugal and Greece.

<sup>14</sup>The empirical investigation of short-run migration flows is limited by the fact, that data on a business cycle frequency is still very rare. Therefore, most studies use data on an annual basis from 1980 until now. For Germany there is a new data set with monthly data.

<sup>15</sup>There are still some missing years in that panel. In the period 1980-2010 there are 42 corridors without missing observations, in 1990-2010 the number increases to 50 corridors and in 1996-2010 to 55 corridors.



flows origin from an interplay of complex migration patterns. Basically, immigration to an EA-12 country can be distinguished according to the source country which can be located outside the EU, inside the EU but outside the EA-12, or inside the EA-12. We want to focus on internal migration in the EA-12, thereby we do not account for the nationality of a migrant only for the source country. For instance an increase in immigration from another EA-12 country can be either caused by migration creation or the diversion of immigrants from one destination to another.<sup>16</sup>

The data series for the macroeconomic variables real GDP, real consumption, unemployment rate, employment, labor force, real wage, price inflation, wage inflation, and trade balance were drawn from the AMECO database. Real compensation per employee serves as a proxy for real wages.<sup>17</sup> For the migration business cycle relative fluctuations of variables in source and destination countries matter. Therefore, we construct differentials of output, real wage, and unemployment rate for each migration corridor. The differentials are defined as the difference in a variable, normalized by its corridor average. The wage and the unemployment differentials act as empirical proxies for non observable time-varying migrants wage/unemployment differentials.<sup>18</sup> All variables are in real terms and in terms of the cyclical component, i.e. the deviation of the variable from its trend. In order to extract the cyclical component we take logs of all level variables and apply the HP filter with a smoothing parameter of  $\lambda = 400$ .<sup>19</sup> EA-12 averages are obtained as unweighted averages of all corridors.

### 3.2. Business Cycle Statistics of the Euro Area

In the following we present business cycle facts on the euro area that help to assess whether internal migration patterns vary systematically with the business cycles and how wages, unemployment and migration patterns are interrelated over the business cycle. Thereby our interest is twofold, we want to identify characteristic patterns of the average EA-12 migration corridor and consider heterogeneity across corridors.

Table 1 provides key facts for the business and migration cycle in the average EA-12 corridor with respect to standard deviations and correlations as measures for volatility and cyclicity.

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<sup>16</sup>In 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 EA-12 country to another and thus cannot keep the population of countries constant. A refugee inflow to the EU, as observed recently, does not have an impact on our data because asylum laws prohibit this group of migrants to relocate between different countries.

<sup>17</sup>Gali (2011a) points out, that compensation per employee is a wage concept that comprises other employment-related cost to the employer than wages and exhibits stronger volatility than earnings-based concepts.

<sup>18</sup>While comparable data in source and destination countries is available for average wages, there is a lack of data on skill-specific wage differentials. Grogger and Hansen (2011) provide an approach to construct such a measure.

<sup>19</sup>Thereby we follow Beine et al. (2013) who also use a value of  $\lambda = 400$  for the analysis of business cycle migration with annual data. We check the robustness of our results with respect to the smoothing parameter and also use  $\lambda = 100$  and  $\lambda = 6.25$ . See Table 7 in Appendix 7.2.

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

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

Table 1: Empirical euro area business and migration cycle - Key facts

Column one to three underline that typical results from national and international business cycle analysis are also valid for the EA-12 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. Domestic consumption and employment are highly procyclical, aggregate real wages have a lower positive correlation with output and unemployment is strongly countercyclical. The positive correlation of domestic and foreign variables indicates a high level of integration within the euro area. There is evidence for a migration cycle in the EA-12 because the net migration rate displays a relatively strong volatility. Net migration is positively correlated with the output differential, thus internal migration seems to be procyclical.<sup>20</sup> Over the cycle the net migration rate displays a strong negative correlation with the unemployment rate differential that is mirrored by a positive correlation with the employment differential. The net migration rate is negatively correlated with the real wage but to a lower degree than (un-)employment. One potential explanation could be the fact that across corridors unemployment is less correlated than wages (column three) which indicates a higher labor market dispersion with respect to unemployment.

Table 2 displays the dynamic behavior of net migration and the differentials of real output, unemployment rate and real wage up to the third lag and lead. The net migration rate is positively correlated with output and negatively correlated with unemployment at various lags and leads. In both cases the contemporaneous is the peak correlation. As a first intuition, the negative correlation between the unemployment differential and net migration can be explained by assuming that

<sup>20</sup>However, Hauser (2014) demonstrates for the U.S. labor market that while unconditional labor mobility is procyclical, the picture is less clear for conditional labor mobility. Her SVAR analysis of all migration corridors in the U.S. reveals that subsequent a technology shock some states face a net inflow of workers while others face an outflow. A similar SVAR exercise should be carried out for the EA-12 labor market.

Statistic	$\tau$						
	-3	-2	-1	0	1	2	3
$\rho(dy_{t+\tau}, nm_t)$	0.010	0.058	0.113	0.167	0.100	0.041	-0.019
$\rho(du_{t+\tau}, nm_t)$	-0.012	-0.138	-0.274	-0.307	-0.199	-0.054	0.093
$\rho(dw_{t+\tau}, nm_t)$	-0.072	-0.118	-0.131	-0.099	-0.071	0.008	0.087

For notation see Table 1.  $\rho(dx_{t+\tau}, nm_t)$  denotes the correlation of net migration and the  $\tau$ th lag (lead) of the differential of variable  $x$  if  $\tau$  is negative (positive).

Table 2: Dynamic correlations - Net migration rate (nm)

unemployment is c.p. causal for the migration decision. In the euro area, an exogenous negative labor demand shock decreases output and increases unemployment in one country and consequently native households decide to emigrate to another country with higher output and lower unemployment. Although smaller in size, the negative correlation between the net migration rate and the real wage differential can be observed for the third lag up to the first lead.<sup>21</sup> The maximum correlation  $-0.13$  at the first lag indicates that the wage differential leads the net migration rate by one to two periods. Instead of assuming the wage conditions to be causal for the migration decision, a shock that increases wages and decreases net migration e.g. via an increased unemployment can explain the observed pattern.

Figure 2 highlights the heterogeneity across migration corridors. The left hand graph sorts the 55 migration corridors by sign and size of the contemporaneous correlation of the net migration rate and the real wage differential. While approximately two thirds of all corridors exhibit a negative correlation (e.g. countries), in some corridors both variables are positively correlation with up to 0.5 (e.g.). The right hand side depicts the corridor correlations for net migration and the unemployment differential. With a majority of corridors displaying a negative correlation the picture is less heterogenous. Only one out of six corridors has a positive but small correlation. The signs of the two correlations can act as dimensions to classify migration corridors into four types (see Figure 3 in the appendix).

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

<sup>21</sup>This result only changes slightly by using different time periods and smoothing parameters. The correlation of net migration with the unemployment and the wage differential decreases with a lower  $\lambda$  and a shorter time period.

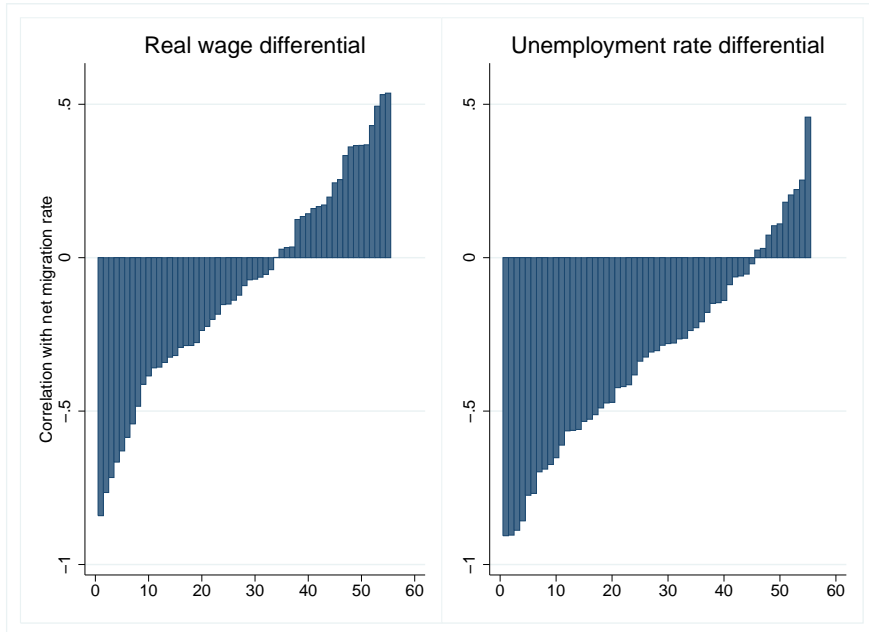


Figure 2: Correlation between the cyclical component of net migration and real wage/unemployment differential for 55 euro area corridors

Source: own figure, Eurostat data.

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 reinterpretation of Gali (2011b). We apply this model to two countries that form a migration corridor and have 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

The two countries of a migration corridor, home and foreign, are populated by a large number of households that are normalized to one and face uniform optimization problems. Each household has a continuum of infinitely lived members indexed by the type of labor  $i \in [0, 1]$ . Within one family, all members perfectly insure each other and thus consume the same level of the aggregate

consumption bundle irrespective of their labor type and employment status. Integrating over the members' period utilities gives the household's period utility. For the representative household in home it is:

$$U(c_t, \{n_{h,t}(i)\}, \{n_{h,t}^*(i)\}; \chi_t) = \log c_t - \chi_t \left( \int_0^1 \frac{n_{h,t}(i)^{1+\psi}}{1+\psi} di - \int_0^1 \frac{n_{h,t}^*(i)^{1+\psi^*}}{1+\psi^*} di \right), \quad (1)$$

where  $c_t$  denotes the consumption aggregate of the domestic consumption good  $c_{h,t}$  and the imported consumption good  $c_{f,t}$  for a given share of the foreign good in the household's consumption expenditures  $0 < \omega < 1$  and household's elasticity of substitution between domestic and foreign goods  $\mu$ :

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

The domestic and foreign good are a CES composite of  $z \in [0, 1]$  differentiated home or foreign produced varieties with price and an elasticity of substitution  $\varepsilon_p$ :

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

where  $\chi_t$  is country-specific aggregate preference shock and its log follows an AR(1) process with persistence parameter  $0 < \rho_L < 1$  and a white noise process  $\varepsilon_{L,t}$  with zero mean and constant variance  $\sigma_L^2$ :<sup>22</sup>

$$\log(\chi_t) = \rho_L \log(\chi_{t-1}) + \varepsilon_{L,t}$$

$\chi_t$  is an exogenous preference shifter that affects the total labor supply of home workers in the home and foreign labor market.<sup>23</sup>

The inverse Frisch elasticity of labor supply  $\psi^{(*)} > 0$  determines the curvature of the disutility of labor of native and emigrant workers from the household.<sup>24</sup> For an unemployed worker the disutility is zero. Expenditure minimizing subject to the consumption indices gives the demand

<sup>22</sup>We use the preference shock as a proxy for an aggregate country-specific labor supply shock.

<sup>23</sup>Later, we will use  $\chi_t$  to model a positive labor supply shock in home, that can be interpreted as an increase of external immigration into the home economy. Because of free labor mobility within the corridor the share of workers that move to the foreign country also increases.

<sup>24</sup>We assume that the disutility from work does not depend on the origin of a worker only on the location where the labor is supplied, i.e. the disutility of a foreign native (emigrant) worker is  $\psi^*$  ( $\psi$ ).

functions for domestic and foreign good varieties and composite goods:

$$c_{h,t}(z) = (p_{h,t}(z)/p_{h,t})^{-\varepsilon_p} c_{h,t}, \quad c_{h,t} = (1 - \omega) (p_{h,t}/p_t)^{-\mu} c_t \quad (2)$$

$$c_{f,t}(z) = (p_{f,t}(z)/p_{f,t})^{-\varepsilon_p} c_{f,t}, \quad c_{f,t} = \omega (p_{f,t}/p_t)^{-\mu} c_t \quad (3)$$

where  $p_{h(f),t}(z)$  is the price of the home (foreign) produced variety  $z$ ,  $p_{h(f),t}$  is the price of the home (foreign) composite good and  $p_t$  is the aggregate consumption price.<sup>25</sup>

In the home country the representative household maximizes the welfare function

$$\max_{\{c_t, w_{h,t}, w_{h,t}^*, b_t, b_t^*\}} E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, \{n_{h,t}(i)\}, \{n_{h,t}^*(i)\}; \chi_t), \quad (4)$$

subject to the budget constraint:

$$p_t c_t + \Theta_t b_t + \Theta_t^* b_t^* = \int_0^1 w_{h,t}(i) n_{h,t}(i) di + \int_0^1 w_{h,t}^*(i) n_{h,t}^*(i) di + b_{t-1}^* + b_{t-1} + \Pi_t. \quad (5)$$

The representative household purchases units of the aggregate consumption bundle  $c_t$  at price  $p_t$  and, since we assume complete financial markets, nominally risk-less domestic and foreign bonds  $b_t$  and  $b_t^*$  that pay a monetary unit at price  $\Theta_t$  and  $\Theta_t^*$ . The home household's labor income is generated by members who work in the home labor market, referred to as native workers, and by members who work in the foreign labor market, referred to as emigrant workers in the home country and immigrant workers in the foreign country. 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 who are demanded domestically and  $n_{h,t}^*(i) \in [0, 1]$  is the fraction of members specialized in type  $i$  labor who are demanded in foreign.<sup>26</sup>  $w_{h,t}(i)$  denotes the nominal wage of a native  $i$ -type worker and  $w_{h,t}^*(i)$  denotes the nominal wage of an emigrant  $i$ -type worker. Additionally, the household receives payments from bond holdings and  $\Pi_t$ , a share of the nominal firm revenue which is distributed over domestic households in a lump-sum fashion.

The wage setting and labor supply will of workers from home be derived in section 4.3. The

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<sup>25</sup>  $p_{h(f),t} \equiv \left( \int_0^1 p_{h(f),t}(z)^{1-\varepsilon_p} dz \right)^{1/(1-\varepsilon_p)}$  and  $p_t = \left( (1 - \omega) p_{h,t}^{1-\mu} + \omega p_{f,t}^{1-\mu} \right)^{1/(1-\mu)}$ .

<sup>26</sup> In general, home variables are without a superscript and foreign variables are denoted by a \* superscript. In case of variables where country of origin and supply differ, the superscript denotes the location of the supply and the subscript ( $h$  or  $f$ ) denotes the location of the origin. Therefore, native and emigrant workers from home share the same subscript but differ with respect to the superscript ( $n_{h,t}$ ,  $n_{h,t}^*$ ). Foreign native workers are denoted by  $n_{f,t}^*$  and foreign emigrants (i.e. immigrants in home) by  $n_{f,t}$ .

intertemporal optimality conditions for the representative household in home can be written as:

$$\Theta_t = \beta E_t \left\{ \frac{c_t}{c_{t+1}} \frac{p_t}{p_{t+1}} \right\} \quad \Theta_t^* = \beta E_t \left\{ \frac{c_t}{c_{t+1}} \frac{p_t}{p_{t+1}} \right\}. \quad (6)$$

#### 4.2. Firms

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

$$y_t(z) = a_t n_t(z)^{1-\alpha}. \quad (7)$$

$a_t$  is the country specific exogenous aggregate technology and its logarithm follows an AR(1) process with persistence parameter  $0 < \rho_A < 1$  and a white noise process  $\varepsilon_{A,t}$  with zero mean and constant variance  $\sigma_A^2$ :

$$\log(a_t) = \rho_A \log(a_{t-1}) + \varepsilon_{A,t}$$

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  $p_{h,t}^O(z)$  to maximize its real life time value

$$E_t \sum_{k=0}^{\infty} (\xi_p)^k \Theta_{t+k} \left\{ p_{h,t+k}^O(z) y_{h,t+k}(z) - w_{t+k} n_{h,t+k}(z) \right\}$$

subject to the sequence of demand constraints  $y_{h,t+k}(z) = c_{h,t+k|t}(z) + c_{h,t+k}^*(z) \quad \forall k = 0, 1, \dots$  from domestic and foreign households for the specific good of firm  $z$

$$c_{h,t+k}(z) = (1 - \omega) \left( \frac{p_{h,t}^O(z)}{p_{h,t+k}} \right)^{-\varepsilon_p} \left( \frac{p_{h,t+k}}{p_{t+k}} \right)^{-\mu} c_{t+k}, \quad (8)$$

$$c_{h,t+k}^*(z) = \omega \left( \frac{p_{h,t}^*O(z)}{p_{h,t+k}^*} \right)^{-\varepsilon_p} \left( \frac{p_{h,t+k}^*}{p_{t+k}^*} \right)^{-\mu} c_{t+k}^*. \quad (9)$$

The first order condition is given by:

$$\frac{p_{h,t}^O}{p_{h,t}} = \mu^P \frac{\sum_{k=0}^{\infty} (\xi_p \beta)^k E_t \left\{ (c_{t+k})^{-1} y_{t+k} m c_{t+k} \left( \frac{p_{h,t+k}}{p_{h,t}} \right)^{\varepsilon_p} \right\}}{\sum_{k=0}^{\infty} (\xi_p \beta)^k E_t \left\{ (c_{t+k})^{-1} y_{t+k} \left( \frac{p_{h,t+k}}{p_{h,t}} \right)^{\varepsilon_p - 1} \right\}}, \quad (10)$$

with price markup  $\mu^P = \frac{\varepsilon_p}{\varepsilon_p - 1}$ . Solving the cost minimization problem of the firm gives the firm specific real marginal costs:

$$mc_t(z) = \frac{w_t/p_{h,t}}{(1-\alpha)a_t n_t^{-\alpha}}, \quad (11)$$

where  $w_t$  denotes the aggregate wage index in the home country.

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

$$p_{h,t}^{1-\varepsilon_p} = (1-\xi_p)(p_{h,t}^O)^{1-\varepsilon_p} + \xi_p p_{h,t-1}^{1-\varepsilon_p}. \quad (12)$$

Finally, the equations (10) and (12) give the non-linear price inflation rate:

$$\Pi_{h,t}^P = \left(\frac{1}{\xi_p}\right)^{\frac{1}{\varepsilon_p}} \left(1 - (1-\xi_p) \left(\frac{g_{1,h,t}}{g_{2,h,t}}\right)^{\frac{1-\varepsilon_p}{1+\varepsilon_p\phi}}\right)^{\frac{1}{\varepsilon_p}}, \quad (13)$$

with

$$\begin{aligned} g_{1,h,t} &= \mu^P y_{h,t} (c_{h,t})^{-1} mc_t + \beta \xi_p E_t \{ (\Pi_{h,t+1}^P)^{\frac{\varepsilon_p}{1-\alpha}} g_{1,h,t+1} \}, \\ g_{2,h,t} &= y_{h,t} (c_{h,t})^{-1} + \beta \xi_w E_t \{ (\Pi_{h,t+1}^P)^{\varepsilon_p - 1} g_{2,h,t+1} \}. \end{aligned}$$

### 4.3. Wage Setting and Migration

Traditionally, the migration literature models the migration decision in terms of an explicit destination specific labor supply decision by the agents. On the contrary, the Galí (2011b) model features an explicit wage setting decision and a wage markup whereby a certain wage level corresponds to a distinct labor supply level. We expand this logic to a setting that allows for migration by letting differentiated types of workers in both countries decide about two wages, the wage when working as a native and the emigrant wage. Thereby we implicitly model the labor supply of native and emigrant work. The wage setting decision takes the firms labor demand for natives and immigrants of each type as given.

We allow for labor mobility in the firm production production as in Ottaviano and Peri (2012). Thus, the composite labor employed by each firm  $z$  in the production function (7) is a CES index of native and immigrant workers:

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



The parameter  $0 < \gamma < 1$  denotes the share of foreign workers in the production and  $\theta > 0$  is the aggregate substitution elasticity between native and immigrant workers which a.o. is determined via the skill difference of home and foreign workers. The native and immigrant labor are defined as CES composites of differentiated types with elasticity of substitution  $\varepsilon_w$ :

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

Expenditure minimizing subject to the labor indexes gives the home firms' demand functions for each type of native and immigrant labor:

$$n_{h,t}(i,z) = \left( \frac{w_{h,t}(i)}{w_{h,t}} \right)^{-\varepsilon_w} n_{h,t}(z), \quad n_{f,t}(i,z) = \left( \frac{w_{f,t}(i)}{w_{f,t}} \right)^{-\varepsilon_w} n_{f,t}(z), \quad (15)$$

and the demand for the native and immigrant composite labor:

$$n_{h,t}(z) = (1 - \gamma) \left( \frac{w_{h,t}}{w_t} \right)^{-\theta} n_t(z), \quad n_{f,t}(z) = \gamma \left( \frac{w_{f,t}}{w_t} \right)^{-\theta} n_t(z), \quad (16)$$

where  $w_{h(f),t}(i)$  denotes the wage for a certain type of native (immigrant) labor,  $w_{h(f),t}$  is the wage index of the native (immigrant) composite labor and  $w_t$  is the aggregate wage index.<sup>27</sup> Aggregating over all firms  $z$  in home gives the aggregate demand for native and immigrant labor:

$$n_{h,t}(i) = \int_0^1 n_{h,t}(i,z) dz, \quad n_{h,t} = \int_0^1 n_{h,t}(z) dz, \quad (17)$$

$$n_{f,t}(i) = \int_0^1 n_{f,t}(i,z) dz, \quad n_{f,t} = \int_0^1 n_{f,t}(z) dz. \quad (18)$$

In the home economy, workers of each labor type  $i$  (or a union representing them) determine the native and emigrant nominal wage for their type in order to maximize their households' utility (1). The wage decision is taken subject to the demand for native labor from firms in the home economy and for immigrant labor from foreign firms. The differentiated types of workers 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.  $\xi_w$  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  $\xi_{wh}^* < \xi_{wf}^*$ . In addition to the standard independence assumptions across agents

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<sup>27</sup>  $w_{h(f),t} \equiv \left( \int_0^1 w_{h(f),t}(i)^{1-\varepsilon_w} di \right)^{1/(1-\varepsilon_w)}$  and  $w_t = \left( (1-\gamma)w_{h,t}^{1-\theta} + \gamma w_{f,t}^{1-\theta} \right)^{1/(1-\theta)}$ .

and time we assume the for a worker of type  $i$  from one country the probabilities of resetting the native wage and the emigrant wage to be independent of each other. Workers from home of a type  $i$  who are able to reset their native nominal wage in period  $t$  choose their optimal wage  $w_{h,t}^O$  and  $w_{h,t}^{O*}$  in order to maximize their household utility subject to the flow budget constraint (5) and the aggregate domestic and foreign firm labor demand for their labor type  $n_{h,t}(i)$  and  $n_{h,t}^*(i)$  as derived above in equations 15 - 17. The first order conditions of the wage setting problem are given by:

$$\left(\frac{w_{h,t}^O}{w_{h,t}}\right)^{1+\varepsilon_w\Psi} = \mu^W \frac{E_t \sum_{k=0}^{\infty} (\beta \xi_{wh})^k \left\{ \left(\frac{w_{h,t+k}}{w_{h,t}}\right)^{\varepsilon_w(1+\Psi)} \frac{n_{h,t+k}}{c_{t+k}} mrs_{h,t+k} \right\}}{E_t \sum_{k=0}^{\infty} (\beta \xi_{wh})^k \left\{ \left(\frac{w_{h,t+k}}{w_{h,t}}\right)^{\varepsilon_w-1} \frac{w_{h,t+k}}{p_{t+k}} \frac{n_{h,t+k}}{c_{t+k}} \right\}} \quad (19)$$

$$\left(\frac{w_{h,t}^{O*}}{w_{h,t}^*}\right)^{1+\varepsilon_w\Psi^*} = \mu^W \frac{E_t \sum_{k=0}^{\infty} (\beta \xi_{wh}^*)^k \left\{ \left(\frac{w_{h,t+k}^*}{w_{h,t}^*}\right)^{\varepsilon_w(1+\Psi^*)} \frac{n_{h,t+k}^*}{c_{t+k}} mrs_{h,t+k}^* \right\}}{E_t \sum_{k=0}^{\infty} (\beta \xi_{wh}^*)^k \left\{ \left(\frac{w_{h,t+k}^*}{w_{h,t}^*}\right)^{\varepsilon_w-1} \frac{w_{h,t+k}^*}{p_{t+k}} \frac{n_{h,t+k}^*}{c_{t+k}} \right\}} \quad (20)$$

with a constant wage markup  $\mu^W = \frac{\varepsilon_w}{\varepsilon_w-1}$  that is assumed to be equal in both countries. The main difference of native and emigrants is that they ground their wage setting decisions on different marginal rates of substitution  $mrs_{h,t+k}^{(*)} = \chi_{t+k}(n_{h,t+k}^{(*)})^{\Psi^{(*)}} c_{t+k}$ . 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 the domestic and foreign country.

All types of labor  $i$  from home that reset their native wage in period  $t$  set the same wage level. Therefore the aggregate native wage in home is a weighted average of optimized and non-optimized native wage profiles:

$$(w_{h,t})^{1-\varepsilon_w} = (1 - \xi_{wh})(w_{h,t}^O)^{1-\varepsilon_w} + \xi_{wh}(w_{h,t-1})^{1-\varepsilon_w}. \quad (21)$$

Combining equation (21) with the recursive formulation of the optimal wage expression (19) gives the native wage inflation rate in home:

$$\Pi_{h,t}^W = \left(\frac{1}{\xi_{wh}}\right)^{\frac{1}{\varepsilon_w}} \left(1 - (1 - \xi_{wh}) \left(\frac{f_{1,h,t}}{f_{2,h,t}}\right)^{\frac{1-\varepsilon_w}{1+\varepsilon_w\Psi}}\right)^{\frac{1}{\varepsilon_w}}, \quad (22)$$

with

$$\begin{aligned} f_{1,h,t} &= \mu^W \frac{n_{h,t}}{c_t} mrs_{h,t} + \beta \xi_{wh} E_t \{ (\Pi_{h,t+1}^W)^{\varepsilon_w(1+\psi)} f_{1,h,t+1} \}, \\ f_{2,h,t} &= \frac{w_{h,t}}{p_t} \frac{n_{h,t}}{c_t} + \beta \xi_{wh} E_t \{ (\Pi_{h,t+1}^W)^{\varepsilon_w-1} f_{2,h,t+1} \}. \end{aligned}$$

Analogously, the aggregate immigrant wage in home is a linear combination of the newly set optimal migrant wage of foreigners and the previous average migrant wage:

$$(w_{f,t})^{1-\varepsilon_w} = (1 - \xi_{wf})(w_{f,t}^O)^{1-\varepsilon_w} + \xi_{wf}(w_{f,t-1})^{1-\varepsilon_w}. \quad (23)$$

Using equation (23) and the foreign country counterpart of equation (20) we can obtain an expression for the immigrant wage inflation rate in home. According to the aggregate wage index the aggregate wage Phillips curve of the home country is a weighted average of native and immigrant wage inflation:

$$\Pi_t^W = (1 - \gamma)\Pi_{h,t}^W + \gamma\Pi_{f,t}^W. \quad (24)$$

The native and emigrant wage setting of workers from home relates to the native labor supply, the emigration and unemployment. Workers are only willing to work if the real wage exceeds their disutility of labor measured in units of the aggregate consumption good. The native and emigrant labor supply of type  $i$  from home is determined by the marginal supplier of native and emigrant labor  $i$ :

$$l_{h,t}(i) = \left( \frac{w_{h,t}(i)}{p_t} \frac{1}{\chi c_t} \right)^{\frac{1}{\psi}}, \quad l_{h,t}^*(i) = \left( \frac{w_{h,t}^*(i)}{p_t} \frac{1}{\chi c_t} \right)^{\frac{1}{\psi^*}}, \quad (25)$$

and the aggregate native and emigrant labor supply is:

$$l_{h,t} \equiv \int_0^1 l_{h,t}(i) di, \quad l_{h,t}^* \equiv \int_0^1 l_{h,t}^*(i) di, \quad (26)$$

The labor demand  $n_{h,t}$  follows the marginal cost of labor  $i$  () and the unemployment rate is defined:

$$u_{h,t} \equiv 1 - \frac{n_{h,t}}{l_{h,t}}, \quad u_{h,t}^* \equiv 1 - \frac{n_{h,t}^*}{l_{h,t}^*}. \quad (27)$$

The net migration from the perspective of the home country is defined as

$$nm_{h,t} \equiv (l_{f,t} - l_{h,t}^*) - (l_{f,t-1} - l_{h,t-1}^*) = -nm_{f,t}. \quad (28)$$

#### 4.3.1. Terms of trade, exchange rates, and implications of complete international financial markets

The nominal exchange rate is assumed to be constant and is normalized to one for the corridor.<sup>28</sup> We assume that the law of one price holds for each individual good such that a good  $z$  produced in the home country has the same price in home and foreign, i.e.  $p_h(z) = p_h^*(z)$ , and analogously for foreign produced goods  $p_f^*(z) = p_f(z)$ . The real exchange rate is equal to the quotient between the foreign and domestic consumption price level

$$q_t = \frac{p_t^*}{p_t}. \quad (29)$$

The bilateral terms of trade between home and foreign is defined as:

$$s_t = \frac{p_{f,t}}{p_{h,t}}. \quad (30)$$

Introducing the domestic and foreign consumption price level in equation (29) yields:

$$q_t = \frac{[(1 - \omega^*)(s_t)^{1-\mu} + \omega^*]^{\frac{1}{1-\mu}}}{[(1 - \omega) + \omega(s_t)^{1-\mu}]^{\frac{1}{1-\mu}}}. \quad (31)$$

Under the assumption of perfect complete financial markets and acknowledging the fact that foreign households face exactly the same intertemporal optimization problem that gave rise to the home households FOC (6) one can show that households in both countries smooth consumption over time and diversify between countries:

$$c_t = c_t^* q_t. \quad (32)$$

The latter describes the international portfolio condition<sup>29</sup> in case of perfect financial markets.

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<sup>28</sup>In 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 sub-periods before and after the Euro introduction. The first sub-period is modeled with a pegged exchange rate system, in the second sub-period 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.

<sup>29</sup>We assume both countries to have symmetric initial conditions.

#### 4.4. Equilibrium

Good market clearing for each home produced good variety  $z \in [0, 1]$  requires that in every period  $t$  the total production of the variety is consumed at home and abroad:

$$y_t(z) = c_{h,t}(z) + c_{h,t}^*(z), \quad (33)$$

with domestic absorption of good  $z$  (2) and exports of good  $z$  (foreign country counterpart of equation 3). Combining this condition with the portfolio diversification condition and using the law of one price for the good variety  $z$  links aggregate domestic consumption to the production of good  $z$ :

$$y_t(z) = \frac{p_{h,t}(z)^{-\varepsilon_p}}{p_{h,t}} \left( \frac{p_{h,t}}{p_t} \right)^{-\mu} ((1 - \omega) + \omega^*(q_t)^{\mu-1}) c_t, \quad (34)$$

Inserting it in the definition of the composite home good  $y_t \equiv (\int_0^1 y_t(z)^{(\varepsilon_p-1)/\varepsilon_p} dz)^{\varepsilon_p/(\varepsilon_p-1)}$  and applying the definition of the home goods price index, the CPI in home and of the terms of trade gives the aggregate resource constraint:

$$y_t = ((1 - \omega) + \omega(s_t)^{1-\mu})^{\frac{\mu}{1-\mu}} ((1 - \omega) + \omega^*(q_t)^{\mu-1}) c_t \quad (35)$$

From the labor market clearing condition  $n_{h,t+k} \equiv \int_0^1 n_{h,t+k}(j) dj$  and the production function (7) firm specific labor demand results as a function of the aggregate production, total factor productivity and price dispersion:

$$n_t = \left( \frac{y_t}{a_t} \right)^{\frac{1}{1-\alpha}} \Delta_t^P \Delta_t^W, \quad (36)$$

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:

$$\Delta_t^P = (1 - \xi_p) \left( \frac{1 - \xi_p (\Pi_t^P)^{\varepsilon_p-1}}{1 - \xi_p} \right)^{\frac{\varepsilon_p}{(1-\alpha)(\varepsilon_p-1)}} + \xi_p \Delta_{t-1}^P (\Pi_t^P)^{\frac{\varepsilon_p}{1-\alpha}}, \quad (37)$$

$$\Delta_t^W = (1 - \xi_w) \left( \frac{1 - \xi_w (\Pi_t^W)^{\varepsilon_w-1}}{1 - \xi_w} \right)^{\frac{\varepsilon_w}{(1-\alpha)(\varepsilon_w-1)}} + \xi_w \Delta_{t-1}^W (\Pi_t^W)^{\varepsilon_w}. \quad (38)$$

The model is closed by assuming that the central bank supplies a monetary asset<sup>30</sup> and that due to its systemic position, the central bank can influence the nominal interest rate in order to

<sup>30</sup>The monetary asset can be understood as contract between the central bank and the agents of the economy. Everyone is legally obligated to hold one unit of that good on which the central bank pays an interest.

stabilize the price inflation and the output to their target rates:

$$1 + i_t = m_t \frac{1}{\beta} \left[ \left( \frac{\Pi_{h,t}^P}{\bar{\Pi}_h^P} \right)^{\phi_\pi} \left( \frac{y_{h,t}}{y_{h,t}^n} \right)^{\phi_y} \right], \quad (39)$$

where  $m_t$  is country-specific aggregate money demand shock that in logs follows an AR(1) process with persistence parameter  $0 < \rho_M < 1$  and a white noise process  $\varepsilon_{M,t}$  with zero mean and constant variance  $\sigma_M^2$ .<sup>31</sup>

$$\log(m_t) = \rho_M \log(m_{t-1}) + \varepsilon_{M,t}$$

$\bar{\Pi}_h^P$  and  $y_{H,t}^n$  denote the inflation and output target variables.<sup>32</sup> The target weights are set exogenously by empirically observed parameters for the Euro area.<sup>33</sup>

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:

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

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.<sup>34</sup>

<sup>31</sup>We use the money supply shock as a proxy for an aggregate country-specific demand shock.

<sup>32</sup>The target variables are the steady state values. Therefore, the target price inflation is equal to zero and the target output is steady state output.

<sup>33</sup>See Taylor (1993), Woodford (2001), Taylor and Williams (2010).

<sup>34</sup>The deterministic symmetric zero inflation steady state is denoted in the Appendix 9.

## 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.<sup>35</sup> In order to analyze the theoretical effects, we calibrate the model to annual data and the average euro area migration corridor. In order to isolate the effects of migration, all firm and trade parameters are assumed to be symmetric across the two countries. Even though it is very common in the DSGE literature to estimate the model parameters with Bayesian techniques, we do not follow this approach. With annual data and few observations it is very problematic to employ Bayesian estimation methods.

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.<sup>36</sup> 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  $\bar{u} \approx 5$  percent. 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 EA 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 is 0.92, 0.98 and 0.98 respectively. In both countries the share of euro area migrants in total employment is set to be

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<sup>35</sup>See e.g. Gali (2011b), Mandelman and Zlate (2008, 2012), Hauser (2014), Dustmann and Görlach (2015).

<sup>36</sup>See Table 10 in Appendix 7.4 for the model parametrization.

$\gamma = 0.07$  which is the unweighted EA average without Germany.<sup>37</sup> 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.<sup>38</sup>

We distinguish between two scenarios which we refer to as the symmetric and the asymmetric corridor. The symmetric corridor assumes the same parameter value for migrants and natives. The asymmetric corridor distinguishes between native and migrant workers according to 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  $\psi$ , their wage rigidity  $\xi_w$  and the wage setting power  $\mu^W$  which is strongly influenced by the substitution elasticity between migrant labor types  $\varepsilon_w$ . 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  $\varepsilon_{wf} = 5.52$  and the consequent markup are lower. Finally, migrants can be expected to adjust their wage more quickly than natives such that annual  $\xi_{wf} = 0.2$  is lower in the case of migrants.

## 5.2. Dynamic responses to shocks

In this section we describe the interrelation of migration patterns and business cycle dynamics from the perspective of the domestic economy.<sup>39</sup> The guiding questions for the analysis relate to our empirical findings. Firstly, we want to explain the finding that in the average euro area corridor both, the unemployment and the wage differential, are negatively correlated with net migration. Secondly, we aim at identifying factors that provide explanations for the observed heterogeneity across corridors.

Initially, we choose parameter values as defined in Table 10 in the Appendix 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 4 – 6 in the Appendix 7.5 summarize the

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<sup>37</sup>See ECB (2014).

<sup>38</sup>Because of the relatively high education level in all countries of the euro area we expect migrants to be relatively similar with respect to the skill level.

<sup>39</sup>Our results show that allowing for migration does not significantly change the dynamic pattern of the output and inflation gap. 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).



corresponding reactions of domestic macroeconomic aggregates including wage and unemployment differentials as well as the corridor-wide labor mobility.<sup>40</sup>

### *Domestic productivity shock*

As can be seen in Figure 4, a positive domestic productivity shock (represented by the blue line) leads to decreasing marginal costs and aggregate producer prices.<sup>41</sup> Because of price rigidities, some producers cannot reset their prices immediately but instead reduce their labor demand. Consequently, workers want to reduce their wage in order to remain employed. The extent to which adjusting workers are willing to reduce their wage depends on the inverse Frisch elasticity. Similarly to the firm side, not all types of workers can react to the shrinking demand by reducing their nominal wage such that the fraction of unemployed workers is higher for types than cannot adjust their wages. 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  $\gamma$ , the labor immigration decision depends on the wage setting decision of the foreign household.<sup>42</sup> 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 4. At the same time, domestic households expect future wage and unemployment differences between

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<sup>40</sup>In order to illustrate the resulting impulse response functions more clearly, we differ from our basic calibration by assuming standard deviations of one for all shocks. Additionally, we use various values for the price and wage stickiness to analyze the extent of relative goods and labor market rigidity explaining observed migration pattern. However, the subsequent comparison between theoretical results and empirical facts relies on the basic calibration.

<sup>41</sup>It 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).

<sup>42</sup>In 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 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 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 4 (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 diversion<sup>43</sup>. 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 5. 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.

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<sup>43</sup>Migration 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 6). 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 6). 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. A domestic labor productivity shock and a labor supply shock increase the unemployment differential and cause a negative net migration rate. However, while the first type of shock increases the wage differential giving rise to a negative correlation with net migration, the second type of shock lowers the wage differential and gives rise to a positive correlation. Therefore, dif-

ferent types of shocks that hit an economy provide one explanation for the observed heterogeneity across corridors. The relative price/wage rigidity affects the impact of e.g. a domestic technology shock on the real wage differential. Depending on wages or prices being more rigid, 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 the quality of the model by comparing the theoretical business cycle statistics of the calibrated model with the empirical facts presented in section 3.2. To that end, we draw 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.<sup>44</sup> The results are summarized in Table 3 and 4.

Variable ( $x$ )	$\sigma(x)/\sigma(y)$		$\rho(x,y)$	
	EA-12 data	Model	EA-12 data	Model
Real output ( $y$ )	1	1	1	1
Real consumption ( $c$ )	0.81	0.67	0.76	0.82
Labor force ( $l$ )	0.39	0.50	0.43	0.29
Employment ( $n$ )	0.76	0.69	0.69	0.78
Unemployment rate ( $u$ )	0.48	0.59	-0.68	-0.66
Real wage ( $w$ )	0.68	0.50	0.17	0.59

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

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

Table 3 underlines that the symmetric calibration<sup>45</sup> of our model is able to match the average euro area business cycle for the period 1980-2010. The first and second column compare empirical and simulated values of the standard deviation of key variables in relation to the standard deviation of output. The proposed model replicates the empirical fact that consumption and employment fluctuate stronger than labor force, unemployment and wages. However, the model overstates the fluctuations of unemployment and understates the fluctuation of real wages. The third and fourth

<sup>44</sup>In order to compare the theoretical model with the empirical unconditional standard deviations we simulate the time series including all shocks. Therefore, the reactions of macroeconomic variables are not conditional on a specific shock. To compare the true conditional reactions, we have to compare the extracted theoretical standard deviations in case of a single shock with the empirical counterparts resulting from a structural VAR.

<sup>45</sup>In Table 8 of Appendix 7.2 we also simulate the asymmetric model but do not find significantly different results.

column compare the correlation of key variables with output in the data and in the simulated model. The correlations predicted by the model all have the correct sign and match in size reasonably well. An exception is the real wage, where the model overstates the correlation with output.

Variable ( $x$ )	$\sigma(nm)/\sigma(x)$		$\rho(dx, nm)$	
	EA-12 data	Model	EA-12 data	Model
Output ( $y$ )	1.55	1.56	0.17	0.11
Unemployment ( $u$ )	-	-	-0.31	-0.26
Real wage ( $w$ )	-	-	-0.10	-0.75

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

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

Table 4 compares key statistics for the migration cycle in the EA-12 for the period 1980-2010 in the data and the simulated model. Again, the proposed model is able to replicated the patterns in the data well. The model predicts a standard deviation of the net migration rate in relation to the output fluctuation that equals the value observed in the data. The correlation of the net migration rate and the differentials of output, unemployment and real wage show the right sign and in case of the former two are very close in magnitude. Again the real wage, where the model overstates the correlation with net migration, poses an exception.

Summarizing our results, we find that our model fits suitable well to describe migration flows over the business cycle in the euro area. The observations that the relative fluctuation of the real wage and the correlation of its differential with the net migration rate are overstated by the model are related to the fact that we model migration as a wage setting decision. Intuitively, both observations indicate that at least one additional channel exists that increases the volatility of wages and reduces the volatility of unemployment and thus has a significant impact on net migration fluctuations in the euro area. In line with this finding, introducing search and matching appears as a valuable extension of the model. 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. 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 euro area. 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 fluctuations over the business cycle.

Our subsequent empirical analysis of bilateral migration and macroeconomic data over the years 1980-2010 supports this notion. We present several key business cycle facts for the EA-12 that provide evidence for business cycle related fluctuations in net migration flows and the crucial role of unemployment differentials in shaping intra-euro area migration patterns. On average, we find a negative correlation of the net migration rate with both, the unemployment and the wage differential, at various lags and leads. In case of unemployment the correlation is stronger and peaks at the contemporaneous correlation, while the wage differential leads the net migration rate by one to two periods. Across corridors we find a considerable heterogeneity in both dimensions that is more pronounced in the case of wage differentials.

In line with these findings we develop a two-country dynamic stochastic general equilibrium model of internal business cycle migration in the euro area and allow for unemployment that occurs as a consequence of 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 under a standard calibration for the euro area a positive technology shock in one country of the 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. 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 fluctuation in migrant flows. The comparison of key statistics from the simulated version of our model with their empirical counterpart underlines that our model is able to replicate

the business and migration cycle in the euro area.

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

## 7. Appendix

### 7.1. Data description

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

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

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

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

**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 and emigration normalized by the average corridor as a share of foreign population.



	AT	BE	DE	EL	ES	FI	FR	IE	IT	LU	NL	PT	Σ
AT	–	80(B)	80(F)	[96(F)]	83(F)	80(B)	[96(F)]	86(F)	[96(F)]	80(B)	80(B)	[96(F)]	7(11)
BE	80*(F)	–	80(F)	80*(B)	80*(F)	80(B)	80*(F)	80(F)	80*(F)	80(F)	80(B)	80*(B)	11(11)
DE	80*(F)	80(B)	–	80*(F)	80*(F)	80(B)	80*(F)	80(F)	80*(F)	80(F)	80(B)	80*(F)	11(11)
EL	[96(F)]	80(B)	80(F)	–	83(F)	80(B)	85*(F)d	85(F)xx	86(F)	x	80(B)	85*(F)xx	6(10)
ES	85*(F)	80(B)	80(F)	85*(F)	–	80(B)	85*(F)	88(F)	86(F)	80(F)	80(B)	85*(F)	11(11)
FI	80*(F)	80(B)	80(F)	80*(F)	80*(F)	–	80*(F)	80(F)	80*(F)	80(F)	80(B)	80*(F)	11(11)
FR	[96(F)]	80(B)	80(F)	x	83(F)	80(B)	–	x	86(F)	80(F)	80(B)	92*(F)	8(9)
IE	[96(F)]	80(B)	80(F)	x	83(F)	80(B)	92(F)xx	–	86(F)	x	80(B)	x	6(8)
IT	86*(F)	80(B)	80(F)	86*(F)	83(F)	80(B)	86*(F)	86(F)	–	80(F)	80(B)	86*(F)	11(11)
LU	80*(F)	80(B)	80(F)	80*(F)xx	80*(F)	80(B)	80*(F)	80(F)xx	80*(F)	–	80(B)	80*(F)	9(11)
NL	80*(F)	80(B)	80(F)	80*(B)	80*(F)	80(B)	80*(F)	80(F)	80*(F)	80(F)	–	80*(B)	11(11)
PT	[96(F)]	80(B)	80(F)	x	83(F)	80(B)	92(F)	x	86(F)	80(F)	80(B)	–	8(9)
Σ	7(11)	11(11)	11(11)	6(8)	11(11)	11(11)	8(11)	7(9)	10(11)	9(9)	11(11)	8(10)	110(124)

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Row: sending country; column: receiving country

Corridors in parenthesis [] are not considered in the baseline estimation due to limited time periods. They are considered within the robustness check.

x: No data available

Corridors with xx are dropped because of the missing net migration value.

80 denotes the initial year of data availability: 1980

\* estimated with immigration/emigration statistics from the receiving country

(F): Only foreign citizens

(B): Both, foreign and domestic country citizens

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

Table 5: List of all corridors

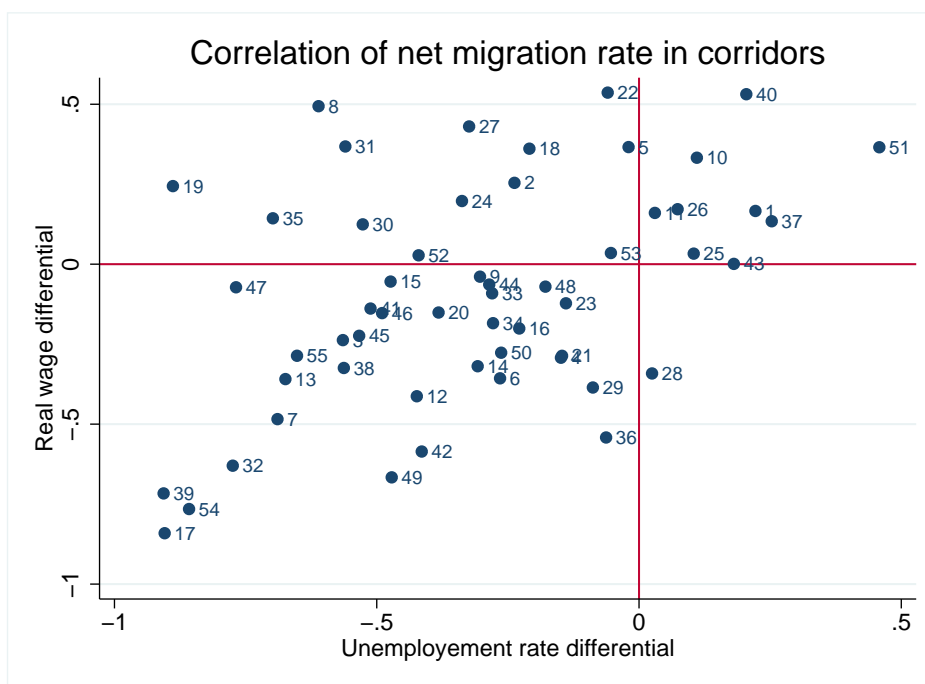


Figure 3: Four types of migration corridors

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

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

Table 6: List of all corridors

## 7.2. Robustness

nm=Net migration rate	1980-2010	1999-2010	1980-2010	1980-2010
$\lambda$	400	400	6.25	100
Fluctuation ( $\sigma(nm)/\sigma(y)$ )	1.55	1.35	2.00	1.64
Cyclicalitity ( $\rho(dy, nm)$ )	0.18*	0.19*	0.13*	0.13*
Unemployment differential ( $\rho(du, nm)$ )	-0.31*	-0.16*	-0.13*	-0.21*
Real wage differential ( $\rho(dw, nm)$ )	-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, asym.	$\rho(x, y)$	Model, asym.
Real output ( $y$ )	1	1	1	1
Real consumption ( $c$ )	0.81	0.67	0.76	0.8
Labor force ( $l$ )	0.39	0.53	0.43	0.32
Employment ( $n$ )	0.76	0.70	0.69	0.73
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

### 7.3. Symmetric zero-inflation Steady State

Variable	Home country	Foreign country
Technology	$a = 1$	$a^* = 1$
Relative price	$p_h = p$	$p_f^* = p^*$
Relative wage	$w_h = w_f = w$	$w_f^* = w_h^* = w^*$
Marginal costs	$mc = \frac{1}{\mu^P}$	$mc^* = \frac{1}{\mu^P}$
Exchange rates	$q = s = 1$	$q = s = 1$
Consumption	$y = c$	$y^* = c^*$
Unemployment	$u = 1 - \left( \frac{1}{(\mu^W)^{\frac{1}{\psi}}} \right)$	$u^* = 1 - \left( \frac{1}{(\mu^W)^{\frac{1}{\psi}}} \right)$
Employment	$n = \left( \frac{1-\alpha}{\Gamma \mu^W \mu^P} \right)^{\frac{1}{1+\psi}}$	$n^* = \left( \frac{1-\alpha}{\Gamma \mu^W \mu^P} \right)^{\frac{1}{1+\psi}}$
Production	$y = \left( \frac{(1-\alpha)}{\Gamma \mu^W \mu^P} \right)^{\frac{1-\alpha}{1+\psi}}$	$y^* = \left( \frac{(1-\alpha)}{\Gamma \mu^W \mu^P} \right)^{\frac{1-\alpha}{1+\psi}}$

Table 9: Steady state: Symmetric equilibrium

with  $\Gamma = \left[ (1-\gamma)^{1+\psi(1-\theta)} + \gamma^{1+\psi(1-\theta)} \right]^{\frac{1}{1-\theta}}$ .

#### 7.4. 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 (2011a)
Price adjustment	$\xi_P = 0.2$	Döpke et al. (2009)
Openness	$\omega = 0.25$	EA average
Trade elasticity	$\mu = 1.5$	EA average
Labor mobility parameter	Value	Target
Native labor supply elasticity	$\psi = 5$	DiCecio and Nelson (2010)
Share of migrant worker	$\gamma = 0.07$	EA 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	$\zeta_A = 0.0195$	EA average
SD labor supply shock	$\zeta_L = 0.1011$	EA average
SD monetary policy shock	$\zeta_M = 0.0207$	EA average
Persistence labor productivity	$\rho_A = 0.92$	EA average
Persistence labor supply	$\rho_L = 0.98$	EA average
Persistence monetary policy	$\rho_M = 0.9$	EA average
Policy parameters	Value	Target
Price inflation target	$\phi_\pi = 1.5$	
Output target	$\phi_y = 0.125$	

Table 10: Calibration

7.5. Impulse response functions

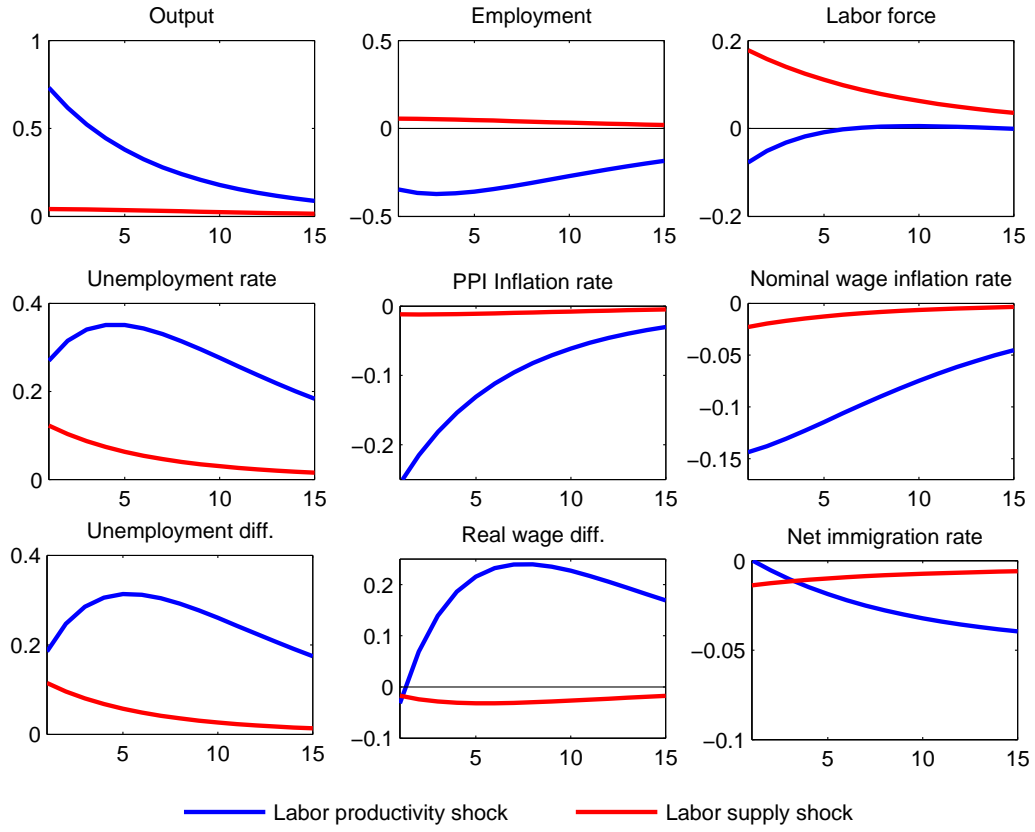


Figure 4: Domestic positive labor productivity vs. labor supply shock

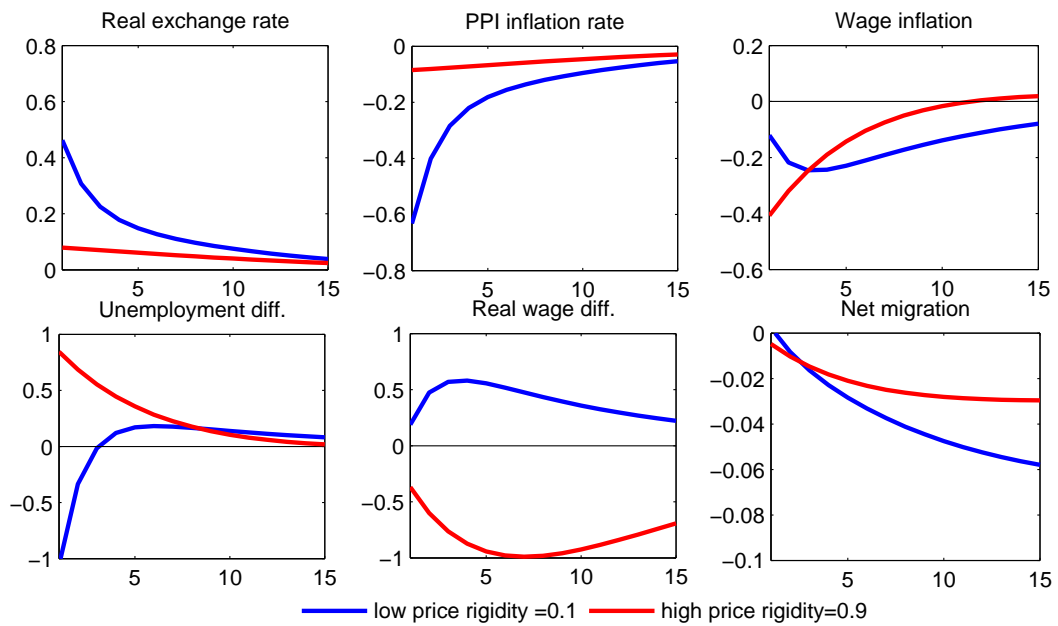


Figure 5: Domestic positive productivity shock and relative price/wage stickiness

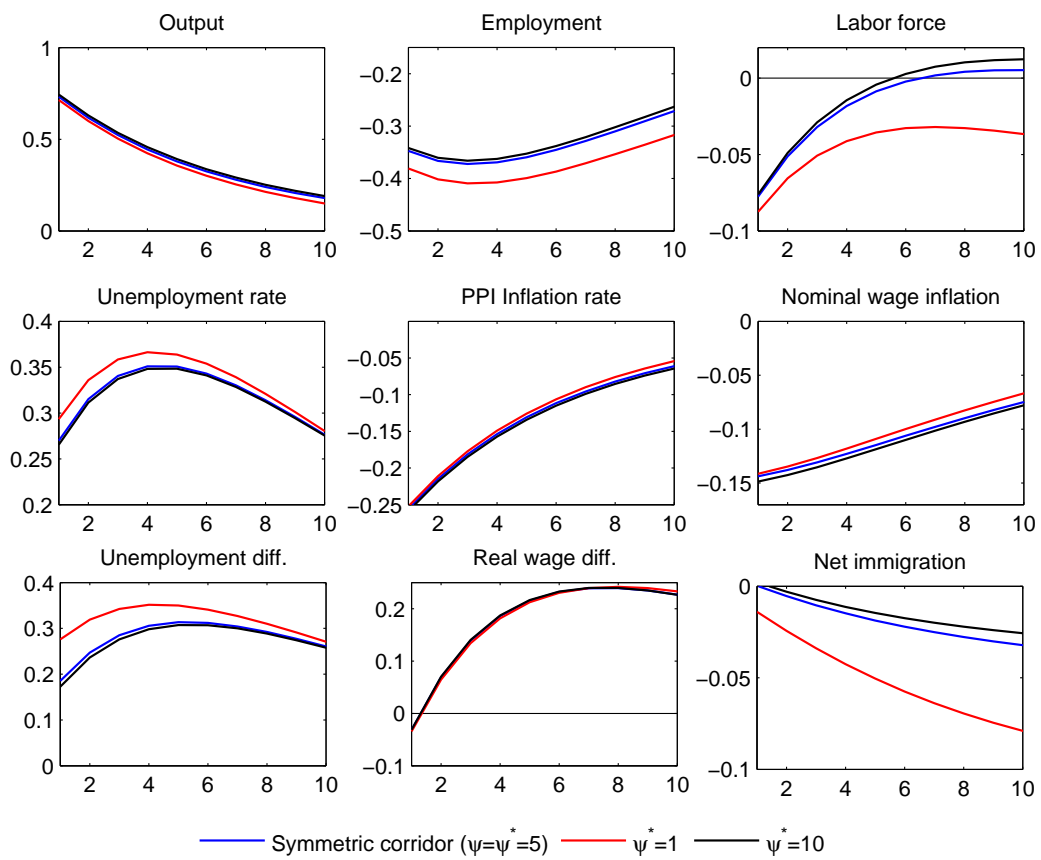


Figure 6: Domestic positive productivity shock and differences between native and migrant workers



## 7.6. Wage dispersion

A second-order Taylor-Approximation of the native wage definition around the deterministic zero inflation steady state leads to:

$$1 = \int_0^1 \left( \frac{w(i)_{h,t}}{w_{h,t}} \right)^{1-\varepsilon_w} di, \quad (40)$$

$$1 = \int_0^1 \exp \left\{ (1-\varepsilon_w) \left( \frac{w(i)_{h,t}}{w_{h,t}} \right) \right\} di, \quad (41)$$

$$= 1 + (1-\varepsilon_w) \int_0^1 (w_{h,t}(i) - w_{h,t}) di + \frac{(1-\varepsilon_w)^2}{2} \int_0^1 (w_{h,t}(i) - w_{h,t})^2 di + \mathcal{O}(\|\Delta_h^W\|^3) \quad (42)$$

$$\int_0^1 (w_{h,t}(i) - w_{h,t}) = -\frac{(1-\varepsilon_w)}{2} \int_0^1 (w_{h,t}(i) - w_{h,t})^2 di + \mathcal{O}(\|\Delta_h^W\|^3) \quad (43)$$

Thus, the native wage dispersion is

$$\Delta_{h,t}^W = \int_0^1 \left( \frac{w(i)_{h,t}}{w_{h,t}} \right)^{-\varepsilon_w} di, \quad (44)$$

$$= \int_0^1 \exp \left\{ -\varepsilon_w \left( \frac{w(i)_{h,t}}{w_{h,t}} \right) \right\} di, \quad (45)$$

$$= 1 - \varepsilon_w \int_0^1 (w_{h,t}(i) - w_{h,t}) di + \frac{\varepsilon_w^2}{2} \int_0^1 (w_{h,t}(i) - w_{h,t})^2 di + \mathcal{O}(\|\Delta_h^W\|^3). \quad (46)$$

From (43) follows:

$$\Delta_{h,t}^W = 1 + \frac{(1-\varepsilon_w)\varepsilon_w}{2} \int_0^1 (w_{h,t}(i) - w_{h,t})^2 di + \frac{\varepsilon_w^2}{2} \int_0^1 (w_{h,t}(i) - w_{h,t})^2 di + \mathcal{O}(\|\Delta_h^W\|^3) \quad (47)$$

$$= 1 + \frac{\varepsilon_w}{2} \int_0^1 (w_{h,t}(i) - w_{h,t})^2 di + \mathcal{O}(\|\Delta_h^W\|^3). \quad (48)$$

The average native wage  $w_{h,t}$  is the expected native wage  $E_t\{w_{h,t}\}$ . Thus,  $\int_0^1 (w_{h,t}(i) - w_{h,t})^2 di = \int_0^1 (w_{h,t}(i) - E\{w_{h,t}(i)\})^2 di = \text{Var}\{w_{h,t}(i)\}$ . Finally, the native wage can be derived as:

$$\Delta_{h,t}^W = 1 + \frac{\varepsilon_w}{2} \text{Var}\{w_{h,t}(i)\} + \mathcal{O}(\|\Delta_h^W\|^3). \quad (49)$$

### Immigrant wage dispersion

Analogously, the immigrant wage dispersion is:

$$\Delta_{i,t}^W = 1 + \frac{\varepsilon_w^*}{2} \text{Var}\{w_{i,t}(i)\} + \mathcal{O}(\|\Delta_i^W\|^3). \quad (50)$$

### 7.7. Price dispersion

From the definition of the aggregate price definition:

$$1 = \int_0^1 \left( \frac{p(z)_{h,t}}{p_{h,t}} \right)^{1-\varepsilon_p} dz, \quad (51)$$

$$1 = \int_0^1 \exp\left\{ (1-\varepsilon_p) \left( \frac{p(z)_{h,t}}{p_t} \right) \right\} dz, \quad (52)$$

$$= 1 + (1-\varepsilon_p) \int_0^1 (p_{h,t}(z) - p_{h,t}) dz + \frac{(1-\varepsilon_p)^2}{2} \int_0^1 (p_{h,t}(z) - p_{h,t})^2 dz + \mathcal{O}(\|\Delta_h^P\|^3) \quad (53)$$

$$\int_0^1 (p_{h,t}(z) - p_{h,t}) = -\frac{(1-\varepsilon_p)}{2} \int_0^1 (p_{h,t}(z) - p_{h,t})^2 dz + \mathcal{O}(\|\Delta_h^P\|^3) \quad (54)$$

$$\Delta_t^P = \int_0^1 \left( \frac{p(z)_{h,t}}{p_{h,t}} \right)^{\frac{-\varepsilon_w}{1-\alpha}} dz, \quad (55)$$

$$= \int_0^1 \exp\left\{ -\frac{\varepsilon_w}{1-\alpha} \left( \frac{p(z)_{h,t}}{p_{h,t}} \right) \right\} dz, \quad (56)$$

$$= 1 - \frac{\varepsilon_p}{1-\alpha} \int_0^1 (p_{h,t}(z) - p_{h,t}) dz + \frac{1}{2} \left( \frac{\varepsilon_p}{1-\alpha} \right)^2 \int_0^1 (p_{h,t}(z) - p_{h,t})^2 dz + \mathcal{O}(\|\Delta_h^P\|^3). \quad (57)$$

From (54) follows:

$$\Delta_t^P = 1 + \frac{(1-\varepsilon_p)\varepsilon_p}{2(1-\alpha)} \int_0^1 (p_{h,t}(z) - p_{h,t})^2 dz + \frac{1}{2} \left( \frac{\varepsilon_w}{1-\alpha} \right)^2 \int_0^1 (p_{h,t}(z) - p_{h,t})^2 dz + \mathcal{O}(\|\Delta_h^P\|^3) \quad (58)$$

$$= 1 + \frac{(1-\varepsilon_p)\varepsilon_p(1-\alpha) + \varepsilon_p^2}{2(1-\alpha)^2} \int_0^1 (p_{h,t}(z) - p_{h,t})^2 dz + \mathcal{O}(\|\Delta_h^P\|^3), \quad (59)$$

$$= 1 + \frac{(\varepsilon_p(1-\alpha - \varepsilon_p\alpha))}{2(1-\alpha)^2} \int_0^1 (p_{h,t}(z) - p_{h,t})^2 dz + \mathcal{O}(\|\Delta_h^P\|^3). \quad (60)$$

$\int_0^1 (p_{h,t}(z) - p_{h,t})^2 dz = \int_0^1 (p_{h,t}(z) - E\{p_{h,t}(z)\})^2 dz = \text{Var}\{p_{h,t}(z)\}$ . Thus,

$$\Delta_{h,t}^P = 1 + \frac{\varepsilon_p(1-\alpha - \varepsilon_p\alpha)}{2(1-\alpha)^2} \text{Var}\{p_{h,t}(z)\} + \mathcal{O}(\|\Delta_h^P\|^3). \quad (61)$$

### 7.8. Aggregate Production

The total native and immigrant labor demand is defined as integrals over domestic firms  $j$  and over native  $i$  and migrant  $i^*$  workers.

$$n_{h,t} = \int_0^1 \int_0^1 n_{h,t}(i,z) di dz, \quad (62)$$

$$= \int_0^1 n_{h,t}(z) \int_0^1 \frac{n_{h,t}(i,z)}{n_{h,t}(z)} di dz, \quad (63)$$

$$= \Delta_{h,t}^W \int_0^1 n_t(z) dz. \quad (64)$$

with  $\Delta_{h,t}^W = \int_0^1 \left( \frac{w_{h,t}(i)}{w_{h,t}} \right)^{-\varepsilon_w} di$ .

$$\int_0^1 y_t(z) = a_t \int_0^1 \left( \left( (1-\gamma)^{\frac{1}{\theta}} (n_{h,t}(z))^{\frac{\theta-1}{\theta}} + \gamma^{\frac{1}{\theta}} (n_{f,t}(z))^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \right)$$

$$\frac{\int_0^1 y_t(z)}{a_t} = \left( \left( (1-\gamma)^{\frac{1}{\theta}} \left( \frac{n_{h,t}}{\Delta_{h,t}^W} \right)^{\frac{\theta-1}{\theta}} + \gamma^{\frac{1}{\theta}} \left( \frac{n_{f,t}}{\Delta_{f,t}^W} \right)^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \right)$$

### 7.9. Dispersion dynamics

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