Labor Mobility and the Level of Unemployment in a Currency Union

Erin P. Gibson
University of Michigan

Christopher L. House
University of Michigan and NBER

Christian Proebsting
KU Leuven

Linda L. Tesar
University of Michigan and NBER

September 11, 2024

Abstract

Unemployment rates are substantially higher and more volatile in the euro area relative to the United States. We ask to what extent the lack of cross-country labor mobility can account for unemployment dynamics in Europe. Our analytical model incorporates frictions in the labor market as well as an endogenous migration decision. Firms are unable to freely adjust wages during economic contractions, generating an asymmetric distribution of unemployment over the business cycle. The model is calibrated to the dynamics of unemployment and net migration in a typical euro area country. An increase in labor mobility to that observed in the United States and holding all other parameters fixed would reduce the volatility of euro area unemployment by 40% unemployment and return 1 million unemployed to the workforce. The welfare cost to a typical euro area country of the currency union is 4.7 percent of permanent consumption; increasing labor mobility reduces this cost to about 4.1 percent.

Keywords: labor mobility, unemployment, currency union

JEL Codes:

1 Introduction

Unemployment rates are persistently higher in Europe than they are in the United States. Figure 1 plots harmonized unemployment rates for the European union, the euro area and the United States for the period 1990 – 2022. With the exceptions of the sharp unemployment spikes in the United States during the Great Recession and the pandemic, European unemployment rates are uniformly higher than the U.S. rate. The average unemployment rates over the 1990:01 to 2023:01 period for the European union and the euro area are 9.4 and 8.7 respectively. Average unemployment for the United States over the 1990:01 to 2020:01 period is 5.8 percent.[1] There are many possible reasons for the generally high unemployment rates in Europe (termed "Eurosclerosis" by Giersch, 1985). Most often, the cause is attributed to European labor market rigidities caused by regulation and unionization. Such rigidities could hinder the ability of workers to relocate in response to changes in economic conditions.

In previous work, House, Proebsting and Tesar (2023), and Foschi et al. (2023) document the relatively higher rates of labor mobility in the United States compared to the euro area. In both currency areas, labor flows are correlated with local business cycles, with workers moving from regions with temporarily higher unemployment to regions with temporarily lower unemployment. However, the responsiveness of migration flows to local economic conditions is three times stronger in the United States than in the euro area. House, Proebsting and Tesar (2023) show that a higher level of labor mobility in the euro area would help stabilize unemployment and therefore serve as a substitute for independent monetary policy.

We return to the issue of migration in this paper, but shift the focus towards its effect on the *level* of unemployment observed in Europe rather than the effect on the cyclical variability of unemployment. While labor mobility can reduce the variance of unemployment differentials across regions, it is not clear that greater labor mobility would reduce the average unemployment rate. There are settings in which this happens – in particular, models that feature asymmetric business cycles with frequent shortfalls in production and employment but relatively infrequent instances of overproduction, have the property that business cycle stabilization implies an increase in average employment.

To quantify the extent to which low labor mobility in Europe results in higher average

[1]We exclude the COVID-19 period for the United States because the unprecedented, short-lived spike in the U.S. unemployment rate during the pandemic is due to lockdowns. The stable unemployment rate in the euro area during the pandemic was by design – governments implemented job retention policies that kept workers connected to firms. For a discussion, see Klitgaard (2022).

unemployment, we utilize a "plucking" model of the business cycle. The plucking model was initially suggested by Friedman (1964) and more recently advocated by Dupraz, Nakamura and Steinsson (2023). Importantly, plucking models feature asymmetric cyclical variations in unemployment. In the standard business cycle framework, macroeconomic variables are assumed to fluctuate around a given trend. Friedman (1964) suggested an alternative perspective in which cycles are caused by random negative shocks that pull the economy below full employment but never cause overemployment. One might imagine a helium balloon bouncing along a ceiling. Every now and then, a negative shock pulls down on the balloon's string (i.e., a recession) after which the balloon gradually floats back to the ceiling (full employment). In this setting, anything that reduces the variance of the balloon's distance from the ceiling (e.g. labor mobility) will cause its average distance to the ceiling diminish (in the limit with zero variance, the balloon simply comes to rest at the ceiling with a distance of zero).

Our analytical framework incorporates frictions in the labor market as well as an endogenous migration decision in a small open economy. We follow Schmitt-Grohé and Uribe (2016) (SGU) in modelling labor market frictions as an inability of firms to freely reduce nominal wages during economic contractions[2]. In our setup, workers consider the risk of unemployment and the anticipated wage rate in alternative locations and, subject to relocation costs, can move in response to local shocks (Caliendo, Dvorkin and Parro, 2019). The model is calibrated to match broad business cycle properties and the degree of labor mobility for a typical country in the euro area.

The model is successful in reproducing the dynamics of unemployment over the business cycle in some dimensions and less successful in other dimensions. The model generates a relationship between the mean level of unemployment and the variance of unemployment. The model also matches the correlation between net migration in a typical euro area country with the unemployment rate. The model generates some asymmetry in unemployment rates over the cycle, but does not generate the significant gap between the duration of expansions and contractions highlighted by Dupraz, Nakamura and Steinsson (2023).

We use the model to examine the effect of increasing labor mobility in Europe. In the counterfactual, the extent of labor mobility is expanded to match that of the United States. Increasing labor mobility reduces both the volatility and the level of unemployment. The

[2]For recent empirical evidence on the prevalence of downward nominal wage rigidity, see e.g., Babecky et al. (n.d.), Caju, Fuss and Wintr (2007), Elsby and Solon (2019), Grigsby, Hurst and Yildirmaz (2021), Jo (2021), Schaefer and Singleton (2022).

volatility of aggregate output increases while the duration of expansions and contractions both decrease. In effect, the additional margin of adjustment that comes with the option to migrate eases the constraint on wage adjustment, weakening the features of the model that generate significant asymmetries. For realistic calibrations, average unemployment rates for euro area economies falls by at most one half of one percent with greater labor mobility.

In the final section of the paper, we solve for the welfare costs of being in the currency union, under the conditions of downward wage rigidity and limited labor mobility. The cost of being in the currency union in the baseline case is approximate 5 percent of permanent consumption. Increased labor mobility reduces the cost to just under 4 percent of permanence consumption.

The idea that downward nominal wage rigidity in combination with suboptimal monetary policy (such as a fixed exchange rate) can generate higher average levels of unemployment has gained traction among macroeconomists and trade economists (Schmitt-Grohé and Uribe, 2016; Dupraz, Nakamura and Steinsson, 2023; Rodríguez-Clare, Ulate and Vasquez, 2022). Rodríguez-Clare, Ulate and Vasquez (2022) show that DNWR can rationalize the increase in unemployment in U.S. states that were particularly exposed to stronger import competition from China. Similar to House, Proebsting and Tesar (2023), their discussion of labor mobility is limited to its effect on the dispersion in unemployment. In contrast, we focus on its effects on the average level of unemployment and ask how labor mobility can mitigate the costs of suboptimal monetary policy. This complements the discussion in Schmitt-Grohé and Uribe (2016) who show that capital controls also reduce the average level of unemployment by preventing overborrowing and strong nominal wage increases during booms.

2 Empirical Patterns

In this section, we present evidence on unemployment dynamics across the euro area and the United States. Unemployment dynamics in both regions are characterized by asymmetries consistent with the plucking narrative. On average, countries in the euro area have both more volatile and higher unemployment rates compared to U.S. states. In both regions, countries or states with more volatile unemployment rates also have higher mean unemployment rates, and this mean-variance relationship is similar across the two regions.

2.1 Data Sources

European unemployment data for individual countries are taken from the short-term labor force statistics reported by the International Labor Organization. The data are collected through the European labor force survey and are based on standard international definitions of unemployment. Unemployment rates are monthly, seasonally adjusted and cover the years 1990 to 2023, with some countries having shorter samples.

Data for aggregate and state-level unemployment in the United States are taken from the local area unemployment statistics reported by the Bureau of Labor Statistics. All data are monthly and seasonally adjusted. The series start in 1976 and we end the series at the onset of COVID in February 2020.

Data on migration in the euro area are drawn from Eurostat and are cross-checked against national sources. U.S. migration flows at the state level are based on publicly available data from the Internal Revenue Service (IRS). For detailed information on the definition and calculation of migration rates, see the discussion in House, Proebsting and Tesar (2023), and Foschi et al. (2023).

2.2 Unemployment Asymmetries

Figure 2 shows the time series of unemployment rates for individual European countries. Dark lines mark the peak of the business cycle expansion (the local minimum of the unemployment rate) and dotted lines show the onset of the recession (the local maximum of unemployment). To fix the dates of expansions and recessions we follow the algorithm developed by Dupraz, Nakamura and Steinsson (2023). The basic idea is to find local minima and maxima of the unemployment rates based on substantial swings in the unemployment rate (see the Appendix for details). As a reference point, we also repeat the exercise for each U.S. state. The U.S. figures are provided in the appendix.

The time series on unemployment rates in Figure 2 indicate that fluctuations in unemployment are not tightly sychronized across the euro area. The average of bilateral correlations between euro area countries is 0.49, in contrast with the cross-state correlation of 0.69. The figures are also suggestive of the asymmetry in unemployment dynamics, with smaller gaps between the end of an expansion and the next recession (i.e. the sudden increase in unemployment in the recession) compared with the longer duration of the subsequent expansion.

These features of the data are more evident in Table 1. The first two columns provide

U.S. data as a point of reference, with the first column providing statistics for the United States as a whole, and the second column showing the moments found by averaging the 50 U.S. states. Similarly, column 3 provides data for the euro area aggregate, and the fourth column the average of the moments of the euro area member countries. Focusing on the state and country averages (columns 2 and 4), which are the relevant statistics of comparison with our model, we see that both the mean and the standard deviation of unemployment are about fifty percent higher in the euro area relative to the United States.

In both regions, unemployment rates are positively skewed, meaning that most of the time, the unemployment rate is below its mean. This characteristic is somewhat more pronounced for the United States (0.69 vs. 0.25). Expansions are longer than contractions. On average, expansions in both regions take about 6.5 years, whereas contractions are only half as long. Consequently, the unemployment rate takes longer to fall during expansions than it takes time to rise during contractions. In both regions, unemployment rates rise twice as quickly during contractions as they fall during expansions. On the other hand, changes in the unemployment rate in the euro area are substantially faster, as already suggested by the higher standard deviation. For instance, during contractions unemployment rates rise by 1.4 percentage points per year in the average U.S. state, whereas they rise by 2.7 percentage points in the average euro area country.

The final asymmetry reported in Table 1 tests more directly the plucking property of the unemployment rate. Following the image of a helium balloon being randomly pulled down and then gradually drifting back, the size of a contraction should be predictive about the size of the following expansion. The stronger the balloon is pulled down, the stronger the subsequent drift up. To test this, we follow Dupraz, Nakamura and Steinsson (2023) and regress the amplitude (in percentage points) of an expansion on its preceeding contraction. For both regions, the size of a contraction is a strong predictor for the size of the subsequent expansion with R^2's above 0.5. In the United States, the relationship is close to one-for-one: for every percentage point increase in the amplitude of a contraction, the amplitude of the subsequent expansion increases by 0.82 percentage points. In the euro area, this coefficient is somewhat smaller (0.62). More importantly, running an analogous regression of the size of a contraction on its preceding expansion has no predictive power: its R^2 is 0.05 in both regions. Hence, the size of an expansion is not predictive of the size of the following contraction.

Together, these statistics indicate a strong asymmetry in unemployment rate dynamics that motivates our model with downward nominal wage rigidity. We later evaluate our model against these moments.

2.3 Relation between the volatility of unemployment and its mean

An important correlate of the plucking view is that there should be a positive relationship between the volatility of unemployment and its average level. The stronger and more often the helium balloon gets pulled down, the more time it spends far below the ceiling. That is, countries with more volatile unemployment rates should have, on average, higher levels of unemployment rates. This prediction is borne out by the data: Figure 3 illustrates the relationship between mean unemployment and the variation in unemployment for U.S. states (in red) and euro area countries (in blue). The slopes are in the 1.6 to 1.8 range and are statistically significantly different from zero, indicating that regions with a percentage point higher standard deviation have average unemployment rates that are about 1.7 percentage points higher. While the slopes are (both economically and statistically) similar in the two regions, the red dots of the U.S. states are bunched in the bottom left corner characterized by stable and low unemployment rates, whereas the blue dots of the euro area countries are equally spread across the regression line.

One interpretation of this figure is that stabilizing unemployment rates in the euro area could bring down their average level as well. In terms of the figure, the idea would be to move down along the regression line towards the bottom left corner. There are obviously many possible reasons why unemployment rates are more stable across U.S. states, ranging from smaller business cycle shocks to various risk-sharing mechanisms such as fiscal transfers and income diversification. In this paper, we study to what extent the lack of labor mobility in the euro area could help explain the higher volatility of unemployment rates and, consequently, their higher level.

Interpreted through the lense of the plucking model the intercept in Figure 3 can be described as 'structural' unemployment: It corresponds to the unemployment rate that would prevail in the absence of any fluctuations, or the height of the ceiling the balloon is bouncing along. The intercept is somewhat higher in the euro area than in the United States (4.71% vs. 2.77%), in line with the view of a more sclerotic European labor market. By subtracting the level of structural unemployment from the average unemployment rate in each region, we obtain a measure of the average cyclical unemployment rate, which is 4.55% in the euro area and 3.13% in the United States. It is this part of the unemployment rate that stabilization policy and labor mobility can hope to bring down.

3 Model

The world economy consists of a currency union that is made up of a continuum of small open economies represented by the unit interval (Gali and Monacelli, 2008). Each economy, indexed by $i \in [0,1]$ is of measure zero and takes the aggregate dynamics of the world economy as given. All economies are ex ante identical, but they are subject to idiosyncratic shocks that wash out at the aggregate, union-wide level. The exposition focuses on a typical economy belonging to the currency union, say, country i. We denote union-wide variables by an asterisk, e.g. $X_t^* \equiv \int_0^1 X_{i,t} di$.

In each period t the economy experiences one event s_t from a potentially infinite set of states. We denote by s^t the history of events up to and including date t. The probability at date 0 of any particular history s^t is given by $\pi(s^t)$. Unless confusion arises, we write $X_{i,t}$ for $X_i(s^t)$.

Model overview Each economy is populated by immobile capital owners and mobile workers. Capital owners accumulate capital and have access to complete financial markets. Workers are hand-to-mouth, supply labor inelastically, but can choose to migrate across economies. There is only a single good in the world economy, which is produced and consumed by each country. The driving process are country-specific shocks to firms' total factor productivity (TFP). The only nominal friction is a restriction on how much nominal wages can fall in a given period. Consequently, negative TFP shocks might cause unemployment.

3.1 Households

The small open economy is populated by capital owners and workers. Capital owners are immobile. Their number is given by $\mathbb{N}_i^k$. Workers are mobile and can move between the small open economy and the rest of the world if they find it optimal to do so. The number of workers in the small open economy available for production in time t is given by $\mathbb{N}_{i,t-1}^w$ and the total population is[3]

$$\mathbb{N}_{i,t-1} = \mathbb{N}_i^k + \mathbb{N}_{i,t-1}^w.$$

Variables are indicated in per capita terms. For instance, $c_{i,t}^w$ is consumption of a single worker while total consumption for workers is $\mathbb{N}_{i,t-1}^w c_{i,t}^w$.

3.1.1 Capital owners

Capital owners receive utility from consumption. At date 0, their expected discounted sum of future period utilities is given by

$$\sum_{t=0}^{\infty} \sum_{s^t} \pi(s^t) \beta^t \frac{\left(c_{i,t}^k\right)^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}},$$

where c_t^k denotes (state-contingent) consumption, σ is the intertemporal elasticity of substitution and β is the discount factor.

In any period t, capital owners rent out their capital stock, $K_{i,t-1}$, to firms at the nominal rental rate $R_{i,t}$. They use these receipts to purchase consumption goods, $c_{i,t}^k$, and investment goods, $I_{i,t}$, at price $P_{i,t}$. Capital owners also have access to a complete set of state-contingent bonds. Let $B_i(s^t, s_{t+1})$ be the quantity of state-contingent bonds purchased by capital owners in country i after history s^t and that pay off in euros, the union's currency, in state s_{t+1}. Their price is denoted by $\varrho(s^t, s_{t+1})$. The nominal exchange rate $E_{i,t}$ is the price of the home currency in euros, such that an increase in $E_{i,t}$ implies an appreciation of the home currency. In our baseline specification, we assume that the country is part of the euro currency area and thus $E_{i,t} = 1$. Finally, capital owners might also receive transfers from the government $T_{i,t}$. Taken together, capital owners choose consumption, investment, next period's capital stock, and a set of bonds to maximize the expected discounted sum of future period utilities subject to a sequence of budget constraints

$$P_{i,t}\left(c_{i,t}^k + I_{i,t}\right) + \sum_{s^{t+1}} \frac{\varrho(s^t, s_{t+1}) B_i(s^t, s_{t+1})}{E_{i,t}} = R_{i,t} K_{i,t-1} + T_{i,t} + \frac{B_i(s^{t-1}, s_t)}{E_{i,t}}$$

[3] Notice the timing convention that follows the convention for the capital stock. Migration takes one period such that the number of workers available for production in t is decided in $t-1$ before the realization of the TFP shock in t.

and a sequence of capital accumulation constraints

$$K_{i,t} = I_{i,t} + (1-\delta)K_{i,t-1} - f(I_{i,t}, K_{i,t-1}),$$

with $f(I,K) = \frac{\phi}{2}\left(\frac{I}{K} - \delta\right)^2 K$ reflecting capital adjustment costs (Hayashi, 1982). Adjustment costs are parameterized by $\phi \geq 0$ and slow down the accumulation and decumulation of capital in the presence of TFP shocks. This is particularly relevant in our small open economy setup, where, absent any adjustment costs, any TFP differentials across countries would lead to large capital flows and strong fluctuations in the capital stock.

The optimal choices of $I_{i,t}$ and $K_{i,t}$ imply a standard capital Euler equation:

$$q_{i,t} = \beta \mathbb{E}_t \left[\left(\frac{R_{i,t+1}}{P_{i,t+1}} + q_{i,t+1} \left(1 - \delta + \frac{\phi}{2} \left(\left(\frac{I_{i,t+1}}{K_{i,t}} \right)^2 - \delta^2 \right) \right) \right) \right]$$

where Tobin's q is

$$q_{i,t} = \left(1 - \phi \left(\frac{I_{i,t}}{K_{i,t-1}} - \delta \right) \right)^{-1}.$$

The optimal demand for bonds yields the international risk-sharing condition (Backus and Smith, 1993):[4]

$$c^k_{i,t} = c^{k,*}_t \left(\frac{P_i(s^t)}{E_i(s^t)P^*(s^t)} \right)^{\sigma},$$

where $c^{k,*}_t \equiv \int_0^1 c^k_{i,t} di$ is union-wide consumption of capital owners and $P^*_t \equiv \int_0^1 P_{i,t} di$ is the union-wide price index. Since we assume that there is only one good in the world economy, the real exchange rates, $\frac{P_i(s^t)}{E_i(s^t)P^*(s^t)}$, are unity and the international risk-sharing condition simplifies to $c^k_{i,t} = c^{k,*}_t$.

[4] The first-order condition with respect to $B_i(s^t, s_{t+1})$ is

$$(c^k_i(s^t))^{-\frac{1}{\sigma}} P_i(s^t) \frac{\varrho(s^t, s_{t+1})}{E_i(s^t)} = \pi(s^{t+1})(c^k_i(s^{t+1}))^{-\frac{1}{\sigma}} P_i(s^{t+1}) \frac{1}{E_i(s^{t+1})}.$$

This condition needs to hold for any country i and hence also for the union as a whole. Replacing $\varrho(s^t, s_{t+1})$ and $\pi(s^{t+1})$ by the union-equivalent of this first-order condition yields

$$\left(\frac{c^{k,*}(s^t)}{c^k_i(s^t)} \right)^{\frac{1}{\sigma}} \frac{P_i(s^t)}{E_i(s^t)P^*(s^t)} = \left(\frac{c^{k,*}(s^{t+1})}{c^k_i(s^{t+1})} \right)^{\frac{1}{\sigma}} \frac{P_i(s^{t+1})}{E_i(s^{t+1})P^*(s^{t+1})}.$$

Iterating this condition and noting that ex-ante, all economies are identical yields the international risk-sharing condition.

3.1.2 Workers

Workers are mobile and earn only labor income.

Labor markets Each worker has an inelastic supply of labor given by L^S. Following the specification in SGU, because of downward nominal wage rigidity, households may not be able to sell all of the hours they supply. While there is no constraint on the amount of wage increases, wages can only fall by a limited amount. Specifically, we require

$$W_{i,t} \geq \eta W_{i,t-1} + (1-\eta) W_{i,t}^{flex},$$

where $W_{i,t}$ is the nominal wage, $W_{i,t}^{flex}$ would be the wage in the absence of any constraint and $\eta \in [0,1]$ is a parameter that governs the degree of downward nominal wage rigidity. If $\eta = 0$ then wages are fully flexible, $W_{i,t} = W_{i,t}^{flex}$. If $\eta = 1$ then nominal wages can never fall, $W_{i,t} = W_{i,t-1}$. The presence of wage rigidity implies that the labor market will in general not clear and some workers will be unemployed. As in Hansen (1985) and Rogerson (1988), workers agree to a risk-sharing contract that guarantees each worker has the same income at date t though in equilibrium not all workers are employed. The equilibrium level of employment is

$$L_{i,t} \leq L^S,$$

and the unemployment rate is given by $ur_{i,t} = 1 - \frac{L_{i,t}}{L_{i,t}^S}$. As in SGU, the labor market either clears (in which case $L_{i,t} = L^S$) or the wage constraint binds (in which case $W_{i,t} = \eta W_{i,t-1} + (1-\eta) W_{i,t}^{flex}$). This can be captured by the slackness condition

$$\left(L^S - L_{i,t}\right)\left(W_{i,t} - \eta W_{i,t-1} - (1-\eta) W_{i,t}^{flex}\right) = 0.$$

When residing in the small open economy, workers earn nominal labor income $W_{i,t} L_{i,t}$. Workers are assumed to be hand-to-mouth, so their consumption satisfies

$$P_{i,t} c_{i,t}^{w} = (1-\tau) W_{i,t} L_{i,t},$$

where τ is labor income tax, which we introduce to discipline the share of aggregate consumption that goes to hand-to-mouth households.

Migration At the beginning of each period, workers choose to migrate or remain in their current country. Migration takes one period and migrants work and consume still in their old location.

Moving across countries entails a one-time moving cost, τ, denoted in utils. Each period, workers in country i receive idiosyncratic (i.e. worker-specific) shocks for each economy j, denoted by $\epsilon_{ij,t}$. Define $v_{i,t}(\epsilon_{i,t})$ as the value of a worker currently living in Home conditional on the aggregate state and the worker's vector of idiosyncratic shocks, $\epsilon_{i,t}$. The value of living in Home at time t is

$$v_{i,t}(\epsilon_{i,t}) = U\left(c^w_{i,t}\right) + \max_j \left\{ \frac{1}{\gamma}\epsilon_{ij,t} - \tau \mathbb{1}_{i \neq j} + \beta \mathbb{E}_t\left(V_{j,t+1}\right) \right\}$$

The flow utility function $U(c)$ is $\frac{c^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}}$. The value $V_{j,t}$ is the expected value of $v_{j,t}(\epsilon_{j,t})$ prior to the realization of the idiosyncratic shocks and thus, $V_{j,t}$ is the average expected utility of any worker in j at the start of time t. The parameter γ governs how strongly idiosyncratic location shocks affect migration decisions.

We follow Artuç, Chaudhuri and McLaren (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, the expected value $V_{i,t}$ – the average utility of a worker in country i at time t – is

$$V_{i,t} = U\left(c^w_{i,t}\right) + \frac{1}{\gamma}\ln\left(\int_j \exp\left\{\gamma\left(-\tau\mathbb{1}_{i\neq j} + \beta\mathbb{E}_t\left(V_{j,t+1}\right)\right)\right\} dj\right). \tag{3.1}$$

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

$$n^i_{j,t} = \frac{\exp\left\{\gamma\left(-\tau\mathbb{1}_{i\neq j} + \beta\mathbb{E}_t\left(V_{j,t+1}\right)\right)\right\}}{\int_k \exp\left\{\gamma\left(-\tau\mathbb{1}_{i\neq k} + \beta\mathbb{E}_t\left(V_{k,t+1}\right)\right)\right\} dk}. \tag{3.2}$$

Naturally, an increase in expected life-time utility in j, $\mathbb{E}_t\left(V_{j,t+1}\right)$, raises immigration. The larger the value of γ, the stronger the migration response. The number of workers choosing to live in country i at time $t+1$ is

$$\mathbb{N}^w_{i,t} = \int_j n^j_{i,t}\mathbb{N}^w_{j,t-1} dj. \tag{3.3}$$

3.2 Firms

Competitive firms employ capital and labor inputs to produce a good that is fully tradable. They choose inputs to maximize profits

$$\max\left\{P_{i,t}\mathbb{N}_{i,t-1}Y_{i,t} - W_{i,t}\mathbb{N}^w_{i,t-1}L_{i,t} - R_{i,t}\mathbb{N}^k_i K_{i,t-1}\right\}$$

subject to the production function

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

The optimal choice of labor and capital imply standard expressions for the demand curves for labor and capital. Namely,

$$W_{i,t}\mathbb{N}^w_{i,t-1}L_{i,t} = (1-\alpha)P_{i,t}\mathbb{N}_{i,t-1}Y_{i,t}$$

and

$$R_{i,t}\mathbb{N}^k_i K_{i,t-1} = \alpha P_{i,t}\mathbb{N}_{i,t-1}Y_{i,t}.$$

3.3 Market Clearing and Definitions

Market clearing in the goods market requires that total production across all economies equals total demand:

$$\int_0^1 Y_{i,t}di = \int_0^1 \left(\mathbb{N}^k_i c^k_{i,t} + \mathbb{N}^w_{i,t-1}c^w_{i,t} + \mathbb{N}^k_i I_{i,t}\right)di.$$

Population movements must balance at the union level as well:

$$\int_0^1 \mathbb{N}^w_{i,t}di = \mathbb{N}^{w,*}, \tag{3.4}$$

where $\mathbb{N}^{w,*}$ is a fixed constant.

We define GDP as the sum of total labor and captial income. This implies that nominal GDP is $P_{i,t}Y_{i,t}$ and real GDP is

$$GDP_{i,t} = P_i Y_{i,t}. \tag{3.5}$$

Aggregate consumption is the sum of capital owners' consumption and workers' consumption:

$$\mathbb{N}_{i,t-1}C_{i,t} = \mathbb{N}_i^k c_{i,t}^k + \mathbb{N}_{i,t-1}^w c_{i,t}^w.$$

3.4 Definition of Equilibrium

The model has one exogenous state, TFP (Z), and three endogenous states, capital (K), worker population N_{-1}^w, and wage (w_{-1}). The recursive competitive equilibrium is defined by a set of functions for (i) household polcies $c^k(K, N_{-1}^w, w_{-1}, Z)$, $c^w(K, N_{-1}^w, w_{-1}, Z)$, $C(K, N_{-1}^w, w_{-1}, Z)$, $N(K, N_{-1}^w, w_{-1}, Z)$, and $K'(K, N_{-1}^w, w_{-1}, Z)$; (ii) workers' location value $V(K, N_{-1}^w, w_{-1}, Z)$; (iii) firm polcies $L(K, N_{-1}^w, w_{-1}, Z)$, and $Y(K, N_{-1}^w, w_{-1}, Z)$; (iv) prices $r^k(K, N_{-1}^w, w_{-1}, Z)$, and $w(K, N_{-1}^w, w_{-1}, Z)$ that satisfy the recursive representation of equilibrium equations provided in Section A.1 of the appendix.

4 Model Solution and Parameter Values

4.1 Model solution

Because the model embodies non-linear, asymmetric equilibrium dynamics, we numerically solve the model using a global solution method. Specifically, we adapt the FiPIt algorithm for solving models with occasionally binding constraints in Mendoza and Villalvazo (2020) to our setting. We obtain a solution for a finite number of grid points in the model state space. For us, the state space includes 5 productivity levels, 20 wage levels, 10 population levels and 30 capital stocks. Once we have computed equilibrium reactions on this grid mesh, we compute reactions for intermediate points by linear interpolation.

We embed this algorithm into an outer loop to solve an additional fixed-point problem. We adjust the average expected utility a worker gets abroad, V^*, to ensure that population movements balance at the union level and satisfy (3.4). Technically, we would also need to adjust the union-wide consumption of capital owners, $c_t^{k,*}$, to ensure that goods markets clear at the union level (3.5). But in practice, $c^{k,*}$, does not affect the optimal choices for W_t., $\mathbb{N}_t^w$ and K_t and hence, we can back out the value for $c^{k,*}$ from (3.5) ex post after we have solved for the optimal choices. To calculate the average values for net migration (and net exports), we simulate the model 300 times for 30 years (plus an initial 40-year burn-in period) and then average the moments across the 300 series. Details of our solution method are included in the appendix.

4.2 Parameter values

The model is expressed at a monthly frequency and is calibrated to match an average euro area country. 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., the labor share) are calibrated accordingly. Taking the calibrated parameters as given, we estimate the remaining parameters. Table 2 lists the parameter values for the benchmark case.

Calibrated parameters We set the discount factor to match an annual real interest rate of 2 percent. The intertemporal elasticity of substitution is set to $\sigma = \frac{2}{3}$. The curvature parameter on the production function is $\alpha = 0.4$, in line with a labor share of 60 percent. The quarterly depreciaton rate is set to the standard value of $\delta = 0.025$. The migration cost parameter τ pins down the share of migrants in the non-stochastic steady state, $\frac{n\mathbb{N}^w}{\mathbb{N}}$, and we choose it so that about 0.75 percent of the population migrates per year, as reported by House, Proebsting and Tesar (2023). This requires the migration cost to be about 37 times annual consumption.

Estimated parameters We estimate the standard deviation of the idosyncratic location preference shocks ($\frac{1}{\gamma}$), the capital adjustment cost parameter (ϕ), the wage rigidity parameter (η), as well as the shock persistence and shock volatility (ρ_Z and σ_Z). Our parameter estimates are chosen to match the following five moments: (i) the OLS slope coefficient of net migration on unemployment, (ii) the volatility (standard deviation) of investment relative to the volatility of GDP, (iii) the average cyclical unemployment rate and (iv) the volatility of the unemployment rate and (v) the persistence of the unemployment rate. These moments are calculated from simulating the data for 300 economies for 30 years (plus a burn-in period of 20 years).

While all parameters are estimated simultaneously, parameters are tightly linked to specific moments. The parameter γ governs the sensitivity of migration rates to utility differentials. Higher values of γ make migration more responsive to fluctuations in workers' expected labor income. House, Proebsting and Tesar (2023) report that for the sample of euro area countries, an increase in a country's unemployment rate by one percentage point is associated with a net outflow of 0.08 people, as suggested by the slope coefficient of an OLS regression of net migration on unemployment. The capital adjustment cost ϕ has a strong influence on the volatility of investment. Absent any adjustment costs, investment would be extremely volatile because capital owners arbitrage any TFP differentials across countries. To match the volatility observed in the data, we need to set $\phi = 2.5$. The shock volatility and the wage rigidity parameter influence the volatility of unemployment and its mean. With $\eta = 0$, wages are completely flexible and the model would not generate any unemployment. As η is increased, the average level of unemployment rises, for a given level of unemployment volatility. By simultaneously adjusting η and σ_Z we are able to match the volatility of unemployment and its mean. The resulting level of wage rigidity is fairly strong. A value of $\eta = 0.995$ suggests that wages can barely fall in the short run. By how much they can fall depends on the level of unemployment. If the unemployment rate is 10%, then our choice for α implies that wages are by about 4% too high. Then, wages can fall by about $12 \times (1-\eta) \times 4\% = 0.24\%$ per year. This is a substantially higher value for η than what is used in Schmitt-Grohé and Uribe (2016), Born and Pfeifer (2020) and Rodríguez-Clare, Ulate and Vasquez (2022), who let nominal wages fall by a maximum of 2% a year. The estimated shock volatility of 0.27% is fairly low and indicates that the model is able to amplify shocks. Finally, a shock persistence of 0.94 per quarter allows us to roughly match the persistence of unemployment in the economy.

4.3 Model and data comparison

Table 3 shows key moments of the baseline model together with data from the euro area countries. The first set of moments refer to targeted moments, such as average cyclical unemployment and the volatility of unemployment. Since we have as many moments as free parameters, we are able to match those moments quite well.

The second of moments refers to standard business cycle moments. Given that our model is fairly simple and abstracts from several elements that are common to medium-size DSGE models, the model performs surprisingly well. The model captures well the volatility of per-capita real GDP (3 percent in both model and data), the strong correlation of consumption and GDP, the negative correlation between unemployment and GDP and the positive correlation between net migration and GDP. The model predicts a path of consumption that is somewhat too smooth compared to the data, a common finding in the international RBC literature Backus, Kehoe and Kydland (1992), and the presence of investment help reduce the positive correlation between net exports and GDP, although it is not as countercyclical as in the data.

The model performs less well in generating asymmetries in unemployment rates. While, consistent with the data, expansions are somewhat longer than contractions, the difference is smaller than in the data (40 vs. 35 months in the mode; 75 vs. 38 months in the data). Similarly, the size of the previous contraction helps predict the size of the expansion in the model, but the R^2 is smaller than in the data (0.19 vs. 0.54). The reason for the lack of asymmetry in the model stems from the strong degree of wage rigidity that constantly pushes the model into the region with a binding wage constraint. On average, unemployment is about 4.5%, and the simulations only indicate few periods with zero unemployment. As long as the wage constraint is binding, negative and positive TFP shocks have similar (although opposite) effects on unemployment. An asymmetric response can only be observed when the economy finds itself close to the wage constraint.

This is also illustrated in Figure 4 that displays the impulse responses for both positive and negative TFP shocks derived from the model simulation. The impulse responses depend on the state in the period the shock occurs and the figure display impulse responses that reflect the average across simulations and states. While negative TFP shock lead to a stronger unemployment response, the asymmetry is modest. A positive TFP shock usually occurs in a state with sufficiently high unemployment such that the shock immediately reduces unemployment. It is only in instances when unemployment is (close to) zero that positive TFP shocks lead to positive wage inflation rather than lower unemployment. And these instances are relatively rare in our model simulations.

5 Effects of Labor Mobility in a Currency Union

We now consider several counterfactual to understand the role of labor mobility in this model. First, we re-run the model assuming each economy can conduct its own monetary policy. By comparing the baseline model to this alternative monetary policy setup we can pin down the 'costs' of the currency union. These costs necessarily depend on the alternative monetary policy and we assume that countries would implement the optimal monetary policy. This generates the maximum gap between the baseline model and the alternative scenario. As shown in SGU, countries could completely undo the inefficiencies arising from the DNWR constraint by adjusting their exchange rate (i.e. by depreciating their currency in response to a negative TFP shock). Hence, the allocations obtained in this counterfactual correspond to the allocations obtained under flexible wages.

Second, we consider a case with higher labor mobility. Specifically, we adjust γ, the inverse of the standard deviation of the idiosyncratic preference shocks in the workers' utility function, 3.1 to match the slope coefficient observed in U.S. data: As reported in House, Proebsting and Tesar (2023), while the slope coefficient of regressing net migration on unemployment is -0.08 for Euro area countries, it is about -0.26 for U.S. states. To match this slope coefficient, we need to raise γ by a factor of 6. As in the case with baseline labor mobility, we consider two types of monetary policy under this high-mobility scenario: a fixed exchange rate and a floating exchange rate with optimal monetary policy. By comparing these two monetary policy scenarios under both baseline mobility and high mobility, we can then study how labor mobility affects the costs of the currency union.

5.1 Effects on macroeconomic aggregates

Table 4 displays moments for the four scenarios: the baseline scenario (column 1), the optimal monetary policy scenario (column 3), the high mobility scenario (column 4) and the high-mobility + optimal monetary policy scenario (column 5). For each scenario, we re-run the model and report averages calculated based on the simulated data. That is, the table ignores any transition dynamics of switching from one policy to the other and rather reports long-run statistics.

Panel A reports the standard deviations of key macro metrics under these different scenarios. Optimal monetary policy stabilizes per-capita GDP and consumption, as well as the unemployment rate. The volatility of GDP and consumption fall by about 60%, whereas the unemployment rate gets completely stabilized. Higher labor mobility has qualitatively similar effects, although quantitatively, the effects are smaller, with reduction in volatility around 35%.

Panel B reports the means of the macro variables, expressed as percent deviation from the non-stochastic steady state. In the baseline scenario, the unemployment rate is 4.5%. In response to the lower labor input, the capital stock is also lower, which pushes GDP down by close to 5%. Consequently, consumption is about 4.7% lower than in the non-stochastic steady state. Optimal monetary policy can stabilize the economy at the non-stochastic steady state such that all variables stay at their steady-state level.

Higher labor mobility also pushes the economy towards the non-stochastic steady state, but the effect is substantially smaller. The unemployment rate falls by about half a percentage point, GDP rises by about three quarters of a percent and consumption rises by half a percent. While higher labor mobility cannot replicate the optimal monetary policy regime, the gains are substantial: A drop of half a percentage point in the unemployment rate corresponds to about 1 mio fewer unemployed who would find a job in the euro area. Recall also that the cyclical unemployment in the United States is about 3%. By pushing the unemployment rate from 4.5 to 4%, higher labor mobility in the euro area would reduce the gap between the two currency unions by about a third.

The dynamic implications of higher labor mobility are illustrated in Figure 4 that shows the impulse responses to both a positive and a negative TFP shock. The case with baseline mobility has been discussed before. The dotted lines in the figure show corresponding reactions in a high-labor-mobility environment. While the initial unemployment response is similar in both scenarios, the half-life of an initial increase in unemployment is about 2 years as opposed to about 7 years in the baseline. This is driven by a quicker and larger net outflow of workers and goes along with a more muted response in wages.

5.2 Effects on welfare

The combination of downward nominal wage rigidity and a fixed exchange rate result in a higher mean unemployment rate. If the economy could implement an optimal exchange rate policy, the economy would be at full employment rate at all times. Hence, being part of a currency union entails welfare costs that are reflected in lower average consumption levels due to inefficiencies in the labor market. The last section showed, however, that labor mobility helps to moderate both fluctuations in unemployment and can reduce mean unemployment, thereby reducing the welfare costs of a fixed exchange rate.

In this section, we quantify by how much labor mobility reduces the welfare costs of a fixed exchange rate. We define the welfare cost of the peg, λ_t conditional on state $s_t \equiv \left\{Z_{i,t}, W_{i,t-1}, \mathbb{N}^w_{i,t-1}\right\}$, , as the percentage increase in the lifetime consumption stream experienced by a household living in the baseline economy with a currency peg at time t to be as well off as a household living in an economy with the optimal exchange rate. We calculate $\lambda_i(s_t)$ separately for both capital owners and workers. For capital owners, $\lambda^k(s_t)$ is calculated as

$$\mathbb{E}_t \left\{ \sum_{j=0}^{\infty} \beta^j U\left(c^k_{i,t+j}(1+\lambda^k_i(s_t))\right) \Bigg| s_t \right\} = \mathbb{E}_t \left\{ \sum_{j=0}^{\infty} \beta^j U\left(c^{k,opt}_{i,t+j}\right) \Bigg| s_t \right\},$$

where $c^{k,opt}_{i,t}$ is consumption in an economy where the central bank follows an exchange rate policy that ensures full employment, $L_{i,t} = L^S$. The measure $\lambda^k_i(s_t)$ depends on the state of the economy and is therefore stochastic. Following SGU, we report the mean of $\lambda^k_i(s_t)$ over the distribution of s_t in the baseline economy, that is, we report $\lambda^k_i = \sum_{s_t} \pi(s_t)\lambda^k_i(s_t)$, where $\pi(s_t)$ is the unconditional probability of s_t in the benchmark economy.

To calculate an equivalent expression for the workers, we need to take into account that workers are mobile and have the option of moving across countries. From (3.1) and (3.2), we have that workers' lifetime utility as of period t equals:

$$V_{i,t} = U(c^w_{i,t}) - \frac{1}{\gamma}\ln(1-n_{i,t}) + \beta\mathbb{E}_t V_{i,t+1}.$$

Then, the welfare cost $\lambda^w_i(s_t)$ for a worker that lives in country i at state s_t is calculated as

$$\mathbb{E}_t \left\{ \sum_{j=0}^{\infty} \beta^j \left[U\left(c^w_{i,t+j}(1+\lambda^w_i(s_t))\right) - \frac{1}{\gamma}\ln(1-n_{i,t}) \right] \Bigg| s_t \right\} = \mathbb{E}_t \left\{ \sum_{j=0}^{\infty} \beta^j \left[U\left(c^{w,opt}_{i,t+j}\right) - \frac{1}{\gamma}\ln(1-n^{opt}_{i,t}) \right] \Bigg| s_t \right\}.$$

As before, we then calculate λ^w_i as the average across $\lambda^w_i(s^t)$. Notice that in these calculations, we keep the migration rates, $1-n_{i,t}$, fixed at their baseline values and do not recalculate them based on the adjusted consumption values $c^w_{i,t}(1+\lambda^w_{i,t})$.

In Panel C of Table 4, we report the welfare measures λ^k and λ^w for both the baseline economy and the economy with higher labor mobility. The table also reports the welfare gains for the economy as a whole, using the consumption shares of capital owners and workers in overall consumption (each 0.5).

The cost of the currency peg is substantial; in the baseline economy the welfare cost is 4.67 percent of (non-stochastic steady-state) consumption. Higher labor mobility helps reduce the cost to roughly 4.12 percent. Workers bear the larger welfare cost of the suboptimal monetary policy in the baseline economy (5.12 percent vs. 4.23 percent for capital owners), but they also gain more from higher labor mobility, with their costs falling to 4.26 percent vs. 3.98 percent for capital owners. That is, about three quarters of the gains from labor mobility accrue to workers.

The welfare metrics are almost entirely driven by first-order effects, that is, changes in average consumption as opposed to changes in the volatility of consumption. This is obviously the case for capital owners because they always consume a constant amount of consumption. But even for workers, higher labor mobility reduces their consumption volatility from 1.73 percent to 1.12 percent, but this only accouns for 0.04 percentage points out of the overall welfare gains of 0.86 percentage points (average consumption rises by 0.82 percentage points). These small welfare gains from reducing consumption volatility are in line with the critique expressed by Lucas (1987) on the irrelevance of stabilization policy for welfare. Our model misses alternative costs from suboptimal monetary policy, such as inflation-induced relative price distortions emphasized in the New Keynesian literature (Woodford, 2003; Galí, 2008). These are evaluated by HPT in a similar model of labor mobility but without asymmetric wage rigidity and are quantitatively about 4 times smaller than those uncovered in our framework.

6 Conclusion

Unemployment rates tend to be higher and more volatile in the euro area than in the United States. While there are a number of differences between the two regions, one key difference is the greater degree of labor mobility in United States. For a given increase in the unemployment rate, workers are about three times more likely to relocate another state (country) in the United States than in the euro area (House, Proebsting and Tesar, 2023; Foschi et al., 2023). This paper deploys a plucking model of unemployment to study the impact of labor mobility on unemployment. Our analytical model incorporates frictions in the labor market as well as an endogenous migration decision. Firms are unable to freely adjust wages during economic contractions. This rigidity amplifies the costs of negative shocks and generates asymmetries in the dynamics of macroeconomic variables including unemployment. Workers make forward-looking decisions regarding where to work, subject to costs of relocating. This additional margin of adjustment –one that we think realistically captures a feature of labor markets in advanced economies – cuts against the friction of downward wage rigidity.

The model is calibrated to the dynamics of unemployment and net migration in a typical euro area country. The resulting model mimics the asymmetry in unemployment dynamics and the responsiveness of net migration to fluctuations in unemployment. A counterfactual of increasing the degree of labor mobility to that observed in the United States – holding all other parameters of the model fixed – would decrease both the level and the variability of unemployment in the euro area.

References

Artuç, Erhan, Shubham Chaudhuri, and John McLaren. 2010. "Trade shocks and labor adjustment: A structural empirical approach." *American Economic Review*, 100(3): 1008–45.

Babecky, Jan, Philip Du Caju, Theodora Kosma, Martina Lawless, Julián Messina, and Tairi Rõõm. n.d.. "Downward Nominal and Real Wage Rigidity: Survey Evidence from European Firms." *The Scandinavian Journal of Economics*, 112(4): 884–910.

Backus, David K., and Gregor W Smith. 1993. "Consumption and Real Exchange Rates in Dynamic Economies with Non-Traded Goods." *Journal of International Economics*, 35(3-4): 297–316.

Backus, David K., Patrick J. Kehoe, and Finn E. Kydland. 1992. "International Real Business Cycles." *Journal of Political Economy*, 100(4): 745–775.

Born, Benjamin, and Johannes Pfeifer. 2020. "The new keynesian wage phillips curve: Calvo vs. rotemberg." *Macroeconomic Dynamics*, 24(5): 1017–1041.

Caju, Philip Du, Catherine Fuss, and Ladislav Wintr. 2007. "Downward wage rigidity for different workers and firms: an evaluation for Belgium using the IWFP procedure." National Bank of Belgium Working Paper Research 124.

Caliendo, Lorenzo, Maximiliano Dvorkin, and Fernando Parro. 2019. "Trade and labor market dynamics: general equilibrium analysis of the china trade shock." *Econometrica*, 87(3): 741–835.

Dupraz, Stéphane, Emi Nakamura, and Jón Steinsson. 2023. "A plucking model of business cycles." National Bureau of Economic Research.

Elsby, Michael W. L., and Gary Solon. 2019. "How Prevalent Is Downward Rigidity in Nominal Wages? International Evidence from Payroll Records and Pay Slips." *Journal of Economic Perspectives*, 33(3): 185–201.

Foschi, Andrea, Christopher L House, Christian Proebsting, and Linda L Tesar. 2023. "Labor Mobility and Unemployment over the Business Cycle." Vol. 113, 590–96.

Friedman, Milton. 1964. "Monetary studies of the national bureau." *The National Bureau Enters Its 45th Year*, 44: 7–25.

Galí, Jordi. 2008. *Monetary policy, inflation, and the business cycle: An introduction to the New Keynesian framework.* Princeton University Press (Princeton, New Jersey: 2008).

Gali, Jordi, and Tommaso Monacelli. 2008. "Optimal monetary and fiscal policy in a currency union." *Journal of international economics*, 76(1): 116–132.

Giersch, Herbert. 1985. "Eurosclerosis." Kieler Diskussionsbeiträge.

Grigsby, John, Erik Hurst, and Ahu Yildirmaz. 2021. "Aggregate nominal wage adjustments: New evidence from administrative payroll data." *American Economic Review*, 111(2): 428–71.

Hansen, Gary D. 1985. "Indivisible labor and the business cycle." *Journal of Monetary Economics*, 16(3): 309–327.

Hayashi, Fumio. 1982. "Tobin's marginal q and average q: A neoclassical interpretation." *Econometrica: Journal of the Econometric Society*, 213–224.

House, Christopher L, Christian Proebsting, and Linda L Tesar. 2023. "Quantifying the benefits of labor mobility in a currency union." National Bureau of Economic Research.

Jo, Yoon J. 2021. "Establishing downward nominal wage rigidity through cyclical changes in the wage distribution." Texas A&M University, Department of Economics Working Papers 20211216-001.

Klitgaard, Thomas. 2022. "How Have the Euro Area and US Labor Market Recoveries Differed?" Federal Reserve Bank of New York.

Lucas, Robert E. 1987. *Models of business cycles.* Vol. 26, Basil Blackwell Oxford.

Mendoza, Enrique G, and Sergio Villalvazo. 2020. "FiPIt: A simple, fast global method for solving models with two endogenous states & occasionally binding constraints." *Review of Economic Dynamics*, 37: 81–102.

Rodríguez-Clare, Andrés, Mauricio Ulate, and Jose P Vasquez. 2022. "Trade with Nominal Rigidities: Understanding the Unemployment and Welfare Effects of the China Shock." CESifo.

Rogerson, Richard. 1988. "Indivisible labor, lotteries and equilibrium." *Journal of Monetary Economics*, 21(1): 3–16.

Schaefer, Daniel, and Carl Singleton. 2022. "The extent of downward nominal wage rigidity: New evidence from payroll data." *Review of Economic Dynamics*.

Schmitt-Grohé, Stephanie, and Martin Uribe. 2016. "Downward Nominal Wage Rigidity, Currency Pegs, and Involuntary Unemployment." *Journal of Political Economy*, 124(5): 1466–1514.

Woodford, Michael. 2003. *Interest and prices: Foundations of a theory of monetary policy.* Cambridge University Press.

Table 1: STATISTICS ON UNEMPLOYMENT DYNAMICS

	United States		Euro area	
	Aggregate	Ave state	Aggregate	Ave country
Moments				
Average unemployment rate (in %)	6.23	5.89	9.39	9.23
Std. deviation (monthly)	1.63	1.75	1.40	2.96
Skewness (monthly)	0.61	0.69	0.05	0.25
Speed				
Speed of expansions (pp/year)	0.61	0.79	0.54	1.19
Speed of contractions (pp/year)	1.18	1.37	1.39	2.70
Duration				
Duration of expansion (months)	83	82	71	75
Duration of contraction (months)	39	41	37	38
Regression				
Expansion on preceding contraction				
β	1.12	0.82	0.74	0.62
R^2	0.89	0.52	0.76	0.54
Contraction on preceding expansion				
β	-0.80	-0.21	-0.71	0.26
R^2	0.69	0.05	0.30	0.05
Time period	1976 - 2020.2		1990 - 2023.2	

Notes: Each column corresponds to a separate sample. Column 1 refers to statistics for the national U.S. unemployment rate series, column 2 refers to average statistics across U.S. state-level unemployment rate series. Column 3 and 4 report the statistics for the euro aggregate and the average across euro area countries. **Moments**: Reports first, second and third moment of monthly unemployment rates. **Speed**: Reports the average decrease in the unemployment rate during expansions, measured in percentage points per year, and the average increase in the unemployment rate during contractions. **Duration**: Reports the duration of expansions and contractions in months. **Regressions**: The first specification ("expansion on preceding contraction") reports the coefficient in an OLS regression of the size of the subsequent expansion (percentage point fall in unemployment rate) on the size of a contraction (percentage points increase in unemployment). The second specification ("contraction on preceding expansion") reports the coefficient in an analogous regression of the size of the subsequent contraction on the size of an expansion. Regressions are pooled across U.S. states (column 2) or euro area countries (column 4).

Table 2: Calibration

Parameter		**Value**	**Target**
Calibrated parameters			
Discount factor per quarter	β	0.995	2% annual real interest rate
Coefficient of risk aversion	$\frac{1}{\sigma}$	1.5	Standard value
Capital share	α	0.4	60% labor share
Depreciaton rate per quarter	δ	0.025	Standard value
Migration cost	τ	$37c^w$	0.75% annual migration rate (HPT)
Estimated parameters			
Capital adjustment cost	ϕ	2.5	Std dev of I to GDP: 2.78
Migration elasticity	γ	0.25	Net migration response to unempl differentials (HPT)
Wage rigidity per quarter	η	0.995	Std dev of unemployment rate: 2.62%
Shock persistence per quarter	ρ_Z	0.94	
Shock volatility	σ_Z	0.003	Average cyclical unemployment rate: 4.55%

Table 3: MODEL AND DATA COMPARISON

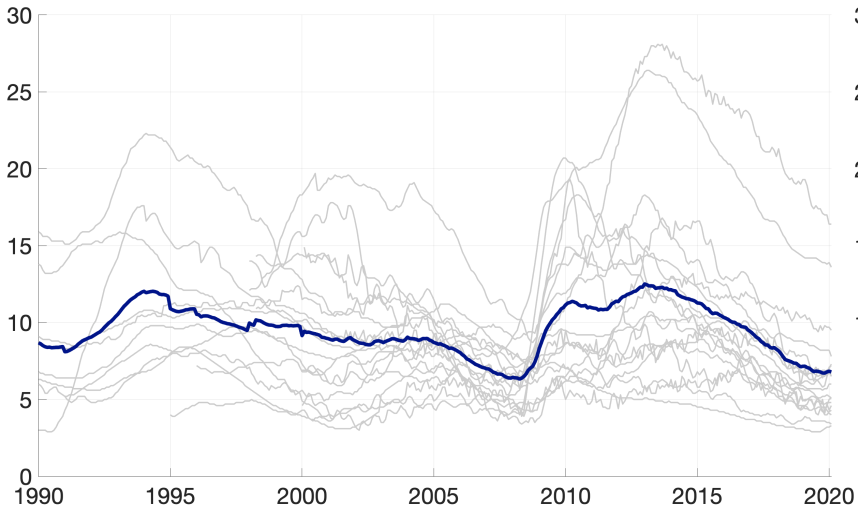
	Data	Model
Targeted moments		
Mean cyclical unempl. (%)	4.55	4.53
SD unempl. (%)	2.62	2.66
Reg. net migr. on unempl.: β	-0.08	-0.08
SD I / SD GDP	2.78	2.78
Business Cycle moments		
SD GDP (%)	3.04	3.11
SD C / SD GDP	0.94	0.56
SD NX / SD GDP	0.81	0.76
SD net. migr. (%)	0.27	0.23
Corr(C, GDP)	0.88	0.89
Corr(unempl.,GDP)	-0.41	-0.93
Corr(NX,GDP)	-0.27	0.14
Corr(net migr., GDP)	0.28	0.73
Pers. of GDP	0.91	0.93
Plucking statistics		
Duration of expansion (months)	75	40
Duration of contraction (months)	38	35
Reg. expansion of prev. contraction: R^2	0.54	0.19
Reg. contraction of prev. expansion: R^2	0.05	0.01

Notes: Statistics calculated at quarterly frequency unless noted otherwise. Time-series for GDP, consumption and investment are transformed into logs and then linearly detrended. Model statistics are averages from 300 simulations.

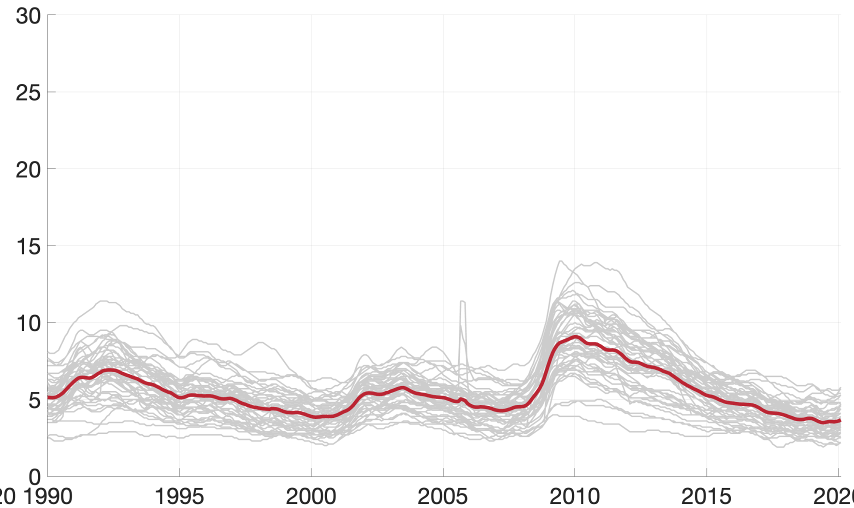
Table 4: Policy experiments

	Baseline mobility		High mobility	
	Fixed	Float	Fixed	Float
Panel A: Standard deviations (%)				
GDP	3.11	1.43	2.21	1.29
Unemployment	2.63	0.00	1.77	0.00
Population	0.61	0.59	1.01	1.03
Consumption	1.73	0.79	1.12	0.54
Cons. workers	2.89	1.31	1.85	0.91
Cons. capital owners	0.00	0.00	0.00	0.00
Panel B: Avg. % dev. from non-stochastic steady state				
GDP	−4.95	0.00	−4.21	0.00
Unemployment	4.53	0.00	3.97	0.00
Capital stock	−5.24	0.00	−4.31	0.00
Consumption	−4.69	0.00	−4.11	0.00
Cons. workers	−5.03	0.00	−4.21	0.00
Cons. capital owners	−4.23	0.00	−3.98	0.00
Panel C: Welfare costs of currency union				
Cost for worker	5.12		4.26	
Cost for capital owner	4.23		3.98	
Average cost	4.67		4.12	

Notes: Statistics are calculated at quarterly frequency. GDP and consumption are calculated in per-capita terms.



(a) Euro area



(b) United States

Figure 1: UNEMPLOYMENT: EURO AREA VS. UNITED STATES

Note: The figure plots unemployment rates for the euro area (blue, thick line) and its member states (left), and the United States (red, thick line) and its member states.

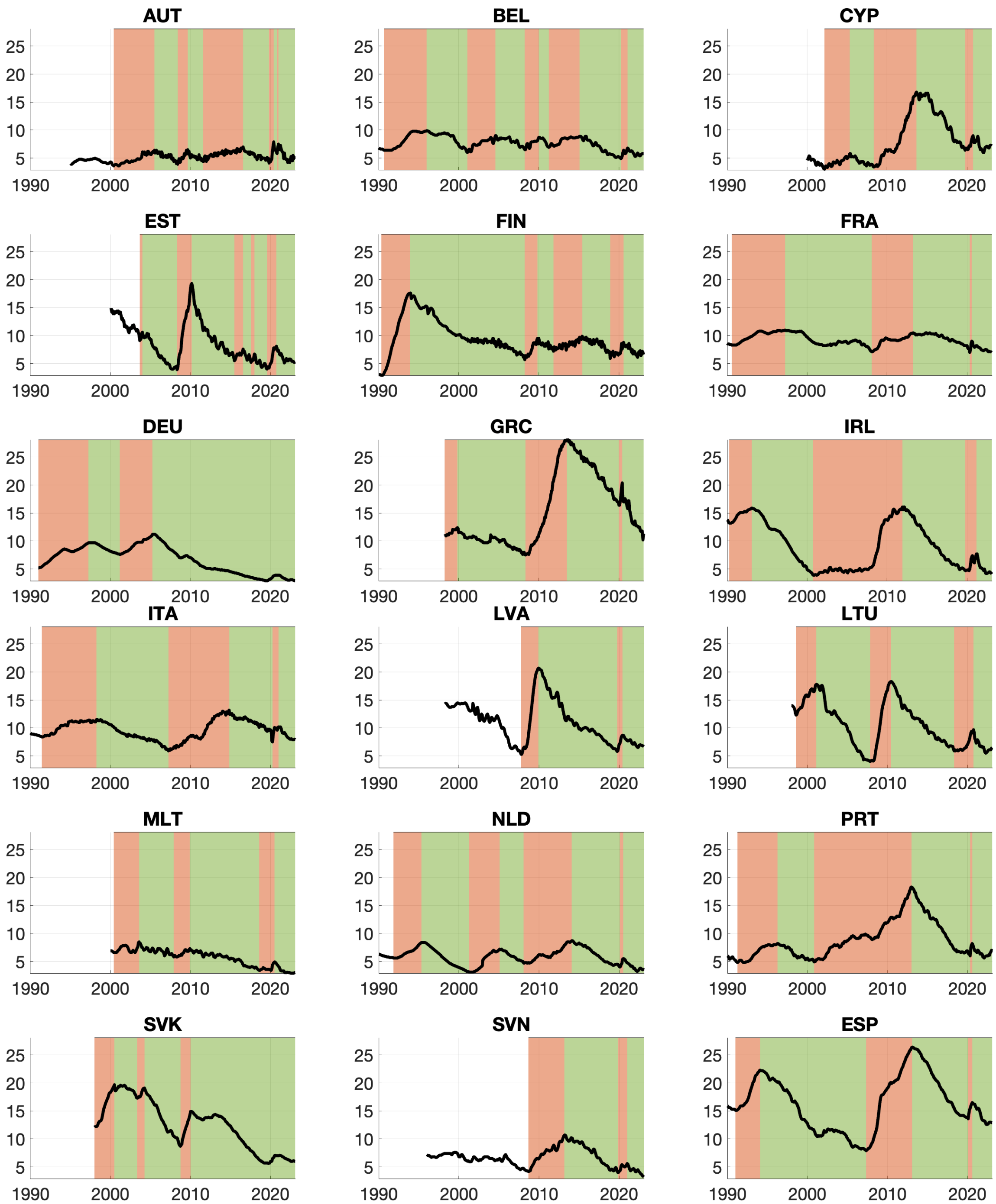


Figure 2: Peaks and Troughs in Unemployment Rates across the Euro Area

Notes: Figure displays unemployment rates for euro area countries. Business cycle expansions are shaded green, while business cycle contractions are shaded red.

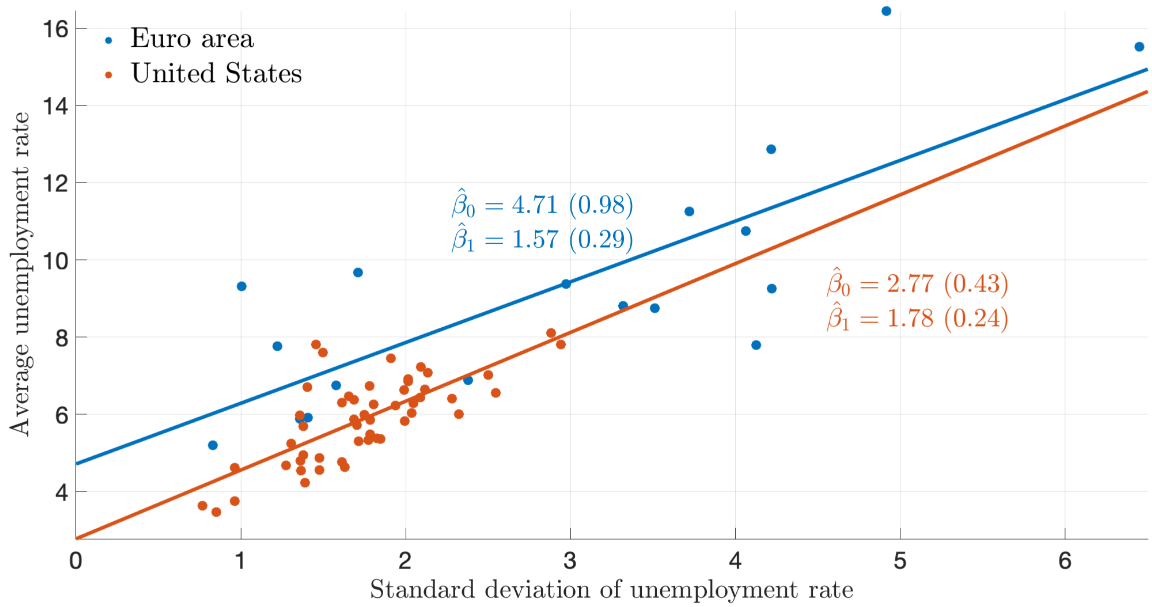


Figure 3: Volatility and average unemployment

Note: The figure plots the time-series standard deviation for each euro area country / U.S. state against its time-series mean. The coefficients indicate the estimated intercept (β_0) and slope (β_1) of a regression of the standard deviaton on the mean. Simple standard errors are in parentheses.

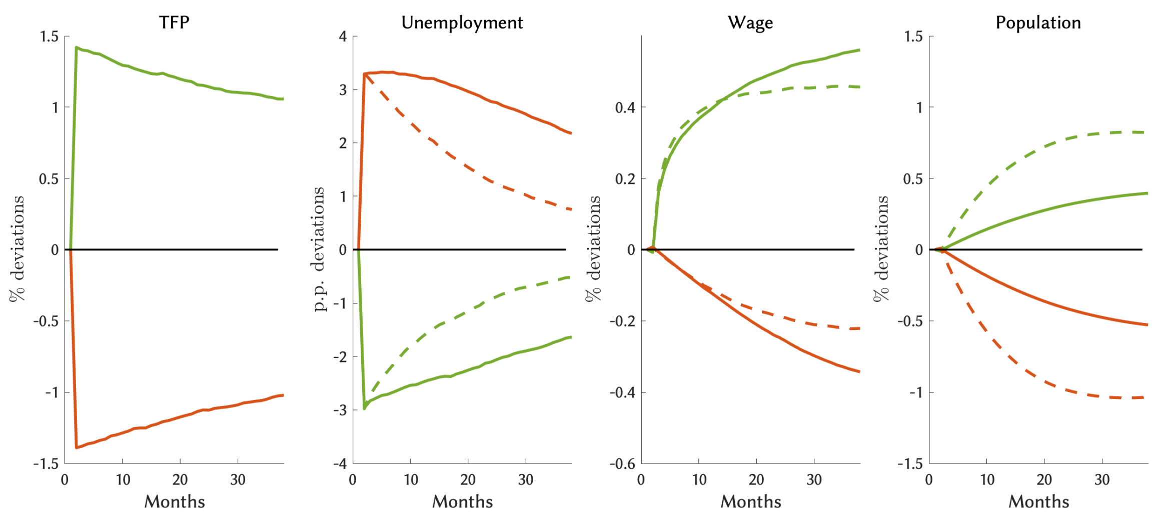


Figure 4: Impulse response to TFP shock

Note: The figure plots the impulse response to a positive (green) and a negative (red) TFP shock based on model simulations.