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Quantifying the Benefits of Labor Mobility in a Currency Union

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Unemployment differentials are greater between countries in the euro area than between U.S. states. In both regions, net migration responds to unemployment differentials, though the response is smaller in the euro area compared to the United States. We use a multi-country DSGE model with cross-border migration to quantify Mundell's hypothesis that labor mobility could substitute for independent monetary policy in a currency union. While not as effective as independent monetary policy, increased labor mobility reduces business cycle fluctuations for most countries in the euro area. However, Mundell's conjecture does not hold uniformly. For countries that primarily face demand shocks, labor mobility stabilizes inflation and unemployment and improves welfare. If supply shocks are dominant however, labor mobility increases the cost of being in a currency union by magnifying inflation volatility.

JEL Codes: F22, F41, F45

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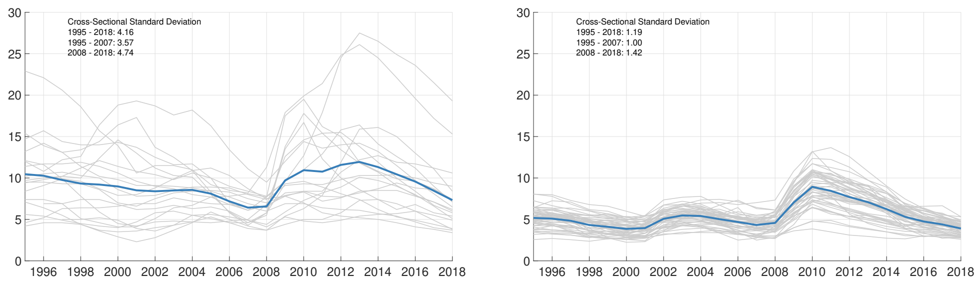
[The case] for flexible exchange rates [is] best if each nation (and currency) has internal factor mobility but external factor immobility. [If] factors are mobile across national boundaries then a flexible exchange system becomes unnecessary.'

– 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 18 euro area economies and 48 U.S. states between 1995 and 2018, together with the averages for the United States and the euro area (the dark lines). Average unemployment in both the United States and euro area 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 1995-2018, is about three times greater in the euro area (4.2%) than the United States (1.4%).



(a) Euro area (b) U.S.

FIGURE 1

Unemployment Rates in Euro Area Countries and US States. Figure displays unemployment rates for euro area countries and the US states (grey, thin lines), as well as their respective averages (blue, thick lines). See Appendix A for data sources.

Large 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 precondition for an optimal currency area. Despite concerns about the extent of labor market integration in Europe, member states moved ahead with the adoption of the euro. The global financial crisis of 2008, and its asymmetric effects across the euro area, presented a challenge to the currency union. While the euro survived, the difficulties of macroeconomic adjustment at the national level imposed large costs on members of the currency union. Our paper quantifies the cost of membership in the euro area and asks how that cost depends on labor mobility.[1]

1. We abstract from the long-run benefits that could come with membership in a currency union, such as increased trade, more integrated financial markets and reduced exchange rate uncertainty.

We begin by establishing some basic facts about cyclical labor mobility in the euro area relative to the United States. Empirically, migration rates are substantially lower in the euro area relative to the United States. In both regions, there is a clear relationship between migration and unemployment though the relationship is much stronger in the United States. In the data, workers in the United States are three times more likely to relocate when local unemployment is relatively high than are workers in the euro area.

We then develop a multi-country DSGE model that incorporates frictions in the labor market giving rise to unemployment and endogenous migration. The model matches country size, migration patterns, trade flows, and unemployment rates. In the model, each country experiences productivity shocks and shocks to demand for its export good. In equilibrium, price and wage rigidities cause inefficient variations in production and employment and generate country-specific variations in unemployment. If a country were to have flexible exchange rates, it could use monetary policy to stabilize these country-specific fluctuations. In a currency union instead, cross-country differences in unemployment induce migration.

We use our quantitative model 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 the euro area. We estimate the structural parameters of the model to match the empirical elasticity of net migration to unemployment in the euro area. We then consider a counterfactual with the higher level of labor mobility observed in the United States. Higher labor mobility reduces the standard deviation of unemployment differentials by 25 basis points – roughly a tenth of the average unemployment differential across countries.[2] Increased labor mobility reduces the volatility of per capita GDP and consumption, but increases the volatility of aggregate GDP and consumption. The alternative scenario of flexible exchange rates, on the other hand, eliminates cross-country variations in cyclical unemployment rates almost entirely and reduces the volatility of both per capita and aggregate variables.

Which counterfactual is preferred – flexible exchange rates or more flexible labor markets – is ultimately a welfare question. We construct a welfare measure based on a second-order approximation to household utility in the neighborhood of the non-stochastic steady state. Our welfare measure captures the costs of consumption volatility as well as output losses caused by price and wage inflation. In the baseline model, calibrated to the euro area, the welfare costs of business cycles for the average country are significant– about 1.85 percent of consumption. If countries had independent monetary policy and floating exchange rates, this cost would fall to roughly 0.53 percent. The difference, 1.31 percent, is the cost of being in the currency union for an average country. This cost would fall to 1.01 if migration rates in the euro area were comparable to migration rates in the United States. Thus, Mundell's conjecture holds for the euro area overall.

On deeper inspection, we find that whether labor mobility reduces the opportunity cost of being in the currency union depends on the underlying source of business cycle fluctuations. Indeed, when we examine the welfare results on an individual country basis, we find that not all countries gain from greater mobility. The mixed results for Mundell's conjecture can be traced to two sources: the role of inflation stabilization in our welfare

2. We define unemployment differentials as unemployment rates demeaned in both the cross-sectional and the time dimension. These double-demeaned unemployment rates reflect country-specific cyclical fluctuations in unemployment rates beyond cyclical fluctuations in euro-area wide unemployment rates.

metric, and the prevalence of productivity shocks for many countries in the euro area. For countries that are more exposed to productivity shocks, greater labor mobility actually increases inflation volatility and thus increases the cost of being in the currency union.

To understand the intuition for this finding, consider first a shock that increases the demand for a country’s exports. Monetary policy would respond by raising interest rates, letting the exchange rate appreciate to offset the upward pressure on prices. Similarly, in-migration would raise labor supply, expand output and again offset the upward pressure on prices. The responses to a productivity shock, however, have sharply different implications for prices. As productivity increases, the price level falls. Monetary policy would prevent prices from falling by lowering interest rates and allowing the exchange rate to depreciate. In contrast, labor mobility would push prices down even more. Attracted by higher wages, workers enter from abroad, increasing the supply of labor, putting further downward pressure on wages and prices. Thus, labor mobility is an imperfect substitute for independent monetary policy. While monetary policy allows a central bank to stabilize business cycle fluctuations and inflation, labor mobility could amplify fluctuations in output and inflation if the cycle is driven predominantly by productivity shocks.

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 led to a resurgence of research on this topic. Our contribution to this literature is two-fold: First, we provide a quantitative assessment of the benefits of labor mobility over the business cycle in a DSGE model that matches the countries in the euro area. Second, our model clarifies settings in which labor mobility reduces unemployment rate differentials and welfare costs and settings where monetary policy is a more powerful tool for reducing volatility and stabilizing inflation. 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 (2022) who study optimal monetary policy in a currency union with labor mobility. Cook et al. (2013) show that the optimal-currency-area logic can be reversed if economies face supply shocks.

Our work also relates to studies on the link between trade and migration (Davis and Weinstein, 2002; Burstein et al., 2020; Di Giovanni et al., 2015; Caliendo et al., 2021). For example, Caliendo et al. (2021) add migration to a quantitative trade model to study the welfare effects of the EU enlargement in 2004 for both low-skilled and high-skilled workers. While sharing some features with their model, our approach differs in that we focus on the interplay of migration and unemployment rates at the business cycle frequency in a New Keynesian model, as opposed to the long-run effects of a permanent reduction in migration costs.

Several researchers have embedded migration channels into DSGE models of the business cycle. Hart and Clemens (2019) study a two region model to evaluate the consequences of labor flows for business cycle volatility. Using a model calibrated to Spain, Bentolila et al. (2008) argue that immigration flattens empirical Phillips curve relationships. Bandeira et al. (2019) study how immigration amplifies the reaction to austerity policies in Greece following the debt crisis. Lozej (2019) uses a small open economy model to analyze the role of migration in alleviating country-specific shocks using a model calibrated to Ireland with search and matching frictions. The key distinguishing feature of our paper is that our aim is to quantitatively evaluate the tradeoff between monetary policy and labor mobility (i.e., Mundell's tradeoff) for the euro area as a whole.

The seminal paper on the response of migration to labor market conditions is Blanchard and Katz (1992). They 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 of 100 workers leads to an out-migration of 65 workers in the first year, together with an increase in unemployment of 30 workers.[3,4] 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., 2019). 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. We follow Blanchard and Katz (1992) in studying the relationship between migration and local economic conditions. We analyze migration in a large sample of European countries with new data on observed migration flows (as opposed to migration flows inferred from changes in population). Our data indicate that the difference between the U.S. and Europe is even larger than estimated in Beyer and Smets (2015). We use the estimated cyclical relationship between migration and unemployment as moments for the calibration and estimation of a DSGE model to quantify the effects of migration on economic outcomes under fixed and flexible exchange rates.

3. EMPIRICAL ANALYSIS

In this section we present evidence on migration and unemployment across U.S. states and across countries in the euro area. This analysis shows that labor migration rates are substantially lower in the the euro area relative to the United States. At the same time, unemployment differentials in the euro area countries are consistently greater than across U.S. states. In both regions, there is a clear relationship between labor migration and unemployment differentials though the relationship is much stronger in the United States compared to the euro area. We use these findings when we calibrate our multi-country model in Section 6.

3.1. *Data*

Geographical Coverage and Sample Period. We analyze migration flows in the United States and the euro area. The sample for the United States consists of 48 states (excluding Alaska and Hawaii due to their geographical isolation). Our set of euro area countries

3. In a recent paper, Furlanetto and Robstad (2019), using data on Norway, provide evidence that an exogenous inflow of migrants can actually lower unemployment.

4. Molloy et al. (2011); Dao et al. (2017); Kaplan and Schulhofer-Wohl (2017) document a slight decline in U.S. mobility since the early 1990s.

includes 18 members as of 2018 (we exclude Luxembourg, due to its high share of cross-border commuters and its paucity of migration data).[5] Our sample for the United States, covers 1977-2018. The time span is dictated by the lack of state-level unemployment and migration data prior to the mid-1970s. Our sample for the euro area covers 1995-2018 because prior to 1995, migration data is available only for a handful of countries and restrictions on labor mobility were still prevalent.

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. This distinguishes us from most of the migration literature that focuses on migration of foreigners.[6] Definitions of migrants based on foreign citizenship would miss important labor flows that are the core of the adjustment mechanism in currency unions. For example, migration figures reported by Spain would not include the large exodus of Spaniards attracted by better labor market conditions in Germany in the early 2010s. Missing flows of nationals in the euro area would also bias downward our estimates of migration flows and therefore undermine our comparison with U.S. data that records flows of people across states irrespective of their state of birth.

Data on migration in the euro area is provided primarily by Eurostat. Eurostat records migration flows of both nationals and non-nationals.[7] We complement this data using information provided by national statistical agencies whenever we are sure that the national data captures migration of both foreigners and nationals. While our main analysis focuses on in- and out-migration for each country, we also create a database of bilateral migration flows that is used to calibrate our multi-country model. Data on unemployment rates are collected through national labor force surveys and are reported by Eurostat.[8]

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 mailing addresses of tax returns and encompass all U.S. tax filers. Data on state population and unemployment rates are provided by the Bureau of Economic Analysis and the Bureau of Labor Statistics.

5. Our sample includes Belgium, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Latvia, Lithuania, Malta, Netherlands, Austria, Portugal, Slovenia, Slovakia and Finland. Belgium, Germany, Ireland, Spain, France, Italy, Netherlands, Austria, Portugal and Finland adopted the euro in 1999. The remaining countries adopted the euro in the following years: Greece (2001), Slovenia (2007, pegged since 2004), Cyprus (2008. pegged since 1999), Malta (2008, pegged since 2003), Slovakia (2009), Estonia (2011, pegged since 1999), Latvia (2014, pegged since 2005), Lithuania (2015, pegged since 2002).

6. See e.g. Mayda (2010) or Beine et al. (2019) who rely on data from the International Migration Database hosted by the OECD that only captures movements by non-nationals.

7. Despite this harmonized definition, 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 Ireland). In line with our data for the United States, we do not distinguish between national and foreign migrants. Appendix A.2 provides more details on data sources and the construction of our database for Europe.

8. Labor force surveys are harmonized across European countries and use the same definition of unemployment as in the United States.

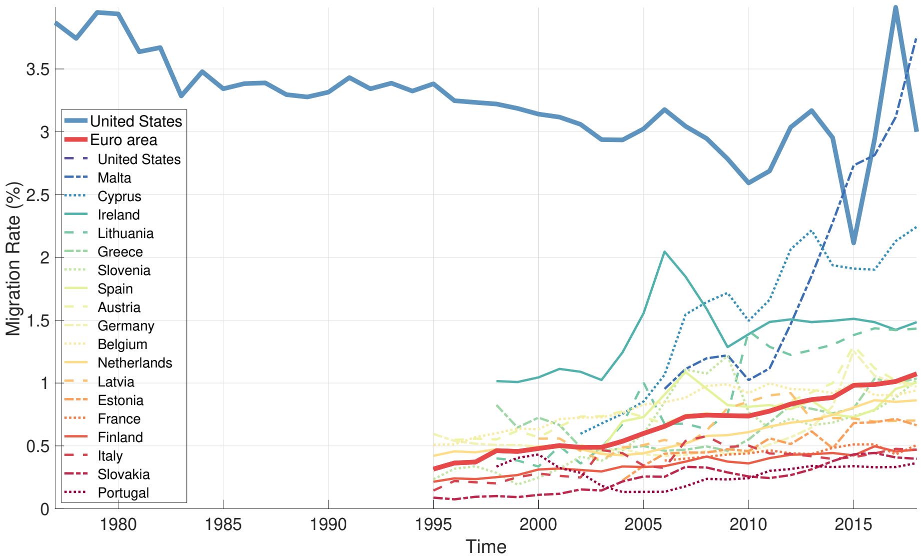


FIGURE 2

Migration Rates over Time. The figure plots the migration-to-population ratio over time for the average U.S. State, the average euro area country and individual euro area countries. The average for the euro area sample is an average over all countries with available data in any given year. All averages are simple averages. See Appendix A for data sources.

Migration. This section shows that migration rates have been declining in the United States and have been gradually increasing in the euro area. Despite these trends, there remains substantially more migration in the United States relative to the euro area.

We define the gross migration rate as the average of inflows and outflows over one year divided by the population.[9] 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.

The gross migration rate for the United States is 3.24 percent (averaged across states and time periods). For the euro area, the gross migration rate is only 0.75 percent. Figure 2 displays average gross migration rates for the United States and the euro area sample over time. Migration rates have been trending down slightly in the United States while they have increased in the euro area. The increase in mobility in the euro area could reflect the liberalization of labor markets over our sample period. Free movement of labor between original member states and member states that entered since 2004 was only established over a seven-year transition period.

There are many possible reasons for the differences in migration rates. Language, culture, and institutional differences all present barriers to labor flows that could be greater in the euro area relative to the United States (see for instance Beine et al.,

9. 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.

2019). In the model in Section 4 we are agnostic about the specific frictions that impede labor mobility. For whatever reason, labor mobility is lower in the euro area than in the United States and Mundell's conjecture suggests that maintaining a currency union will therefore be more costly for the euro area.

For purposes of macroeconomic stabilization, it is the *net* migration rate that matters. The net migration rate is the difference between a state's total inflows and total outflows as a share of its population

$$\text{Net migration}_{i,t} = \frac{\text{In-migration}_{i,t} - \text{Out-migration}_{i,t}}{\text{Population}_{i,t}}. \tag{3.1}$$

Net migration rates fluctuate over time as relatively more people enter or exit countries or states. Unlike gross migration rates which are substantially different between the United States and the euro area, fluctuations in net migration rates are quite comparable. The average standard deviation of net migration across all U.S. states is 0.48 and is about 0.39 in the euro area.

Unemployment Rates. We now turn our attention to the difference in unemployment rates in the United States and the euro area. 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 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. This 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.[10]

Consider the unemployment rate for country i in the euro area. 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 the euro area 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 the euro area. The average unemployment rate $\overline{ur}$ is 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

$$\widehat{ur}_{i,t} = ur_{i,t} - ur_i - (ur_t - \overline{ur}). \tag{3.2}$$

The rate $\widehat{ur}_{i,t}$ is an indication of whether country i's unemployment is high relative to its own long-run 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 3 plots the cross-sectional standard deviations of the demeaned unemployment rates together with their average over time. The standard deviation of U.S. unemployment is about 1. The standard deviation is higher in the euro area at 2.8. The earlier observation of greater unemployment rate dispersion in the euro area relative to the United States (see Figure 1) is not driven by long-run differences across countries (or

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

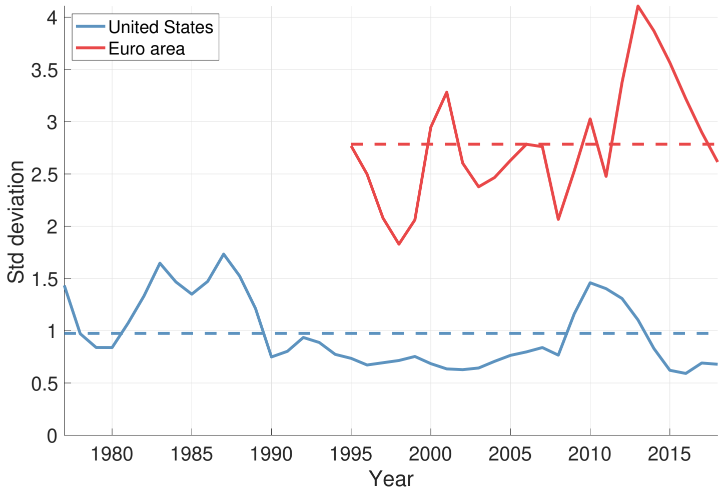


FIGURE 3

Cross-Sectional Standard Deviations in Unemployment Rates. The figure plots cross-sectional standard deviation in demeaned unemployment rates, $\widehat{ur}_{i,t}$, for the U.S. states and for the euro area countries. The dotted lines are the respective time averages. See the text for the definition of demeaned unemployment rates. See Appendix A for data sources.

states), but remains even after removing country (state) 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 the euro area diverge particularly during the debt crisis in 2011 - 2013, with a standard deviation of roughly 4 percentage points.

An important factor in considering whether a region is an optimal currency area is the extent to which macroeconomic fluctuations are due to a common business cycle or are country specific. To get a sense of whether common factors explain variation in unemployment rates, we decompose the variance for each state or country i as

$$var\left(ur_{i,t}-ur_i\right)=var\left(\widehat{ur}_{i,t}\right)+var(ur_t)+2cov\left(\widehat{ur}_{i,t},ur_t\right) \tag{3.3}$$

This decomposes fluctuations in a country's unemployment rate (relative to its average) into the variance of the idiosyncratic (double-demeaned) unemployment rate ($var(\widehat{ur}_{i,t})$), the variance of the unemployment rate in the euro area ($var(ur_t)$) and the covariance between the two terms. This covariance is positive if the idiosyncratic component comoves with the euro-area-wide component, that is if a country experiences the same business cycles as the average, but to a stronger extent. This is the case for countries like Spain and Greece. In contrast, Germany has a negative covariance, which indicates that its business cycles tend to be of a smaller amplitude than those of the average country in the euro area. By construction the covariance term is zero on average.

Figure 4 shows the decomposition for the countries in the euro area and for U.S. states. The most striking feature is the difference between the variance of the idiosyncratic unemployment fluctuations in the euro area compared to the United States. For U.S. states, the average variance of state unemployment is 3.4 while for countries in the euro area it is 9.3. The idiosyncratic component accounts for only 29 percent of total variance for U.S. states while it accounts for 81 percent of the variance in the euro area.

This suggests that the cost of a currency union in the euro area, where country-specific fluctuations are relatively large, is greater than the costs of the common currency in the United States. We later use the model to ask how higher labor mobility in the euro area can reduce the country-specific fluctuations in the unemployment rate.

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

$$\widehat{ur}_{i,t+h} = \beta_0^h \widehat{ur}_{i,t} + \beta_1^h \widehat{ur}_{i,t-1} + \beta_2^h \widehat{ur}_{i,t-2} + \epsilon_{i,t}^h \qquad \forall h = 0,1,..,H \tag{3.4}$$

up to a nine year horizon $H = 9$. The coefficients provide us with estimates of unemployment at horizon h given an initial unemployment differential. The upper part of Figure 6 displays the estimated coefficients $\hat{\beta}_0^h$ for the United States (a), and the euro area (b). Unemployment differentials are persistent in all cases, but particularly so in the euro area. Following an innovation of 1 percentage point, unemployment differentials initially rise by 0.5 to 0.8 percentage points in the euro area and stay above 1% for 3 to 4 years.

To summarize, unemployment rates are more disperse across the euro area than across U.S. states, and they reflect greater idiosyncratic variation. In both regions, dispersion in unemployment is quite persistent.

3.2. *Unemployment Rates and Net Migration*

We are interested in the relationship between net migration flows and unemployment differentials and how this relationship differs between the euro area and the United States. To study this relationship we regress net migration on the unemployment rate

$$\widehat{nm}_{i,t} = \beta \widehat{ur}_{i,t} + \epsilon_{i,t}, \tag{3.5}$$

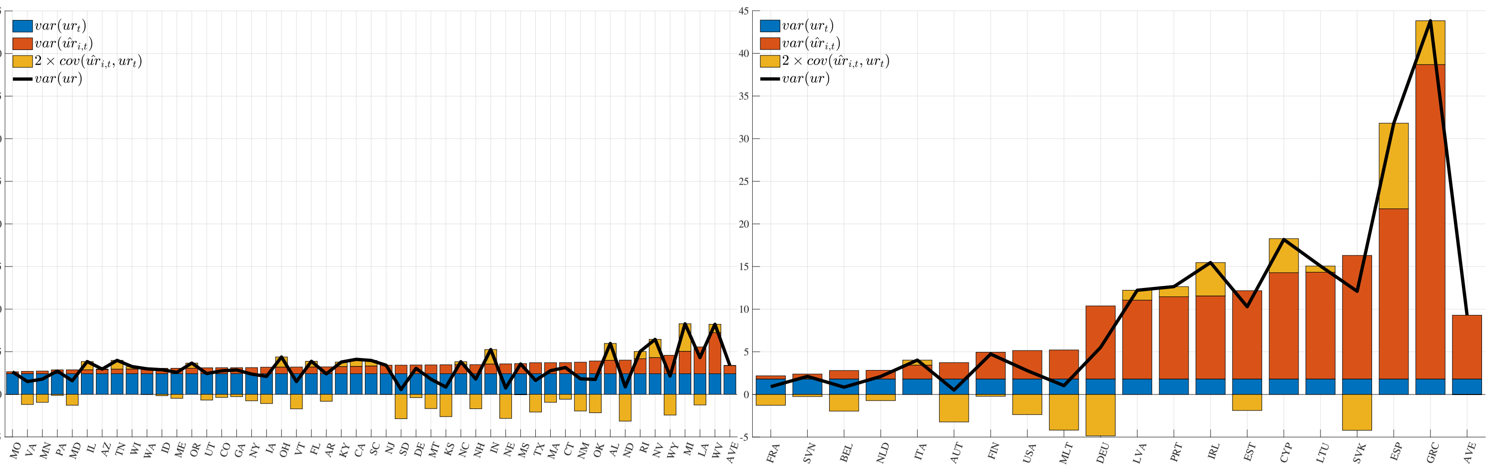
where $\widehat{ur}_{i,t}$ is the double-demeaned unemployment rate as defined in (3.2) and $\widehat{nm}_{i,t}$ is the double-demeaned net migration rate.[11] This specification implicitly assumes that what matters for migration choices is a country's unemployment rate relative to the regional unemployment rate at a particular point in time.[12]

Figure 5a shows the scatterplot of the data and the estimated coefficients for β. The U.S. coefficient is -0.26 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 0.26 percentage points. To put this in context, if the labor force participation rate were 0.65, an increase of 100 unemployed workers in a state coincides with an out-migration of 40 (26/0.65) 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 out-migration.

The estimated coefficient for regression (3.5) is smaller in the euro area than in the United Staters. For the time period as a whole, the estimated coefficient for the euro

11. We have also estimated versions of (3.5) including measures of regional wage differentials. While the wage coefficients have the "correct" sign, they are not statistically significant and including them does not change the coefficient on $\widehat{ur}_{i,t}$. See Appendix Section B.3 for details.

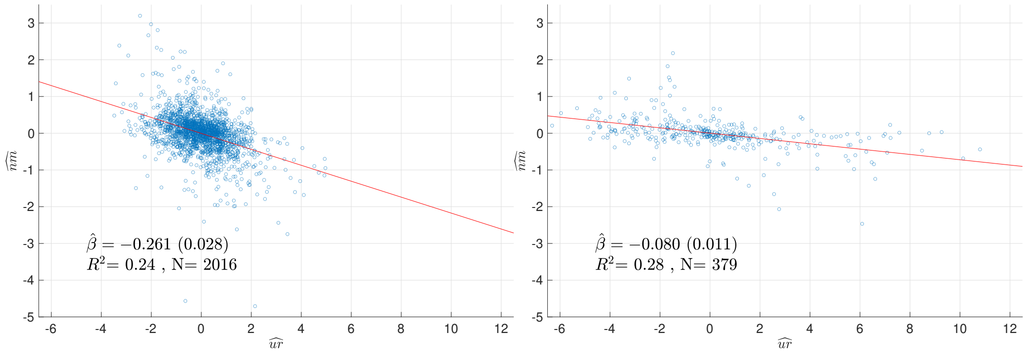
12. The relevance of *relative* labor market conditions is consistent with the DSGE model presented in the next section and "gravity" approaches to study migration flows (Anderson, 2011).



(a) United States

(b) Euro area

Figure 4: Variance Decomposition of the Unemployment Rate. The figure displays the time-series variance decomposition of the unemployment rates in both the United States and the euro area based on equation (3.3.) States / Countries are sorted by the idiosyncratic component $var(\widehat{ur}_{i,t})$. The figure also displays the composition for the average state / country (AVE) as the bar most to the right. See Appendix A for data sources.



(a) United States: 1977 - 2018 (b) Euro area: 1995 - 2018

Figure 5

Net Migration vs. Unemployment. The first panel plots the demeaned state net migration rates after controling for wages, $\widehat{nm}_{i,t} - \hat{\alpha}\widehat{w}_{i,t}$ against the demeaned state unemployment rates $\widehat{ur}_{i,t}$ for the United States over 1977 - 2018. See equation (3.5). The second panel plots the corresponding data for the sample of euro area countries, 1995 - 2018. Driscoll and Kraay (1998) standard errors in parentheses. The estimated coefficient on wages is $\hat{\alpha} = 0.007(0.003)$ for the U.S. states and $\hat{\alpha} = 0.002(0.007)$ for the euro area. See Appendix A for data sources.

area is $\hat{\beta} = -0.08$ (0.01). Consistent with the finding that migration flows have become smaller in the United States and larger in the euro area, there is a slight time trend in the estimated β coefficient in both regions: The relatonship between net migration and unemployment rates is somewhat weakening in the United States, while it has slightly increased in the euro area.[13]

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 the euro area. 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 6 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

13. While these estimates technically reflect only correlations, Foschi et al. (2024) find similar coefficients using instruments for regional labor market conditions. Franceschin and Görlach (2024) decompose migration elasticities by education within Europe and find comparable estimates though they emphasize that more educated workers have higher mobility.

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 6 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. Column (b) of Figure 6 repeats the local projections for the euro area samples. The overall dynamics of migration flows are similar, but are clearly smaller than the U.S. reactions. The cumulative reduction in population is less than half of the response in the U.S. (-0.55 vs. -1.30) and is more delayed.

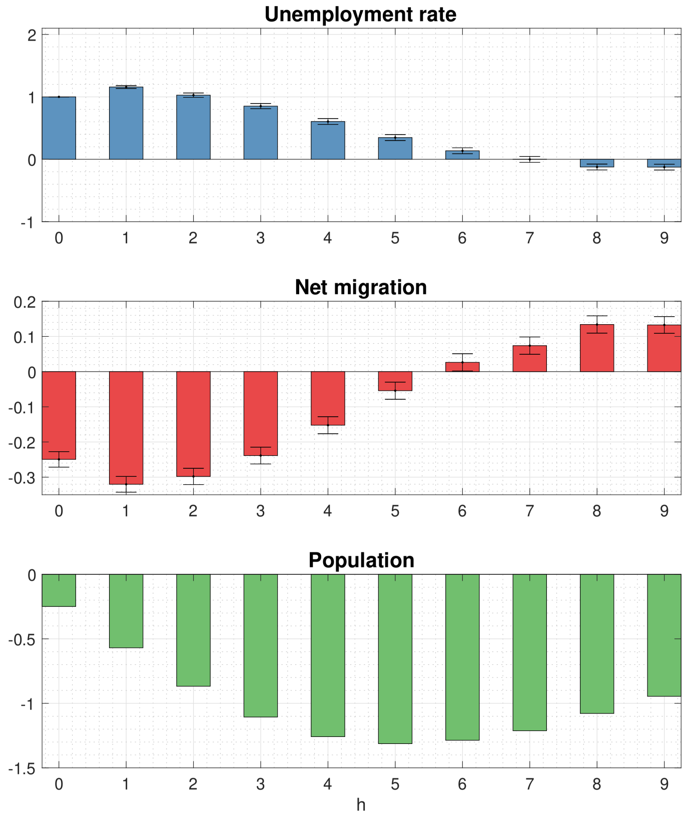
To summarize our empirical findings, (i) Labor is less mobile in the euro area relative to the United States. (ii) Unemployment differentials persist and are larger in the euro area relative to the United States. (iii) Net migration reacts to regional differences in unemployment rates though the relationship is notably weaker in the euro area. (iv) The implied long-run changes in population are economically significant in both regions.

4. A DSGE MODEL WITH CROSS-COUNTRY LABOR MOBILITY

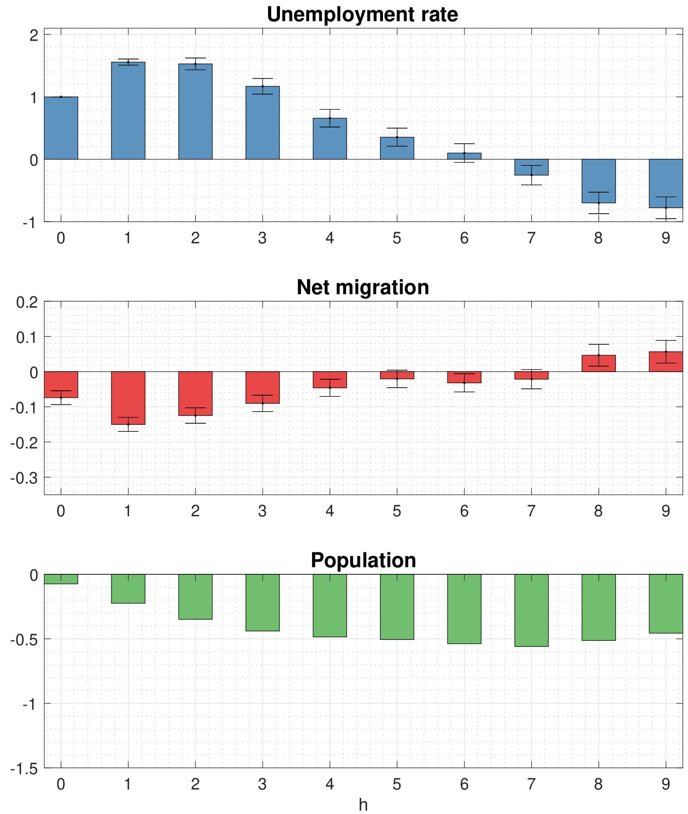
Whether increased labor mobility in the euro area would compensate for the lack of independent monetary policy is not a question we can answer using data alone. Instead, to get at this question, we use a multi-country model of the euro area parameterized to mimic the migration responses and unemployment patterns documented in Section 3. We then quantitatively evaluate Mundell's conjecture by comparing the benefits of independent monetary policy under different degrees of labor mobility.

While the model we use is necessarily complex, the main story the model tells is fairly straightforward. Countries in the euro area experience supply and demand shocks for their output. When a contractionary shock reduces labor demand, wage rigidity prevents the labor market from clearing and causes temporarily high unemployment. Workers in each country have the choice of remaining in the local economy or migrating to another country based on relative labor market conditions. In equilibrium, workers move from high unemployment areas to low unemployment areas, mitigating fluctuations in output and employment across countries. Alternatively, if countries had access to their own monetary policy, adjustment would occur through the exchange rate.

The model requires several mechanisms to generate a combination of persistent unemployment, sluggish price dynamics, and realistic migration and trade flows. Our unemployment specification builds on work by Erceg et al. (2000) and Galí (2011). We introduce labor mobility by adapting the setup in Artuç et al. (2010) and Caliendo et al. (2019) to our framework. The model includes a trade network (based on Eaton and Kortum, 2002) that reflects observed trade patterns in the euro area. To allow for exchange rates and monetary policy to influence economic activity, we introduce price and wage rigidity through a Calvo mechanism (Woodford, 2003; Galí, 2008). We describe each of these components in this section.



(a) United States



(b) Euro area

Figure 6: Local Projections. The figure displays the estimated coefficients (and standard errors) from local projection regressions (see equation (3.4)) for the United States (panel (a)) and for the euro area (panel (b)). 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. See Appendix A for data sources.

4.1. *Households, Population and Migration*

The model consists of $i=1,...,N-1$ euro area countries plus a rest of the world (RoW) aggregate. In each country, there are capital owners and workers. Capital owners are immobile. The number of capital owners in country i is $\mathbb{N}_i^k$. Workers are mobile and move from one country to the next if they find it optimal to do so. The number of workers in country i at time t is given by $\mathbb{N}_{i,t}^w$. The total population for country i at time t is

$$\mathbb{N}_{i,t}=\mathbb{N}_i^k+\mathbb{N}_{i,t}^w.$$

The net migration rate in the model – the counterpart to (3.1) – is $\mathbb{N}_{i,t}/\mathbb{N}_{i,t-1}-1$. Unless otherwise indicated, variables in the model are expressed in per capita terms. For instance, $c_{i,t}^w$ is consumption of a single worker while total consumption for workers is $\mathbb{N}_{i,t}^w c_{i,t}^w$.

4.1.1. Capital Owners.

Capital owners receive utility from the consumption of the final good produced in their country of residence. At each date t, capital owners in country i act to maximize expected utility

$$\mathbb{E}_t\left[\sum_{j=0}^{\infty}\beta^j\frac{\left(c_{i,t+j}^k\right)^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}}\right] \tag{4.6}$$

subject to the nominal budget constraints

$$P_{i,t}c_{i,t}^k+P_{i,t}I_{i,t}+\frac{B_{i,t}}{(1+i_{€,t})E_{i,t}}-\frac{B_{i,t-1}}{E_{i,t}}=K_{i,t-1}\left(R_{i,t}u_{i,t}-P_{i,t}a(u_{i,t})\right)+\Pi_{i,t}-T_{i,t}^k,$$

and the capital accumulation constraint

$$K_{i,t}=K_{i,t-1}(1-\delta)+\left[1-f\left(\frac{I_{i,t}}{I_{i,t-1}}\right)\right]I_{i,t}.$$

Nominal expenditure on consumption and investment is $P_{i,t}c_{i,t}^k$ and $P_{i,t}I_{i,t}$ where $c_{i,t}^k$ and $I_{i,t}$ are consumption and investment for the capital owner and $P_{i,t}$ is the nominal price of the final good. $B_{i,t}$ is the face value of nominal bonds maturing at date $t+1$ denominated in euros held by a capital owner of country i. These bonds pay the nominal interest rate $i_{€,t}$.[14] Finally, $E_{i,t}$ is the nominal exchange that converts euros into country i's currency with $E_{i,t}=1$ if countries are in a currency union.

Capital owners earn nominal rental income $R_{i,t}K_{i,t-1}u_{i,t}$, receive nominal profits $\Pi_{i,t}$ and pay lump-sum nominal taxes $T_{i,t}^k$. Capital available for production in period t is $K_{i,t-1}$. Capital owners can adjust the utilization rate, $u_{i,t}$, at the nominal cost $K_{i,t-1}P_{i,t}a\left(u_{i,t}\right)$ with $a(1)=0$, $a'(1)=\frac{R_i}{P_i}$ and $a''(1)>0$ governing the cost of changing utilization. The investment adjustment cost function f satisfies $f(1)=f'(1)=0$ and $f''(1)\geq 0$ as in Christiano et al. (2005).

14. To ensure that the stochastic equilibrium is stationary, we impose a small quadratic penalty on bond holdings. We set the cost sufficiently low that its effect on the equilibrium is negligible. See Schmitt-Grohé and Uribe (2003) for additional discussion.

4.1.2. Workers. Workers are mobile and earn only labor income. Each worker in country i earns nominal labor income $W_{i,t}L_{i,t}$ and pays taxes at rate τ_i^w. Workers are assumed to be "hand-to-mouth", so their consumption satisfies[15]

$$P_{i,t}c_{i,t}^w = (1-\tau_i^w)W_{i,t}L_{i,t}. \tag{4.7}$$

At the level of the individual, labor supply is inelastic and thus the only meaningful choice workers make is in which country to work. Before describing the migration decision, we first discuss how effective labor $L_{i,t}$ is determined.

Labor Markets. To generate time-varying unemployment rates, we add wage rigidity as in Erceg et al. (2000) and follow Hansen (1985), Rogerson (1988) and Galí (2011) by adding indivisible labor. We differ from these papers by assuming that labor is supplied inelastically.

Each worker inelastically supplies one unit of labor in their country of residence.[16] Workers are randomly assigned a type $\iota \in [0,1]$ according to a uniform distribution. As in Erceg et al. (2000), for each type ι, and each country, there is a labor union with market power that acts in the interest of its workers in setting a wage rate and choosing who works.

Type-specific labor $L_{i,t}(\iota)$ is employed by labor-aggregating firms who, in turn, sell aggregate effective labor to goods-producing firms. Labor-aggregating firms behave competitively and choose labor types $L_{i,t}(\iota)$ to maximize their profits

$$W_{i,t}L_{i,t} - \int_0^1 W_{i,t}(\iota)L_{i,t}(\iota)d\iota.$$

Here $W_{i,t}$ is the nominal wage charged for a unit of effective labor while $W_{i,t}(\iota)$ is the nominal wage paid for a unit of type ι labor. Labor-aggregating firms take $W_{i,t}$ and $W_{i,t}(\iota)$ as given. Effective labor $L_{i,t}$ is produced from the following combination of labor types $L_{i,t}(\iota)$:

$$L_{i,t} = \zeta_i + \left(\int_0^1 \left(L_{i,t}(\iota) - \zeta_i\right)^{\frac{\psi_w - 1}{\psi_w}} d\iota\right)^{\frac{\psi_w}{\psi_w - 1}}, \tag{4.8}$$

where $\zeta_i > 0$ is a Stone-Geary-type minimum labor demand parameter (Geary, 1950; Stone, 1954) that guarantees a positive, finite wage for each labor type when labor is supplied inelastically, and $\psi_w > 1$ is the elasticity of substitution across labor types.[17]

15. This specification follows Caliendo et al. (2019) and simplifies the solution to the model by allowing us to abstract from changes in worker-specific asset holdings as they change location. Allowing migrants to hold assets would result in propagating ex post heterogeneity among migrants.

16. Similar to Mandelman and Zlate (2012), Borjas et al. (2008) and Lozej (2019) we treat labor supplied by workers as perfect substitutes regardless of the country of origin. The degree of substitutability of native workers and immigrant workers is a subject of active research (see e.g. Ottaviano and Peri, 2012; Borjas et al., 2008; Furlanetto and Robstad, 2019; Bentolila et al., 2008; Brücker et al., 2014; Prean and Mayr, 2016; Dustmann et al., 2010) . See Dustmann et al. (2016) for additional discussion.

17. A standard CES-specification would imply that the optimal wage set by trade unions is the cost of supplying labor times a gross markup. Since this cost is zero in our setup, the optimal wage would be zero.

Given (4.8), demand for each labor type satisfies

$$L_{i,t}(\iota)=\zeta_i+\left(\frac{W_{i,t}(\iota)}{W_{i,t}}\right)^{-\psi_w}\left(L_{i,t}-\zeta_i\right) \tag{4.9}$$

and the aggregate wage index is $W_{i,t}=\left(\int_0^1\left(W_{i,t}(\iota)\right)^{1-\psi_w}d\iota\right)^{\frac{1}{1-\psi_w}}$.

Labor unions set wages $W_{i,t}(\iota)$ to maximize the total amount paid to their workforce taking the demand curve (4.9) as given. Wages are set according to a Calvo mechanism with a wage reset probability $1-\theta_w$. A union that can reset its wage at time t chooses a reset wage $W^*_{i,t}(\iota)$ to maximize their real wage payments over the life of the wage contract,

$$\mathbb{E}_t\left[\sum_{j=0}^{\infty}(\theta_w\beta)^j\frac{W^*_{i,t}(\iota)}{P_{i,t+j}}\left(\zeta_i+\left(\frac{W^*_{i,t}(\iota)}{W_{i,t+j}}\right)^{-\psi_w}\left(L_{i,t+j}-\zeta_i\right)\right)\right].$$

All labor unions that adjust at time t choose the same reset wage so $W^*_{i,t}(\iota)=W^*_{i,t}$ where

$$\left(W^*_{i,t}\right)^{\psi_w}=\frac{\psi_w-1}{\zeta_i}\frac{\mathbb{E}_t\sum_{j=0}^{\infty}(\theta_w\beta)^j\left(L_{i,t+j}-\zeta_i\right)W^{\psi_w}_{i,t+j}P^{-1}_{i,t+j}}{\mathbb{E}_t\sum_{j=0}^{\infty}(\theta_w\beta)^j P^{-1}_{i,t+j}} \tag{4.10}$$

Given the Calvo specification, wages for effective labor adjust according to

$$W_{i,t}=\left(\theta_w W^{1-\psi_w}_{i,t-1}+(1-\theta_w)\left(W^*_{i,t}\right)^{1-\psi_w}\right)^{\frac{1}{1-\psi_w}}. \tag{4.11}$$

The unemployment rate is defined as $ur_{i,t}=1-\int_0^1 L_{i,t}(\iota)d\iota$. In the non-stochastic steady state, wages are equal across types so $W_i(\iota)=W_i$ and employment is $L_i(\iota)=L_i$. Using (4.10), the steady-state unemployment rate is $ur_i=1-\frac{\psi_w}{\psi_w-1}\zeta_i$.

Log-linearizing (4.10) and (4.11) yields the wage Phillips curve,

$$\pi^w_{i,t}=-\frac{(1-\theta_w\beta)(1-\theta_w)}{\theta_w}\left[\frac{\Delta ur_{i,t}}{1-ur_i}\right]+\beta\mathbb{E}_t\left[\pi^w_{i,t+1}\right],$$

where we use $\Delta ur_{i,t}=ur_{i,t}-ur_i$ to denote deviations from steady state.[18] Notice that if wages were fully flexible ($\theta_w\to 0$) the unemployment rate would be constant.

Migration. At the start of each period, workers choose to migrate or remain in their current country. Migration takes place at the beginning of each period and migrants immediately work and consume in their new location.

A worker moving from country i to country j incurs a migration cost τ^i_j (with $\tau^i_i=0$). In addition to migration costs, workers receive idiosyncratic (i.e. worker-specific) shocks for each destination j, denoted by $\epsilon_{j,t}$.[19] Define $v_{i,t}(\epsilon_t)$ as the value of a worker living

18. See Appendix Section C.1 for a derivation.

19. Since every worker draws his or her own shock $\epsilon_{j,t}$, we could add a subscript to denote the individual worker. We suppress this index for ease of notation.

in country i at time t conditional on the aggregate state and the worker's vector of idiosyncratic shocks, $\epsilon_t = [\epsilon_{1,t}, \epsilon_{2,t}, ..., \epsilon_{N,t}]$ drawn at that date. The value for a worker living in country i at time t is

$$v_{i,t}(\epsilon_t) = \max_j \left\{ \varphi_j U\left(c^w_{j,t}\right) + \frac{1}{\gamma}\epsilon_{j,t} - \tau^i_j + \beta \mathbb{E}_t\left(V_{j,t+1}\right) \right\}. \tag{4.12}$$

The flow utility function $U(c)$ is $\frac{c^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}}$, and $\varphi_j > 0$ are location-specific constants. The value $V_{i,t}$ is the expected value of $v_{i,t}(\epsilon_t)$ prior to the realization of the vector ϵ_t and thus, $V_{i,t}$ is the average expected utility of workers in country i at the start of time t. The parameter γ governs how strongly idiosyncratic location shocks affect migration decisions.

We follow Artuç et al. (2010) and assume that the idiosyncratic shocks are i.i.d. over time and across individuals and are distributed according to a Type-I extreme value distribution with zero mean. Given these assumptions, $V_{i,t}$ is

$$V_{i,t} = \frac{1}{\gamma}\ln\left\{ \sum_j \exp\left\{ \gamma\left(\varphi_j U\left(c^w_{j,t}\right) - \tau^i_j + \beta\mathbb{E}_t\left(V_{j,t+1}\right)\right)\right\}\right\}. \tag{4.13}$$

Migration decisions depend on this average utility. The fraction of workers that relocate from i to j, denoted by $n^i_{j,t}$, is then[20]

$$n^i_{j,t} = \frac{\exp\left\{\gamma\left(\varphi_j U\left(c^w_{j,t}\right) - \tau^i_j + \beta\mathbb{E}_t\left(V_{j,t+1}\right)\right)\right\}}{\sum_k \exp\left\{\gamma\left(\varphi_k U\left(c^w_{k,t}\right) - \tau^i_k + \beta\mathbb{E}_t\left(V_{k,t+1}\right)\right)\right\}}. \tag{4.14}$$

Naturally, markets with higher expected utility attract more workers. The number of workers living in country i at time t is

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

As the difference in the value of working in country i rises relative to country j, $n^i_{j,t}$ rises and more workers flow from i to j. Log-linearizing (4.14) and using the workers' budget constraint (4.7) yields[21]

$$\Delta\ln n^i_{j,t} - \Delta\ln n^i_{i,t} \approx \gamma\left\{\Delta\ln w_{j,t} - \Delta\ln w_{i,t} - \left(\frac{\Delta ur_{j,t}}{1-ur_j} - \frac{\Delta ur_{i,t}}{1-ur_i}\right) + \beta\mathbb{E}_t\left(\Delta V_{j,t+1} - \Delta V_{i,t+1}\right)\right\}. \tag{4.15}$$

The parameter γ is critical for our analysis because it governs the sensitivity of migration rates to utility differentials. The greater is γ, the more responsive migration is to

20. The model predicts bi-directional migration flows across countries. Consistent with the empirical evidence, gross migration rates in the model generally exceed net migration rates.

21. Log-linearizing equation (4.14) gives

$$\Delta\ln n^i_{j,t} - \Delta\ln n^i_{i,t} \approx \gamma\left\{\varphi_i\left(c^w_i\right)^{1-\frac{1}{\sigma}}\Delta\ln c^w_{j,t} - \varphi_j\left(c^w_j\right)^{1-\frac{1}{\sigma}}\Delta\ln c^w_{i,t} + \beta\mathbb{E}_t\left(\Delta V_{j,t+1} - \Delta V_{i,t+1}\right)\right\}$$

Setting $\varphi_i = \left(c^w_i\right)^{\frac{1}{\sigma}-1}$ and using the log-linearized budget constraint $\Delta\ln c^w_{i,t} = \Delta\ln w_{i,t} + \Delta L_{i,t}$ together with $\Delta\ln L_{i,t} = \frac{\Delta ur_{i,t}}{1-ur_i}$ yields (4.15).

differences in utility. Utility differences reflect differences in real labor incomes that are either driven by cross-country fluctuations in the real wage, $w \equiv \frac{W}{P}$, or the level of unemployment, ur. Below, we choose γ so that the data generated by the model produces an elasticity of net migration to unemployment differentials that matches the empirical regression coefficient from (3.5). In Section 7, when we simulate counterfactual experiments with greater labor mobility, we adjust γ so that the model-implied regression coefficient matches that of the United States.

4.2. *Firms, Production and Trade*

Production of the final good takes place in three stages. This setup allows us to separate the sticky price dynamics (in the first stage) from the trade dynamics (in the second and third stages). In the first stage, material inputs are produced from capital and labor inputs. The material input producers set their prices according to the Calvo mechanism. In the second stage, some materials are transformed into non-tradable intermediate goods, whereas others serve as inputs for producers of tradable varieties. As in Eaton and Kortum, countries purchase tradable varieties from the lowest-cost supplier available to them (depending both on the factory price and also on trade costs and exchange rates) and combine the tradable varieties into a tradable intermediate good. In the last stage, non-tradable intermediate goods and tradable intermediate goods are combined into a final good, which is used for consumption, investment and government purchases.

Material inputs. Firms use capital and labor to produce material inputs. There is a continuum of material inputs and firms are monopolistically competitive. Material input producers adjust their prices infrequently according to the standard Calvo mechanism.

Competitve firms produce aggregate material inputs $M_{i,t}$ from a CES combination of individual material inputs $m_{i,t}(s)$, with $s \in [0,1]$.

$$M_{i,t} = \left[\int_0^1 m_{i,t}(s)^{\frac{\psi_m - 1}{\psi_m}} ds \right]^{\frac{\psi_m}{\psi_m - 1}}. \tag{4.16}$$

Denoting the price of material input s by $P_{i,t}^m(s)$, the demand for each variety is

$$m_{i,t}(s) = M_{i,t} \left(\frac{P_{i,t}^m(s)}{P_{i,t}^M} \right)^{-\psi_m}, \tag{4.17}$$

where $P_{i,t}^M$ is the price of a unit of aggregate material input:

$$P_{i,t}^M = \left[\int_0^1 P_{i,t}^m(s)^{1-\psi_m} ds \right]^{\frac{1}{1-\psi_m}}. \tag{4.18}$$

The individual material producing firms hire labor, $L_{i,t}(s)$, and capital, $K_{i,t}(s)$, to produce a specific variety of the material:

$$m_{i,t}(s) = \left(K_{i,t}(s)\right)^{\alpha} \left(L_{i,t}(s)\right)^{1-\alpha}. \tag{4.19}$$

Cost minimization implies that individual material firms have a common capital-to-labor ratio

$$\frac{K_{i,t}(s)}{L_{i,t}(s)} = \frac{\alpha}{1-\alpha} \frac{W_{i,t}}{R_{i,t}} = \frac{\mathbb{N}_i^k u_{i,t} K_{i,t-1}}{\mathbb{N}_{i,t}^w L_{i,t}}. \tag{4.20}$$

and a common nominal marginal cost of production

$$MC_{i,t} = (W_{i,t})^{1-\alpha} (R_{i,t})^{\alpha} \left(\frac{1}{1-\alpha}\right)^{1-\alpha} \left(\frac{1}{\alpha}\right)^{\alpha}.$$

The individual material input producers are monopolistically competitive and act in the interest of the capital owners in their country. They adjust their prices $P^m_{i,t}(s)$ according to the Calvo mechanism with reset probability $1-\theta_p$. Taking the demand curve for their variety (4.17) as given, the profit maximization problem for a material input producer in country i that can reset its price is

$$\max_{P^{M,*}_{i,t}} \mathbb{E}_t \left[\sum_{j=0}^{\infty} (\theta_p \beta)^j \frac{\left(c^k_{i,t+j}\right)^{-\frac{1}{\sigma}}}{P_{i,t+j}} \left[P^{M,*}_{i,t} - MC_{i,t+j}\right] M_{i,t+j} \left(\frac{P^{M,*}_{i,t}}{P^{M}_{i,t+j}}\right)^{-\psi_m} \right].$$

The optimal reset price is

$$P^{M,*}_{i,t} = \frac{\psi_m}{\psi_m - 1} \frac{\mathbb{E}_t \sum_{j=0}^{\infty} (\theta_p \beta)^j \frac{\left(c^k_{i,t+j}\right)^{-\frac{1}{\sigma}}}{P_{i,t+j}} \left(P^M_{i,t+j}\right)^{\psi_m} MC_{i,t+j} \mathbb{N}_{i,t+j} M_{i,t+j}}{\mathbb{E}_t \sum_{j=0}^{\infty} (\theta_p \beta)^j \frac{\left(c^k_{i,t+j}\right)^{-\frac{1}{\sigma}}}{P_{i,t+j}} \left(P^M_{i,t+j}\right)^{\psi_m} \mathbb{N}_{i,t+j} M_{i,t+j}}. \tag{4.21}$$

Using (4.18), $P^M_{i,t}$ evolves according to

$$P^M_{i,t} = \left[\theta_p \left(P^M_{i,t-1}\right)^{1-\psi_m} + (1-\theta_p) \left(P^{M,*}_{i,t}\right)^{1-\psi_m}\right]^{\frac{1}{1-\psi_m}}. \tag{4.22}$$

Some of the material inputs $M_{i,t}$ are transformed into tradable varieties that are traded subject to iceberg costs and eventually assembled into a traded intermediate good; others are directly transformed into a non-tradable intermediate good.

Traded intermediate goods. Traded intermediates are modelled as in Eaton and Kortum (2002). Each country demands a set of tradable varieties, which can potentially be produced in any country. Competition ensures that the price paid reflects the minimum unit cost across suppliers (inclusive of trade costs).

There is a continuum of varieties of tradable goods indexed by $\nu \in [0,1]$ and produced by perfectly competitive firms. The production function for each variety is linear. Specifically,

$$y^T_{i,t}(\nu) = z^T_i(\nu) M^T_{i,t}(\nu)$$

where $y^T_{i,t}(\nu)$ is the quantity of variety ν produced, $M^T_{i,t}(\nu)$ is the amount of material input used in production and $z^T_i(\nu)$ is productivity for good ν.

While every country can produce every variety, countries will specialize in those varieties for which they have a comparative advantage. Varieties for which the country has a comparative disadvantage will be imported from abroad. Letting $x^T_{i,t}(\nu)$ be the quantity of variety ν purchased by country i we can write the quantity of net exports of ν as

$$nx_{i,t}(\nu) = y^T_{i,t}(\nu) - x^T_{i,t}(\nu).$$

The nominal cost to produce one unit of variety ν in country i is $P^M_{i,t}/z^T_i(\nu)$. We adopt the standard formulation of trade costs: To ship one unit from country j to country i requires producing $\kappa^j_i \geq 1$ units in country j (with $\kappa^i_i = 1$). Competition implies that the price paid for variety ν in country i is the lowest effective price available: $P^T_{i,t}(\nu) = \min_j \left\{ \kappa^j_i P^M_{j,t} E^j_{i,t} / z^T_j(\nu) \right\}$ where $E^j_{i,t} \equiv \frac{E_{j,t}}{E_{i,t}}$ is the nominal exchange rate in units of country i's currency relative to country j's currency.

The tradable varieties are combined into an aggregate "traded" intermediate good $Y^T_{i,t}$

$$Y^T_{i,t} = \left(\int_0^1 \left(x^T_{i,t}(\nu) \right)^{\frac{\psi_T - 1}{\psi_T}} d\nu \right)^{\frac{\psi_T}{\psi_T - 1}}. \tag{4.23}$$

where ψ_T is the elasticity of substitution across the tradable varieties. Following Eaton and Kortum (2002) the productivity parameters z^T_i are drawn from a Fréchet distribution with shape parameter ϑ and scale parameter Z^T_i. Assuming that $1 + \vartheta > \psi_T$ and following the steps in Eaton and Kortum (2002), one can solve for the equilibrium (nominal) price of the traded intermediate good $P^T_{i,t}$ as

$$P^T_{i,t} = \left[\Gamma\left(1 + \frac{1 - \psi_T}{\vartheta}\right) \right]^{\frac{1}{1-\psi_T}} \Phi_{i,t}^{-\frac{1}{\vartheta}}, \tag{4.24}$$

where $\Gamma(\cdot)$ is the Gamma function and where $\Phi_{i,t} \equiv \sum_{j=1}^N Z^T_j \left(P^M_{j,t} E^j_{i,t} \kappa^j_i \right)^{-\vartheta}$. The share of country i's total expenditures on traded intermediate goods from country j is given by

$$\varpi^j_{i,t} = Z^T_j (P^M_{j,t} E^j_{i,t} \kappa^j_i)^{-\vartheta} \Phi^{-1}_{i,t}.$$

Non-traded intermediate good. In addition to the traded intermediate goods, there is also a non-traded intermediate good denoted by superscript N. The non-traded intermediate good is produced by competitive firms in each country. Its production is also linear,

$$Y^N_{i,t} = Z^N_{i,t} M^N_{i,t}, \tag{4.25}$$

where $M^N_{i,t}$ is the quantity of material inputs used in production of the non-traded intermediate $Y^N_{i,t}$. Notice that the productivity of non-traded goods producers, $Z^N_{i,t}$, is time-varying and constitutes one of the stochastic variables in our model. The price of the non-traded good is

$$P^N_{i,t} = \frac{P^M_{i,t}}{Z^N_{i,t}}.$$

Final Goods. The final goods are assembled by competitive firms from a CES combination of the traded and non-traded intermediate goods. Final goods producers solve

$$\max \left\{ P_{i,t} Y_{i,t} - P^N_t Y^N_t - P^T_t Y^T_t \right\}$$

subject to

$$Y_{i,t}=\left(\omega_{i,t}^{\frac{1}{\psi_y}}\left(Y_{i,t}^N\right)^{\frac{\psi_y-1}{\psi_y}}+(1-\omega_{i,t})^{\frac{1}{\psi_y}}\left(Y_{i,t}^T\right)^{\frac{\psi_y-1}{\psi_y}}\right)^{\frac{\psi_y}{\psi_y-1}}. \tag{4.26}$$

Here, ψ_y is the elasticity of substitution between non-traded and traded goods. The weights $\omega_{i,t}$ for each country pair fluctuate around a long-run average $\bar{\omega}_i$, calibrated to the average share of non-traded goods in a country's aggregate demand. Fluctuations in $\omega_{i,t}$ and $Z_{i,t}^N$, serve as forcing variables in our model.

4.3. *Monetary Policy*

Monetary policy in the euro area is set by the ECB. The ECB follows a “Mankiw rule” that targets GDP-weighted averages of unemployment and inflation throughout the euro area (Mankiw, 2001). The specific monetary policy rule is

$$i_{€,t}=\phi i_{€,t-1}+(1-\phi)\left[\bar{r}+\phi_{ur}\sum_{i=1}^{N}\frac{\mathbb{N}_i GDP_i}{\mathbb{N}_€ GDP_€}ur_{i,t}+\phi_\pi\sum_{i=1}^{N}\frac{\mathbb{N}_i GDP_i}{\mathbb{N}_€ GDP_€}\pi_{i,t}\right]. \tag{4.27}$$

Here $\mathbb{N}_€$ and $GDP_€$ denote the steady-state population and GDP for the euro area. The parameters ϕ, ϕ_u and ϕ_π govern interest rate persistence, the interest rate reaction to unemployment and the reaction to inflation, respectively. The RoW follows an analagous interest rate rule that responds to fluctuations in unemployment and inflation in the RoW.

4.4. *Aggregation and Market Clearing*

Market clearing for materials requires

$$M_{i,t}=M_{i,t}^N+\int_0^1 M_{i,t}^T(\nu)d\nu.$$

Market clearing for the traded varieties requires that each country's sales of traded varieties equal their production. Country i's sales are given by all countries' expenditure on traded intermediate goods from country i, $\sum_{j=1}^N \varpi_{j,t}^i \mathbb{N}_{j,t} E_{i,t}^j P_{j,t}^T Y_{j,t}^T$, whereas perfect competition and zero profits imply that the value of production must be equal to its cost, $\mathbb{N}_{i,t} P_{i,t}^M M_{i,t}^T$:

$$\sum_{j=1}^N \varpi_{j,t}^i \mathbb{N}_{j,t} E_{i,t}^j P_{j,t}^T Y_{j,t}^T=\mathbb{N}_{i,t} P_{i,t}^M M_{i,t}^T.$$

Combining this with the equation (**??**) that determines the share of country i's total expenditures on traded intermediate goods from country j, $\varpi_{j,t}^i$, yields a gravity equation as in Eaton and Kortum (2002)[22]

$$\varpi_{j,t}^i X_{j,t}=\frac{\left(\frac{\kappa_j^i}{E_{j,t}P_{j,t}^T}\right)^{-\vartheta}X_{j,t}}{\sum_{k=1}^N\left(\frac{\kappa_k^i}{E_{k,t}P_{k,t}^T}\right)^{-\vartheta}X_{k,t}}Q_{i,t},$$

22. See Appendix Section C.3 for a derivation.

with $X_{j,t} \equiv \mathbb{N}_{j,t} E_{j,t} P^T_{j,t} Y^T_{j,t}$ denoting country j's total expenditure on tradable intermediate goods and $Q_{i,t} \equiv \mathbb{N}_{i,t} E_{i,t} P^M_{i,t} M^T_{i,t}$ denoting country i's total sales.

The market clearing condition for the final good is

$$\mathbb{N}_{i,t} Y_{i,t} = \mathbb{N}_{i,t} \left(C_{i,t} + G_{i,t}\right) + \mathbb{N}^k_i \left(I_{i,t} + a(u_{i,t}) K_{i,t-1}\right),$$

where aggregate consumption in country i is $\mathbb{N}_{i,t} C_{i,t} = c^k_{i,t} \mathbb{N}^k_i + c^w_{i,t} \mathbb{N}^w_{i,t}$ and $G_{i,t}$ is government consumption. The level of total government spending $\mathbb{N}_{i,t} P_i G_{i,t}$ is assumed constant. Government spending is financed with taxes $\mathbb{N}^w_{i,t} \tau^w_i W_{i,t} L_{i,t} + \mathbb{N}^k_i T^k_{i,t} = \mathbb{N}_{i,t} P_{i,t} G_{i,t}$. We assume that changes in nominal government spending or nominal labor tax revenue are balanced by adjusting the tax on capital owners, $T^k_{i,t}$. This ensures that migration decisions are not driven by changes in the tax burden for workers.[23] Finally, the bond market clearing condition is $\sum_{i=1}^N \mathbb{N}^k_i B_{i,t} = 0$.

Real GDP is defined as total production evaluated at fixed (steady state) prices P_i,

$$GDP_{i,t} = P_i Y_{i,t} + NX_{i,t},$$

where real net exports are $NX_{i,t} = \int_0^1 P^T_i(v) nx_{i,t}(\nu) dv$.

4.5. *Forcing Variables*

To generate migration and unemployment as seen in the data, the model requires shocks that generate 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 preference weights ($\omega_{i,t}$) in equation (4.26) and shocks to TFP in the non-traded sector ($Z^N_{i,t}$) in equation (4.25). Specifically, we assume that

$$\omega_{i,t} = \omega_i (1 - \rho_\omega) + \rho_\omega \omega_{i,t-1} + \varepsilon^\omega_{i,t}$$

$$Z^N_{i,t} = Z^N_i (1 - \rho_Z) + \rho_Z Z^N_{i,t-1} + \varepsilon^Z_{i,t}.$$

where $\rho_\omega < 1$ is the persistence of the shock to the preference weights and $\rho_Z < 1$ is the persistence of non-tradeable TFP.

5. EQUILIBRIUM IN A SIMPLIFIED SETTING

The model presented in Section 4 includes many real-world features that enable us to compare it with data. However, the added realism makes it difficult to see the key forces driving our results. In this section we consider a special case of the model that can be solved analytically to provide intuition for the core results.

Consider a currency union composed of a continuum of ex-ante identical small open economies, as in Gali and Monacelli (2005). In the limit, countries do not purchase any of their own traded intermediates but instead purchases all intermediates from abroad. Since we are focusing on a single country and all countries are ex-ante identical, we suppress the i subscripts.

23. We ignore cross-country fiscal transfers, which are empirically negligible in the euro area.

We make the following simplifying assumptions: (a) There is no capital and consequently no capital owners ($\mathbb{N}^k = 0$, $\alpha = 0$); (b) the elasticity between traded and non-traded goods is 1 ($\psi_y = 1$); (c) utility is logarithmic ($\sigma = 1$); (d) trade is balanced every period and (e) we consider a static version of the model (i.e., we focus on the model's limiting behavior as $\beta \to 0$). This last assumption greatly simplifies both the migration decision (4.15) and the price and wage setting decisions (4.21 and 4.10) by removing the forward-looking components. As in the more complex model, fluctuations in aggregate labor supply can be due either to changes in the employment rate (due to sticky wages) or to changes in the number of workers (due to migration). In this simplified model, the change in the number of workers is directly linked to workers' total wage compensation: $\widetilde{\mathbb{N}}_t = \hat{\gamma}\left(\tilde{w}_t + \tilde{L}_t\right)$ where we use a tilde to denote log deviations from steady state and where $\hat{\gamma} = \left(1 - n^2\right)\gamma$ is the effective migration elasticity.

The following Lemma summarizes the key conditions that characterize the equilibrium. All proofs are in the Appendix.

Lemma 1. Starting from an initial steady state, the first-order approximate solution to the model must satisfy the equations below.

1. $\widetilde{\mathbb{N}}_t = -(1+\vartheta)\left(\tilde{E}_t + \tilde{P}_t^M\right) - \Theta_{w,p}\tilde{P}_t^M + \tilde{\omega}_t$ (AD)
2. $\widetilde{\mathbb{N}}_t = \hat{\gamma}(1-\omega)\left(\tilde{E}_t + \tilde{P}_t^M\right) + \hat{\gamma}\left[\Theta_p + \Theta_{w,p}\right]\tilde{P}_t^M + \hat{\gamma}\omega\tilde{Z}_t^N$ (AS)

where $\Theta_p = \frac{\theta_p}{1-\theta_p}$ and $\Theta_{w,p} = \frac{\theta_w}{(1-\theta_p)(1-\theta_w)}$.

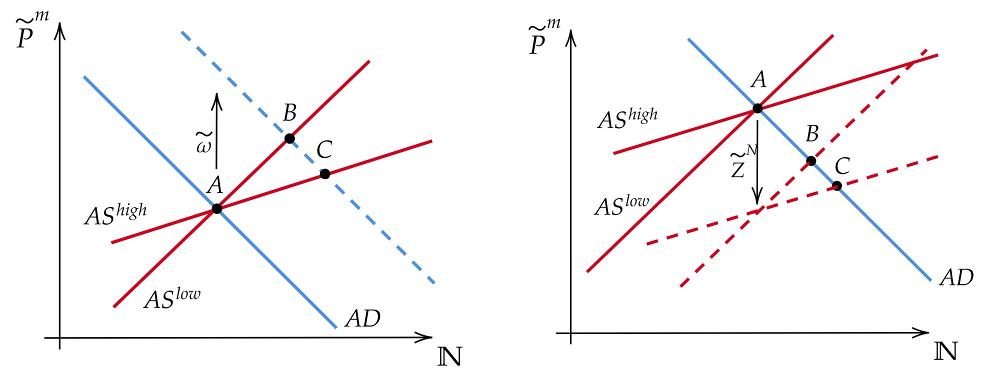
This is a system of two equations in three endogenous variables: population $\widetilde{\mathbb{N}}_t$, the nominal price of materials $\tilde{P}_t^M$ and the nominal exchange rate $\tilde{E}_t$. The first equation (AD) is analogous to an aggregate demand expression. As the real exchange rate for tradables $\tilde{E}_t + \tilde{P}_t^M$ increases, aggregate demand, and therefore the demand for labor, falls.Preference shocks ω_t shift the AD curve. The slope of the demand curve is governed by the trade elasticity ϑ.

The second equation (AS) is an aggregate supply equation and is increasing in the real exchange rate. The migration elasticity $\hat{\gamma}$ enters only the supply equation; a greater migration elasticity implies a flatter aggregate supply curve. Productivity shocks in the non-traded sector shift the AS curve.

Since there are three variables, we need an additional condition to solve for the equilibrium. The additional condition is an equation describing monetary policy. Here, we consider two extreme cases. In the first case, the country is part of a currency union with a fixed nominal exchange rate ($\tilde{E}_t = 0$). In the second case, the monetary authority in the small country sets policy to stabilize the price of materials and thus ensures that $\tilde{P}_t^M = 0$ – a form of price-level targeting.

Note that if prices and wages are flexible (i.e., $\theta_p = \theta_w = 0$), then supply and demand are functions of the sum $\tilde{E}_t + \tilde{P}_t^M$ and the equilibrium allocations are independent of whether the monetary authority sets the exchange rate $\tilde{E}_t$ or the price $\tilde{P}_t^M$. With independent monetary policy and price-level targeting ($\tilde{P}_t^M = 0$) we attain the flexible-price allocations regardless of the degree of wage and price rigidity.

Figure 7 illustrates the equilibrium changes in migration and prices that arise in a currency union in response to preference and productivity shocks. Consider first a rightward shift in AD caused by an increase in the preference shock $\tilde{\omega}_t$ (panel (a)).



(a) Response to positive demand shock

(b) Response to positive supply shock

FIGURE 7

Effect of labor mobility in simplified model. The figure displays the AS and AD curve in the simplified small open economy model with fixed exchange rate (see Lemma 1). Panel A considers an increase in the preference parameter ω, panel B considers an increase in the productivity in the non-traded sector, Z^N. The flatter AS curve corresponds to a model calibration with higher labor mobility (higher γ).

The figure shows two aggregate supply curves. The steep AS line corresponds to a low migration elasticity while the flatter AS line reflects a high elasticity. The increase in demand causes prices to rise and leads to in-migration. The newly arriving workers affect both supply and demand: They directly increase production, but they also demand more domestic goods. Due to trade openness, the supply effect dominates the demand effect (as in Farhi and Werning, 2014) and in-migration mitigates the increase in $\tilde{P}_t^M$. Indeed, if the migration elasticity approaches infinity, the equilibrium approaches the flexible-price outcome.

Migration has the opposite effect on price variation in response to supply shocks (panel (b)). An increase in productivity ($\tilde{Z}_t^N$) raises wages and encourages in-migration. In contrast to a demand shock, which is inflationary, higher productivity reduces $\tilde{P}_t^M$. The arrival of immigrant workers causes prices to fall even further. The increase in productivity shifts AS down. In the figure, both the high-migration supply curve and the low-migration supply curve shift down by the same amount. With low mobility, the equilibrium moves from point A to point B corresponding to a fall in the materials price and an increase in migration. With high mobility, the equilibrium shifts from A to C resulting in a *larger* inflow of migrants and a *larger* fall in the materials price. If supply shocks are prevalent, migration does not substitute for exchange rate adjustment but actually magnifies changes in output, prices and wages.

5.1. *Welfare in the Simple Model*

In the simplified model of this section, welfare is the ex-ante expected utility for workers, $\mathbb{E}(V_t)$, where V_t is given by equation (4.13). A natural measure of welfare $\mathbb{W}_t$ is thus,[24]

$$\mathbb{W}_t = \mathbb{E}\left(\ln c_t^w - \frac{1}{\gamma}\ln n_t\right),$$

24. See Appendix D for detailed derivations of the conditions in this section.

where n_t is the share of workers that choose to remain in the country. Workers care both about consumption and the option to relocate. The option value is given by the term $-\frac{1}{\gamma}\ln n_t$ (which is positive since $n_t < 1$).

Let $\mathbb{V}(x)$ denote the variance of x and let $\bar{\mathbb{W}}$ be welfare in the non-stochastic steady state. In the Appendix we show that the change in expected welfare relative to the steady state $\Delta\mathbb{W}_t = \mathbb{W}_t - \bar{\mathbb{W}}$ can be approximated, up to a second order, as

$$\begin{aligned}\Delta\mathbb{W}_t \approx & -\frac{1}{2}\mathbb{V}(\tilde{c}_t^w) - \mathbb{E}\left(\frac{\psi_m}{2}\Theta_p\mathbb{V}(\pi_t^p) + \frac{1}{2}\Theta_w\mathbb{V}(\pi_t^w)\right) \\ & + (1-\bar{\omega})\mathbb{E}\left(\tilde{P}_t^M - \tilde{P}_t^T\right) - \mathbb{E}\left(\frac{\Delta ur_t}{1-\bar{ur}}\right) - \frac{1}{\gamma}\mathbb{E}(\tilde{n}_t) + \frac{1}{2}\frac{1}{\gamma}\mathbb{V}(\tilde{n}_t)\end{aligned} \tag{5.28}$$

with $\Theta_p = \frac{\theta_p}{1-\theta_p}$ and $\Theta_{w,p} = \frac{\theta_w}{(1-\theta_w)(1-\theta_p)}$. The cost of remaining in the currency union is the difference $\mathbb{W}_t^{\text{Flex}} - \mathbb{W}_t^{\text{CU}}$.

Expression (5.28) shows the sources of potential welfare gains and losses that arise in the simple model. The first term captures welfare costs associated with consumption fluctuations. This is a standard cost of business cycles. See Lucas (1987, 2003). The second term, which is common in the New Keynesian literature, captures welfare costs from reduced average consumption arising from inefficient variation in prices and wages – a cost unique to models with price and wage rigidity.

The second row of equation (5.28) includes other, less common welfare terms that arise in our setting. The term $(1-\bar{\omega})\mathbb{E}\left(\tilde{P}_t^M - \tilde{P}_t^T\right)$ shows that there are potential welfare gains to be captured by adjusting the terms of trade. This term is proportional to the share of traded goods in the economy, $1-\bar{\omega}$, and has been studied by, among others, Benigno and Benigno (2003).[25] The term $\mathbb{E}\left(\frac{\Delta ur_t}{1-\bar{ur}}\right)$ reflects the fact that, because our model has an inefficient flexible price equilibrium, policies that raise or lower average per capita employment have welfare effects. Terms like this can often be eliminated in closed economy settings provided that the flexible price equilibrium is efficient. The last two terms ($\mathbb{E}(\tilde{n}_t)$ and $\mathbb{V}(\tilde{n}_t)$) reflect welfare gains from changes in migration rates. As shown in the Appendix, these terms are negligible for equlibria in which n, the fraction of workers who choose to remain in the home country, approaches 1 (in the data, this is the relevant case even for the U.S.).

For the welfare analysis in this paper, we restrict our attention to quantifying the welfare costs to the first two terms in (5.28). Our interest is in Mundell's tradeoff at the business cycle frequency. Business cycle costs are typically framed in terms of employment and inflation volatility – the first two terms in expression (5.28). Moreover, stabilizing consumption and inflation are the primary objectives of most central banks (in the U.S. this is the “dual mandate” of the Federal Reserve). In contrast, the remaining terms capture changes in welfare arising from long-run shifts in *trend* consumption and fall outside the scope of our analysis. (Indeed, in our empirical section, we explicitly remove all trend variation at the outset.)

25. Building on the results of Benigno and Benigno (2003), Gali and Monacelli (2005, 2008) study a model with log utility and a unit trade elasticity in which terms of trade effects have no long-run consequences for welfare.

5.1.1. Welfare Costs of Consumption Volatility. The following proposition describes how labor mobility affects consumption volatility in and out of a currency union under the assumptions of the simple model. (Note that we are maintaining our assumption that, outside the currency union, the monetary authority follows a price level targeting rule, $\tilde{P}_t^M = 0$).

Proposition 1. Welfare Costs of Consumption Variability in the Simple Model.

1. In the case of demand shocks only, consumption is more volatile under fixed exchange rates than under flexible exchange rates regardless of the degree of labor mobility, $\hat{\gamma} \in [0,\infty)$.
2. In the case of supply shocks only, consumption is less volatile under fixed exchange rates than under flexible exchange rates provided that labor is mobile, i.e., $\hat{\gamma} > 0$; if labor is immobile ($\hat{\gamma} = 0$) then consumption is equally volatile in and out of the currency union.
3. Greater labor mobility reduces consumption volatility both in the currency union and under flexible exchange rates.
4. **Mundell's Tradeoff**: Greater labor mobility reduces the cost of remaining in the currency union provided that demand shocks are sufficiently prevalent. Specifically, assuming that demand and supply shocks are uncorrelated, greater labor mobility reduces the welfare cost of the currency union if the following condition is satisfied:

$$\hat{\gamma}\omega^2 \frac{2(1+\vartheta)}{2\hat{\gamma}\Psi(1-\omega)+\Psi(1+\vartheta)+(1-\omega)} < \frac{\sigma_\omega^2}{\sigma_Z^2}$$

where $\Psi \equiv \frac{1-\omega+\Theta_p+\Theta_{w,p}}{1+\vartheta+\Theta_{w,p}}$.

Parts *(1)* and *(2)* of the proposition show that consumption is more volatile in the currency union than under flexible exchange rates if demand shocks are sufficiently prevalent. Price level targeting eliminates the effects of demand shocks on consumption but countries in a currency union must endure fluctuations in consumption. In contrast, maintaining a price level target amplifies the effect of supply shocks on consumption. Without any adjustment in monetary policy, positive supply shocks increase consumption and reduce prices. Maintaining a price level target requires the monetary authority to expand the money supply, further expanding consumption. Thus, in the presence of supply shocks, price level targeting amplifies consumption volatility and implies that consumption is more stable in the currency union.

Part *(3)* states that greater labor mobility always reduces consumption variability. Intuitively, workers base their migration decisions on consumption differentials. As a result, a higher migration elasticity reduces the degree of consumption differentials that can prevail in equilibrium. In the limiting case of perfect labor mobility, consumption would be constant. This occurs for both the currency union and for independent monetary policy however. Part *(4)* provides a condition under which Mundell's hypothesis holds. Intuitively, the proposition says that as long demand shocks are sufficiently prevalent – i.e., as long as consumption volatility is lower outside the union than inside the union – increased labor mobility reduces consumption volatility by more for a country inside the union than for a country outside the union. Put differently, labor mobility reduces the cost of being in the union. In an extreme case, if there were only demand shocks, then price level targeting would completely eliminate consumption fluctuations under floating exchange rates and labor mobility would reduce the cost of remaining in the union by reducing consumption volatility inside the union.

5.1.2. Welfare costs of inflation. Naturally, by maintaining a price level target, the monetary authority can fully eliminate price fluctuations and thus fully eliminate the welfare costs of price and wage volatility. It follows that the cost of remaining in the currency union depends only on the variance of price and wage inflation in the currency union. The following proposition charaterizes the relationship between labor mobility and the welfare costs of inflation.

Proposition 2. Welfare Costs of Inflation Variability in the Simple Model.

1. The welfare costs of price and wage volatility are positive in the currency union. There are no welfare costs of price and wage volatility under flexible exchange rates.
2. **Mundell's Tradeoff**: Within the currency union, greater labor mobility reduces the welfare costs of price and wage volatility if demand and supply shocks are uncorrelated, and if demand shocks are sufficiently prevalent. Specifically, greater labor mobility reduces the welfare cost of the currency union if the following condition is satisfied:

$$\frac{\hat{\gamma}\omega^2}{\Psi} < \frac{\sigma_\omega^2}{\sigma_Z^2}.$$

Part (*1*) states, almost trivially, that a policy of strict inflation targeting completely eliminates inflation and the associated welfare costs. The lack of stabilization policy in a currency union, instead, entails welfare costs from price and wage volatility. Part (*2*) of the proposition shows that labor mobility reduces these welfare costs if demand shocks are sufficiently prevalent. This result follows directly from our discussion of Figure 7: A positive demand shock puts upward pressure on prices, but in-migration limits the price increase and reduces inflation volatility. On the other hand, a positive supply shock puts downward pressure on prices, which is amplified from an influx of migrants, raising inflation volatility and raising costs. The proposition provides a condition under which the benefits of labor mobility outweigh their costs. Intuitively, if demand shocks account for relatively more business cycle variation than do supply shocks, Mundell's hypothesis holds in the simple model.

Note that both propositions imply that when demand shocks account for relatively more business cycle variation than supply shocks, Mundell's hypothesis holds. Below, we will find that this intuition carries over to the results based on the full quantitative model.

6. MODEL SOLUTION AND ESTIMATION

The model is expressed at a quarterly frequency and is calibrated to match the euro area sample of 18 countries. Given a set of parameters, we solve the model using a first-order approximation around a zero inflation steady state. We partition the parameters into a set of calibrated parameters and a set of estimated parameters. Parameters that have commonly accepted values used in the international business cycle literature or parameters that have direct analogues in the data (e.g., trade shares, country sizes, etc.) are calibrated accordingly. Taking the calibrated parameters as given, we estimate the remaining five parameters.

6.1. *Calibrated Parameters*

Table 1 lists the calibrated parameter values for our baseline specification.

Households, Population and Migration The discount factor is set to $\beta = 0.99$, which implies an annual real interest rate of 4 percent. The intertemporal elasticity of substitution is set to $\sigma = 0.5$. We implicitly adjust the labor tax rates τ_i^w such that the share of total consumption in aggregated consumption accounted for by workers is $\frac{\mathbb{N}_i^w c_i^w}{\mathbb{N}_i C_i} = 0.5$ in steady state. This corresponds to the fraction of hand-to-mouth consumers in Campbell and Mankiw (1989) and is consistent with the calibration in Martin and Philippon (2017) for euro area countries and estimates on marginal propensities to consume of about 0.5 (Johnson et al., 2006; Jappelli and Pistaferri, 2014; Fagereng et al., 2021).

Data on population $\mathbb{N}_i^w$ is taken from Eurostat. The migration cost parameters τ_j^i enter the system of log-linearized equations only through their effect on bilateral migration shares n_j^i. Instead of explicitly solving for the migration cost parameters, we directly condition on the observed bilateral matrix of migration shares.[26] The location parameters are set to equalize steady-state utilities for each location, $\varphi_i = \left(c_i^w\right)^{\frac{1}{\sigma}-1}$.[27]

We set the wage rigidity parameter to $\theta_w = 0.87$, consistent with estimates by Druant et al. (2012) and Grigsby et al. (2021). We use Eurostat data on unemployment rates to calibrate ur_i for each country. For the average country in our sample, the unemployment rate is 9.5 percent.

Firms, Production and Trade We set $\alpha = 0.30$ to match a labor income share $\frac{wL}{GDP} = (1-\alpha)\frac{\psi_m - 1}{\psi_m}$ of 0.63 (Karabarbounis and Neiman, 2013), given an elasticity of substitution between material input varieties of $\psi_m = 10$ (Basu and Fernald, 1995; Basu and Kimball, 1997). Capital depreciates at 8 percent per year. We set the Calvo pricing parameter to approximate observed frequencies of price adjustment from 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).

The baseline trade elasticity is $1 + \vartheta = 1.5$, which is often used in international business cycle models (see e.g. Backus et al., 1994).[28] The elasticity of substitution between non-traded and traded goods is set to $\psi_y = 0.44$ (Stockman and Tesar, 1995). Trade costs

26. This requires a complete bilateral matrix. For most country pairs, at least one of the two countries reports data. However, we are missing data for a small number of country pairs. We impute the missing flows based on a gravity equation framework. Appendix Section A.2 provides more details on this procedure as well as a table with the exact bilateral migration flows (Table A12).

27. This setting ensures that a 1% deviation in consumption has the same effect on migration for all countries.

28. Estimates of the trade elasticity range from 0.5 to as high as 6. Head and Mayer (2014) cite high values for studies that exploit *cross-country* variations in tariffs across finely disaggregated goods (see also Fontagné et al., 2022). Because the focus of our paper is on business cycle fluctuations, estimates that use *time-series* variation in tariffs or exchange rates are more relevant. Those estimates tend to be quite low, especially in the short run (Boehm et al., 2023).

TABLE 1: Calibration. Values marked with c.s. are country- or country-pair specific (see the Appendix for specific values). TiVA: Trade in Value Added Database.

Parameter		Value	Target / Source
Households, Population and Migration			
Discount factor	β	0.99	Standard value
Intertemporal elasticity of substitution	σ	0.5	Standard value
Share workers' consumption	$\bar{\mathbb{N}}_i^w \bar{c}_i^w / (\bar{\mathbb{N}}_i \bar{C}_i)$	0.5	Martin and Philippon (2017), Johnson et al. (2006) Fagereng et al. (2021), Jappelli and Pistaferri (2014)
Relative population	$\bar{\mathbb{N}}_i^w / \left(\sum_j \bar{\mathbb{N}}_j^w\right)$	c.s.	Eurostat ('95-'15), see Table A10
Location preference parameter	φ_i	c.s.	$\varphi_i \left(\bar{c}_i^w\right)^{1-\frac{1}{\sigma}} = 1$
Bilateral migration flows	$\bar{n}_j^i$	c.s.	Migration database based on authors' calculation, see Table A12
Nominal wage rigidity	θ_w	0.86	Druant et al. (2012)
Unemployment rate	$\bar{ur}_i$	c.s.	Eurostat ('95-'15), see Table A10
Firms, Production and Trade			
Elasticity of substitution bw. materials	ψ_m	10	Basu and Fernald (1995), Basu and Kimball (1997)
Curvate of production function	α	0.3	Labor income share of 0.63 for Germany Karabarbounis and Neiman (2013)
Depreciation rate	δ	0.02	Annual depreciation rate of 8 percent
Sticky price probability	θ_p	0.77	Price duration: 13 months (Alvarez et al., 2006)
Trade elasticity	$1+\vartheta$	1.5	e.g. Cravino (2017); Boehm et al. (2023)
Penalty term	ι	1e-4	Standard value
Elasticity of substitution bw. Y^N and Y^T	ψ_y	0.44	Stockman and Tesar (1995)
Preference weight non-traded good	$\bar{\omega}_i$	c.s.	Share non-traded goods in final demand; OECD TiVA (2005-2015), see Table A10
Bilateral trade shares of traded goods	$\bar{\varpi}_i^j$	c.s.	Import shares for traded goods; OECD TiVA (2005-2015), see Table A11
Country size	$\bar{\mathbb{N}}_i \bar{Y}_i / \left(\sum_j \bar{\mathbb{N}}_j \bar{Y}_j\right)$	c.s.	Total demand; OECD TiVA (2005-2015), see Table A10
Fiscal and Monetary Policy			
Gov't purchases over final demand	$\bar{G}_i / \bar{Y}_i$	c.s.	Eurostat ('95-'15), see Table A10
MP rule persistence	ϕ	0.75	Clarida et al. (2000)
MP rule unemployment coefficient	ϕ_u	-1.40	Mankiw (2001)
MP rule inflation coefficient	ϕ_π	1.40	Mankiw (2001)

κ_i^j and the Fréchet parameters Z_i^T are set implicitly to match trade flows relative to each country's domestic spending using OECD data on trade in value added. The same data allows us to calculate the steady-state share of non-traded goods in a country's total demand, ω_i, and a country's overall size, measured by total demand, $\mathbb{N}_i Y_i$. For the average country in our sample, non-traded goods constitute about 37 percent of overall demand and imports make up roughly 31 percent of of GDP.

Fiscal and Monetary Policy We set the steady-state ratio of government purchases to GDP to the observed value in each country. The monetary policy rule (4.27) is parameterized as $\phi=0.75$, $\phi_u=-1.4$ and $\phi_\pi=1.4$, in line with Mankiw (2001).

6.2. *Estimated Parameters*

We estimate the variance of the idiosyncratic location preference shocks ($\frac{1}{\gamma}$), the investment adjustment cost parameter (f''), the utilization adjustment cost parameter (a'') and the two persistence parameters (ρ_ω and ρ_Z). Given an initial guess for $\left[\gamma,f'',a'',\rho_\omega,\rho_Z\right]$, we choose realizations of preference and productivity shocks ($\epsilon_{i,t}^{\omega}$ and $\epsilon_{i,t}^{Z}$) to match unemployment differentials and consumption differentials for every country.[29] The model then generates the remaining endogenous variables. Our parameter estimates are chosen to match the following seven euro-area moments: (i) the OLS slope coefficient of net migration on unemployment in equation (3.5), (ii) the volatility (standard deviation) of investment relative to the volatility of GDP, (iii) the volatility of utilization relative to the volatility of GDP, (iv) the autocorrelation of GDP, (v) the contemporaneous correlation of GDP and the unemployment rate and (vi and vii) the autocorrelation of the two structural innovations ($\epsilon_{i,t}^{\omega}$ and $\epsilon_{i,t}^{Z}$).

We target the population-weighted average volatilities of the double-demeaned data (we also double-demean the data generated by the model). We double-demean variables that have a trend (e.g. GDP) by first taking logs, then removing a country-specific linear trend and finally adjusting the log deviations from this linear trend by subtracting a weighted average of deviations for all of the countries in our sample.

The slope coefficient of regression (3.5) is the most important moment to target since it summarizes the relationship between labor mobility and unemployment in the euro area. We target the standard deviation of investment to GDP and utilization to GDP because these moments are important for determining the investment adjustment costs and the capital utilization elasticity. We target the persistence of GDP overall and the correlation of GDP with the unemployment rate to ensure that the model matches overall business cycle features. Finally, we also target the persistence of the structural innovations ($\epsilon_{i,t}^{\omega}$ and $\epsilon_{i,t}^{Z}$). Under the null hypothesis that the model is correctly specified, these innovations should have zero serial correlation. Because we are targeting seven moments to estimate only five parameters, we are technically over-identified and thus the model moments will not exactly match the moments in the data.

29. Note that while our empirical analysis was based on annual data, we calibrate our model at a *quarterly* frequency. We recover the innovations ϵ_t^{ω} and ϵ_t^{Z} to match the quarterly unemployment rate and consumption differentials.

6.3. *Model and Data Comparison*

Table 2 shows the measures of model fit for the seven targeted moments described above as well as other business cycle moments. By double-demeaning the data, we remove country and time fixed effects leaving just country-specific variation. Similarly, the shocks in the model are idiosyncratic, country-specific innovations. We refer to the country-specific fluctuations in the data and in the model as “business cycle” fluctuations with the understanding that the common component of the business cycle has been removed. Recall that Figure 4 showed that only about a fifth of unemployment variation in the euro area can be attributed to a common cycle and that the majority of unemployment variation is country-specific.

Column (1) reports the (population-weighted) moments in the data, column (2) reports results for the baseline model and columns (3) and (4) show results for the model with only preference shocks (ω) and only productivity shocks (Z^N) (we hold the estimated parameters fixed in those specifications.)

The table shows that the estimated model does a good job matching key business cycle moments in the euro area. This suggests that the model should serve as a reasonable framework to evaluate the relative effects of exchange rate flexibility and labor mobility. Columns (3) and (4) also indicate that both shocks are needed to match the data. Demand shocks (ω) produce greater fluctuations in unemployment and migration compared to TFP shocks. TFP shocks (Z^N) are necessary for generating sufficiently volatile, procyclical investment rates and countercyclical net exports. TFP shocks also play an important role in producing inflation and investment volatility. Demand and supply shocks have different implications for inflation; as foreshadowed by the simplified model in Section 5.

7. EFFECTS OF LABOR MOBILITY IN A CURRENCY UNION

We are interested in whether labor mobility is indeed an effective substitute for independent monetary policy in the euro area. To get at this question, we use the estimated model to explore different counterfactuals – in particular, we solve the model assuming the countries either have independent monetary policies or have higher migration rates. In each scenario, we use the same sequence of shocks as in the baseline model. To simulate the counterfactual with greater labor mobility, we adjust γ to match the U.S. slope coefficient from our regression of net migration on unemployment (-0.26 rather than -0.08, see Figure 5). In simulations with flexible exchange rates, we assume that each country pursues an independent monetary policy following (4.27). We begin by examining business cycle outcomes, we then present a utility-based welfare measure, and we conclude with a discussion of the economic reasoning for our findings.

7.1. *Stabilizing Fluctuations in Production and Employment*

Table 3 presents results for five scenarios. The first panel of the table shows the volatility of per capita variables and the second panel shows the volatility of aggregate variables. Columns (1), (2) and (3) report model simulations with the baseline rate of labor mobility but under different assumptions about monetary policy and price adjustment. The baseline case in column (1), labeled “Fixed,” reflects current conditions in the euro area with a fixed exchange rate and an average migration elasticity that matches the data. The slope coefficient on net migration is -0.08 and the volatility of unemployment is

TABLE 2

Estimation. Moments are calculated based on double-demeaned quarterly data (except moments that refer to net migration, which refer to annual data; in that case, we time-aggregate the simulated quarterly data). The displayed moments are calculated as the weighted average across countries. See Appendix Sections A and C.7.3 for data sources.

Description	Data	Model		
		Both shocks	Only ω	Only Z^N
Estimated Parameters				
Migration propensity (γ)		0.20	0.20	0.20
Investment adjustment cost (f'')		1.37	1.37	1.37
Utilization adjustment cost (a'')		0.02	0.02	0.02
Persistence preference weights (ρ_ω)		0.96	0.96	0.96
Persistence TFP shocks (ρ_Z)		0.88	0.88	0.88
Targeted Moments				
Slope coefficient $\widehat{nm}_{i,t}$ on $\widehat{ur}_{i,t}$	−0.08	−0.08	−0.05	−0.05
Volatility investment to GDP	3.63	3.55	1.20	4.00
Volatility utilization to GDP	0.98	1.02	1.00	1.13
Persistence GDP	0.95	0.94	0.93	0.95
Corr. GDP and unempl.	−0.63	−0.59	−0.88	−0.52
Persistence $\varepsilon^Z_{i,t}$	0.00	0.09	0.00	0.09
Persistence $\varepsilon^\omega_{i,t}$	0.00	0.35	0.35	0.00
Other Moments				
Time-Series Standard Deviation				
Unemployment rate	2.28	2.28	2.41	0.78
Consumption per capita	2.87	2.87	2.02	2.04
Investment per capita	8.05	13.51	2.60	12.53
GDP per capita	2.45	3.86	2.19	3.06
GDP	2.59	3.97	2.22	3.15
Inflation	2.20	2.72	0.62	2.73
Net exports over GDP	1.25	1.01	0.46	1.19
Net migraton rate	0.26	0.17	0.15	0.09
Persistence				
Net exports over GDP	0.89	0.97	0.97	0.96
Investment per capita	0.87	0.96	0.97	0.96
Net migration rate	0.65	0.79	0.83	0.74
Correlation with GDP				
Consumption per capita	0.81	0.95	0.93	1.00
Investment per capita	0.84	0.79	0.44	0.99
Net exports over GDP	−0.43	−0.53	0.47	−0.81
Inflation	0.07	0.04	0.85	−0.03

TABLE 3

Mundell's Tradeoff. The table displays several moments as observed in the data (1995 - 2018) and derived from alternative model simulations. Data moments are based on double-demeaned data. The weighted average across countries is displayed. For the high mobility case, we adjust the migration parameter (γ) to match the slope coefficients for the United States. For the floating exchange rate case, all countries follow a Mankiw rule. Inflation measures record annualize rates. The last row displays the cost of the currency union, calculated as the welfare cost under fixed exchange rates less the welfare cost under floating exchange rates.

	Baseline mobility			High mobility	
	(1)	(2)	(3)	(4)	(5)
	Fixed	Float	Flex	Fixed	Float
Panel A: Volatility, Per-Capita Variables (%)					
Unemployment rate	2.28	0.29	0.00	2.03	0.29
GDP per capita	4.68	3.76	3.79	4.23	3.73
Consumption per capita	2.87	2.08	2.11	2.27	1.80
Net migration	0.18	0.16	0.15	0.72	0.64
Panel B: Volatility, Aggregate Variables (%)					
GDP	4.47	3.83	3.90	5.23	5.06
Consumption	3.38	2.84	2.80	4.66	4.33
Panel C: Volatility Measures for Welfare (%)					
Consumption volatility workers	4.60	2.90	3.06	4.02	2.77
Consumption volatility capital owners	3.66	3.26	3.14	5.45	5.05
Wage inflation	0.92	0.37	1.58	0.79	0.40
Material price inflation	0.89	0.50	1.60	0.86	0.56
Panel D: Welfare Costs (% of consumption)					
Consumption volatility workers	0.29	0.13	0.15	0.22	0.11
Consumption volatility capital owners	0.19	0.15	0.14	0.39	0.36
Wage inflation	0.31	0.04	0.00	0.22	0.05
Material price inflation	1.30	0.35	0.00	1.21	0.44
Total	1.85	0.53	0.14	1.74	0.73
Panel E: Cost of Currency Union					
Total	1.31	–	–	1.01	–
Total (Only demand shocks)	1.36	–	–	1.02	–
Total (Only supply shocks)	0.32	–	–	0.41	–

2.28 as in the data. Column (2), labeled "Float," reports the results for baseline mobility but with independent monetary policy and floating exchange rates. Column (3), labeled "Flex," is the baseline model but with flexible wages and prices. Columns (4) and (5) show results for the model (fixed and floating) with rates of labor mobility similar to the United States with a slope coefficient on net migration of -0.26.

To see the impact of labor mobility, we can compare the baseline in column (1) to the higher labor mobility case in column (4). Increased labor mobility stabilizes unemployment, per capita GDP and per capita consumption, but makes aggregate GDP and aggregate consumption more volatile. To understand this result, consider the impact of a worker moving from a high unemployment country to a low unemployment country. The worker increases labor supply in the destination country, which raises both aggregate output and aggregate consumption. The reverse happens in the country of origin, and the net result is an increase in the dispersion of macroeconomic aggregates across the euro area. Per capita output becomes less dispersed due to decreasing returns to scale in labor – output changes by less than the change in the population.

Next consider a shift from fixed exchange rates in (1) to floating exchange rates in (2). Floating exchange rates reduce macroeconomic volatility, both at the aggregate level and per capita. For instance, the volatility of unemployment falls from 2.28 to 0.29 and the volatility of per capita consumption falls from 2.87 to 2.08. Note that by allowing exchange rates to adjust, the floating regime in (2) comes close to matching the flexible-price allocations in (3).

The Mundellian hypothesis that labor mobility can take the place of floating exchange rates can be evaluated by comparing the shift to floating exchange rates (moving from column (1) to column (2)) relative to the shift to greater labor mobility (moving from column (1) to column (4)). If labor mobility were a perfect substitute for independent monetary policy, columns (2) and (4) would be identical. Based on our estimates, both higher mobility and flexible exchange rates work to reduce fluctuations in unemployment and per capita macroeconomic variables. In contrast, flexible exchange rates and labor mobility have different consequences for aggregate variables. Flexible exchange rates reduce fluctuations in macroeconomic aggregates by effectively dampening the business cycle. Labor mobility leans into the business cycle, increasing the volatility of macroeconomic aggregates.

Figure 8 shows that the basic pattern in Table 3 holds for most of the countries in the euro area. The dark bars display the volatility of the unemployment rate in the baseline model and correspond to (the square root of) the idiosyncratic variance displayed in Figure 4. For each country, the volatility of unemployment in the baseline falls with higher migration. The reductions are greatest for Belgium and Ireland – each of which experience reductions in unemployment volatility of more than 20 percent. For the typical country however, the stabilizing role of migration is more modest with reductions in unemployment volatility of about 10 percent. In all cases, floating exchange rates dramatically reduce unemployment volatility relative to the baseline.

7.2. *Welfare Cost of a Currency Union*

We next turn to quantifying the welfare costs of maintaining a currency union under different degrees of labor mobility. As we did in the simple model in Section 5, we restrict our attention to the welfare costs associated with consumption variability and inefficient wage and price inflation variability. Equation (7.29) gives the percent change in the aggregate consumption good required to make residents of country i indifferent between the stochastic equilibrium in the benchmark model and the stochastic equilibrium

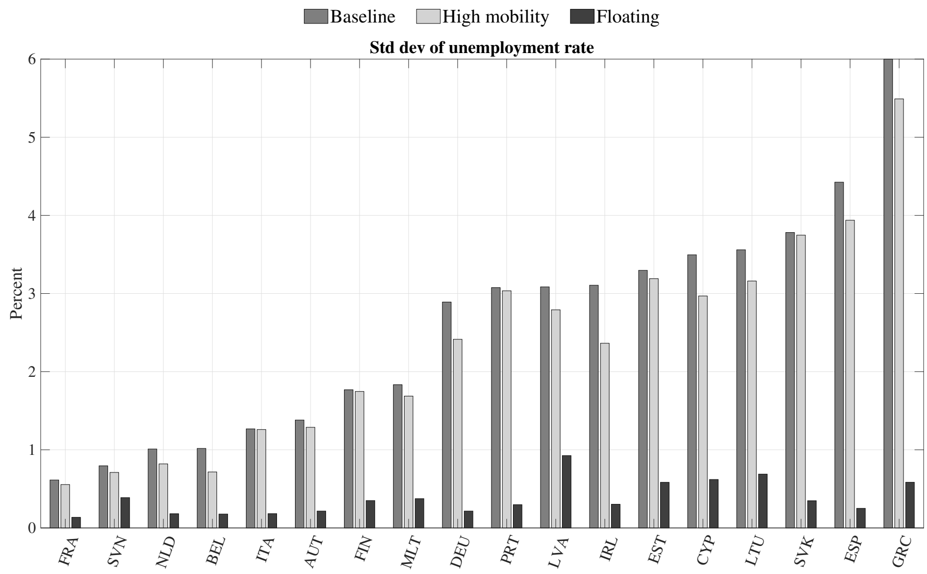


Figure 8

Unemployment Volatility by Country. The figure displays the standard deviation of the unemployment rate in the baseline model, the high-mobility counterfactual and the floating exchange rate counterfactual.

associated with an alternative policy (i.e., dC_i/C_i is the compensating variation).

$$\frac{dC_i}{C_i} = \frac{1}{2}\frac{1}{\sigma}\left[\frac{\mathbb{N}_i^w c_i^w}{\mathbb{N}_i C_i} d\mathbb{V}(\tilde{c}_i^w) + \frac{\mathbb{N}_i^k c_i^k}{\mathbb{N}_i C_i} d\mathbb{V}\left(\tilde{c}_i^k\right)\right] + \frac{1}{2}\frac{Y_i}{C_i}\left[\psi_m \Theta_p d\mathbb{V}(\pi_i) + (1-\alpha)\Theta_w d\mathbb{V}(\pi_i^w)\right] \tag{7.29}$$

where $\Theta_p = \frac{\theta_p}{(1-\theta_p\beta)(1-\theta_p)}$, $\Theta_w = \frac{\theta_w}{(1-\theta_w\beta)(1-\theta_w)}$, and $\tilde{c}_{i,t}$ is the date t consumption percent deviation of consumption relative to the non-stochastic steady state.

In deriving this expression (see Appendix C.8), we assume that national welfare includes the utility of workers located in each country, irrespective of when they arrived. We take a weighted average of the utility of capital owners and workers, where the Pareto weights are chosen so that the marginal benefit of additional consumption for workers and capital owners is equal in the steady state. Similar to the welfare measure we considered in Section 5, this welfare measure abstracts from potential second-order changes in long-run capital accumulation, population levels, unemployment rates and long-run asset accumulation that could arise in the stochastic equilibrium under different monetary policies.

Welfare in a Currency Union with Labor Mobility. To calculate the variances in the expressions above, we use the recovered shocks from our estimation procedure. This means the variances reflect the business cycle conditions that prevailed during our sample period. By using these shocks, we can sidestep the estimation of the variance-covariance matrix of shock innovations. Table 3 reports the population-weighted average of the statistics from the model.

Panel C of Table 3 reports the volatility measures used in the welfare calculations in (7.29). These statistics are the standard deviations of the percent difference between the macroeconomic variable in the model and its non-stochastic steady state value. The first two rows report the volatility of consumption of workers and of capital owners. The final two rows report the volatility of wage and price inflation. A comparison of columns (1) and (4) shows the impact of increased mobility within the currency union. We see that consumption volatility for workers declines with greater mobility, while volatility increases for capital owners. Intuitively, higher mobility stabilizes labor income and hence workers' consumption. In contrast, capital income (and hence, capital owners' consumption) becomes more volatile because workers leave already depressed regions.

Panel D reports the per capita cost (as a percent of steady state consumption) of each component of equation (7.29). The last row reports the total welfare cost. The welfare costs from consumption variability are small while the welfare costs associated with inflation are substantial. This is a standard finding in New Keynesian models (Rotemberg and Woodford, 1997; Galí, 2008; Coibion et al., 2012). The cost of consumption volatility for workers is only 0.29 percent in the baseline and 0.19 for the capital owners. In contrast, the welfare costs of wage and price inflation is 1.61 percent of annual consumption (1.30+0.31).

Mundell's hypothesis is that cross-country labor reallocation can substitute for an independent monetary policy. There are two ways to see this in Table 3. Comparing column (1) with column (2) shows that independent monetary policy reduces business cycle volatility in the baseline. Floating exchange rates reduce the volatility of per capita GDP and cut the volatility of both inflation measures by roughly 50 percent. The welfare cost of business cycles declines from 1.85 to 0.53. A comparison of column (1) with column (4) shows how the cost of business cycle volatility changes due to higher migration. Migration reduces business cycle costs from 1.85 to 1.74. While higher labor mobility improves welfare, plausible rates of labor reallocation are not enough to make up for the lack of independent monetary policy.

The disadvantage of this comparison is that we are comparing a policy choice (independent monetary policy) with labor migration, which is not a typical policy tool. A different way of thinking about Mundell's hypothesis is to ask how the cost of giving up independent monetary policy is affected by the amount of labor mobility. The cost of giving up monetary policy in the baseline (low mobility) case is 1.31 percent of aggregate consumption. The cost of not having independent monetary policy in the high mobility case (column 4 versus column 5) is 1.01. Thus, in line with Mundell's hypothesis, for the average country in the euro area, higher labor mobility reduces the opportunity cost of being in the union.

The simple model in Section 5 showed that a key determinant of whether labor mobility could substitute for flexible exchange rates was the relative exposure to supply and demand shocks as they have different implications for inflation. Labor mobility exacerbated inflation in the face of supply shocks and tempered inflation in the face of demand shocks. This effect is present in the quantitative model as well. If the only shocks driving business cycles are demand shocks, then the benefits of labor mobility are more significant (Panel E). If the only shocks are supply shocks however, greater labor mobility actually makes giving up monetary independence even more costly.

Similar results are borne out when we turn to the welfare results for individual countries. Figure 9 shows the welfare measures for each country separately. While we saw above that increased migration reduces unemployment volatility in all countries, Figure 9 shows that not all countries experience an increase in welfare. Two of the largest countries in the euro area, Germany and Spain, experience large welfare gains from greater labor mobility. Gains are also positive for Greece, Portugal, Malta, Belgium

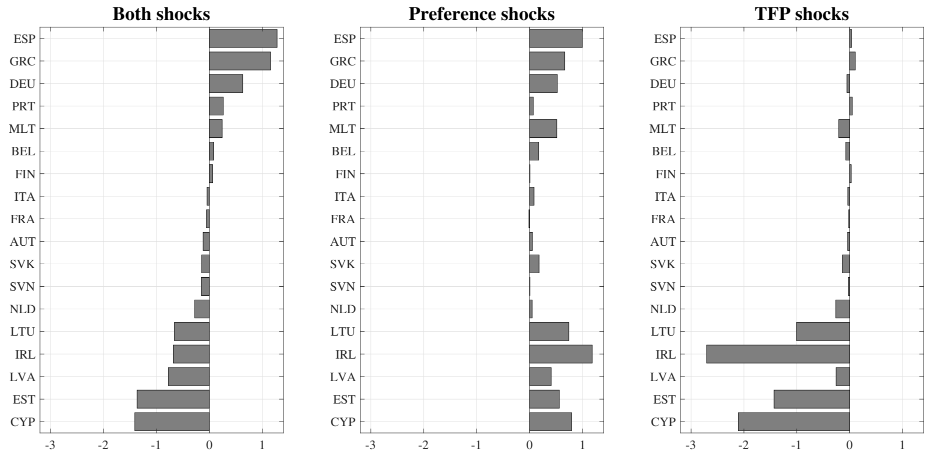


FIGURE 9

Gains from Mobility by Country. The figure displays the gains from mobility defined as the opportunity cost of the union in the baseline model less the opportunity cost of the union in the high-mobility counterfactual. The opportunity cost of the union is defined as the welfare cost in the union less the welfare cost under floating exchange rates. Results are displayed for the case when both shocks are included, only preference shocks are included or only TFP shocks are included.

and Finland. On the other hand, several countries in the euro area experience significant welfare losses from greater migration, particularly very small countries on the periphery (Cyprus, Ireland and the Baltics, for example).

The middle panel in Figure 9 shows the welfare improvements of high migration if the countries experienced only preference shocks (shocks to $\omega_{i,t}$). In this case, every country benefits from higher migration. The rightmost panel shows the opposite case in which countries experience only productivity shocks ($Z^N_{i,t}$). In this case, almost all countries suffer. Spain, Germany and Greece are dominated by preference shocks and thus labor mobility improves welfare by stabilizing inflation. Cyprus, Ireland and the Baltics however tend to experience TFP shocks and welfare declines with greater mobility as inflation becomes more volatile. Again, supply shocks present a problem for Mundell's argument and, according to our estimates, many countries in the euro area are buffeted by productivity disturbances.

Country differences in evaluating Mundell's trade-off do not only depend on differences in exposure to supply and demand shocks. As shown in the propositions in Section 5.1, differences in structural parameters across countries also affect the potential gains from labor mobility. The model captures some differences in structural parameters, such as trade and migration patterns, population size, labor market frictions and the size of the government sector. Additionaly, Mundell's trade-off for any specific country does not only depend on its own supply and demand shocks, but also the types of shocks experienced by its trading partners.

The results in Table 3 are all contingent on the monetary policy rule in our baseline specification – a "Mankiw rule" in which the monetary authority targets material price inflation and the unemployment rate. Table **??** shows how the welfare calculations change as we change the specification of monetary policy. In the table, we consider, besides the baseline Mankiw rule, three alternative rules that put a very high weight on either material price inflation, unemployment or wage inflation. For each monetary policy rule,

TABLE 4

Alternative Monetary Policies. Mankiw rule: $\phi_{ur} = -1.4$ and $\phi_\pi = 1.4$. Inflation targeting: $\phi_{ur} = 0$ and $\phi_\pi = 1000$. Unemployment targeting: $\phi_{ur} = 100$ and $\phi_\pi = 1.4$. Wage inflation targeting: $\phi_{ur} = 0$ and $\phi_w = 1000$.

	Both shocks		Only ω shocks		Only Z^N shocks	
	Base	High	Base	High	Base	High
Currency union						
Welfare cost	1.85	1.74	1.75	1.60	0.57	0.82
Mankiw rule						
Welfare cost	0.53	0.73	0.38	0.58	0.25	0.41
Cost of union	1.31	1.01	1.36	1.02	0.32	0.41
Inflation targeting						
Welfare cost	0.22	0.31	0.12	0.23	0.30	0.45
Cost of union	1.62	1.43	1.63	1.37	0.27	0.38
Unemployment targeting						
Welfare cost	0.26	0.34	0.12	0.24	0.29	0.40
Cost of union	1.59	1.40	1.62	1.35	0.28	0.42
Wage inflation targeting						
Welfare cost	0.26	0.33	0.12	0.24	0.29	0.40
Cost of union	1.59	1.40	1.63	1.36	0.28	0.42

we calculate the welfare cost of the business cycle fluctuations and the cost of union by subtracting the welfare costs from those incurred in a currency union (row 1).

The table shows that strict inflation targeting is preferable to the other rules as it eliminates almost all of the costs of business cycles. This is perhaps not surprising given the body of New Keynesian theory that emphasizes inflation stabilization as a universal remedy for addressing business cycle fluctuations. While the quantitative cost of giving up independent monetary policy differs across specifications, the cost of the currency union falls with greater mobility in all cases and Mundell's hypothesis holds for all of these policy rules. Consistent with our previous results, the cost of the currency union increases with mobility when supply shocks are more prevalent.

8. CONCLUSION

Unemployment rates differ widely across the euro area, raising concerns about whether sharing a common monetary policy is sustainable without further reforms. In this paper, we examine Mundell's assertion that if factors are mobile across national boundaries, then a flexible exchange rate system becomes unnecessary. We ask whether increased labor mobility helps to offset the opportunity cost of giving up independent national monetary policies. Using country specific data on migration and unemployment we contrast the degree of cyclical labor mobility in the United States with labor mobility in the euro area. The data paint a clear picture: while migration flows clearly react to cyclical variations in unemployment rates in both the euro area and in U.S. states, labor reallocation is faster and three times larger in the United States.

Motivated by these facts we quantify the role of labor mobility in stabilizing business cycles in a multi-country DSGE model, augmented to include cross-country migration and labor market frictions that give rise to unemployment. The model is calibrated to match the main features of euro area countries including country size, migration patterns, and trade flows. The model features shocks to productivity and demand for each country's output. These shocks cause shifts in labor demand and, in turn, lead to flows of workers across countries. The model parameters are estimated to ensure that the simulated output matches the observed rates of labor mobility and business cycle fluctuations in the euro area.

We use the model to evaluate two counterfactuals: (i) an increase in the rate of labor mobility in the euro area to match U.S. rates, and (ii) a switch to independent monetary policy and flexible exchange rates. We calculate the costs of business cycles under each scenario and ask whether the opportunity cost of the currency union declines as labor becomes more responsive to business cycles. Our results caution against a simple answer. While, on average, labor mobility stabilizes unemployment rates (as does monetary policy), labor mobility increases the dispersion in aggregate output and consumption across the euro area. Labor mobility can also generate large changes in wage and price inflation. We find that there is substantial heterogeneity across the euro area in the assessment of the benefits of labor mobility, as that assessment depends on a country's exposure to different types of shocks.

This paper focuses specifically on the extent to which macroeconomic adjustment operates through increased labor mobility. There exist, of course, other margins of adjustment to asymmetric business cycles, such as higher trade flows, increased substitutability between home and foreign goods, increased integration of financial markets and coordinated fiscal policy. These margins of adjustment are beyond the scope of this paper. Our analysis suggests that increased labor mobility involves pros and cons that were not ex ante obvious. We suspect that similar subtleties would be present for other adjustment mechanisms and that the various margins of adjustment might interact in complex ways with each other. We leave this work for future research.

9. DATA AVAILABILITY STATEMENT

The data and code underlying this research is available on Zenodo at https://dx.doi.org/10.5281/zenodo.14518395.

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