Quantifying the Benefits of Labor Mobility in a Currency Union*†

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Abstract

Unemployment differentials are much greater between European countries than between U.S. states. In both regions, net migration responds to unemployment differentials, though the response is smaller in Europe compared to the United States. This paper explores to what extent the relative lack of labor mobility in Europe hinders macroeconomic stabilization in the euro area. We use a multi-country DSGE model with cross-border migration and search frictions in the labor market to evaluate the trade-off between increased labor mobility and flexible exchange rates. The model is calibrated to match bilateral migration and trade flows in Europe. Our model suggests that higher labor mobility would reduce unemployment differentials across the euro area by one-fifth, larger than the reduction under flexible exchange rates. Differences in trade openness, size and labor market frictions across countries shape this trade-off, with labor mobility benefiting some countries substantially more than independent monetary policy, and vice versa.

Keywords: international migration, optimal currency areas, international business cycles.

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[The case] for flexible exchange rates [is] best if each nation (and currency) has internal factor mobility but external factor immobility. [If] factors are mobile across national boundaries then a flexible exchange system becomes unnecessary.'

– Mundell, Robert A. 1961. *A Theory of Optimum Currency Areas.*

1 Introduction

Unemployment differentials are much larger between countries in the euro area than they are between U.S. states. Figure 1 plots unemployment rates in 12 Western European euro area economies and 48 U.S. states between 1995 and 2015, together with the euro area and U.S. averages (the dark lines). Average unemployment in both the United States and Europe declined prior to the Great Recession and then increased by roughly 5 percentage points during the crisis. This similarity at the aggregate level, however, masks a tremendous amount of variation across countries in the euro area that is not observed across U.S. states. The cross-sectional standard deviation of unemployment, averaged over 1995-2015, is more than three times greater in the euro area (3.8%) than the United States (1.2%).

Large and persistent unemployment differentials within the euro area pose a significant risk to the currency union because a common monetary policy cannot be tailored to country-specific economic conditions. Mundell (1961) famously argued that factor mobility was a necessary pre-condition for an optimum currency area; in the face of a country-specific shock, factor inputs must adjust if relative prices cannot. Despite concerns about the extent of labor market integration in Europe, member states moved ahead with the adoption of the euro. In 2008, the global financial crisis and its asymmetric effects across Europe presented a challenge to the currency union. While the euro survived, the question remains: are European labor markets flexible enough to adjust to macroeconomic shocks in the absence of independent, national monetary policies? If they are not sufficiently flexible, what is the cost of maintaining the currency union? Empirically, net migration responds to unemployment differentials in Europe, but substantially less than in the United States. Whether labor mobility is sufficient in Europe is the central question of our paper.

To answer this question, we develop a multi-country DSGE model that incorporates both a search and matching framework giving rise to unemployment, and a migration decision that generates cross-border labor flows. We calibrate the model to the multi-country economy of Europe. The model reflects country size, migration patterns, trade, unemployment and currency regimes. We estimate the structural parameters of the model to match the empirical elasticity of net migration to unemployment in Europe.

The model allows us to evaluate Mundell's conjecture that factor mobility serves as a substitute for independent monetary policy in a realistic setting that reflects the actual economic conditions in Europe. In the spirit of Mundell (1961), we examine the responses to country-specific shocks that generate changes in the demand for labor. Our analysis suggests that, if the euro area had the same degree of labor mobility as the United States, the cross-sectional standard deviation of unemployment differentials across countries would fall by a fifth and would be accompanied by substantial increases in migration. Flexible exchange rates also reduce unemployment differentials but by a smaller amount and results in increased exchange rate volatility that may be difficult to tolerate in an integrated economy.

While both policies - increased labor mobility or flexible exchange rates - work to reduce unemployment differentials across countries, they do so through very different mechanisms. Consider a fall in demand for a good produced in a particular country. When there is labor mobility, workers flow out of that country and migrate to countries with lower unemployment and relatively higher labor demand. The supply of labor falls, limiting the fall in the real wage and preventing a sharp drop in the price of the country's export goods. In addition, as workers relocate, they shift their consumption away from goods produced in the country experiencing the negative shock towards goods produced in the rest of the world. This further exacerbates the initial fall in demand and partially offsets the effects of outmigration on unemployment. In the second case - flexible exchange rates - the country experiencing the fall in demand for its exports would cut interest rates to stimulate the economy and to depreciate the exchange rate. Rather than reduce labor supply (as was the case with mobile labor), the cut in the interest rate and the change in the exchange rate support demand for the country's exports.

The relative effectiveness of migration and monetary policy in response to shocks depends on the trade elasticity and the flexibility of wages and prices. Since migration works through the labor supply channel and monetary policy through the labor demand channel, changes in these parameters generally make one policy more effective, but the other policy less effective. Migration is most effective in countries where wages are slow to respond to shocks and when the demand for a country's goods is inelastic. Monetary policy on the other hand, is most effective when the trade elasticity is high, consumers readily respond to changes in the terms of trade and real wages adjust more quickly. Given the heterogeneity across European countries in their openness to trade and the flexibility of labor markets, it is understandable that national policy makers may have conflicting views about the relative benefits of increased labor mobility and independent monetary policy. We confirm this in a final exercise, where we rank countries by the stabilizing effects of these two policies: More open economies, larger economies and economies with higher labor market frictions benefit more from higher labor mobility.

2 Related Literature

Our research relates to the classic literature on ”optimal currency areas”, dating back to Friedman’s *Case for Flexible Exchange Rates* (Friedman, 1953). The European debt crisis and the divergence in economic outcomes across the euro area spurred a resurgence of research on this topic. Among the papers most closely related to our work is Farhi and Werning (2014) who study labor migration in response to external demand shortfalls and the impact on the economies that receive the labor inflow as well as on those economies experiencing the ouflow. They find that labor outflows can benefit those who are staying, especially if economies are tightly linked through trade. Complementary to our work is Hauser and Seneca (2018) who show that a mobile labor force reduces the welfare costs of joining a monetary union. Relatedly, Mandelman and Zlate (2012) study the insurance role of remittances for consumption smoothing in an international business cycle model calibrated to the U.S. and Mexico. Their model abstracts from nominal rigidities, which play a key role in our analysis, and consequently does not address the issue of optimal currency areas. Our contribution to this literature is two-fold: First, our model clarifies settings that make labor mobility particularly powerful in reducing unemployment rate differentials, such as labor market frictions and low trade elasticities. Second, we provide a quantitative assessment of the benefits of labor mobility over the business cycle in a rich DSGE model.

Our work also relates to studies investigating different mechanisms in which trade and migration are interrelated (Davis and Weinstein, 2002; Burstein et al., 2017; Di Giovanni, Levchenko and Ortega, 2015; Caliendo, Dvorkin and Parro, 2015). For example, building on the quantitative trade literature for policy analysis, Caliendo et al. (2017) add migration to an Eaton-Kortum framework to study the welfare effects of the EU enlargement in 2004 for both low-skilled and high-skilled workers. They find large welfare gains for the new member countries, while the welfare gains are small for the old member countries, and even negative if the enlargement had not reduced trade barriers as well. While sharing some features with their model, our approach differs in that we focus on the interplay of migration and unemployment rates at business cycle frequency, as opposed to the effect of a permanent reduction in migration costs. Consequently, our model includes nominal rigidities, search and matching frictions in the labor market and international bond markets, which are all features that are missing in Caliendo et al. (2017).

Our paper is not the first to empirically analyze the response of migration to labor market conditions. The seminal paper in this literature is Blanchard and Katz (1992) who estimate the joint behavior of employment growth, the employment rate and the participation rate in response to a positive region-specific labor demand shock in the United States. Using a VAR approach they find that a decrease in employment by 100 workers leads to an outmigration of 65 workers in the first year, together with an increase in unemployment by 30 workers. Subsequent studies have documented a slight decline of interstate mobility since the early 90s in response to local labor demand shocks (Molloy, Smith and Wozniak, 2011; Dao, Furceri and Loungani, 2017; Kaplan and Schulhofer-Wohl, 2017; Yagan, 2014), similar to our results. Applying the Blanchard and Katz (1992) method to European data, Beyer and Smets (2015) report that in response to labor market shocks, migration reacts less than half as much in Europe, although the role of migration as an adjustment mechanism has become more important over time. See also Jauer et al. (2014). The low migration response in Europe has been confirmed by several studies (Decressin and Fatas, 1995; Huart and Tchakpalla, 2015) and is in line with our results. Our contribution to this literature is two-fold: First, we substantially increase the sample of European countries and gather new data on observed migration flows (as opposed to migration flows deduced from population movements). Our data indicate that the difference between the U.S. and Europe is even larger than estimated in Beyer and Smets (2015). Second, while the cited literature is mostly empirical, we use the estimated cyclical relationship between migration and unemployment as moments for the calibration and estimation of our DSGE model to quantify the effects of migration on economic outcomes under fixed and flexible exchange rates.

3 Empirical Analysis

3.1 Data

Geographical Coverage We analyze migration flows within three geographical areas: the United States, Canada and Europe. The sample for the United States consists of 48 states (excluding Alaska and Hawaii due to their geographical isolation). The Canadian sample includes all ten provinces. We consider two samples of European countries. Our first sample is a "narrow" set that includes only the twelve core euro area countries of Western Europe (including Denmark whose currency is pegged to the euro during our sample period). These countries are a fairly homogenous group in terms of economic development and moreover they removed restrictions on labor mobility in the late 1980's to early 1990's.[1] Our second sample is

[1] The "narrow" sample includes Belgium, Denmark, Germany, Ireland, Greece, Spain, France, Italy, Netherlands, Austria, Portugal, Finland. We exclude Luxembourg due to its tiny size, the paucity of migration data

a "wide" set which includes an additional 17 European countries. These additional countries are either part of the European Union or part of the European Free Trade Association, and liberalized cross-border labor flows somewhat later.[2]

Sample Period For the United States and Canada, our sample period is 1977-2015. The sample choice is governed by the lack of unemployment and migration data at the subnational level prior to the mid 1970's. For the European sample, we focus on 1995-2015. Before 1995, migration data is available only for a handful of countries and restrictions on labor mobility were still prevalent in a number of euro area countries.

Data Sources We collect data on population, unemployment rates and migration by state and by country. We follow the United Nations in defining a migrant as any person moving into or out of a country or state irrespective of their nationality or their country/state of birth. Data on annual, bilateral migration flows at the U.S. state level are provided by the Internal Revenue Service (IRS) and begin in 1975. Migration data are based on the the mailing addresses of tax returns and encompass all U.S. tax filers. Migration rates between states are measured as returns with changes of address from one state to another. We use the IRS data - as opposed to alternative sources used in the literature, such as the American Community Survey and the Current Population Survey - because the IRS data do not suffer from small sample sizes that could be problematic for measuring migration flows of small states.[3] Data on state population and unemployment rates are provided by the Bureau of Economic Analysis and the Bureau of Labor Statistics.

Data for Canadian provinces come from Statistics Canada. Migration data start in 1972 and unemployment data start in 1977.

Data on migration in Europe are provided by both Eurostat and national statistical agencies. The underlying data sources vary across countries. Administrative data are used in countries where registration is mandatory (e.g., all Scandinavian countries); otherwise, survey data is used (e.g. in the UK). There are two complications associated with the European data. First, there are discrepancies in the definition of what constitutes a migrant prior to 2008. Second, for each country pair, we have two measures of in- and out-migration. We adjust the

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and the high share of cross-border commuters in the total share of the workforce, which was above 40% in 2010 according to Statistics Luxembourg.

[2]The "wide" sample includes all of the countries in the "narrow" sample plus Bulgaria, Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Romania, Slovenia, Slovak Republic, Sweden, United Kingdom, Iceland, Norway, and Switzerland.

[3]The IRS data are used by the U.S. Census to calculate state-level net migration rates since 1981. The U.S. Census adjusts the raw IRS data to account for households that do not file taxes. As discussed in the Appendix (Section A.1), these adjustments are rather small.

data to account for both features. Details on these adjustments are in Appendix A. Again, a migrant is defined by a change in residency. For instance, both a German and French citizen moving from France to Germany are counted as emigrants from France and immigrants to Germany. Our panel data for Europe are unbalanced, as displayed in Appendix Table A4. We have complete data for twelve countries. For another nine countries, data begin in 1998.[4] Data on unemployment rates are collected through national labor force surveys and reported by Eurostat.[5] Appendix A.3 provides more details on data sources and the construction of the migration database for Europe.

Migration We begin by examining migration patterns in North America and Europe. As we will show, migration rates have been declining in the United States and have been gradually increasing in Europe. Despite these trends, there remains substantially more migration in the United States and Canada relative to Europe.

We define the gross migration rate as the average of inflows and outflows over one year divided by the population at the beginning of the year.[6] That is, the gross migration rate of country or state i at time t is

$$\text{Gross migration}_{i,t} = \frac{1}{2}\frac{\text{In-migration}_{i,t} + \text{Out-migration}_{i,t}}{\text{Population}_{i,t}}$$

where $\text{Population}_{i,t}$ is country or state i's population at the beginning of year t.

Table 1 reports migration rates for the the United States, Canada and the two European samples. In the table, migration rates are first averaged over time, and then averaged across countries (or states), using simple averages. The table shows that migration rates are substantially higher in North America than in Europe. The U.S. gross migration rate is more than 3% while it is less than 1% in both European samples. Canadian migration is in between with a gross migration rate of 2%. These differences in migration rates could be due to geographical differences between the three regions. One might think that larger, more populous regions would have less cross-border migration than smaller regions. Table 1 shows that U.S. states are, on average, smaller in terms of population than European countries, which could explain the relatively low migration rates in Europe. Figure 2 shows that while countries or states

[4]The first group consists of Belgium, Czech Republic, Denmark, Germany, Italy, Netherlands, Slovenia, Finland, Sweden, Iceland, Norway, Switzerland. The second group consists of Ireland, Greece, Spain, Cyprus, Latvia, Lithuania, Austria, Portugal, United Kingdom

[5]Labor force surveys are harmonized across Europe and use the same definition of unemployment as in the United States.

[6]For the United States, we divide the average number of migrating tax returns by the number of all tax returns observed in t that originate from state i. This is also the approach used by the U.S. Census.

with greater populations do have less migration, the U.S. rate remains substantially greater than the European rate even after controlling for population. In addition to country size, there are many additional possible explanations for the difference in migration rates between North America and Europe. Language, culture, institutional differences, and so forth, all present barriers to labor flows that could be greater in Europe relative to the United States and Canada. For instance, Beine, Bricongne and Bourgeon (2013) show that migration flows are by about 85% larger between countries that share the same language. In our analysis in Section 4 we are agnostic about the specific frictions that impede labor mobility. The purpose of the model is to capture the consequences of lower mobility in Europe abstracting from the underlying cause.

Figure 3 displays average gross migration rates for the United States, Canada and the two European samples plotted over time. Migration rates have been trending down in the United States and Canada (see Molloy, Smith and Wozniak, 2011). Since the mid-70s migration rates have fallen from 3.75% to 3% in the United States, and from 3.2 percent to 1.75% in Canada. In contrast, migration has gradually increased in Europe though the rate is still well below the U.S. rate. See Jauer et al. (2014) for a thorough analysis of migration patterns before and after the financial crisis.

Not all migrants moving to a U.S. state come from another U.S. state. We define the *internal* migration rate as the number of migrants from state i that come from or leave for another U.S. state, as a share of state i's total population. That is, internal migration for U.S. states excludes migration flows from or to areas outside the United States. Similar calculations are made for Canada and Europe.[7] Table 1 shows that almost all of the migrants in U.S. states come from other U.S. states; i.e., the difference between the gross migration rate and the internal migration rate is relatively small. In Europe (and Canada), the difference is larger reflecting the greater importance of external migration in those regions.

The last row in Table 1 reports the standard deviation of the *net* migration rate over time. The net migration rate is the difference between a state's total inflows and total outflows as a share of its population

$$\text{Net migration}_{i,t} = \frac{\text{In-migration}_{i,t} - \text{Out-migration}_{i,t}}{\text{Population}_{i,t}}.$$

Net migration includes all migratory flows (both internal and external to the region). Because, on average, overall net migration in the United States will be close to zero (each incoming

[7] For calculating internal migration we include migration to and from Alaska, Hawaii and Washington D.C. as internal to the United States. Similarly, we include all 29 European countries as internal migration in both the 'Europe' and 'Core euro area' cases.

migrant is another state's outgoing migrant), we report the standard deviation of net migration over time. The bottom row of Table 1 reports the standard deviation of net migration for the United States, Canada and Europe. Unlike the gross migration rates and the internal migration rates, which were substantially different between the United States and Europe, net migration rates are more comparable. The average across all states is 0.48 in North America, and about 0.3 in Europe. Net flows in Europe are therefore more than half as large as in North America, despite substantially lower gross flows. Countries in Europe therefore tend to experience either inflows or outflows of migrants, while these flows tend to cancel out in North America.

Unemployment Rates We now turn our attention to the difference in unemployment rates in the United States, Canada and Europe. As described below, we first de-mean unemployment rates in both the cross-sectional and the time dimension. This removes long-run average differences as well as common cyclical variations in unemployment rates. We apply a similar "double demeaning" procedure to the other variables below. We do this because many regions have persistently high (or low) unemployment rates and persistently high (or low) migration rates that are not related to the short-run business cycle adjustments that are the focus of our analysis. Double demeaning the data removes both the state average unemployment rate and the yearly national average unemployment rate. The double-demeaning procedure is similar to applying country and time fixed effects though there are small differences because our panel is not balanced and because we use a country-weighted average for the time fixed effect.[8] We use the same statistical procedure with the model generated data.

Consider the unemployment rate for country i in Europe. A similar construction applies for a U.S. state or for a Canadian province. Let country i's unemployment rate at time t be $ur_{i,t}$ and let the long-run average unemployment rate in country i be $ur_i = \frac{1}{T}\sum_{t=1}^{T} ur_{i,t}$. The aggregate unemployment rate for Europe at time t is the population-weighted sum of countries' unemployment rates, $ur_t = \frac{1}{N}\sum_{i=1}^{N} \frac{pop_i}{pop} ur_{i,t}$, where N is the number of countries in the European sample, pop_i/pop is the share of country i's population in Europe. The average unemployment rate $\overline{ur}$ is simply the time series average $\overline{ur} = \frac{1}{T}\sum_{t=1}^{T} ur_t$. Then, the double-demeaned unemployment rate for country i is

$$\widehat{ur}_{i,t} = ur_{i,t} - ur_i - (ur_t - \overline{ur}). \tag{3.1}$$

Our empirical analysis centers on the properties of the unemployment rates $\widehat{ur}_{i,t}$. The rate $\widehat{ur}_{i,t}$ is an indication of whether country i's unemployment is high relative to its own long-run

[8] Repeating our analysis with conventional state and time fixed effects yields virtually the same results.

rate and relative to other countries' rates at a given point in time. In effect this captures the country-specific, cyclical component of a country's unemployment rate.

Figure 4 plots the standard deviations of the demeaned unemployment rates, together with their average over time, $\sum_t std\left(\widehat{ur}_{i,t}\right)$. For the United States and Canada the standard deviation of unemployment rates is about 1. For the two European samples, the standard deviation is roughly 2.5. The earlier observation of greater unemployment rate dispersion in Europe relative to the United States (see Figure 1) is not driven by long-run differences across countries (or states), but remains even after removing country averages and common cyclical changes in unemployment. Unemployment rates were somewhat more dispersed in the U.S. during the early 1980's and in the Great Recession. Unemployment rates in Europe diverge particularly during the debt crisis in 2011 - 2013, with a standard deviation of almost 5 percentage points in the core euro area.

We next examine the persistence of unemployment differentials. Following Jordà (2005), we estimate a local projection of unemployment rates on their own lags. For each horizon h we estimate the following regression

$$\widehat{ur}_{i,t+h} = \beta_0^h \widehat{ur}_{i,t} + \beta_1^h \widehat{ur}_{i,t-1} + \beta_2^h \widehat{ur}_{i,t-2} + \epsilon_{i,t}^h \qquad \forall h = 0, 1, .., H \tag{3.2}$$

up to a nine year horizon $H = 9$. $\hat{\beta}_0^h$ is an estimate of the impulse response of unemployment rates to its own innovation at horizon h. The upper part of Figure 5 displays the estimated coefficients $\hat{\beta}^h$ for the United States (a), Canada (b), Europe (c) and the euro area (d). The estimates show that unemployment rate differentials are persistent in all cases, but particularly so in Europe and the euro area. In response to an innovation of 1 percentage point, unemployment differentials initially rise by 0.5 to 0.8 percentage points in Europe and stay above 1% for 3 to 4 years.[9]

To summarize, this section has shown that (demeaned) unemployment rates are more dispersed across European countries than U.S. states and that this dispersion is quite persistent, especially in the euro area.

3.2 Unemployment Rates and Net Migration

We are particularly interested in the relationship between net migration flows and unemployment differentials and how this relationship differs across regions. To study this relationship

[9] In an earlier version of this paper, we estimated the AR(2) specification

$$\hat{u}_{i,t} = \beta_i + \beta_1 \hat{u}_{i,t-1} + \beta_2 \hat{u}_{i,t-2} + \epsilon_{i,t}^u.$$

The comparison of the Jorda projections with the parametric AR(2) representation is very similar.

we regress net migration on the unemployment rate as follows:

$$\widehat{nm}_{i,t} = \beta \widehat{ur}_{i,t} + \epsilon_{i,t}, \tag{3.3}$$

where $\widehat{ur}_{i,t}$ is the double-demeaned unemployment rate as defined in (3.1) and $\widehat{nm}_{i,t}$ is the double-demeaned net migration rate (calculated analogously). This specification, which focuses on demeaned variables, implicitly assumes that what matters for migration choices is a country's unemployment rate relative to the regional unemployment rate at a particular point in time.[10]

Table 2 displays the results of this regression and Figure 6a shows the scatterplot of the data. As before, the time period for the North American samples is 1977-2014, and 1995-2015 for the European samples. The U.S. coefficient is -0.27 with a standard error of 0.03 (Driscoll and Kraay (1998) standard errors are reported). Thus in years when a state has a 1 percentage point higher de-meaned unemployment rate, net migration falls by 0.27 percentage points. In other words, an increase of 100 unemployed workers in a state coincides with out-migration of 27 people from that state. These regressions are not meant to be interpreted causally. Rather, we are simply documenting that periods with relatively high unemployment are associated with periods of net outmigration.

Panel (a) of Figure 7 displays the estimated β coefficients for the United States when we run regression (3.3) separately for all years in our sample. While there are year-to-year differences in the estimated slope coefficient, the yearly estimates are close to the estimate of -0.27 found for the full sample. Some papers have argued that migration played a minor role during the Great Recession compared to other recessions.[11] The estimated coefficients in Figure 7 suggest otherwise. In 2010 the estimated coefficient is $\hat{\beta} = -0.25$ (0.05), close to the coefficient estimated on the entire sample. One explanation for why we find an important role for migration is that we control for long-run trends by demeaning the data. States in the Sun Belt have seen substantial migration inflows over the last 40 years. But these states were also the most negatively affected states during the Great Recession. Their rise in unemployment coincided with reduced inflows of workers and therefore pushed their migration rates down to those observed in other states, flattening out the relationship between unemployment and net migration. Failure to control for long-run trends yields a coefficient of $\hat{\beta} = -0.05$ in 2009-2010

[10] The relevance of *relative* unemployment rates is consistent with the DSGE model presented in the next section and the "gravity approach" that has been successfully used to describe trade flows (Anderson, 2011).

[11] For instance, using micro data from the American Community Survey (ACS) Yagan (2014) reports that migration only played a minor insurance role during the Great Recession as compared to the 2001 recession. Similarly, Beraja, Hurst and Ospina (2016) maintain a "no cross-state migration" assumption in their analysis of regional business cycles based on a small correlation between interstate migration and employment growth during the Great Recession.

(see Figure 8).[12]

The relationship between unemployment rates and net migration is much smaller in Europe. The estimated coefficient for the core euro area is almost identical to the one for Europe as a whole ($\hat{\beta} = -0.09$ (0.01) vs. $\hat{\beta} = -0.08$ (0.01)). Canada's coefficient ($\hat{\beta} = -0.23$ (0.02)) is closer to that of the United States.

So far, we have focused on the *contemporaneous* relationship between unemployment rates and net migration at an annual frequency. As we described above, unemployment rate differentials tend to persist over time. This is particularly true for Europe. One would therefore expect migration flows to persist as well, potentially resulting in substantial changes in regional populations. To quantify these population changes, we perform a local projection analysis by estimating the horizon-specific regressions

$$\widehat{nm}_{i,t+h} = \beta_0^h \widehat{ur}_{i,t} + \beta_1^h \widehat{ur}_{i,t-1} + \beta_2^h \widehat{ur}_{i,t-2} + \epsilon_{i,t}^h \qquad \forall h = 0, 1, .., H$$

with $H = 9$. The estimated coefficient β_0^h provides us with an estimate of the response of net migration to changes in unemployment rates at horizon h. Based on the estimated coefficients β_0^h, we can also calculate the implied cumulative population response at each horizon. The cumulative response is the change in population associated with the estimated migration flows (ignoring population changes due to birth and death).

The middle panels in Figure 5 show the estimated response of net migration over time to a 1 percentage point unemployment differential (i.e., the panels report the estimated coefficients $\hat{\beta}_0^h$ for each h). For the United States (column a), the net migration rate falls by a bit more than 0.25 percent. In the following year, net migration falls more, to roughly −0.3 percent. It takes 5 to 6 years to return to its mean, slightly before the unemployment rate differential dissipates. The lower row of panels in Figure 5 show the cumulative change in population implied by the net migration estimates. Following an increase in unemployment of 1 percentage point above its mean, a state's population falls by roughly 1.3% after five years, and remains below average for several years afterwards. This reduction in population is substantial and even exceeds the initial increase in the unemployment rate. It is conceivable that these migration flows have significant feedback effects and alter the response of macroeconomic variables over the business cycle.

Columns (c) and (d) of Figure 5 repeat the local projections for the European samples. The overall dynamics of migration flows are similar, but are clearly smaller than the U.S.

[12] Beraja, Hurst and Ospina (2016) find a slope of 0 rather than −0.05. This difference can be attributed to our use of IRS data instead of ACS data and that we focus on the unemployment rate instead of the employment rate.

reactions. The fall in population is only about one third of the response in the U.S. (-0.47 vs. -0.3). While the population response is somewhat stronger for the euro core area (-0.95), it is even more delayed (nine years) and its magnitude has to be interpreted against the backdrop of more persistent (the upper panel) and larger unemployment rate differentials (see Figure 4).

To summarize, we find that (i) Labor is less mobile in Europe relative to the United States. (ii) Unemployment differentials are larger and more persistent in Europe relative to the United States. (iii) Net migration reacts to regional differences in unemployment rates in both the United States and in Europe though the relationship is notably weaker in Europe. (iv) The implied changes in population are economically significant in both regions.

4 A DSGE Model with Cross-Country Labor Mobility

In this section, we develop a multi-country model with cross-border migration to analyze the tradeoff between labor mobility and exchange rate adjustment emphasized by Mundell. The distinctive features of the model are labor mobility across countries, unemployment, and price rigidity. The first two features allow us to directly compare the model to the empirical patterns in Section 2. The third feature allows monetary policy to affect real economic activity. We introduce labor mobility in a tractable way following the work by Artuç, Chaudhuri and McLaren (2010) (ACM) and Caliendo, Dvorkin and Parro (2015) (CDP). We introduce unemployment into our model through the standard Diamond-Mortensen-Pissarides (DMP) search-and-matching framework (see Diamond, 1982; Mortensen, 1982; Pissarides, 1985).

4.1 Households

The world is populated by $i = 1, ..., \mathcal{N}$ countries. In each country, there are two types of households: natives who always work and live in their country and whose (fixed) number is given by $\mathbb{N}^i$, and a number of migrants, denoted by $\mathbb{M}_{i,t}$, who are free to move across countries. Due to migration, the population of country i, denoted by $\mathbb{N}_{i,t}$, might fluctuate over time and its size at time t is given by

$$\mathbb{N}_{i,t} = \mathbb{N}^i + \mathbb{M}_{i,t}. \tag{4.1}$$

We abstract from commuting and impose that household members have to live in the same place that they work. Households (natives and migrants) supply a fixed amount of labor l_i in the country of their current residence, so that total labor supply in country i is simply equal to country i's population times l_i. We later calibrate the cross-country differences in labor supply to match observed labor force participation rates.[13] We implicitly assume that labor supplied by migrants and natives are perfect substitutes, similar to Mandelman and Zlate (2012). We think this is a reasonable assumption given the relative homogeneity of labor across Europe. The degree of substitutability of natives and immigrants is a subject of ongoing debate and varies depending on the region and time period under consideration (see e.g. Peri, Ottaviano et al., 2006; Borjas, Grogger and Hanson, 2008; Furlanetto and Robstad, 2017). We also assume that migrants and natives are equally productive. In Appendix B.2, we present some evidence that migrants in Europe are more highly educated, suggesting that our assumption is somewhat conservative regarding the relevance of migration for the macroeconomy.

Household members living in country j consume country j's final good. These country-specific final goods cannot be traded. As described later, firms in every country produce the final good using combinations of tradable intermediate goods sourced from different countries. That is, production of the final consumption good features home bias, so that the law of one price does not hold.

Before characterizing the maximization problem of natives—which is relatively standard in the open-economy literature, we first describe the problem of migrants. Here, we adopt the framework in ACM and CDP to our setting.

Migrants Migrants receive income from their labor, $w^h_{i,t} l_i$ (where $w^h_{i,t}$ describes the real wage in country i at time t), which they directly use to pay for consumption. While this "hand-to-mouth" formulation follows Caliendo, Dvorkin and Parro (2015) and considerably simplifies the solution to the model, it abstracts from remittance flows.[14] In making their decisions whether to move across countries, migrants face migration costs, denoted by τ^i_j. These migration costs are time-invariant, depend on the origin i and destination j of the migrant and are measured in terms of utility. We normalize the cost of staying in one's country, τ^i_i, to 0. We later back out these migration costs, τ^i_j, from our data on migration flows. Migrants have additive idiosyncratic shocks for each destination j, denoted by $\epsilon_{j,t}$. The variance of these idiosyncratic shocks is given by $\frac{1}{\gamma}$ and plays, as we will see, a crucial role in

[13] Notice that we assume that when a migrant moves, he or she adopts the labor force participation rate in the destination country.

[14] In the working paper version of this model, we proposed an alternative formulation where migrants are part of a large household that sends workers overseas. In that model, risk sharing within households implies remittance flows. The quantitative results are fairly similar across the two types of formulation. The current formulation emphasizes that migrants' location choice is individually rational instead of being in the interest of the large household. While we believe that remittances could play a role in shaping the aggregate response to migration flows, careful measurement of these flows in the data should guide future efforts to model remittances in a realistic way.

shaping the response of migration to aggregate shocks. We follow ACM and CDP and assume that the idiosyncratic shocks are i.i.d. over time and distributed Type-I Extreme Value with zero mean. This allows for simple aggregation of idiosyncratic, discrete location decisions of migrants.

At the beginning of period t, after observing the economic conditions across all countries and the realizations of their own idiosyncratic shocks, migrants decide whether to relocate. Migration takes place within a period and migrants directly work and consume in their new location. We denote by $e_{i.t}(\epsilon_t)$ the value to a migrant (i.e. his lifetime utility) of living in country i at time t. This lifetime utility is conditional on the aggregate state and the vector of idiosyncratic shocks, $\epsilon_t = \begin{bmatrix} \epsilon_{1,t} & \epsilon_{2,t} & ... \end{bmatrix}$. The *expected* lifetime utility of a migrant living in country i at time t before the realizations of the idiosyncratic shocks (but conditional on the aggregate state) is denoted by $E_{i,t}$.

For a migrant currently living in country i, the lifetime utility can therefore be described by

$$e_{i,t}(\epsilon_t) = \max_j \left\{ U\left(w^h_{j,t} l_j\right) + \frac{1}{\gamma}\epsilon_{j,t} - \tau^i_j + \beta \mathbb{E}_t \left(E_{j,t+1}\right) \right\}. \tag{4.2}$$

Migrants choose to relocate to the country that delivers the highest lifetime utility. Their choice to move to j depends both on the current-period utility over consumption, $U\left(w^h_{j,t} l_j\right)$, the idiosyncratic preference component, $\frac{1}{\gamma}\epsilon_{j,t}$, the migration cost expressed in utility terms, τ^i_j, and the expected value of living in j in the next period, $\mathbb{E}_t\left(E_{j,t+1}\right)$, discounted by a factor β. Our assumptions on the distribution of ϵ_t makes it easy to calculate the expected value of $e_{i,t}(\epsilon_t)$ before the realizations of the idiosyncratic shocks:

$$E_{i,t} = \frac{1}{\gamma} \ln \left\{ \sum_j \exp\left(U\left(w^h_{j,t} l_j\right) - \tau^i_j + \beta E_{j,t+1}\right)^\gamma \right\}.$$

Since shocks are i.i.d. across migrants, we can think of $E_{i,t}$ as the average utility of a representative migrant living in country i at time t. Aggregate migration flows will then depend on this average utility. In particular, one can show that the share of migrants that relocate from i to j, denoted by $n^i_{j,t}$, is described by

$$n^i_{j,t} = \frac{\exp\left(U\left(w^h_{j,t} l_j\right) - \tau^i_j + \beta E_{j,t+1}\right)^\gamma}{\sum_k \exp\left(U\left(w^h_{k,t} l_k\right) - \tau^i_k + \beta E_{k,t+1}\right)^\gamma}.$$

Markets with higher expected lifetime utility attract, all things being equal, more migrants. The shares naturally sum up to 1 across destinations, $\sum_j n^i_{j,t} = 1$. Given this expression for migration shares, the number of migrants living in country i at time t follows the law of motion

$$\mathbb{M}_{i,t} = \sum_j n^j_{i,t} \mathbb{M}_{j,t-1}.$$

Since migrants experience idiosyncratic preferences shocks for locations, the model predicts simultaneous, bidrectional migration flows across countries. That is, gross migration rates generally exceed net migration rates in the model, which is consistent with the empirical evidence reported in Table 1. The level of gross flows depends both on the level of migration costs, τ^i_j, and the variance of the idiosyncratic shocks, $\frac{1}{\gamma}$. Migration flows also respond to changes in labor market conditions. To see this, we rewrite the log difference in the share of migrants moving to j to the share of migrants staying in i:

$$\ln(n^i_{j,t}) - \ln(n^i_{i,t}) = \gamma \left[\left(U\left(w^h_{j,t} l_j\right) - \tau^i_j + \beta E_{j,t+1} \right) - \left(U\left(w^h_{i,t} l_i\right) + \beta E_{i,t+1} \right) \right] \tag{4.3}$$

If real wages rise in j relative to wages in i, migrants are more likely to move from i to j because higher real wages imply higher utility. But this response is smaller if γ is low. Intuitively, a low γ translates into a higher variance of the idiosyncratic shock, implying that non-pecuniary benefits rather than wage differentials play a more important role in shaping migration flows across countries. Observing how migration flows react to changes in labor market conditions—as we did in the empirical section—therefore informs us about the value of γ. We will later estimate γ from the observed relationship between net migration and unemployment rates that we reported in the previous Section.

Natives As migrants, natives obtain utility from consumption of the final good. Their nominal expenditure on consumption amounts to $\mathbb{N}^i P_{i,t} c_{i,t}$, where $P_{i,t}$ is the nominal price of the final good in country i at time t. Natives' nominal labor income is given by $\mathbb{N}^i W^h_{i,t} l_i$. Since labor is assumed to be uniform across countries, both natives and migrants receive the same nominal wage, $W^h_{i,t} = w^h_{i,t} P_{i,t}$. Natives own the capital stock and receive income from renting capital to firms. Let $\mathbb{N}_{i,t-1} K_{i,t-1}$ denote the capital stock in country i at the beginning of period t. Households can adjust the rate at which this capital stock is utilized, $u_{i,t}$, depending on the date-t realization of the state. Varying the utilization of capital requires $\mathbb{N}_{i,t-1} K_{i,t-1} a\left(u_{i,t}\right)$ units of the final good. Households then rent $\mathbb{N}_{i,t-1} K_{i,t-1} u_{i,t}$ effective units of capital to intermediate-good-producing firms and earn a rental price of $R^k_{i,t}$ per effective unit of capital. Every period households invest $\mathbb{N}_{i,t} P_{i,t} X_{i,t}$ in the capital stock. Households receive nominal profits $\mathbb{N}_{i,t} \Pi_{i,t}$ and pay lump-sum nominal taxes $\mathbb{N}_{i,t} T_{i,t}$ to the government.

Every period, households invest in nominal bonds, denominated in a reserve currency, with $S_{i,t}$ denoting the nominal exchange rate that converts country i's currency into this reserve currency.[15] The bonds pay interests at rate i_t. To receive a payout of $\mathbb{N}^i \frac{B_{i,t}}{S_{i,t+1}}$ of the final good in $t+1$, households in country i have to purchase $\mathbb{N}^i \frac{B_{i,t}}{S_{i,t}}$ this period. Date-t income from bond holdings purchased in $t-1$ is then $\mathbb{N}^i \frac{B^i_{t-1}}{S_{i,t}}$.

Households choose consumption $c_{i,t}$, investment $X_{i,t}$, the rate of capital utilization $u_{i,t}$, next period's capital stock, $K_{i,t}$, and bond holdings B^i_t for all $t \geq 0$ to maximize the expected discounted sum of future period utilities $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(c_{i,t})$ subject to the budget constraints[16]

$$\begin{aligned} &\mathbb{N}^i P_{i,t} c_{i,t} + \mathbb{N}_{i,t} P_{i,t} X_{i,t} + \mathbb{N}^i \left(\frac{B^i_t}{(1+i_t)S_{i,t}} - \frac{B^i_{t-1}}{S_{i,t}} \right) \\ &= \mathbb{N}^i W^h_{i,t} l_i + \mathbb{N}_{i,t-1} K_{i,t-1} \left(R^k_{i,t} u_{i,t} - P_{i,t} a(u_{i,t}) \right) + \mathbb{N}_{i,t} \left(\Pi_{i,t} - T_{i,t} \right), \end{aligned}$$

and the capital accumulation constraint

$$\mathbb{N}_{i,t} K_{i,t} = \mathbb{N}_{i,t-1} K_{i,t-1} (1-\delta) + \mathbb{N}_{i,t} X_{i,t}.$$

The resulting first-order conditions are standard. The Euler equations associated with the non-contingent bonds, B^i_t, require

$$1 = \beta(1+i_t)\mathbb{E}_t \left\{ \Psi_{i,t+1} \frac{s_{i,t}}{s_{i,t+1}} \right\},$$

where $s_{i,t} = P_{i,t} S_{i,t}$ is the real exchange rate and $\Psi_{i,t+1} = \frac{U'_{i,t+1}}{U'_{i,t}}$ is the household's stochastic discount factor. The utilization choice is described by $r^k_{i,t} = a'(u_{i,t})$, where $r^k_{i,t} = \frac{R^k_{i,t}}{P_{i,t}}$ is the real rental price of capital. We assume that $a(1) = 0$ and $a'(1) = r^k_i$, so that $u = 1$ in steady state. The curvature parameter $a''(1) > 0$ governs the cost of changing utilization. The first order condition for $K_{i,t}$ requires

$$1 = \beta \mathbb{E}_t \left\{ \Psi_{i,t+1} \left[u_{i,t+1} r^k_{i,t+1} + 1 - \delta - a(u_{i,t+1}) \right] \right\}.$$

[15]The exchange rate to convert country j's currency into country i's currency is given by $S^j_{i,t} = \frac{S_{j,t}}{S_{i,t}}$. If countries i and j are part of the same currency union, $S_{i,t} = S_{j,t}$ for all t.

[16]Because models with incomplete markets often have non-stationary equilibria, we impose a small quadratic penalty cost of holding claims on other countries. This cost implies that the equilibria is always stationary. For our purposes, we set the cost sufficiently low that its effect on the equilibrium is negligible. See Schmitt-Grohé and Uribe (2003) for a discussion of "closing" models in environments with incomplete markets. For clarity purposes, we abstract from these standard quadratic adjustment costs in the budget constraint.

4.2 Firms

There are two groups of firms in the model. First, there are firms that produce a non-tradable "final good" used for consumption, investment and government purchases. The final good producers take intermediate goods sourced from different countries as inputs. Second, there are intermediate goods firms that produce the inputs for the final good. These intermediate goods are produced in a two-stage process: Variety producers use capital and labor as inputs and then supply their goods to intermediate goods firms. We assume that the prices of the sub-intermediate variety goods are adjusted only infrequently according to the standard Calvo mechanism.

4.2.1 Tradable Intermediate Goods

Each country produces a single (country-specific) type of tradable intermediate good. We employ a two-stage production process to allow us to use a Calvo price setting mechanism. In the first stage, monopolistically competitive domestic firms produce differentiated "sub-intermediate" goods which are used as inputs into the assembly of the tradable intermediate good for country i. In the second stage, competitive intermediate goods firms produce the tradable intermediate good from a CES combination of the sub-intermediates. These firms then sell the intermediate good on international markets at the nominal price $p_{i,t}$. We describe the production of the intermediate goods in reverse, starting with the second stage.

Second-Stage Producers The second stage producers assemble in a competitive way the tradable intermediate good from the sub-intermediate varieties using a CES production function with an elasticity of substitution equal to ψ_q. Denoting the price of a sub-intermediate good ξ by $p_{i,t}(\xi)$, it is straightforward to show that the demand for each sub-intermediate good has an iso-elastic form

$$q_{i,t}(\xi) = Q_{i,t}\left(\frac{p_{i,t}(\xi)}{p_{i,t}}\right)^{-\psi_q}, \tag{4.4}$$

where $Q_{i,t}$ is the real quantity of country i's tradable intermediate good produced at time t, and $p_{i,t}$ is its price. This price is a combination of the prices of the sub-intermediates. In particular,

$$p_{i,t} = \left[\int_0^1 \left(p_{i,t}(\xi)\right)^{1-\psi_q} d\xi\right]^{\frac{1}{1-\psi_q}}. \tag{4.5}$$

First-Stage Producers The sub-intermediate goods $q_{i,t}(\xi)$ which are used to assemble the tradable intermediate good $Q_{i,t}$ are produced in the first stage. The first-stage producers hire workers, $L_{i,t}(\xi)$, through human resource agencies at the nominal wage $W^f_{i,t}$ and rent capital,

$K_{i,t}(\xi)$, at the nominal rental price $R^k_{i,t}$. Unlike the firms in the second stage, the first-stage, sub-intermediate goods firms are monopolistically competitive. They minimize costs taking the demand curve for their product (4.4) as given. These firms have a Cobb-Douglas production function

$$q_{i,t}(\xi) = Z_{i,t}\left(K_{i,t}(\xi)\right)^{\alpha}\left(L_{i,t}(\xi)\right)^{1-\alpha}.$$

First-stage producers charge a markup for their products. The desired price naturally depends on the demand curve (4.4). Each type of sub-intermediate good producer ξ freely chooses capital and labor each period but there is a chance that their nominal price $p_{i,t}(\xi)$ is fixed to some exogenous level. In this case, the first-stage producers choose an input mix to minimize costs taking the date-t price $p_{i,t}(\xi)$ as given. Cost minimization implies that all sub-intermediate firms choose the same capital-to-labor ratio,

$$\frac{K_{i,t}(\xi)}{L_{i,t}(\xi)} = \frac{\alpha}{1-\alpha}\frac{W^f_{i,t}}{R^k_{i,t}} = \frac{\mathbb{N}_{i,t-1}u_{i,t}K_{i,t-1}}{\mathbb{N}_{i,t}L_{i,t}},$$

whcih equals the ratio of the total amount of capital services, $\mathbb{N}_{i,t-1}u_{i,t}K_{i,t-1}$ to the total number of employed workers, $\mathbb{N}_{i,t}L_{i,t}$ in country i at time t. It follows that the nominal marginal cost of production is common across all the sub-intermediate goods firms

$$MC_{i,t} = \frac{\left(W^f_{i,t}\right)^{1-\alpha}\left(R^k_{i,t}\right)^{\alpha}}{Z_{i,t}}\left(\frac{1}{1-\alpha}\right)^{1-\alpha}\left(\frac{1}{\alpha}\right)^{\alpha}.$$

Pricing The nominal prices of the sub-intermediate goods are adjusted only infrequently according to the standard Calvo mechanism. In particular, for any firm, there is a probability θ^p that the firm cannot change its price that period. When a firm can reset its price it chooses an optimal reset price to maximize the discounted value of profits per "staying" household. Firms in country i act in the interest of the "staying" household, so they apply the household's stochastic discount factor to all future income streams. It is well known that the solution to this optimization problem requires

$$p^*_{i,t} = \frac{\psi_q}{\psi_q - 1}\frac{\sum_{j=0}^{\infty}\left(\theta^p\beta\right)^j\sum_{s^{t+j}}\pi(s^{t+j}|s^t)\frac{U^i_{1,i,t+j}}{P_{i,t+j}}\left(p_{i,t+j}\right)^{\psi_q}MC_{i,t+j}\mathbb{N}_{i,t+j}Q_{i,t+j}}{\sum_{j=0}^{\infty}\left(\theta^p\beta\right)^j\sum_{s^{t+j}}\pi(s^{t+j}|s^t)\frac{U^i_{1,t+j,i}}{P_{i,t+j}}\left(p_{i,t+j}\right)^{\psi_q}\mathbb{N}_{i,t+j}Q_{i,t+j}}.$$

Because the sub-intermediate goods firms adjust their prices infrequently, the nominal price of the tradable intermediate goods is sticky. In particular, using (4.5), the nominal price of the tradable intermediate good evolves according to

$$p_{i,t} = \left[\theta^p p_{i,t-1}^{1-\psi_q} + (1-\theta^p)\left(p_{i,t}^*\right)^{1-\psi_q}\right]^{\frac{1}{1-\psi_q}}. \tag{4.6}$$

4.2.2 Nontradable Final Goods

The final goods are assembled from a (country-specific) CES combination of tradable intermediates produced by the various countries in the model. The final goods firms are competitive in both the global input markets and the final goods market. The final goods producers solve

$$\max_{y_{i,t}^j}\left\{P_{i,t}Y_{i,t} - \sum_{j=1}^{\mathcal{N}} S_{i,t}^j p_{j,t} y_{i,t}^j\right\}$$

subject to the CES production function

$$Y_{i,t} = \left(\sum_{j=1}^{\mathcal{N}} \left(\omega_{i,t}^j\right)^{\frac{1}{\psi_y}} \left(y_{i,t}^j\right)^{\frac{\psi_y-1}{\psi_y}}\right)^{\frac{\psi_y}{\psi_y-1}} \tag{4.7}$$

Here, $y_{i,t}^j$ is the amount of country-j intermediate good used in production by country i at time t and ψ_y is the trade elasticity. The weights $\omega_{i,t}^j$ for each country pair fluctuate around a long-run average $\bar{\omega}_i^j$. We require $\sum_j \bar{\omega}_i^j = \sum_j \omega_{i,t}^j = 1$. We calibrate the average values $\bar{\omega}_i^j$ to match average bilateral trade shares (see below). Demand for country-specific intermediate goods is given by

$$y_{i,t}^j = Y_{i,t}\omega_{i,t}^j\left(S_{i,t}^j \frac{p_{j,t}}{P_{i,t}}\right)^{-\psi_y}$$

As we explain later, fluctuations in $\omega_{i,t}^j$ serve as the main forcing variables in our model.

4.3 Fiscal and Monetary Policy

The model includes both fiscal and monetary policy variables. On the fiscal side, a government's expenditure consists of government purchases, unemployment benefits and lump-sum taxes. The lump-sum taxes ensure that the government budget constraint is balanced every period.

Monetary policy is conducted through a Taylor Rule of the form

$$1 + i_{i,t} = \phi_i(1 + i_{i,t-1}) + (1-\phi_i)\left[\bar{\imath}_i + \left(\frac{Q_{i,t}}{\bar{Q}_i}\right)^{\phi_Q}(\pi_{i,t})^{\phi_\pi}\right] \tag{4.8}$$

where we assume the same reaction parameters ϕ_i, ϕ_Q and ϕ_π across all countries. In our setup, $Q_{i,t}$ corresponds to real GDP per capita and $\pi_{i,t}$ is the CPI-based inflation rate. Steady-state values are denoted by an upper bar. Countries in the euro area have a fixed nominal exchange rate for every country in the union and a common nominal interest rate. Monetary policy for these countries is set by the ECB, which follows the same Taylor rule as in (4.8), with the exception that it reacts to GDP-weighted averages of innovations in GDP and inflation for the countries in the union.

4.4 Labor Market

The labor market is governed by a search-and-matching mechanism. For a worker (either a migrant or a native) to be employed by a sub-intermediate good firm they first have to be hired by an employment agency. The employment agency hires unemployed workers at the real household wage $w^h_{i,t}$. The agency then uses the workers to search for vacancies. Vacancies are posted by human resource (HR) firms that pay a match wage $w_{i,t}$ for successful matches. The HR firms then supply matched labor services to the sub-intermediate good firms that pay the firm wage $w^f_{i,t}$. Below, we describe the labor market in greater detail, starting with the worker / employment agency side.

4.4.1 Value Functions

Workers: Workers can only find jobs through an employment agency.[17] Employment agencies hire workers and try to match them with firms. At the beginning of every period t, the agencies pay workers the real wage $w^h_{i,t}$ regardless of whether they can match them or not. If the employment agency cannot immediately match the worker, the agency pays $w^h_{i,t}$, but it retains the unemployment benefit $b_i \geq 0$. If the employment agency matches the worker, the agency collects the real match wage $w_{i,t}$ paid by the HR firm. This match wage varies over time and is paid as long as the match survives. This setup guarantees that all workers receive the same wage, $w^h_{i,t}$, and therefore operates as an insurance mechanism against unemployment. Note that all wages respond to aggregate conditions and can change from period to period.

We denote the match probability for a job hunter hired by an employment agency in

[17] This assumption is not strictly necessary for our model, but helps keeping the model tractable. It implies that unemployed and employed workers both receive the same wage from the employment agency. As a result, a migrant's employment status bears no effect on their migration decision. In Appendix B.2, we present some evidence that lagged unemployment rates of recent immigrants are a bit higher than the unemployment rate of the receiving country. This suggests that our assumption of an identical unemployment rate among migrants that stay and migrants that leave could be somewhat conservative regarding the impact of migration on unemployment rates. Alternatively, one could assume no risk sharing between unemployed and employed workers such that unemployed workers will be more likely to migrate.

country i at time t by $f_{i,t}$. This probability is endogenous and discussed later. With that probability, the employment agency receives the value from the match, denoted by $\mathcal{E}_{i,t}$, which is the wage received from the producing firm, $w_{i,t}$, less the wage paid to the worker, $w^h_{i,t}$, for the duration of the match. We assume a share $d_x \in (0,1)$ of workers loose their job every period. In addition, some migrants might voluntarily separate from their job and move to another country. As a result, the actual share of jobs that ends every period is time-varying and denoted by $d_{i,t+1}$. The value of having an employed worker is therefore[18]

$$\mathcal{E}_{i,t} = w_{i,t} - w^h_{i,t} + \beta \mathbb{E}_t \left\{ \Psi_{i,t+1}(1 - d_{i,t+1})\mathcal{E}_{i,t+1} \right\}. \tag{4.9}$$

With probability $1 - f_{i,t}$, the employment agency cannot match the job hunter. In that case, the employment agency receives only the unemployment benefit, b_i, net of the wage paid to the worker, $w^h_{i,t}$. The profit from hiring a job hunter is:

$$\mathcal{H}_{i,t} = f_{i,t}\mathcal{E}_{i,t} + (1 - f_{i,t})(b_i - w^h_{i,t}).$$

We assume free entry in the market of employment agencies, so the profit from hiring a job hunter, $\mathcal{H}_{i,t}$, must be zero in equilibrium. Combining this with (4.9) implies

$$w^h_{i,t} = f_{i,t} \left\{ w_{i,t} + \beta \mathbb{E}_t \left[\Psi_{i,t+1}(1 - d_{i,t+1})\mathcal{E}_{i,t+1} \right] \right\} + (1 - f_{i,t}) b_i. \tag{4.10}$$

The wage received by the worker, $w^h_{i,t}$, is a weighted average of the match wage plus the continuation value, and the unemployment benefits. The lower the match probability, $f_{i,t}$, the higher the weight on the unemployment benefits. Intuitively, an increase in the unemployment rate lowers this match probability $f_{i,t}$ and will therefore directly translate into a lower wage received by the worker.

Firms: At the beginning of every period, HR firms post vacancies $V_{i,t}$ to hire workers. There is no initial setup cost of posting a new vacancy, but every vacancy, no matter whether it is new or old, requires the firm to pay a per-period cost $\varsigma > 0$ in terms of the final good.

We denote the probability that a vacancy gets filled by $g_{i,t}$. If a vacancy gets filled, the HR firm immediately receives the value of a filled vacancy, denoted by $\mathcal{J}_{i,t}$. If not, the vacancy stays posted the next period. The value of a posted vacancy to a firm is then given by the

[18] We implicitly assume that employment agencies cannot distinguish between natives and migrants. This ensures that all workers receive the same wage. Alternatively, we could assume that wage discrimination is ruled out by law.

following value function:

$$\mathcal{V}_{i,t} = -\varsigma + g_{i,t}\mathcal{J}_{i,t} + (1 - g_{i,t})\,\beta\mathbb{E}_t\left\{\Psi_{i,t+1}\mathcal{V}_{i,t+1}\right\}.$$

The value to an HR firm of having a filled job is the difference between the wage received from the producing firm, $w^f_{i,t}$, and the wage paid to the employment agency, $w_{i,t}$. With probability $d_{i,t+1}$, the job gets destroyed and the HR firm has to post a new vacancy. The value of having a filled vacancy is therefore

$$\mathcal{J}_{i,t} = w^f_{i,t} - w_{i,t} + \beta\mathbb{E}_t\left\{\Psi_{i,t+1}\left[(1 - d_{i,t+1})\,\mathcal{J}_{i,t+1} + d_{i,t+1}\mathcal{V}_{i,t+1}\right]\right\}$$

We assume that HR firms have to incur a quadratic cost to adjust the number of posted vacancies, expressed in proportion to the per-period posting cost.[19] HR firms choose the number of posted vacancies to maximize the discounted stream of expected net profits

$$\max_{V_t}\mathbb{E}_t\sum_{s=0}^{\infty}\beta^{t+s}\left\{\Psi_{i,t+s}V_{t+s}\left(\mathcal{V}_{i,t+s} - \varsigma\Upsilon\left(\frac{V_{i,t+s}}{V_{i,t+s-1}}\right)\right)\right\},$$

with $\Upsilon(1) = \Upsilon'(1) = 0$ and $\Upsilon''(1) \geq 0$. Taking the first-order condition with respect to V_t gives

$$\frac{\mathcal{V}_{i,t}}{\varsigma} = \Upsilon_{i,t} + \frac{V_{i,t}}{V_{i,t-1}}\Upsilon'_t - \beta\mathbb{E}_t\left\{\Psi_{i,t+1}\left(\frac{V_{i,t+1}}{V_{i,t}}\right)^2\Upsilon'_{t+1}\right\}, \tag{4.11}$$

where $\Upsilon_{i,t} = \Upsilon\left(\frac{V_{i,t}}{V_{i,t-1}}\right)$.

4.4.2 Labor Flows and Matching

Every period, job hunters, $H_{i,t}$, are matched with vacancies, $V_{i,t}$. The number of unemployed at the end of the period is the labor force less the number of people employed. Recall that all variables in the model are in per capita terms so the number of job hunters in country i at time t is $\mathbb{N}_{i,t}H_{i,t}$ and the number of people unemployed is $\mathbb{N}_{i,t}\left[l_i - L_{i,t}\right]$. The total number of job hunters consists of three groups: (i) everyone who was unemployed at the end of the previous period, $\mathbb{N}_{i,t-1}\left[l_i - L_{i,t-1}\right]$, (ii) all the workers who were employed last period but either got laid off or voluntarily separated to migrate, $d_{i,t}\mathbb{N}_{i,t-1}L_{i,t-1}$ and (iii) new entrants

[19] As argued by Yashiv (2006), vacancy adjustment costs are one way to match the persistent response of the unemployment rate to aggregate shocks found in the data.

into the labor force pool, $l_i\left[\mathbb{N}_{i,t}-\mathbb{N}_{i,t-1}\right]$. thus,

$$\mathbb{N}_{i,t}H_{i,t}=\mathbb{N}_{i,t-1}\left[l_i-L_{i,t-1}\right]+d_{i,t}\mathbb{N}_{i,t-1}L_{i,t-1}+l_i\left[\mathbb{N}_{i,t}-\mathbb{N}_{i,t-1}\right].$$

Note that a reduction in the labor force caused by out-migration, i.e. $l_i\left[\mathbb{N}_{i,t}-\mathbb{N}_{i,t-1}\right]<0$, directly reduces the number of job hunters in country i. These workers enter their destination country as unemployed job hunters. In Appendix B.2, we present some evidence that unemployment rates among recent immigrants are indeed higher than for the average worker.

The actual number of jobs that end every period consists of workers that exogenously loose their job and migrants that voluntarily separate. The share of jobs that end every period is therefore:

$$d_{i,t}=d_x+(1-n^i_{i,t})\mathbb{M}_{i,t-1}l_i(1-ur_{i,t-1}-d_x)\frac{1}{\mathbb{N}_{i,t-1}L_{i,t-1}}.$$

The term $(1-n^i_{i,t})\mathbb{M}_{i,t-1}l_i$ is the number of migrants in the labor force that move out of country i at the beginning of t. Of these, a share $(1-ur_{i,t-1}-d_x)$ had a job (i.e. they were neither unemployed last period nor did they exogenously loose their job). Dividing the number of these "employed" outmigrants by the number of last period's employment gives the voluntary separation rate.

Job hunters $H_{i,t}$ and vacancies $V_{i,t}$ are matched according to a standard matching function. The number of matches per period is

$$M_{i,t}=\bar{m}_iH^{\zeta}_{i,t}V^{1-\zeta}_{i,t}$$

where $\bar{m}_i>0$ is a match efficiency parameter. The job finding rate, $f_{i,t}$, is defined as matches per job hunter

$$f_{i,t}\equiv\frac{M_{i,t}}{H_{i,t}}=\bar{m}_i\left(\frac{V_{i,t}}{H_{i,t}}\right)^{1-\zeta}=\bar{m}_i\lambda^{1-\zeta}_{i,t},$$

where $\lambda=\frac{V}{H}$ is the standard measure of labor market tightness. Similarly, the job filling rate is

$$g_{i,t}\equiv\frac{M_{i,t}}{V_{i,t}}=\bar{m}_i\lambda^{-\zeta}_{i,t}.$$

Firms produce output using labor from both the already employed and the newly matched job hunters. The law of motion for employment is therefore

$$\mathbb{N}_{i,t}L_{i,t}=(1-d_{i,t})\mathbb{N}_{i,t-1}L_{i,t-1}+\mathbb{N}_{i,t}M_{i,t}.$$

Since the number of people unemployed at the end of the period is $\mathbb{N}_{i,t}\left[l_i-L_{i,t}\right]$ and the total labor force is $\mathbb{N}_{i,t}l_i$, the unemployment rate is simply

$$ur_{i,t} = 1 - \frac{L_{i,t}}{l_i}. \tag{4.12}$$

4.4.3 Wage Rigidity

Following Shimer (2010), we introduce wage rigidity through backward-looking wage setting into the match wage $w_{i,t}$. Specifically, $w_{i,t}$, is a weighted average of the past match wage, $w_{i,t-1}$ and the current target match wage, denoted $w^*_{i,t}$:[20]

$$w_{i,t} = \theta^w w_{i,t-1} + (1-\theta^w)w^*_{i,t}. \tag{4.13}$$

The target wage, $w^*_{i,t}$, is determined through Nash bargaining. Given a match (indexed by ξ), the HR firm and the employment agency bargain over the target wage, say $w^*_{i,t}(\xi)$, taking the other variables in the economy as given. The target wage solves the Nash bargaining problem

$$w^*_{i,t}(\xi) = \arg\max_{w(\xi)} \left\{ \left(\mathcal{E}_{i,t}\left(w(\xi)\right) - (b_i - w^h_{i,t})\right)^{\varrho} \mathcal{J}_{i,t}\left(w(\xi)\right)^{1-\varrho} \right\}$$

where we write $\mathcal{E}_{i,t}\left(w(\xi)\right)$ and $\mathcal{J}_{i,t}\left(w(\xi)\right)$ to indicate that the value of this match (to both the HR firm and the employment agency) depends on the bargained wage. In what follows, we suppress the index ξ because in equilibrium, all matches result in the same wage. The worker's bargaining power is $\varrho \in (0,1)$. Differentiating the bargaining objective with respect to $w^*_{i,t}$ gives

$$\varrho\mathcal{J}(w^*_{i,t}) = (1-\varrho)\left(\mathcal{E}(w^*_{i,t}) - (b_i - w^h_{i,t})\right).$$

Note that the value to the employment agency of having an employed worker that receives a wage $w^*_{i,t}$ this period can be rewritten as $\mathcal{E}(w^*_{i,t}) = w^*_{i,t} - w_{i,t} + \mathcal{E}(w_{i,t})$, where $\mathcal{E}(w_{i,t})$ is the value of having an employed worker that receives the equilibrium wage $w_{i,t}$, as defined in (4.9). Similarly, $\mathcal{J}(w^*_{i,t}) = -w^*_{i,t} + w_{i,t} + \mathcal{J}(w_{i,t})$. Thus, the target wage satisfies

$$w^*_{i,t} = w_{i,t} + \varrho\mathcal{J}_{i,t} - (1-\varrho)\left(\mathcal{E}_{i,t} - (b_i - w^h_{i,t})\right)$$

where we are writing $\mathcal{E}(w_{i,t}) = \mathcal{E}_{i,t}$ and $\mathcal{J}(w_{i,t}) = \mathcal{J}_{i,t}$. Combining this expression with (4.13) gives

$$w_{i,t} = w_{i,t-1} + \frac{1-\theta^w}{\theta^w}\left[\varrho\mathcal{J}_{i,t} - (1-\varrho)\left(\mathcal{E}_{i,t} - (b_i - w^h_{i,t})\right)\right].$$

[20]See also Christoffel and Linzert (2005) for the same approach.

4.5 Forcing Variables

To generate migration and unemployment as seen in the data, the model requires shocks that imply relative differences in cross-country labor demand. Purely aggregate shocks to the region as a whole will not have differential effects on wages and employment opportunities across countries. The forcing variables we consider are shocks to the preferences weights ($\omega_{i,t}^{j}$) in equation (4.7).[21] Specifically, we assume that, for each country-pair, $\omega_{i,t}^{j}$ is given by

$$\omega_{i,t}^{j} = \frac{\bar{\omega}_{i}^{j} \exp\left(\varepsilon_{t}^{j}\right)}{\sum_{k} \omega_{i,t}^{k}},$$

where ε_{t}^{j} is a shock variable that follows an AR(1) process with persistence ρ. It is common to all countries that use goods from country j, including the country j itself. These shock variables cause fluctuations in demand for country j's tradable intermediate good that can be interpreted either as changes in production technology or changes in consumer preference. They formalize the idea of "terms-of-trade" shocks that Mundell (1961), McKinnon (1963) and Kenen (1969) considered in their early discussions of optimal currency areas.[22] Our formulation ensures that even though preference weights fluctuate, they always sum to 1 for every final good producer, i.e. $\sum_{j} \omega_{i,t}^{j} = 1$ for all t.

4.6 Aggregation and Market Clearing

For each country i, aggregate production of the tradable intermediate goods is given by

$$\mathbb{N}_{i,t} Q_{i,t} = Z_{i} \left(\mathbb{N}_{i,t-1} u_{i,t} K_{i,t-1}\right)^{\alpha} \left(\mathbb{N}_{i,t} L_{i,t}\right)^{1-\alpha}.$$

This is also equal to real aggregate GDP.[23] The market clearing condition for the tradable intermediate goods is

$$\mathbb{N}_{i,t} Q_{i,t} = \sum_{j=1}^{\mathcal{N}} \mathbb{N}_{j,t} y_{j,t}^{i}.$$

[21] See Itskhoki and Mukhin (2017) for a recent paper that uses similar shocks.

[22] Both Mundell (1961) and Kenen (1969) consider what they call a "productivity" shock. Their narrative emphasizes that this shock generates excess demand for the foreign product and excess supply of the domestically produced good and unemployment at home. Whether these follow from a productivity shock is debatable, but they are captured by a negative "terms-of-trade" shock in our model.

[23] This expression for aggregate production is accurate only to a first-order approximation. For additional discussion of this approximation see Galí (2008) and Woodford (2003).

Final goods production is given by (4.7). The market clearing condition for the final good is

$$\mathbb{N}_{i,t}Y_{i,t} = \mathbb{N}_{i,t}C_{i,t} + \mathbb{N}_{i,t}X_{i,t} + \mathbb{N}_{i,t}G_{i,t} + a(u_{i,t})\mathbb{N}_{i,t-1}K_{i,t-1} + \varsigma\mathbb{N}_{i,t}V_{i,t},$$

where

$$\mathbb{N}_{i,t}C_{i,t} = c_{i,t}\mathbb{N}^i + w^h_{i,t}l_i\mathbb{M}_{i,t}$$

is aggregate consumption in country i. The labor market clearing condition is given by (4.12). Finally, the bond market clearing condition requires

$$\sum_{i=1}^{\mathcal{N}} \mathbb{N}^i B^i_t = 0.$$

4.7 Steady State

We solve the model by log-linearizing the equilibrium conditions around a zero-inflation steady state in the absence of aggregate stochastic shocks.[24] We first solve for the real rental price of capital, r^k_i and the real price of the intermediate good, $\frac{p_i}{P_i}$. We adjust the technology levels Z_i so that the real price of the intermediate good, and hence real exchange rates, are unity in all countries. We then solve for the share of net exports in GDP, which depends on the trade preference weights, $\bar{\omega}^j_i$, and country size as measured by their domestic absorption, $\mathbb{N}_iY_i$. Given the shares of net exports and government purchases in GDP, we can derive the shares of investment and consumption in GDP.

We calibrate countries' population, $\mathbb{N}_i$, directly to the data. We impose that the share of mobile households in a country's total population, $\mathbb{M}_i/\mathbb{N}_i$, is identical across countries. We implicitly adjust the migration costs τ^i_j to match the observed bilateral migration rates n^i_j.

The real wage paid by firms, w^f_i, is proportional to GDP per employed worker, $w^f_i \propto \frac{Q_i}{L_i}$, where we directly back out employment, L_i, from data on labor force participation, l_i, and the unemployment rate, ur_i. From the optimality conditions of the labor market, we then derive the real wage received by the household, w^h_i, which pins down consumption of migrants $(w^h_i l_i)$. Consumption of natives is then solved for as the residual to match the share of consumption in GDP calculated before.

4.8 Calibration and Estimation

The model is expressed at a quarterly frequency and calibrated to a European sample of 29 countries as well as a rest-of-the-world aggregate for the period 1995 - 2015. Appendix A

[24] See the Technical Appendix for details on the calculation of the steady state.

contains all information on the exact data series used for the calibration.

We partition the models' parameters into two groups: for the first group of parameters, we choose values commonly adopted in the literature or we directly calibrate them to ratios observed in the data. Given these parameter values, we then estimate the remaining three parameters that are either new to our model or where we have little guidance from previous studies. Table 5 lists the parameter values used for our baseline calibration. We discuss the calibrated parameters below.

4.8.1 Calibrated Parameters

Preferences, Technology and Nominal Price Rigidity We assume a discount factor of $\beta = 0.99$, which implies a real annual interest rate of about 4 percent. We assume a log utility function $U(\cdot) = \log(\cdot)$ over consumption.

The elasticity of substitution between varieties is $\psi_q = 10$, implying a markup of roughly 11 percent, in line with studies by Basu and Fernald (1995) and Basu and Kimball (1997) among others. We calibrate the curvature of the production function, α, to match the average labor income share, defined as $\frac{w^f L}{Q} = (1-\alpha)\frac{\psi_q - 1}{\psi_q}$.[25] Karabarbounis and Neiman (2013) report a labor income share for Germany of about 0.63 between 1975 and 2010. This corresponds to $\alpha = 0.30$. We set the depreciation rate to 0.021 for both samples, which implies an annual depreciation rate of 8%. For the utilization cost function we follow Del Negro et al. (2013) by setting $a'' = 0.286$. This implies that a 1% increase in the real rental price causes an increase in the capital utilization rate of 3.5%.

We calibrate the Calvo parameter to roughly match observed frequencies of price adjustment in the micro data. Evidence on price adjustment in Europe suggests an average duration of prices of 13 months, which corresponds to $\theta_p = 0.77$ (Alvarez et al., 2006).

Trade and Country Size The trade elasticity ψ_y is set to 0.5. This is comparable to parameter values used in international business cycle models with trade. Using aggregate data Heathcote and Perri (2002) estimate an elasticity of $\psi_y = 0.90$ at quarterly frequency, whereas Backus, Kehoe and Kydland (1994) calibrate an elasticity of 1.5.[26] Firm-level estimates of short-run elasticities range from almost 0 in Boehm, Flaaen and Pandalai-Nayar (Forthcoming) to values closer to 1.5 in Cravino (2014) and Proebsting (2015). We consider a higher trade elasticity in the sensitivity analysis below.

[25] Our model features several distinct wages. For the purposes of our calibration, we count any income generated by HR firms and employment agencies as labor income, so the relevant labor income is $w^f L$.

[26] Their model is calibrated to the U.S. They cite several studies that find lower elasticities for Europe.

In steady state, our trade preference weights, ω_i^j, are equal to the share of imports in domestic absorption:

$$\omega_i^j = \frac{y_i^j}{\sum_j y_i^j}.$$

To calibrate ω_i^j, we therefore rely on bilateral trade data. In particular, we use data from the OECD on trade in value added (TiVA). The data has information on the value added content of final demand by source country for all country pairs in our European data sample, which allows us to calculate both ω_i^j and $\mathbb{N}_i Y_i$. We adjust the weights to ensure that net exports are zero in steady state. The steady-state calibration is based on an average over the years 2000-2005. For the average European country in our sample, the import share is about 40 percent.

Migration We implicitly adjust the migration costs, so that the migration rates n_j^i in the model match observed bilateral migration flows from our migration database. For most country pairs, at least one of the two countries reports figures for the migration flows between the two countries. For the remaining country pairs, we estimate the missing flows based on a gravity equation framework. Appendix Section A.3 provides more details on the estimation procedure. The average annual gross migration rate across all European countries in our model matches the rate of 0.73% reported in Table 1.

We set the share of mobile households to $\frac{\mathbb{M}_i}{\mathbb{N}_i} = 20\%$. While there is little guidance on this number in the data, it turns out that this share only plays a minor role in model. Conditional on matching the observed degree of labor mobility (i.e. the migration rates n_j^i and the response of net migration to unemployment differentials), this share mostly affects the dynamics of the model through our assumption that mobile households are hand-to-mouth consumers. A higher share of mobile households would therefore imply a stronger correlation between consumption and GDP. Our estimation procedure discussed in the next subsection makes sure that we match this correlation in the data. In Appendix C.1, we show that our results are robust to assuming shares of mobile households between 15% and 40%.

Labor Market As discussed in the empirical section, data on unemployment rates in Europe are provided by Eurostat. Country-specific steady-state unemployment rates are measured as the sample averages, ur_i and average to 8.5%. Similarly, we use sample averages to calibrate the labor supply l_i to observed ratios of labor force to population using data from Eurostat. The OECD publication "Benefits and Wages" reports official net replacement rates as a function of unemployment duration, previous income and a worker's famility situation. On average, the data suggest a replacement rate of about 0.59. That is, we set b_i to $0.59w_i$. We set the matching elasticity to 0.72. This value is the estimate reported by Shimer (2005), which he bases on U.S. data for 1951-2003 and is close to the estimates by Burda and Wyplosz (1994) for France, Germany and Spain. As is common in this literature, we set the household's bargaining power equal to the matching elasticity. For the job separation rate we follow Christoffel et al. (2009) who calibrate the quarterly separation rate in their search-and-matching DSGE model for the euro area to 6%. We set the vacancy cost to 0.004, which corresponds to the estimate by Shimer (2010) for the US and is only somewhat higher than the calibrated value for the euro area model in Christoffel et al. (2009). We impose a low wage rigidity parameter of 0.9 per quarter, in accordance with Shimer (2010), but also consider higher degrees of wage rigidity in the sensitivity analysis.[27]

Fiscal and Monetary Policy We set the steady-state ratio of government purchases to GDP to the observed value in each country across our sample period. Countries changed monetary policy over the sample period, especially during the 1990s and with the introduction of the euro in 1999. In our model, we do not account for these changes. Instead, we assign countries to the euro area according to their currency as of 2010.[28] Some countries followed a peg with the euro over (most of) the data period.[29] The remaining countries follow an independent monetary policy. All monetary authorities follow a Taylor rule with $\phi_i = 0.75$, $\phi_{GDP} = 0.50$ and $\phi_\pi = 1.50$, which is in line with estimates reported by Galí and Gertler (1999).

4.8.2 Estimation

Given these parameter values, we estimate the remaining three parameters. These parameters describe the variance of the idiosyncratic preference location shocks, $\frac{1}{\gamma}$, the persistence of the shock process, ρ, and the curvature of the vacancy adjustment cost function, Υ''.

Our estimation procedure is as follows: Given a set of parameter values, we simulate the model by choosing the realizations of ϵ_t^j that perfectly match the observed country-level unemployment rate differentials $\hat{u}_{j,t}$ in equation (3.1) for every country.[30] We then calculate

[27]Our formulation follows Shimer (2010) who studies a large range of values centered around $\theta_w = 0.86$ (or $\theta_w = 0.95$ at monthly frequency). Christoffel and Linzert (2005) study values in the range of 0.90 to 0.97. Hall (2005) argues that a completely rigid real wage norm vastly increases the sensitivity of the standard search and matching model to shocks and can therefore help solving the "Shimer puzzle" (Shimer, 2005).

[28]This includes Belgium, Germany, Ireland, Greece, Spain, France, Italy, Cyprus, Luxembourg, Netherlands, Austria, Portugal, Slovenia, Slovakia and Finland.

[29]Bulgaria, Denmark, Estonia, Latvia and Lithuania. The latter three joined the euro area in 2011, 2014 and 2015, respectively.

[30]Note that while our empirical analysis was based on annual data, we calibrate our model at a *quarterly*

the following three moments from the model-implied data series and compare them to their counterparts in the data: (i) the OLS slope coefficient from regressing the net migration rate on the unemployment rate (see equation (3.3)), (ii) the contemporaneous correlation between consumption and GDP and (iii) an autocorrelation of zero for the structural shocks ϵ_t^j. We choose the three parameter values to minimize the squared difference between the model-implied moments and the actual moments taken from the data.

We choose these three moments because they are particularly sensitive to our three parameters: As discussed, the value for γ governs the responsiveness of migration flows to changes in labor market conditions and therefore directly relates to the first moment. The correlation between consumption and GDP in an open economy strongly depends on the persistence of the shock process, which influences households' decision between consumption and saving. Finally, the vacancy adjustment cost makes unemployment rates respond more slugglishly and therefore affects its persistence. Since we choose the structural shocks to match the observed unemployment rates (and hence, we match the persistence of the unemployment rate by construction), the relevant moment is the autocorrelation of the recovered shocks, which—since these shocks are structural—must be zero.

Table 5 compares moments of the data with moments of the model. The second column of the table reports estimates for our baseline model specification as described in Table 5. The third column reports estimates for a high-trade-elasticity case and the fourth column reports estimates for a low-wage-rigidity case.

Our estimate of $\gamma = 0.12$ implies a variance of the idiosyncratic shock of $\frac{1}{\gamma} = 8.3$. To better interpret this estimate, we log-linearize the first-order condition for migration, (4.3):

$$\tilde{n}_{j,t}^i - \tilde{n}_{i,t}^i = \gamma \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \left(\widetilde{w}_{j,t+s}^h - \widetilde{w}_{i,t+s}^h \right) + \mathbb{E}_t \sum_{s=1}^{\infty} \beta^s \left[(1 - \tilde{n}_{j,t+s}^j) - (1 - \tilde{n}_{i,t+s}^i) \right) \tag{4.14}$$

The left-hand side is the log change in the number of migrants moving from country i to j less the log change in the number of migrants who stay in i. The first term on the right-hand side is the expected discounted sum of the wage differential between the two countries. Recall that the 'household' wage w^h reflects both changes in the wage rate $w_{i,t}$ and changes in the job finding rate (see equation (4.10)). The term $1 - \tilde{n}_{i,t}^i$ describes the migration rate out of country i and can be interpreted as the option value associated with being in country i at that time (see ACM for further discussion). To the extent that very temporary shocks leave the expected 'option value' differential across i and j unchanged, our estimate of $\gamma = 0.12$ suggests that a temporary 1% increase in the wage differential raises the number of migrants

frequency. We therefore recover the innovations ϵ_t^j to match the quarterly unemployment rate differentials.

by approximately 0.12%.

To interpret the estimate of Υ'', notice that the log-linearized first-order condition for vacancy creation by the HR firms, (4.11), is

$$\Delta \tilde{V}_t = \frac{1}{\Upsilon''} \sum_{s=0}^{\infty} \beta^s \mathbb{E}_t \left[\tilde{\mathcal{V}}_{t+s} \right]$$

where $\mathcal{V}_t$ is the value of having an open vacancy. The term, $[\Upsilon'']^{-1}$ is the elasticity of vacancy creation to the value of having an open vacancy. Our estimate of $\Upsilon'' = 1.61$, implies that a temporary 1% increase in the value of a vacancy causes a $1/1.61 = 0.62\%$ increase in the number of posted vacancies.

Finally, our estimate of the persistence of the shock process is $\rho = 0.963$ (quarterly). This estimate is close to the common calibration of productivity shocks in business cycle models.

The estimates in the baseline specification do not change dramatically in the High Trade Elasticity specification (column 3). If wages are assumed to be more rigid (column 4), the migration elasticity (γ) is estimated to be smaller, meaning that migrants are less sensitive to wage differentials, whereas our estimate of vacancy adjustment costs is somewhat larger.

Model and Data Comparison The bottom sections of Table 5 report measures of model fit for both the targeted moments and selected non-targeted moments in the data, the baseline model and for two alternative specifications (high trade elasticity and high wage rigidity).

Since we have three parameters to estimate and three moments to match, we obtain a perfect fit for the targeted moments. The model does relatively well with the untargeted moments. The model matches the (annual) persistence of GDP ($\widehat{Q}_{i,t}$), but generates insufficient overall volatility in GDP in the cross section. One reason for this could be that our model does not include TFP shocks, which would generate additional fluctuations in GDP beyond movements in factor inputs. This could also explain why the (negative) correlation between the unemployment rate and GDP is stronger in the model than in the data. The model slightly underpredicts the persistence of consumption, but matches the persistence of investment almost perfectly. The low trade elasticity helps raise the persistence of investment in the absence of investment adjustment costs. The degree of risk sharing, measured by the relative standard deviation of consumption to GDP, is somewhat stronger in the model relative to the data, as is often observed in standard international business cycle models.[31]

[31] Our finding that the standard deviation of consumption exceeds the standard deviation of GDP in the data is partly driven by our sample composition that includes several emerging economies in Central and Eastern Europe. The standard deviation of consumption relative to output is often greater than 1 in less advanced economies (see e.g. Neumeyer and Perri, 2005).

Lastly, we look at the persistence of net migration. The local projections in Figure 5 presented evidence that population movements are very sluggish in response to unemployment differentials. The slope coefficient of $t + 1$ net migration on unemployment differentials in t in the data is -0.074, only slightly smaller (in absolute terms) than the contemporaneous coefficient of -0.080. In the model, the one-year ahead coefficient is -0.071 and therefore close to the estimate of -0.074 in the data. The model is therefore consistent with the gradual response of population changes to aggregate shocks.[32]

5 Mundell's Tradeoff: Mobility vs. Flexible Exchange Rates

We next use our model to evaluate Mundell's conjecture: that adjustment in the allocation of labor across countries can substitute for flexible exchange rates. We compare our benchmark model to two counterfactuals. The first counterfactual considers the effect of increased labor mobility in Europe maintaining fixed exchange rates. The second simulation replaces the common currency in the euro area with country-specific monetary policy and floating exchange rates. In each experiment, we hold the sequences of country-specific shocks (recovered in the estimation procedure) fixed while we change the model parameters. The country-specific shocks are alter the demand for the local good that, in turn, affect the demand for labor. The resulting changes in labor demand generate dispersion in unemployment rates and income across the currency union. As Mundell conjectured, one way to mitigate this dispersion is the endogenous adjustment of labor supply through the movement of workers across countries. Alternatively, central banks could use monetary policy and exchange rate adjustments to stimulate export demand.

5.1 Aggregate Results

To quantify outcomes across the policy experiments, we consider several measures of economic dispersion across the euro area, shown in Table 6. The first rows of each panel are the cross-sectional standard deviations (averaged over 1995 - 2005) of the unemployment rate, aggregate

[32]The presence of idiosyncratic i.i.d. preference shocks combined with fixed moving costs are key for this persistence. Better labor market conditions abroad give workers an incentive to move abroad. But not all workers will move immediately because some might have drawn low preference shock for living abroad. It is therefore optimal for these workers not to move and to wait until they draw a higher preference shock. This gradual adjustment can also be seen from equation (4.14): The migration choice is inherently forward looking and reacts to future wage differentials.

GDP, per capita consumption, net migration, net exports and the nominal exchange rate.[33] The last two rows in each panel report the model-based slope coefficients from the regressions of the net migration rates on the unemployment differentials and the average gross migration rate for the European sample. Column (1) reports the empirical measures as observed in the actual data, column (2) is the estimated benchmark model, and columns (3) through (5) list results for different counterfactual scenarios.

Because we recover country-specific shocks that perfectly reproduce the paths of unemployment rates across countries, the standard deviation of unemployment differentials in the benchmark model is identical to the standard deviation in the data of 2.46 (see the first row of Table 6). Our estimation procedure also matches the OLS slope coefficient (-0.08) of the net migration regression for Europe and the observed gross migration rate (0.73).

The first counterfactual allows for adjustment to local demand shocks through the reallocation of labor (Column 3). For this simulation, we use the same sequence of shocks, but we set migration parameters to match U.S. migration patterns. Specifically, we raise the migration elasticity to match the U.S. slope coefficient from our regression of net migration on unemployment (-0.27 rather than -0.08, see Table 2), and we scale down the migration costs to match the higher gross flows observed in the United States (3.23 compared to 0.73 in the benchmark economy, see Table 1).[34] Notice that these changes leave aggregate variables in the steady state unchanged; our analysis focuses on how changes in policy affect fluctuations around the steady state.

Higher labor mobility (Column 3) reduces the cross-sectional standard deviation of unemployment rates from 2.46 to 1.95. Because labor now flows to countries where demand for the location-specific good is high and out of countries where demand is low, output dispersion across countries increases. By equalizing wages across countries, migration also reduces the dispersion in consumption per capita, which falls from 1.75 to 1.43. The standard deviation of net exports falls slightly, while the standard deviation of net migration increases by a factor of three.

Column (4) shows what would happen if labor were completely immobile in Europe. Had

[33] Lifetime utility of the representative household is another obvious benchmark. However, errors in calculating the first-order approximation are likely to be large – and the model is too complex to calculate second-order approximations – so we refrain from reporting utility calculations.

[34] A stronger responsiveness of migration flows to labor market conditions indicate a higher migration elasticity rather than lower migration costs, as shown in equation (4.14). In the language of Artuç, Chaudhuri and McLaren (2010), the higher γ for this counterfactual means that non-pecuniary benefits play a smaller role than in the benchmark economy. A high γ (or: a low variance of the idiosyncratic shocks) also implies smaller gross flows because it reduces the probability that a worker draws a sufficiently high preference shock that justifies migration. To match the gross flows in the U.S. sample, we therefore require a strong reduction in migration costs to offset the higher γ.

there been no migration in response to shocks, there would have been significantly more dispersion in unemployment and GDP relative to the benchmark. This simulation suggests that although migration rates in Europe are low compared to the United States, the current degree of labor mobility in Europe does provide a significant buffer to country-specific shocks.

We now consider a counter-factual experiment in which countries respond to shocks by allowing the exchange rate to adjust. Monetary policy in each country is governed by a standard Taylor rule as in (4.8). A comparison of columns (3) and (5) suggests that Mundell was correct: flexible exchange rates, like increased labor mobility, serve to mitigate the impact of country-specific shocks on unemployment. Increased migration reduces the standard deviation of unemployment differentials to 1.95, while net migration flows increased three-fold. The alternative policy of flexible exchange rates also reduces unemployment differentials, but less so (to 2.19) and this is achieved through substantial fluctuations in nominal exchange rates. The implied cross-sectional standard deviation of the nominal exchange rate is about 6 times the cross-sectional standard deviation of output. Empirically, this value roughly corresponds to the amount of exchange rate variability observed in the floating exchange rate countries in our sample. The dispersion in net exports is substantially higher in the flexible exchange rate counterfactual, reflecting the responsiveness of trade flows to changes in the terms of trade.

While labor mobility and flexible exchange rates both serve to reduce unemployment differentials, they do so through different mechanisms. Panels B and C illustrate the role of underlying parameters that determine the responsiveness of labor demand and labor supply. We first repeat the simulations when the trade elasticity (ψ_y) is increased from 0.5 to 1.5. When we change the trade elasticity, we re-estimate the parameters of the model and extract a new set of shocks. (The parameter estimates for the high trade elasticity case are listed in Table 5.) Comparing outcomes in Panel A (benchmark trade elasticity) with Panel B (higher trade elasticity) we see that the higher trade elasticity tilts the Mundellian tradeoff toward floating exchange rates. Migration is now less effective in reducing unemployment differentials, whereas floating exchange rates are more effective. Panel C repeats the experiment when wages are less flexible relative to the benchmark. Relative again to the baseline in Panel A, we see that migration is now more effective at reducing the dispersion in unemployment, while floating exchange rates have very little impact on the dispersion of unemployment.

The intuition for these results is as follows: Consider a negative shock in country i. Country i experiences downward pressure on real wages, employment and output. Migration limits the decline in wages as workers flow from country i to the rest of Europe. This also limits the decline in the price of goods produced in country i, which further exacerbates the initial drop in demand for its goods. As a result, although migration directly reduces unemployment by reducing labor supply in country i, it also exacerbates the fall in demand, thereby partially offsetting the effect on unemployment. This counterbalancing effect is strong if the trade elasticity is high and consumers are more responsive to relative price changes. But it is weaker if wages are sticky because sticky wages (and hence, prices) respond less to the fall in labor supply from outmigration. Conversely, exchange rate policy stimulates demand through relative price movements and is therefore more effective if the trade elasticity is high (and consumers are more sensitive to relative price movements) and wages and hence prices are more flexible. In sum, Mundell's tradeoff depends on the underlying parameters that determine the responsiveness of labor demand and labor supply. Because the two policies work through different margins, changes in these parameters generally make one policy more effective, but the other policy less effective. As we will see in the next section, this intuition will also go through when looking at individual countries' assessment of Mundell's tradeoff.

5.2 Country Results

The results in Table 6 are suggestive that labor market conditions and the responsiveness of export demand to changes in relative prices affect the tradeoff between increased labor mobility and flexible exchange rates as a mechanism of macroeconomic adjustment. Because our model is calibrated to bilateral trade and migration flows between countries, as well as country size, the model captures how countries will differ in their assessment of the labor mobility/flexible exchange rate tradeoff. To demonstrate this, we draw random shocks for country-specific demand and feed these shocks into the model under three scenarios: the baseline, higher migration and floating exchange rates. In each scenario, we calculate the standard deviation of the unemployment rate for each country.[35] Note that in the previous section, we examined the cross-sectional dispersion in unemployment rates across the euro area. Now we produce the time series for unemployment in each country, take its standard deviation and report an average standard deviation across all countries. We then compare the standard deviation of unemployment under the baseline to the standard deviation under the alternative policy. For example, a value of -0.25 means that the standard deviation of unemployment in that country falls by a quarter under the alternative policy compared to the baseline.

Figure 9 plots the decline in the standard deviation of unemployment due to increased migration (the x-axis) against the decline due to floating exchange rates (the y-axis) for each of the countries in the euro area (or fixed exchange rate). If the two scenarios are equally

[35] We calculate the average standard deviation across 100 simulations of 84 quarters to match the length of the 1995 - 2015 period.

effective in reducing the volatility of unemployment, the country's dot will appear on the 45 degree line. Dots above the 45 degree line mean that a shift toward greater labor mobility will be more effective in reducing unemployment; while dots below are an indication that floating exchange rates will have a greater impact on unemployment. We see that most countries fall above the 45 degree line, with Bulgaria, Lithuania and Slovakia the farthest from the line. In contrast, Greece and Portugal are the furthest below the 45 degree line, in the region where flexible exchange rates have the bigger effect on unemployment. Quantitatively, the differences are large: Flexible exchange rates would lower the volatility of unemployment in Greece by 20%, but by only 5% in Bulgaria. Increased labor mobility reduces unemployment volatility by 11% (Cyprus, Austria) to 22% (Italy). Notice that these differences are purely driven by structural differences across countries because the underlying shocks are random.

To understand why countries make different assessments of the Mundell tradeoff, we run the following regression for the sample of fixed exchange rate countries:

$$100 * \frac{std(ur_i)^{counterf}}{std(ur_i)^{bench}} = \beta_0 + \beta_1 tr_i + \beta_2 \mathbb{N}_i Y_i + \beta_3 ur_i + \beta_4 gm_i + \epsilon_i, \tag{5.1}$$

where $\frac{std(ur_i)^{counterf}}{std(ur_i)^{bench}}$ is the ratio of the standard deviation of unemployment under either counterfactual scenario (higher labor mobility or floating exchange rate) relative to the benchmark value for country i, tr_i is the steady-state share of trade (measured as the average of exports and imports) in GDP, $\mathbb{N}_i Y_i$ is country i's size measured as steady-state GDP and gm_i is the steady-state gross migration rate. To aid interpreting the coefficients, all regressors are standardized subtracting their cross-sectional mean and then dividing by their cross-sectional standard deviation. As a result, the coefficient β_1 can be interpreted as the effect of moving from a country with the sample's mean trade share to a country with a trade share that is 1 standard deviation higher. The standardization makes it easier to compare coefficients and pin down the relevant differences across countries.

The first row displays the estimated coefficient of the intercept ($\hat{\beta}_0$): For an "average" country in our sample, higher labor mobility reduces the standard deviation of unemployment by about 14.8%. Floating exchange rates would yield a reduction of 11.5%. To put these numbers in context, consider that the average unemployment rate among fixed exchange rate countries in our sample is about 9.4% with a standard deviation of 2.8%. This implies that unemployment fluctuates around 6.6% – 12.2% on average. Moving to higher labor mobility would reduce this range to 7% – 11.8%.

The remaining coefficients in the table indicate how this range changes as we move away from the average country. We see that labor mobility is more stabilizing in (i) more open economies, (ii) larger economies, (iii) economies with higher labor market frictions (and therefore more unemployment) and (iv) economies with higher migration rates.[36] The coefficients are economically significant. For instance, moving to higher labor mobility reduces the typical range of unemployment fluctuations to 7.1% – 11.7% for a country that is one standard deviation larger than the average, but only to 6.9% – 11.9% for a country that is one standard deviation smaller than the average. Countries' characteristics have opposite effects on the effectiveness of floating exchange rates, similar to our findings from Table 6 that varying trade elasticity and wage stickiness shape the effectiveness of the two policies in opposite ways.

Labor mobility is more stabilizing in open economies: Workers leaving a depressed economy take their purchasing power with them and thereby counterbalance their positive effect on the labor market. In an open economy, this counterbalancing effect is smaller because demand for a country's products is mostly determined at the union's level. This insight goes back to Farhi and Werning (2014). Our results confirm this finding, but highlight that trade openness itself explains only a fraction in the dispersion across countries observed in Figure 9. A country's size plays a more important role in our benchmark case: While workers leaving a depressed country take their purchasing power with them, this effect is counterbalanced by relative price (terms of trade) movements in favor of the depressed country. These relative price movements are larger the bigger the country. This mechanism is somewhat reminiscent of the risk insurance mechanism of relative price movements discussed in Cole and Obstfeld (1991). As we move to an economy with a higher trade elasticity (column 3), relative price movements and hence an economy's size play a less prominent role. Notice also that trade openness is the most important factor in explaining why some countries benefit more from floating exchange rates than others: Monetary policy is less effective in open economies because it stimulates demand by domestic consumers that, in an open economy, falls to a larger extent on foreign goods. Finally, the results indicate that economies with higher labor market frictions would benefit more from higher labor mobility because job turnover rates and job finding rates are so low that the unemployed find it easier to find a job through migration.

6 Conclusion

Euro area countries experienced large differences in unemployment over the last ten years, raising concerns about whether sharing a common monetary policy is sustainable without further reforms. In this paper, we return to Mundell's claim that cross-country labor mobility

[36] Other steady-state differences across countries that we capture in our model, such as GDP per capita, the labor force participation rate, the share of government purchases in GDP play no statistically significant role. In addition, the model also captures differences in bilateral variables, such as trade and migration flows.

can substitute for independent monetary policy. To evaluate his claim, we first empirically examine whether labor mobility is indeed low in Europe, using the U.S. as a benchmark. The data paint a clear picture: Migration flows react to cyclical variations in unemployment rates in Europe and across U.S. states, but this reaction is faster and about three times larger in the United States.

Motivated by these facts we then quantify the role of labor mobility in Europe in a multi-country New Keynesian dynamic general equilibrium model, augmented to include cross-country migration and a search- and matching-framework in the labor market that gives rise to unemployment. The model is calibrated to match the main features of the European countries in our dataset including country size, trade flows and exchange rate regimes. As a driving force the model features shocks to the demand for each country's export goods. We choose the realizations of these shocks so that the model generates unemployment series that match observed unemployment rates. Our model replicates the low degree of labor mobility in Europe and broadly matches the dynamic behavior of macro variables observed in the data.

We then use the model to simulate outcomes in Europe with higher labor mobility or with flexible exchange rates. In line with Mundell's conjecture, greater labor migration and exchange rate adjustment both reduce the cross-sectional dispersion in unemployment and per capita consumption. However, the two counterfactual scenarios differ along other dimensions. The movement of labor results in higher aggregate output in locations with high demand and further reduces output in locations with low demand, resulting in widening output disparities across Europe. In contrast, exchange rate flexibility works to offset fluctuations in demand and thereby reduces aggregate output differentials at the expense of greater dispersion in net exports.

Differences in trade openness, country size and labor market frictions across the euro area may help explain the range of views across Europe about the costs of macroeconomic adjustment under a shared currency: Closed economies like Greece and Portugal would benefit more from a floating exchange rate than open economies like Bulgaria or Lithuania. Large countries with high labor market frictions, such as Italy and Spain benefit more from higher mobility than small countries with low labor market frictions.

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Table 1: MIGRATION STATISTICS

	Unit	US	CAN	Europe	Euro
Regions	#	48	10	29	12
Population	m	5.57	2.94	17.30	26.28
Migration rate	%	3.23	1.96	0.73	0.64
Internal migration	%	3.11	1.53	0.46	0.34
Net migr rate (std dev)	%	0.48	0.48	0.32	0.30

Notes: Table displays the number of regions (States / Provinces / Countries) for the US, Canada and Europe, their average population (in millions), their average migration rate, the average internal migration rate, and the average standard deviation across time of the net-migration rate. Migration is the average of inmigration and outmigration. Values are simple averages across regions and time ('77-'15 for North America, '95-'15 for Europe).

Table 2: UNEMPLOYMENT RATES AND NET MIGRATION

	US	CAN	Europe	Euro
β	-0.272	-0.231	-0.080	-0.090
	(0.029)	(0.019)	(0.009)	(0.009)
R^2	0.26	0.26	0.28	0.51
No. Obs.	1,872	390	460	224

Notes: Table displays the regression coefficient of the regression (3.3). Time period: '77-'15 for US and Canada, '95-'15 for Europe. Driscoll and Kraay (1998) standard errors in parentheses.

Table 3: Calibration

Parameter		Value	Target / Source
Preferences, Technology & Nominal Rigidities			
Discount factor	β	0.99	4% real interest rate
Curvate of production function	α	0.30	Labor income share of 0.63 for Germany (Karabarbounis and Neiman (2013))
Depreciation rate	δ	0.021	Annual depreciation rate of 8 percent
Utilization cost	a''	0.286	Del Negro et al. (2013)
Elasticity of substitution bw. varieties	ψ_q	10	e.g. Basu and Fernald (1995), Basu and Kimball (1997)
Sticky price probability	θ_p	0.77	Price duration: 13 months (Alvarez et al., 2006)
Trade and Country Size			
Trade demand elasticity	ψ_y	0.5	e.g. Heathcote and Perri (2002), Boehm, Flaaen and Pandalai-Nayar (Forthcoming)
Trade preference weights	ω_i^j	x	Share of imports from j; OECD TiVA (2000, 2005)
Country's absorption	$\mathbb{N}_n Y_n$	x	Nominal GDP; Europe: Eurostat (2005)
Migration			
Population	$\mathbb{N}_i$	x	Europe: Eurostat ('95-'15)
Migration costs	τ_j^i	x	Bilateral gross migration flows (see text for details)
Share of mobile households	$\frac{\mathbb{M}_i}{\mathbb{N}_i}$	0.2	See Robustness in Appendix C.1
Labor Markets			
Unemployment rate	ur	x	Eurostat ('95-'15)
Labor force	l	x	Eurostat ('95-'15)
Separation rate	d	0.06	Christoffel et al. (2009)
Matching elasticity to tightness	ζ	0.72	Burda and Wyplosz (1994)
Bargaining power of workers	ϱ	0.72	Same as matching elasticity
Unemployment benefits	b/w	0.59	Net replacement rate, OECD "Benefits and Wages" database
Vacancy cost	$\frac{\varsigma V_i}{Y_i}$	0.004	Shimer (2010)
Real wage rigidity	θ_w	0.90	Shimer (2010)
Fiscal and Monetary Policy			
Gov't purchases over final demand	$\frac{G_i}{Y_i}$	x	Eurostat ('95-'15)
Taylor rule persistence	ϕ_i	0.75	Clarida, Gali and Gertler (2000)
Taylor rule GDP coefficient	ϕ_Q	0.50	Clarida, Gali and Gertler (2000)
Taylor rule inflation coefficient	ϕ_π	1.50	Clarida, Gali and Gertler (2000)

Notes: Values marked with x are country- or country-pair specific. TiVA: Trade in Value Added Database.

Table 4: STEADY-STATE

Country	GDP	Import share	Popu-lation	Expat share	Unem-ployment	Country	GDP	Import share	Popu-lation	Expat share	Unem-ployment
Austria	4.9%	37.3%	1.6%	6.7%	4.8%	Latvia	0.7%	33.1%	0.5%	12.6%	12.8%
Belgium	4.5%	39.1%	2.1%	4.4%	8.2%	Lithuania	1.3%	59.0%	0.6%	11.8%	11.2%
Bulgaria	0.5%	63.0%	1.6%	10.0%	11.6%	Malta	3.2%	65.9%	0.1%	22.1%	6.5%
Cyprus	4.3%	65.8%	0.1%	21.1%	6.7%	Netherlands	5.0%	36.3%	3.2%	5.3%	5.4%
Czech Republic	1.2%	42.1%	2.1%	5.1%	6.6%	Norway	7.4%	44.2%	0.9%	3.8%	3.6%
Denmark	6.0%	35.8%	1.1%	4.3%	5.6%	Poland	0.9%	23.9%	7.6%	6.8%	12.7%
Estonia	1.0%	48.9%	0.2%	11.7%	9.9%	Portugal	2.3%	23.9%	2.1%	16.9%	9.4%
Finland	4.8%	37.4%	1.1%	5.4%	9.4%	Romania	0.6%	57.1%	4.3%	8.4%	7.0%
France	4.4%	24.9%	12.5%	2.9%	9.3%	Slovak Republic	0.8%	44.7%	1.1%	4.5%	14.3%
Germany	4.8%	26.8%	16.3%	4.7%	7.9%	Slovenia	2.2%	42.1%	0.4%	6.0%	7.1%
Greece	2.4%	21.9%	2.2%	8.8%	13.5%	Spain	2.8%	25.9%	8.5%	3.1%	16.2%
Hungary	0.9%	43.4%	2.0%	4.6%	8.2%	Sweden	5.7%	37.9%	1.8%	3.2%	7.5%
Iceland	5.6%	33.4%	0.1%	9.4%	4.0%	Switzerland	7.6%	39.8%	1.5%	7.6%	3.6%
Ireland	5.0%	55.9%	0.8%	18.8%	8.5%	United Kingdom	5.1%	24.6%	12.1%	7.0%	6.3%
Italy	3.9%	25.7%	11.6%	5.2%	9.5%	RoW	319.1%	4.7%	1176.3%	0.4%	6.0%
Average	–	40.0%	–	8.3%	8.5%						

Notes: Table displays the 29 countries plus the Rest of the World in our sample. GDP and population are measured relative to the European aggregate. The import share is measured as the share of (value added) imports in final demand using the OECD TiVA database. The expat share is the share of nationals living abroad. The average import share and migration share are calculated based on the 29 European countries.

Table 5: Estimation

		(1) Data	(2) Base-line	(3) High trade elasticity	(3) High wage rigidity
Calibrated Parameters					
Trade elasticity	ψ_y		0.500	1.500	0.500
Wage rigidity	θ_w		0.900	0.900	0.950
Estimated Parameters					
Migration elasticity	γ		0.117	0.113	0.126
Vacancy adjustment cost	Υ''		1.612	1.595	1.476
Shock persistence	ρ		0.963	0.980	0.962
Targeted Moments					
Slope coefficient $\widehat{nm}_{i,t}$ on $\widehat{ur}_{i,t}$		−0.080	−0.080	−0.080	−0.080
Persistence ϵ_t^j		0.000	0.000	0.000	0.000
Correlation $\widehat{C}_{i,t}$ and $\widehat{Q}_{i,t}$		0.735	0.735	0.735	0.735
Free Moments					
Std. dev. $\widehat{Q}_{i,t}$		3.540	1.663	1.771	1.625
Std. dev. $\widehat{C}_{i,t}$ rel. to std. dev. $\widehat{Q}_{i,t}$		1.365	0.796	0.743	0.757
Persistence $\widehat{Q}_{i,t}$		0.712	0.688	0.704	0.688
Persistence $\widehat{C}_{i,t}$		0.750	0.682	0.677	0.673
Persistence $\widehat{X}_{i,t}$		0.671	0.646	0.637	0.649
Correlation $\widehat{\frac{nx_{i,t}}{Q_{i,t}}}$ and $\widehat{Q}_{i,t}$		−0.303	0.287	0.020	0.359
Correlation $\widehat{ur}_{i,t}$ and $\widehat{Q}_{i,t}$		−0.587	−0.845	−0.851	−0.845
Slope coefficient $\widehat{nm}_{i,t+1}$ on $\widehat{ur}_{i,t}$		−0.074	−0.071	−0.070	−0.070

Notes: Target refers to data moments for the European sample. $nm_{i,t}$ refers to net migration as percent of population, ur denotes the unemployment rate, $\frac{nx}{Q}$ is net exports over GDP, ϵ refers to the exogenous shocks, X is per capita real investment, C is per capita real consumption and Q is per capita real GDP.

Table 6: COUNTERFACTUAL EXPERIMENTS

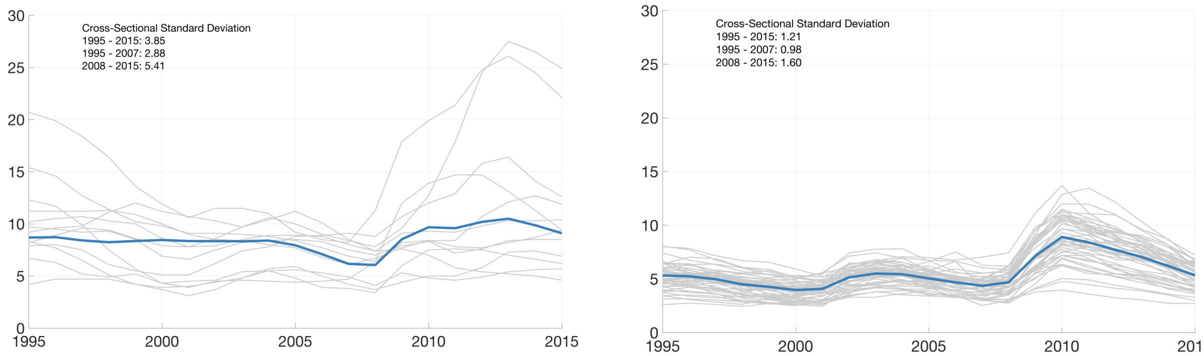
	(1) Data	(2) Estimated Model	(3) High labor mobility	(4) No labor mobility	(5) Flexible exch rate
Panel A: Benchmark					
Cross-Sectional Standard Deviation Across Euro Area					
Unemployment rate	2.46	2.46	1.95	3.44	2.19
GDP	4.32	2.05	2.66	2.39	1.82
Consumption per capita	4.21	1.75	1.43	4.05	1.66
Net migration	0.37	0.23	0.63	0.00	0.23
Net exports	3.60	1.74	1.63	2.39	1.91
Exchange rate	0.00	0.00	0.00	0.00	11.55
Slope coefficient $\widehat{nm}_{i,t}$ on $\widehat{ur}_{i,t}$	−0.08	−0.08	−0.27	−0.00	−0.09
Average gross migration rate	0.73	0.73	3.23	0.00	0.73
Panel B: High Trade Elasticity					
Cross-Sectional Standard Deviation Across Euro Area					
Unemployment rate	2.46	2.46	2.13	2.61	2.12
GDP	4.32	2.16	3.01	1.94	1.88
Consumption per capita	4.21	1.71	1.64	2.18	1.57
Net migration	0.37	0.23	0.68	0.00	0.22
Net exports	3.60	1.47	1.41	1.55	1.49
Exchange rate	0.00	0.00	0.00	0.00	13.79
Slope coefficient $\widehat{nm}_{i,t}$ on $\widehat{ur}_{i,t}$	−0.08	−0.08	−0.27	−0.00	−0.09
Average gross migration rate	0.73	0.73	3.23	0.00	0.73
Panel C: High Wage Rigidity					
Cross-Sectional Standard Deviation Across Euro Area					
Unemployment rate	2.46	2.46	1.92	3.47	2.23
GDP	4.32	2.02	2.61	2.34	1.82
Consumption per capita	4.21	1.62	1.31	3.82	1.56
Net migration	0.37	0.23	0.63	0.00	0.23
Net exports	3.60	1.69	1.58	2.14	1.85
Exchange rate	0.00	0.00	0.00	0.00	11.06
Slope coefficient $\widehat{nm}_{i,t}$ on $\widehat{ur}_{i,t}$	−0.08	−0.08	−0.27	−0.00	−0.09
Average gross migration rate	0.73	0.73	3.23	0.00	0.73

Notes: Table displays several statistics as observed in the data (1995 - 2015) and various model settings. Statistics are calculated for the euro area. For the High Labor Mobility case (column (3)) we adjust the migration parameters (γ and Φ'') to match the slope coefficients for the United States. For the Flexible Exchange Rate case (column (5)), countries follow a Taylor rule with $\phi_i = 0.75$, $\phi_\pi = 1.5$ and $\phi_Q = 0.5$.

Table 7: DETERMINANTS OF STABILIZING EFFECTS AT THE COUNTRY LEVEL

	High labor mobility		Floating exchange rate	
	Benchmark model	High trade elasticity	Benchmark Model	High trade elasticity
Intercept	−14.78	−9.46	-11.58	−13.67
Trade share	−1.27	−2.13	5.44	5.27
Size (GDP)	−2.20	−0.27	1.39	0.93
Unemployment rate	−1.88	−2.11	0.34	0.21
Migration rate	1.42	0.82	-1.07	−1.04

Notes: Table presents estimated coefficients from the cross-country regression in (5.1) for both the benchmark economy and the economy with a high trade elasticity. The explained variable is the time-series standard deviation of the unemployment rate in the counterfactual (high labor mobility or floating exchange rate) relative to the benchmark economy. Country sample includes all countries in the euro area area or with a fixed exchange rate. Explanatory variables are standardized, so that the coefficients indicate by how much the standard deviation of unemployment moves in the counterfactual policy experiment (in % of the standard deviation in the benchmark case) for an increase in the variable of interest by one standard deviation.



(a) Euro area

(b) U.S.

Figure 1: Unemployment Rates in Euro Area Countries and US States

Notes: Figure displays unemployment rates for core euro area countries and the US states (grey, thin lines), as well as their respective averages (blue, thick lines).

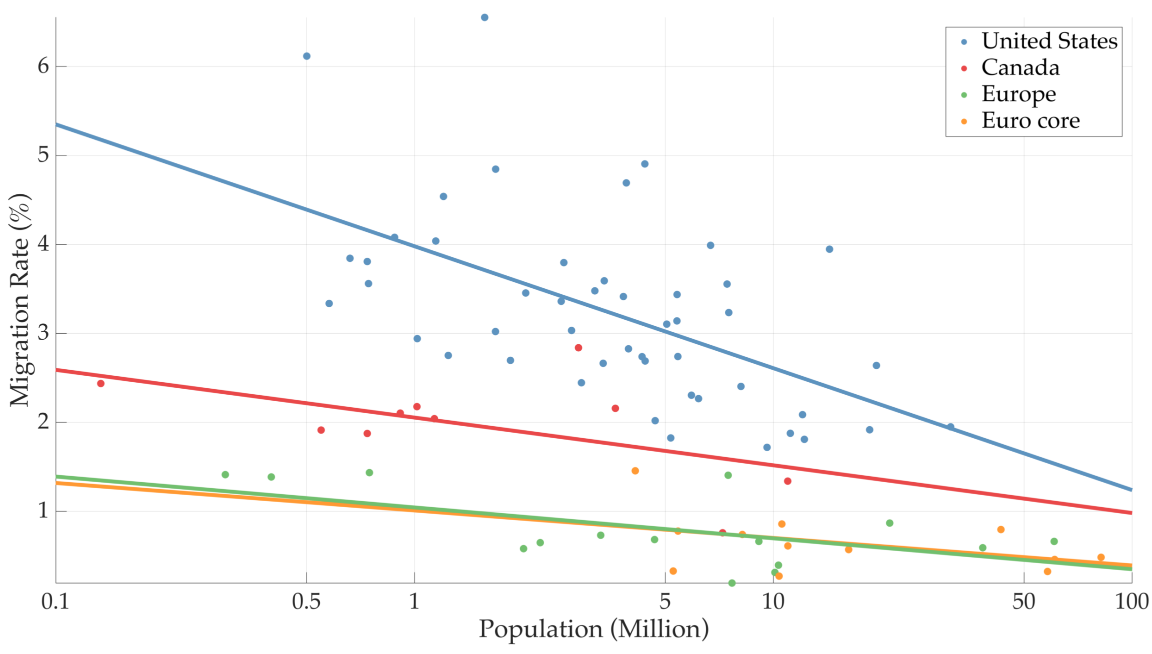


Figure 2: Migration Rates vs. Population

Note: The figure plots the migration-to-population ratio against population for US States, Canadian Provinces, European and core euro area countries. Migration is measured as the average of immigration and emigration. Values are averages over 1995 - 2015. The 'core euro area' sample is a subset of the 'Europe' sample.

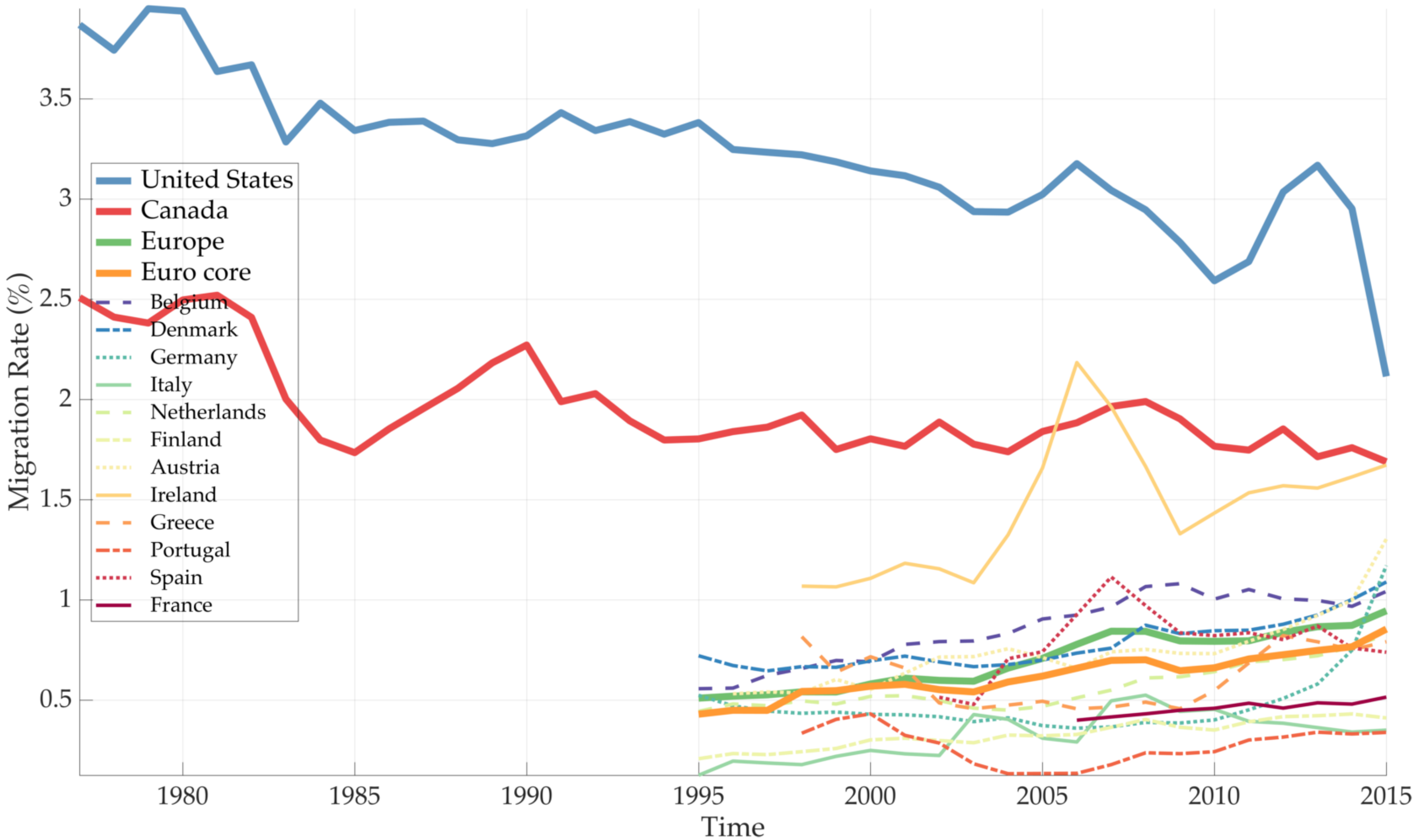


Figure 3: Migration Rates over Time

Note: The figure plots the migration-to-population ratio over time for the average of US States, the average of Canadian Provinces, the average of European countries, the average of core euro area countries and individual core euro area countries. The averages for the two European samples are averages over all countries with available data in any given year.

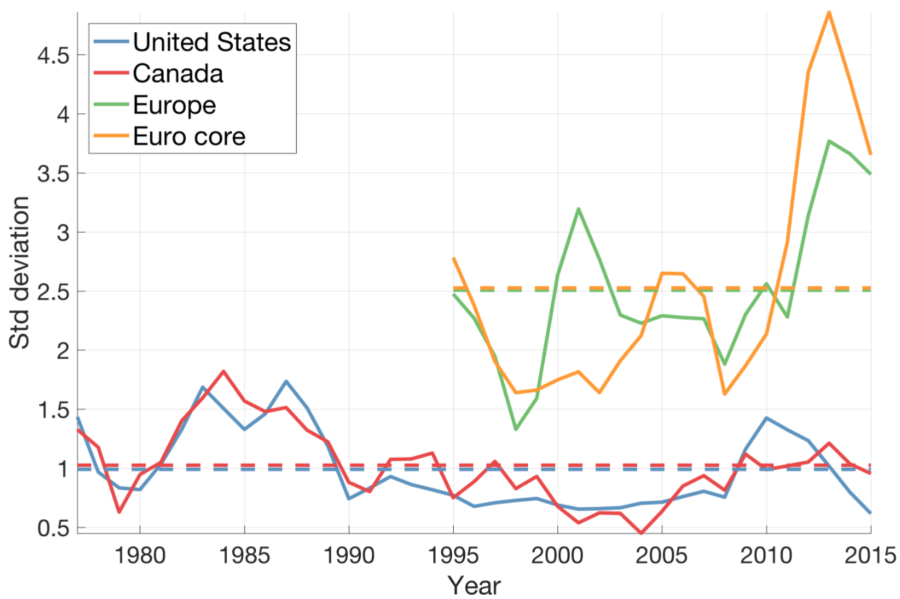
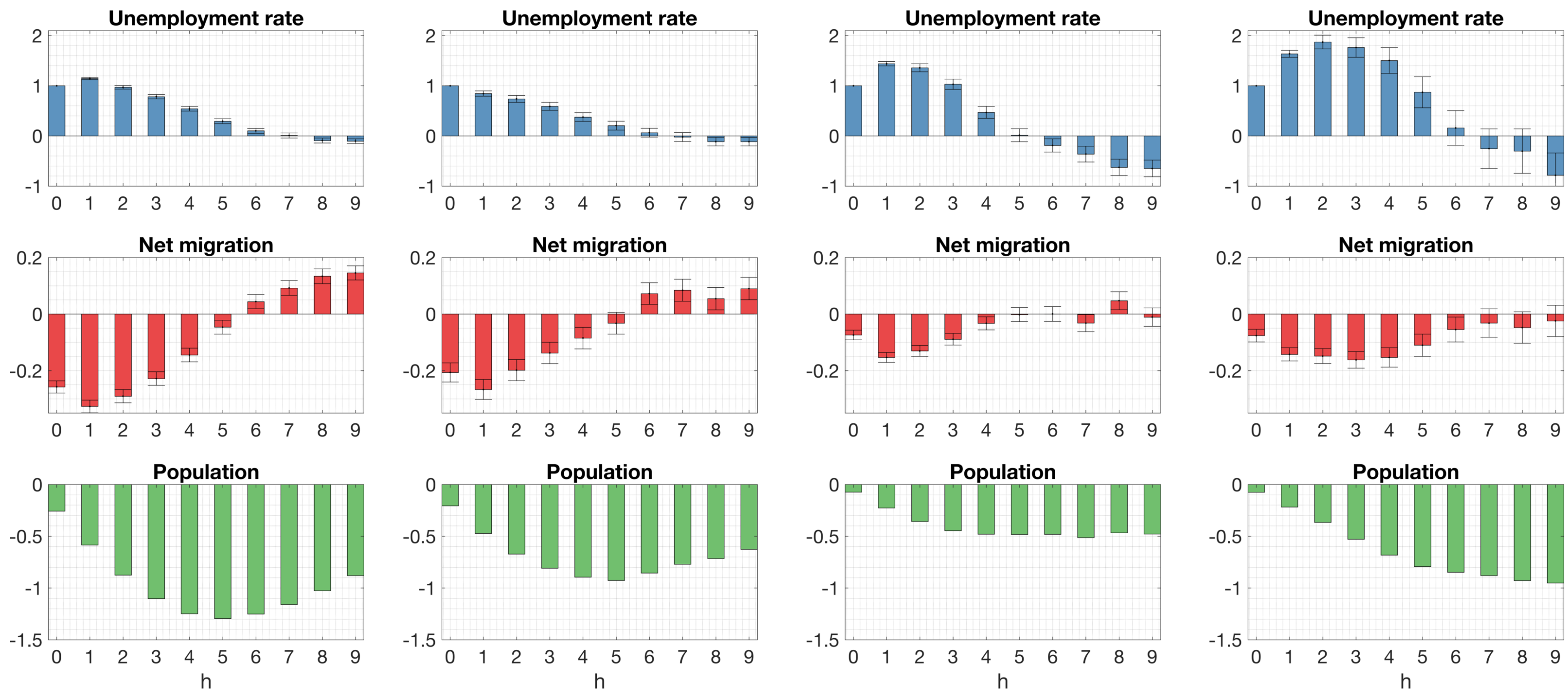


Figure 4: Cross-Sectional Standard Deviations in Unemployment Rates

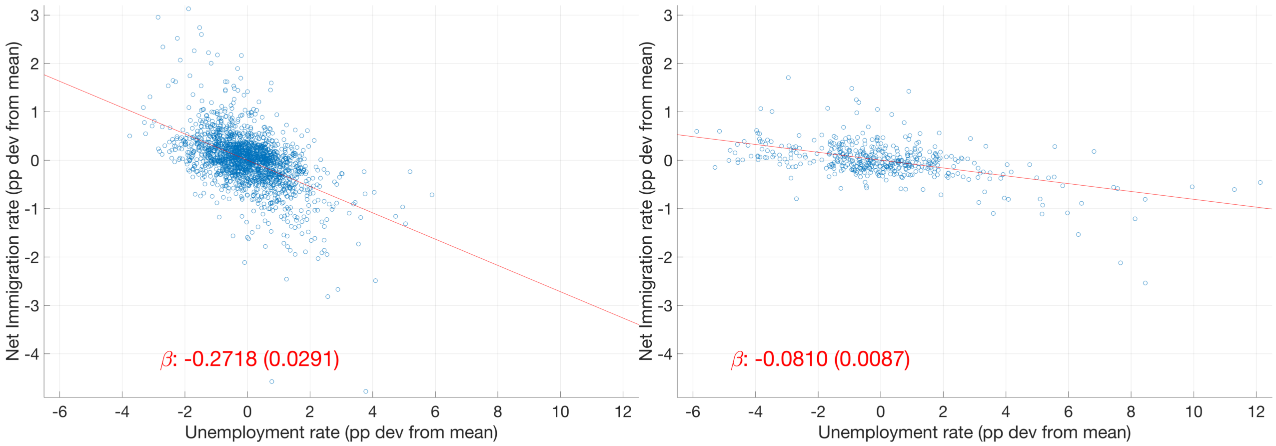
Note: The figure plots cross-sectional standard deviation in demeaned unemployment rates, $\widehat{ur}_{i,t}$, for four regions: US states, Canadian provinces, European countries and core euro countries. The dotted lines are the respective time averages. See the text for the definition of demeaned unemployment rates.



(a) U.S. (b) Canada (c) Europe (d) Euro core

Figure 5: LOCAL PROJECTIONS

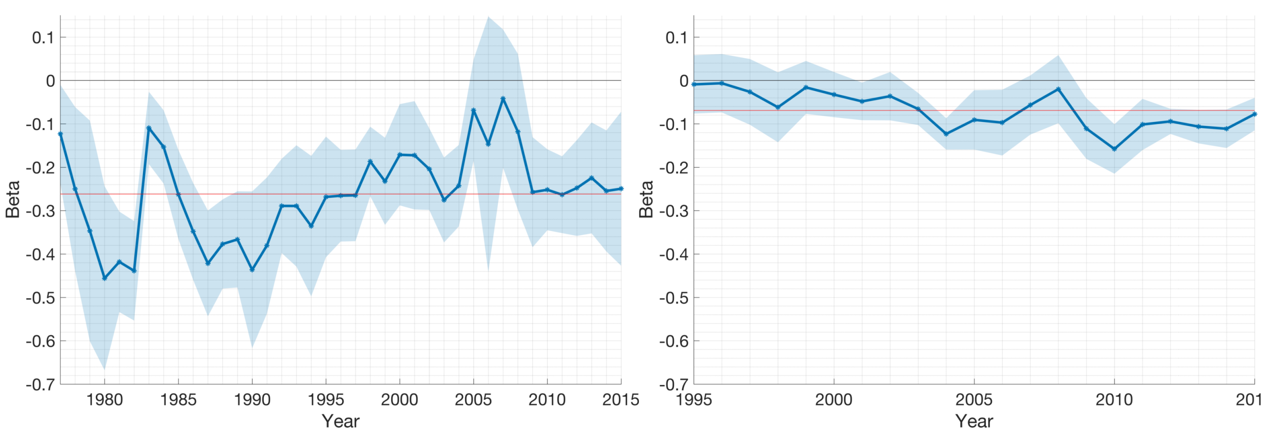
Notes: Figure displays the estimated coefficients (and standard errors) from local projection regressions (see equation (3.2)) for the U.S. (panel (a)), Canada (panel (b)), Europe (panel (c)) and the Euro core (panel (d)). The first set displays the coefficients from regressing the demeaned unemployment rate at time $t+h$, $\widehat{ur}_{i,t+h}$, on the demeaned unemployment rate at time t, $\widehat{ur}_{i,t}$ controling for two lags $\widehat{ur}_{i,t-1}$ and $\widehat{ur}_{i,t-2}$. The second set regresses the demeaned net migration rate at at time $t+h$, $\widehat{nm}_{i,t+h}$, on the demeaned unemployment rate at time t, $\widehat{ur}_{i,t}$ controling for two lags $\widehat{ur}_{i,t-1}$ and $\widehat{ur}_{i,t-2}$. The estimated population response at horizon h is calculated from the estimated coefficients as $\left(\sum_{k=0}^{h}(1+\beta_0^k)\right)-1$ of the net migration regression.



(a) U.S.: 1977 - 2015 (b) Europe: 1995 - 2015

Figure 6: Net Migration Rate vs. Unemployment Rate

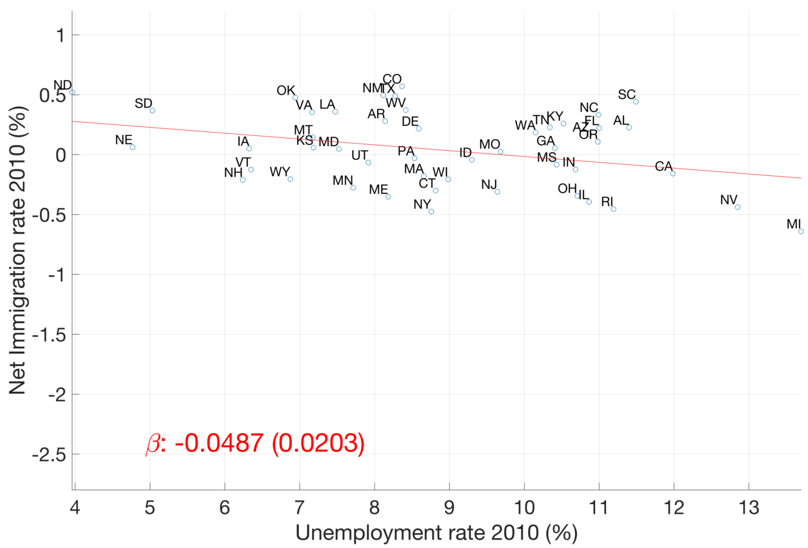
Note: The first panel plots the demeaned state net migration rates $\widehat{nm}_{i,t}$ for the U.S. against the demeaned state unemployment rates $\widehat{ur}_{i,t}$ over 1977 - 2015. The second panel plots the corresponding data for the European countries, 1995 - 2015. Driscoll and Kraay (1998) standard errors in parentheses.



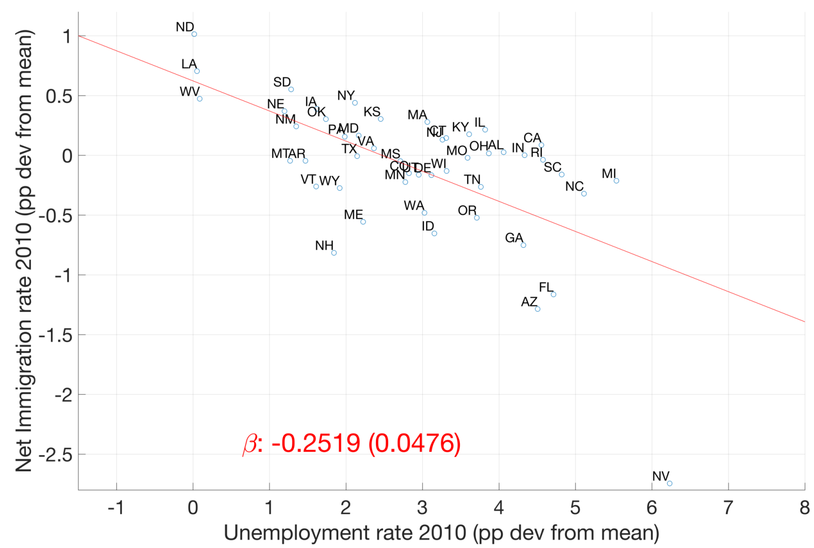
(a) U.S.: 1977 - 2015 (b) Europe: 1995 - 2015

Figure 7: Net Migration Rate vs. Unemployment Rate: Repeated Cross Sections

Note: The figure displays the coefficients from regressions of demeaned state / country net migration rates vs. demeaned state / country unemployment rates (see equation (3.3)). Every coefficient corresponds to a single year. Confidence intervals are $\hat{\beta} \pm 1.96\widehat{stderr}$, where standard errors are regular standard errors.



(a) Raw Data



(b) Demeaned Data

Figure 8: State Net Migration Rate '09-'10 vs. State Unemployment Rate Growth '07-'10

Notes: Panel (a) shows state net migration rates between 2009 and 2010 against the percentage point change in the unemployment rate during 2007-2010. Panel (b) displays state net migration rates between 2009-2010 demeaned by their state-specific average value 1977-2014, against the state unemployment rates between 2009 and 2010 demeaned by their state-specific average value 1977-2014. Regular standard errors in parentheses.

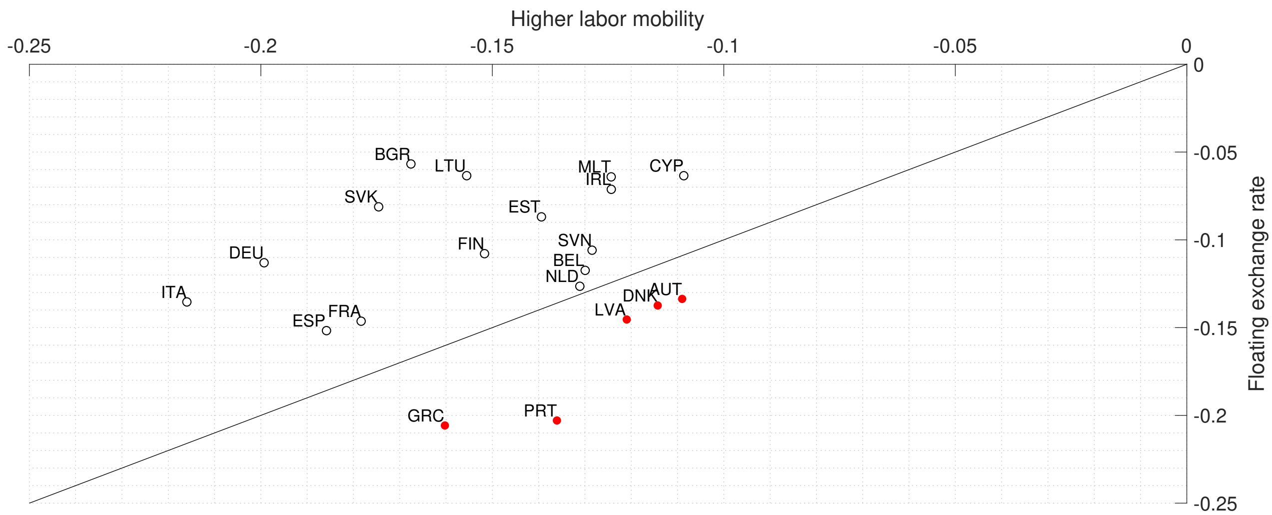


Figure 9: Stabilizing Effects of Labor Mobility and Floating Exchange Rates

Note: The figure displays the reduction in the standard deviation of unemployment following either an increase in labor mobility or the implementation of independent monetary policy across countries in the euro area and countries being pegged to the euro. Results are based on 100 simulations of length 84 featuring random draws to country-specific demand.