European Unemployment Insurance

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We study federally-provided unemployment insurance in a group of small economies. In each, the labor market is characterized by search and matching frictions, risk-averse workers, endogenous hiring and separation, and unobservable search effort. Countries are subject to idiosyncratic, persistent business cycle shocks. International financial markets are incomplete. Federal unemployment insurance serves to automatically redistribute internationally, thus completing international markets. Calibrating to the European Monetary Union, for given labor-market policies at the country level, and in line with these assumptions, we find that there are notable welfare gains from introducing federal insurance. Once we allow countries to adjust their labor-market policies in response to the scheme, the scope of a European unemployment insurance program is much reduced.

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Unemployment benefits are the keystone of automatic stabilizers in industrialized economies, for example McKay and Reis (2016). An important feature of such benefits is that they are provided in a centralized manner to all the workers that qualify in a given jurisdiction. To the extent that there are asymmetric shocks to different regions in the jurisdiction, such benefits then do not only serve to insure workers against unemployment spells but they also redistribute resources across regions. They, therefore, implicitly, implement fiscal transfers across regions. Such fiscal transfers can be desirable, particularly in currency unions, Fahri and Werning (2017). Currently, there appears to be a smaller degree of risk-sharing across EMU member states than in other federations; see Sala-i-Martin and Sachs (1991) and more recently Furceri and Zdzienicka (2015).[1] Not surprisingly, then, there are renewed calls for centralized elements in the European welfare state, Five Presidents (2015).[2]

The current paper computes the optimal labor-market policy mix in a union of countries that jointly finance part of the unemployment benefits provided. We consider the optimal design of a common unemployment benefit scheme, a mechanism through which the individual countries can insure themselves against asymmetric labor productivity shocks. Our modeling, we believe, provides ample scope for a centralized unemployment insurance system to be beneficial. First, we assume that there is *no* other means of international insurance, neither private, nor public. Second, we assume that there is *no* international lending that would help countries smooth idiosyncratic shocks. Last, we assume that countries cannot insure through trade in goods. In the baseline, every member participating in the scheme retains full sovereignty. That is, the member states control – subject to budgetary constraints – their domestic labor-market policies. This matters because European transfers distort the incentives of domestic governments to reduce unemployment.

More in detail, we extend Jung and Kuester (2015) to a federal fiscal union. We model the union as a group of individual economies, all of which are subject to idiosyncratic business-cycle shocks.[3] The labor market in each of the countries is subject to Mortensen and Pissarides-type (1994) search and matching frictions. While the group-level insurance scheme is fixed at the level of the group, the countries retain full control over domestic labor-market policy, in particular, hiring subsidies, layoff restrictions, and their own (additional) unemployment-

[1]The latter work suggests that, for the EMU to achieve the level of intra–federal risk sharing observed in Germany, a supranational fiscal stabilization mechanism financed by a gross contribution of 1.5–2.5% of GNP is required.

[2]The debate about the need for a European welfare system is, of course, as old as the European integration project itself. Starting, at least, with the call for harmonisation of economic and social policies in the 1970 "Werner Report." Negotiations of the Maastricht Treaty that ultimately implemented monetary union, instead, largely sidestepped this, agreeing instead on fiscal rules on overall fiscal deficits and debt, Bini-Smaghi, Padoa-Schioppa and Papadia (1994). Brunnermeier, James and Landau (2016) summarize the struggle between different view points on European economic policy more generally.

[3]We abstract from shocks at the area-wide level under the assumption that aggregate demand management/stabilization can be achieved through common policies, say, monetary policy. We abstract from modeling these policies or monetary frictions explicitly.

insurance system.[4] The federal unemployment insurance scheme covers some of the member states' spending on unemployment benefits, with the amount per unemployed depending on the individual country's unemployment level. The federal unemployment insurance system is financed via fixed transfers from the member states.

We calibrate the model to the euro area. Where in doubt, we try to err on one side: making assumptions that should lead us to overstate the role for international insurance. For example, we attribute all cyclical fluctuations in a country to idiosyncratic country-level shocks. In our baseline, the calibration entails considerable fluctuations in unemployment that arise from wage rigidity. These fluctuations are socially inefficient. In line with Jung and Kuester (2015), the optimal domestic response of the government is to use its policy instruments with a view toward reducing the size of unemployment fluctuations. This is achieved by vacancy subsidies and layoff taxes. Once unemployment has been stabilized, instead, quantitatively there is little need for varying the generosity of unemployment insurance in response to fluctuations in output – even if workers are risk-averse. For the European level, this means that countries have considerable means of stabilizing their own business cycles and unemployment rates. Still, there remains scope for international insurance.

The main findings are as follows ...

The remainder of this paper is organized as follows. The next section relates our work to the existing literature. Section I presents the model. Section II provides analytical results that characterize the optimal response of member states's policies to a federal unemployment insurance system.Section III presents the calibration of the model economy to the euro area. Section IV discusses the optimal policy mix at the country level and for the group as a whole. Section V provides sensitivity analysis with respect to the basic assumptions. Here we entertain alternative ways of modeling the source of fluctuations in the baseline economy. In particular, we assess entirely exogenous wages, as in Landais, Michaillat and Saez (2010) and demand externalities as in Krueger, Mitman and Perri (2016). A final section concludes.

A. Related literature

To the best of our knowledge, our paper is the first that quantifies the optimal labor-market policy mix in a fiscal union of sovereign states, where the latter retain the right and ability to control their own labor-market instruments. Various strands of the literature, though, have studied either the domestic context or have considered simplified setups that abstract from moral hazard at the country level.

[4]This feature forms part of the proposals of European unemployment benefit schemes, that are currently under discussion; see, for example, Andor (2016); Bénassy-Quéré, Ragot and Wolff (2016), among others.

Our paper closely follows Jung and Kuester (2015). These authors study the optimal labor-market policy mix, in steady state, and over the business cycle in a closed economy subject to the same frictions that we discuss in each of the member states. A key finding of their paper is that the optimal labor-market policy mix may make fluctuations in unemployment insurance generosity over the business cycle irrelevant. The current paper extends these findings to a union of member states and group-level provision of benefits. Other papers that study the closed economy context, for a limited set of instruments are Landais, Michaillat and Saez (2010) and Mitman and Rabinovich (2011). These two studies restrict themselves to just one instrument: unemployment benefits. What we highlight, instead, is the case of an optimal response of the government to a federal unemployment benefit scheme.

Related work in the open economy context is Moyen, Stähler and Winkler (2016). They are concerned with the optimal design of an unemployment insurance system in a two-country currency union, when a central planner can choose unemployment benefits and UI taxes in both countries, in a differential way. That is, they abstract from optimal policy responses at that level of the member state.

Next to a quantitative exploration, they deliver insightful pencil and paper solutions. In these, they show that cross-country transfers can be implemented optimally through the unemployment insurance system and in a way that does not affect the level of unemployment. Our paper, instead, focuses on a union of sovereign states, in which each of these can adjust their labor-market instruments in response to the group-level unemployment insurance system.

In terms of international risk-sharing more generally, Backus, Kehoe and Kydland (1992) find that the standard two-country RBC model exhibits too low a correlation between domestic consumption and domestic output. Our strong assumptions can be taken as a means of enforcing a stronger correlation to start with. Evers (2015) studies the scope and welfare effects for fiscal centralization in a two-country DSGE model of the euro area. Like us, Evers finds that fiscal centralization is beneficial, while an intermediate sharing of resources is not. While we derive at this result due to moral hazard of individual country governments, he derives it based on fixed fiscal rules.

Dolls et al. (2015) provide a microsimulation study of a European unemployment insurance, that partly replaces national unemployment insurance schemes. They explore a system that provides benefits of 50 percent per year from the European level for the first 12 months of an unemployment spell. They provide an overview of likely effects keeping constant the policy system in place. That is, next to general equilibrium effects of a European UI scheme, they abstract from moral hazard at the country level. Nevertheless, since Dolls et al. (2015) allow for permanent asymmetries, they find that a European unemployment system leads to permanent transfers to and from a select group of members. Dolls et al. (2015) also provide more details on the evolving institutional discussion.

Kekre (2016). Fahri and Werning (2017) in more detail.

Persson and Tabellini (1996)

I. The model

This section lays out the model economy. Where there is overlap, the exposition here closely follows Jung and Kuester (2015). We extend their study of the optimal labor-market policy mix in a single country to a union of federal countries. First, we describe the technological constraints of the economy. Then, we formulate the planner's problem of the individual country. Thereafter, we describe the decentralized economy. In doing so, we focus on the government's instruments, the firms' hiring decisions and the bargaining between the firm and the worker. Last, we describe the group's planner's problem.

A. Technological constraints of the model economy

The economy consists of a unit mass of economies. The economies share a joint budget constraint at the federal level, but otherwise live in autarky. That is, international insurance only occurs through the centralized fiscal authority. This, clearly, is a strong assumption, but it helps to keep the setup tractable.

Each country is populated by a continuum of workers with measure one and an infinite measure of potential one-worker firms. Workers are homogeneous in regard to their *ex ante* efficiency of working. Firms produce a homogeneous good that cannot be stored. Countries are subject to persistent idiosyncratic productivity shocks. Time is discrete. Variables pertaining to individual countries are indexed by superscript $i \in [0,1]$. For example, $c^i_{u,t}$ marks consumption of the unemployed in country i at time t. For expositional ease, whenever the exposition will be clear without the superscript, we opt not to carry it.

Labor market flows. — We denote the measure of workers who are employed in a particular country at the *beginning* of period t by e^i_t and the measure of workers who are unemployed at the beginning of the period by u^i_t, so that $u^i_t = 1 - e^i_t$. Employment at the beginning of the next period evolves according to

(1)
$$e^i_{t+1} = (1 - \xi^i_t)e^i_t + m^i_t,$$

where m^i_t are new firm-worker matches formed in period t. ξ^i_t is the rate of separation of existing firm-worker matches. A worker can be recruited only through the posting of a vacancy at a resource cost of $\kappa_v > 0$. Let v^i_t be the number of vacancies. New matches are created according to the matching function

$$m^i_t = \chi \left(v^i_t\right)^\gamma \left([\xi^i_t e^i_t + u^i_t] s^i_t\right)^{1-\gamma} . \tag{2}$$

The term in parentheses is explained as follows. The mass of workers who are potentially searching during period t equals $\xi^i_t e^i_t + u^i_t$. That mass comprises the workers laid off at the beginning of the period, $\xi^i_t e^i_t$, and the mass of workers who entered the period unemployed, u^i_t. s^i_t is the share of these workers who search for a job. Parameter $\chi > 0$ governs the matching-efficiency, and $\gamma \in (0,1)$ is the elasticity of matches with respect to vacancies.

For subsequent use, we define labor-market tightness as $\theta^i_t := v^i_t/([\xi^i_t e^i_t + u^i_t] s^i_t)$, and the job-finding rate as $f^i_t := m^i_t/([\xi^i_t e^i_t + u^i_t] s^i_t)$.

Consumption, value of the worker and search. — Workers are risk-averse and have period utility functions $\mathtt{u} : \mathcal{R} \to \mathcal{R}$ that are twice continuously differentiable, strictly increasing and concave in the period's consumption level. $\beta \in (0,1)$ is the time-discount factor. Workers who are not employed enjoy an additive utility of leisure $\overline{h}$. Workers employed throughout period t consume $c^i_{e,t}$. Workers who are employed at the beginning of t but whose match is severed in t consume $c^i_{0,t}$. Workers who enter the period unemployed consume $c^i_{u,t}$.

Value of an employed worker

The value of an employed worker at the beginning of the period, before idiosyncratic shocks are realized, then is

$$V^i_{e,t} = \quad (1-\xi^i_t)\left[\mathtt{u}(c^i_{e,t}) + \beta E_t V^i_{e,t+1}\right] + \xi^i_t V^i_{0,t}. \tag{3}$$

Here ξ^i_t marks the probability that the match separates in the course of the period. If the match does not separate, the worker consumes $c^i_{e,t}$ and the match continues into $t+1$. E_t marks the expectation operator. $V^i_{0,t}$ is the value in t of a worker who has just been laid off. Apart from the consumption stream in the first period, this has the same value as $V^i_{u,t}$, the value of a worker who enters the period unemployed: $V^i_{0,t} = V^i_{u,t} + \mathtt{u}(c^i_{0,t}) - \mathtt{u}(c^i_{u,t})$. The value $V^i_{u,t}$ will be explained in detail below. For now it suffices to define the surplus of the currently employed worker from employment, namely, $\Delta^{e,i}_{u,t} := V^i_{e,t} - V^i_{u,t}$.

Value of an unemployed worker and search

Unemployed workers need to actively search in order to find a job. Search is a 0-1 decision. Workers are differentiated by their utility cost of search, $\iota \sim F_\iota(0, \sigma_\iota^2)$. For tractability, these costs are independently and identically distributed both across workers and across time. $F_\iota(0, \sigma_\iota^2)$ marks the logistic distribution with mean 0 and variance $\sigma_\iota^2 := \pi \frac{\psi_s^2}{3}$, where a lower-case π refers to the mathematical constant. All workers whose disutility of search falls below a certain cutoff value $\iota_t^{s,i}$ do search for a job. For the worker who is just at the cutoff value, the utility cost of search just balances with the expected gain from search:

$$\iota_t^{s,i} = f_t^i \, \beta \, E_t \left[\Delta_{u,t+1}^{e,i} \right]. \tag{4}$$

The gain from search is the discounted increase in utility when employed in the next period rather than unemployed multiplied by the probability, f_t^i, that a searching worker will find a job. Using the properties of the logistic distribution, s_t^i, the share of unemployed workers who search is given by

$$s_t^i = Prob(\iota \leq \iota_t^{s,i}) = 1/\left(1 + \exp\left\{-\iota_t^{s,i}/\psi_s\right\}\right). \tag{5}$$

The value of an unemployed worker *ex ante*, that is, before the search preference shock has realized, is given by

$$\begin{aligned} V_{u,t}^i \quad = \quad & \mathtt{u}(c_{u,t}^i) + \overline{h} \\ & + \int_{-\infty}^{\iota_t^{s,i}} \left[-\iota + f_t^i \beta E_t V_{e,t+1}^i + (1 - f_t^i) \beta E_t V_{u,t+1}^i \right] dF_\iota(\iota) \\ & + \int_{\iota_t^{s,i}}^{\infty} \beta E_t V_{u,t+1}^i dF_\iota(\iota). \end{aligned} \tag{6}$$

Regardless of his own search decision, in the current period the unemployed worker receives consumption $c_{u,t}^i$ and enjoys utility of leisure $\overline{h}$. If the worker decides to search (second row), he suffers utility cost ι_i. Compensating for this, with probability f_t^i the worker will find a job. In that case, the worker's value at the beginning of the next period will be $V_{e,t+1}^i$. With probability $(1 - f_t^i)$ the worker remains unemployed, in which case the worker's value at the beginning of the next period will be $V_{u,t+1}^i$. If the worker does not search (third row), the worker will continue to be unemployed in the next period.

Production and separation. — Each firm j that enters the period matched to a worker can either produce or separate from the worker. Production entails a firm-specific resource cost,

ϵ_j. For analytical tractability, we specify this as a shock that is independently and identically distributed across both matches and time, $\epsilon_j \sim F_\epsilon(\mu_\epsilon, \sigma_\epsilon^2)$. $F_\epsilon(\cdot,\cdot)$ marks the logistic distribution with mean μ_ϵ and variance $\sigma_\epsilon^2 = \pi\frac{\psi_\epsilon^2}{3}$. The firm separates from the worker and avoids paying the resource cost whenever the idiosyncratic cost shock, ϵ_j, is larger than a threshold $\epsilon_t^{\xi,i}$. Using the properties of the logistic distribution, conditional on the threshold, the separation rate can be expressed as

$$\xi_t^i = Prob(\epsilon_j \geq \epsilon_t^{\xi,i}) = 1/\left(1 + \exp\left\{(\epsilon_t^{\xi,i} - \mu_\epsilon)/\psi_\epsilon\right\}\right). \tag{7}$$

Each firm-worker match that does not separate, produces an amount $\exp\{a_t^i\}$ of output. Total production in the economy therefore is given by

$$y_t^i = e_t^i(1 - \xi_t^i)\exp\{a_t^i\}, \tag{8}$$

where $e_t^i(1-\xi_t^i)$ is the mass of existing matches that are not separated in t. Aggregate productivity, a_t^i, evolves according to

$$a_t^i = \rho_a\, a_{t-1}^i + \varepsilon_{a,t}^i, \quad \rho_a \in [0,1),\ \varepsilon_{a,t}^i \sim N(0,\sigma_a^2).$$

It is the heterogenous realizations of the country-specific TFP shocks that generate scope for cross-country insurance.

Resource Constraints. — Each country's output is used for consumption, production costs, and vacancy posting. Additionally, by participating in a federal insurance scheme, the local authority has access to net transfers. Let net transfers to country i be denoted by T_t^i. These are given by

$$T_t^i := B_{F,t}\left(u_t^i\right) - \tau_F. \tag{9}$$

Here $B_{F,t}\left(u_t^i\right)$ mark payments from the federal level to the individual country. These payments are function of u_t^i. That is, they are conditional on the mass of workers that are not employed at the beginning of the period, for which the member state pays unemployment benefits. Note that all countries, realistically, are subject to the same structure of the transfer scheme. In our numerical exercise, we will optimally parameterize a flexible function $B_{F,t}$. τ_F marks a fixed payment from each country to the federal level, that finances the federal insurance scheme.

With this notation at hand, the total resources that a country has at its disposal are

$$y_t^i = e_t^i c_{e,t}^i + u_t^i c_{u,t}^i + e_t^i \int_{-\infty}^{\epsilon_t^{\xi}} \epsilon \, dF_\epsilon(\epsilon) + \kappa_v v_t^i + T_t(u_t^i). \tag{10}$$

At the federal level, the scheme has to have a balanced budget, that is, for all t, the sum of benefit payments across countries in the monetary union needs to equal revenue

$$\int_0^1 B_{F,t}\left(u_t^i\right) \, \mathrm{d}i = \int_0^1 \tau_F \, \mathrm{d}i.$$

The law of large numbers implies that the above condition reduces to

$$\mathbb{E}\, B_{F,t}\left(u_t^i\right) = \tau_F,$$

where $\mathbb{E}$ marks unconditional expectations. We restrict our attention to equilibria in which the federal unemployment insurance scheme is implemented under full commitment by a central fiscal authority that is a Stackelberg leader. We then focus on the equilibrium induced by the optimal response of the individual atomistic member countries.

B. *The individual member country's problem*

A central element of this paper is that we account for the optimal response of member states' governments to the federal insurance system. Toward this end, in each country, we consider a utilitarian planner who gives equal weight to all workers in that country. Since consumption in the period of separation, $c_{0,t}^i$, does not affect the search incentives of a worker who was just laid off, the planner will provide such a worker with full insurance. In formulating the planner's problem, we anticipate this result and set $c_{0,t}^i = c_{e,t}^i$. There are three states in the planner's problem: aggregate technology, a_t^i, the stock of workers who are employed at the beginning of the period, e_t^i, and the (state-contingent) value of the utility difference from working, $\Delta_{u,t}^{e,i}$, that the planner had promised for t to the worker who searched in $t-1$.[5] In addition, the individual country's planner takes as given the federal unemployment insurance system.

Using the assumptions laid out above, and using the properties of the logistic distribution,

[5]Recall from equation (4) that the expected utility difference governs the search decision.

the planner's objective can be written as

$$
\begin{aligned}
W_t^i &= \max_{\xi_t^i,\theta_t^i,c_{e,t}^i,c_{u,t}^i,\{\Delta_{u,t+1}^{e,i}\}} e_t^i\mathtt{u}(c_{e,t}^i) + u_t^i\mathtt{u}(c_{u,t}^i) + (e_t^i\xi_t^i + u_t^i)(\Psi_s(s_t^i) + \overline{h}) \\
&\qquad + \beta E_t W_{t+1}^i
\end{aligned}
\tag{11}
$$

s.t.

$$
\begin{aligned}
e_{t+1}^i &= e_t^i(1-\xi_t^i) + (\xi_t^i e_t^i + u_t^i)s_t^i\chi\left(\theta_t^i\right)^\gamma, \\
e_t^i &= 1 - u_t^i, \\
s_t &= \left(1 + \exp\left\{\frac{-\chi(\theta_t^i)^\gamma\beta E_t\Delta_{u,t+1}^{e,i}}{\psi_\iota}\right\}\right)^{-1}, \\
\Delta_{u,t}^{e,i} &= \mathtt{u}(c_{e,t}^i) - \overline{h}(1-\xi_t^i) - \mathtt{u}(c_{u,t}^i) + \beta E_t(1-\xi_t^i)\Delta_{u,t+1}^{e,i} \\
&\quad + (1-\xi_t^i)\psi_s\log(1-s_t^i), \\
e_t(1-\xi_t^i)\exp\{a_t^i\} &= e_t^i c_{e,t}^i + u_t^i c_{u,t}^i + e_t^i(1-\xi_t^i)\mu_\epsilon - e_t^i\Psi_\xi(\xi_t^i) \\
&\quad + (e_t^i\xi_t^i + u_t^i)s_t^i\theta_t^i\kappa_v + B_{F,t}(1-e_t^i) - \tau_F, \\
a_t^i &= \rho_a\, a_{t-1}^i + \varepsilon_{a,t}^i,\ \varepsilon_{a,t}^i \sim N(0,\sigma_a^2).
\end{aligned}
$$

The first term on the right-hand side of the objective is the consumption-related utility of employed workers, and the second term is the consumption-related utility of unemployed workers. The third term refers to the value of leisure and the utility costs of search.[6] The final term is the continuation value.

The planner maximizes over separations, ξ_t^i (understanding that this implicitly defines the separation cutoff $\epsilon_t^{\xi,i}$), market tightness, θ_t^i, and consumption levels $c_{e,t}^i$ and $c_{u,t}^i$ for those who, respectively, are employed and unemployed at the beginning of the period. In addition, the planner maximizes over promised utility differences for the next period, $\{\Delta_{u,t+1}^{e,i}\}$. The latter are contingent on the future state of the economy.

The first two constraints are, respectively, the aggregate laws of motion of employment and unemployment. The third constraint is the incentive constraint that is formed by merging the search conditions (4) and (5). Here, we have replaced the job-finding rate by $\chi(\theta_t^i)^\gamma$, in line with the matching technology. Key to inducing search effort is the planner's promise of an increase in utility when a worker moves from unemployment to employment. The fourth constraint, interpretable as a promise-keeping constraint, describes the evolution of this utility difference. Last, the planner is bound by the aggregate resource constraint that equates the right-hand sides of (8) and (10), and by the law of motion of the aggregate productivity shock. The aggregate resource constraint, in turn, accounts for the European transfer scheme.

Appendix A provides the first-order conditions of the planner's problem that characterize the

[6]Here $\Psi_s(s_t^i) := -\psi_s\left[(1-s_t^i)\log(1-s_t^i) + s_t^i\log(s_t^i)\right]$. $\Psi_\xi(\xi_t^i)$, which is used further below, is defined in an analogous manner.

constrained-efficient allocation.

Demand Externalities. — In the model above, the federal unemployment insurance provides partial insurance against aggregate productivity shocks. By implementing optimal labor-market policies, countries themselves can quite notably smooth the cycle. In this class of models, therefore, the costs of cyclical fluctuations are not large to start with. In order to evaluate the welfare implications of the federal scheme in a setup where *a priori* the benefits from additional consumption smoothing may be larger still, we extend the model to allow for the feedback from aggregate demand to productivity. We follow Krueger, Mitman and Perri (2016) and assume that the current TFP depends positively on current aggregate consumption $c_t = e_t c_{e,t} + (1 - e_t) c_{u,t}$. Concretely, we consider an environment where total output reads

$$y_t^i = e_t^i (1 - \xi_t^i) \exp\{a_t^i\} c_t^{\phi}, \tag{12}$$

where $\phi > 0$ captures the size of the spillovers between aggregate demand and productivity.

C. *The federal problem*

The federal planner chooses the scheme $B_F(u_t), \tau_F$ so as to maximize *ex-ante* utilitarian welfare of the union's constituents. In doing so, the federal planner anticipates the response of the member countries' governments. The federal planner also ensures that the unemployment insurance budget is balanced.

II. Optimal policy

We devote this section to building intuition for the effect of federal unemployment insurance on the individual country's labor-market policy mix. In particular, here we will characterize the effect that a federal unemployment insurance system has on the policy choices of the individual country's social planners, in both the steady state and over the business cycle. We will also highlight the implications of this for the level of unemployment in the union as a whole.

To be completed

III. Calibration

The focus of the current paper is on spelling out the consequences of a European unemployment insurance system that is aimed at providing cyclical stabilization. Therefore, we deliberately abstract from the differences in labor-market settings that exist in the euro area to date, and therefore also from any asymmetric benefits or costs, or permanent unilateral (positive or negative) transfers associated with such a scheme. Rather, we seek to start from a "euro-area" calibration.

Our strategy, therefore, is as follows. We calibrate parameters to match euro-area averages and "typical" cyclical fluctuations of the labor market. What sets the euro area apart, in particular, is that labor markets are considerably less fluid than in the US; for example, Elsby, Hobijn and Sahin (2013). We specify simple tax and benefit rules that we deem roughly in line with the current average settings in the euro area. We then calibrate the model's parameters such that it matches key properties of the euro-area business cycle. It is beyond the scope of the current paper to spell out the degree to which shocks originate domestically or in the rest of the euro area. The decision that we take here is to assign all fluctuations to country-specific shocks. This will likely overstate the scope of European insurance, and should be borne in mind when interpreting the quantitative results that follow.Subsequently, in Section IV, we treat the resulting parameters as structural and ask what the labor market policy mix *should* look like.

A. Data used for the calibration

One period in the model is a month. We calibrate the model to the period 1991M1 to 2015M12.[7] Much of the data series that we compare the model to, however, have a quarterly frequency. Where applicable, the data series are seasonally adjusted.

The sample period above includes the deep recession that ensued after the financial and debt crises. The main data source is the ECB's area-wide-model database (AWM). That database presents area-wide aggregates for a fixed composition of the Euro area with 19 members. National-account aggregates are GDP weighted, the employment and unemployment series are sums of the local equivalents.

Output y in the model is taken to be real gross domestic product. Labor productivity, $\frac{y}{e(1-\xi)}$, is measured as output per employed worker. Employment and the unemployment rate are the respective equivalents of the database. Our measure of the wage, w, is the ratio of the total compensation of employees deflated with the GDP deflator to the number of employed workers. The AWM database does not include estimates of labor-market flow rates, or overall flows. We largely follow the strategy in Christoffel, Kuester and Linzert (2009) and resort to the various data sources that provide us with some information on the euro-area labor market.

The OECD reports vacancies for much of the euro area labor-market (stocks of unfilled vacan-

[7]Our choice of the initial date is dictated by the availability of internationally comparable OECD Harmonized Unemployment data that we use to construct time series of the market tightness in euro area. In particular, the series for Germany, Eurozone's largest economy, starts only in 1991. 2015Q4 constitutes the last period available in the current release of area-wide-model database.

cies from the "Short–Term Labour Situation Database"). The euro-area numbers reported below are derived by summing the vacancies for those member states for which there are observations.[8]

As regards, job-finding and separation rates, Elsby, Hobijn and Sahin (2013) provide annual estimates for monthly job-finding and separation rates for selected OECD countries. Among their sample are the euro area countries Austria, Finland, France, Germany, Ireland, Italy, Portugal, and Spain. Averaging over the job-finding and separation rates reported therein, we obtain our targets for the the steady-state job finding and separation rates for our "euro-area" calibration of the model.

The annual data in Elsby, Hobijn and Sahin (2013) are not easily suited for calibrating the volatility of labor-market flow rates over the business cycle.To the best of our knowledge, there does not exist a comprehensive, higher-frequency, data base with flow rates for the euro area. Therefore, we opt for a compromise. In calibrating the model to replicate the monthly standard deviation of job-finding rates, we proxy this measure using the flow rates for Germany, reported in Hartung, Jung and Kuhn (2016).

The business cycle properties of the data are reported in Table 1. Whenever the frequency of the raw series is monthly, for assessing the fluctuations we take a quarterly average of the monthly data. Following Shimer (2005), the table reports the log deviations of these quarterly averages from an HP trend with a smoothing parameter of 1600. The business cycle properties

Table 1—Business cycle properties of the data

		y	$Lprod$	$urate$	v	f	ξ	w	θ
Standard deviation		1.20	0.74	5.99	15.74	6.54	8.75	0.56	18.42
Autocorrelation		0.90	0.83	0.95	0.95	0.56	0.77	0.86	0.95
	y	1.00	0.80	-0.88	0.66	-0.27	0.50	0.23	0.81
	$Lprod$	-	1.00	-0.47	0.29	-0.36	0.37	0.04	0.42
	$urate$	-	-	1.00	-0.70	0.25	-0.55	-0.30	-0.86
Correlation	v	-	-	-	1.00	0.61	-0.66	0.44	0.91
	f	-	-	-	-	1.00	-0.55	-0.38	0.65
	ξ	-	-	-	-	-	1.00	0.11	-0.62
	w	-	-	-	-	-	-	1.00	0.40
	θ	-	-	-	-	-	-	-	1.00

Note: The table reports summary statistics of the data. The sample is 1991Q1 to 2015Q4. *Lprod* is labor productivity per worker. *urate* is the unemployment rate. All data are quarterly aggregates, in logs, HP(1600) filtered and multiplied by 100 and, hence, can be interpreted as the percent deviation from the steady state. The first row reports the standard deviation. The next row reports the autocorrelation. The following rows report the contemporaneous correlation matrix. Since the data on job finding and separation rates concern only the German economy, the corresponding entries in the correlation matrix report the correlation with the corresponding German series from Eurostat. See the text for details regarding the data.

of the data are well-known. Unemployment and vacancies, u_t and v_t, are volatile and so is

[8]These are Austria, Belgium, Finland, Germany, Luxembourg, Portugal and Spain. In some years, only data for a subset of those countries are available.

market tightness, v_t/u_t. The job-finding rate, f_t, is procyclical and the separation rate, ξ_t, is countercyclical and perhaps somewhat more responsive to the cycle than the job-finding rate. Wages, instead show little cyclicality.

B. *Calibrated parameters*

One period in the model is a month. Table 2 summarizes the calibrated parameters.

Table 2—Parameters for baseline

Preferences		
σ	relative risk aversion.	1
β	time-discount factor.	0.996
$\overline{h}$	disutility of work.	0.302
ψ_s	scaling parameter dispersion utility cost of search.	0.0637
Vacancies, matching and bargaining		
κ_v	vacancy posting cost.	0.243
α	match elasticity with respect to vacancies.	0.300
χ	scaling parameter for match-efficiency.	0.144
η	steady-state bargaining power of firm.	0.300
γ_w	degree of cyclicality of bargaining power of worker.	20
Production and layoffs		
μ_ϵ	mean idiosyncratic cost.	0.0909
ψ_ϵ	scaling parameter dispersion idiosyncratic cost shock.	1.56
ρ_a	AR(1) of aggregate productivity.	0.982
$\sigma_a \cdot 100$	std. dev. of innovation to aggregate productivity.	0.171
Labor market policy		
b	Replacement rate	0.6
τ_v	Vacancy posting subsidy.	0
τ_ξ	Layoff tax	4.25

Note: The table reports the calibrated parameter values in the baseline economy.

The assume CRRA utility with coefficient of relative risk aversion $\sigma = 1$, implying log utility. We calibrate the monthly discount factor β to .996. We set the utility from leisure to $\overline{h} = 0.302$ such that in the steady state 10 percent of workers are without employment ($\xi e + u$). We set $\psi_s = 0.064$ to replicate an elasticity of the average duration of unemployment with respect to UI benefits of 0.8, which is in line with the empirical literature, for example, Meyer (1990).[9] We set a vacancy posting cost of $\kappa_v = .243$ so as to obtain an average unemployment rate of 9.5 percent as in the data.[10] This results in an average cost per hire $\frac{v\kappa_v}{m}$ of 0.15 monthly wages – in line with a broader notion of recruiting costs; see Silva and Toledo (2009). We set the elasticity of the

[9]The elasticity takes into account the effect of a *permanent* increase in UI benefits on an individual's search effort (and thus on the duration of unemployment) but not the general equilibrium effect of UI benefits on the job-finding rate and the separation margin.

[10]The "unemployment rate" in the model is defined as $urate_t = (e_t\xi_t + u_t)s_t/[(e_t\xi_t + u_t)s_t + e_t(1 - \xi_t)]$, and includes only those unemployed workers who do actively search for work.

matching function with respect to vacancies to $\alpha = 0.3$ similar to Shimer (2005) and within the range of estimates deemed reasonable by Petrongolo and Pissarides (2001). We set the firm's bargaining power to $\eta = 0.3$ so that, absent risk aversion, in the steady state the Hosios (1990) condition would be satisfied without any government intervention. We view this as a natural – and customary – choice. In order to determine the matching-efficiency parameter, we target a quarterly job-filling rate of 71 percent as in den Haan, Ramey and Watson (2000). This results in $\chi = 0.144$. The finding of lower match efficiency is consistent with other observations for Europe, for example Jung and Kuhn (2014).

In order to replicate the cyclical volatility of the labor market, we employ a mechanism that attenuates wage fluctuations and thus increases variability of the labor market. We assume a procyclical bargaining power of firms so in recessions, wages tend to be inefficiently high relative to the productivity.[11] Concretely, we specify the following law of motion of the bargaining power

$$\eta_t = \eta \exp\{\gamma_w a_t\}, \gamma_w \geq 0.$$

Note that related assumptions are common in the literature.[12] We choose the value of γ_w that generates an amount of volatility in the job-finding rate, f_t, that is comparable to the data summarized in Table 1. This implies $\gamma_w = 20$. As a result, for a 1 percent negative productivity shock the bargaining power of firms falls by about 20 percent.

We calibrate the location parameter for the idiosyncratic cost shock so that the average cost shock of a firm that decides to produce is zero. This yields $\mu_\epsilon = 0.0909$. We calibrate the dispersion parameter for the idiosyncratic cost shock to $\psi_\epsilon = 1.56$. This ensures an average job-finding rate of $f = 0.1$ (ten percent per month) as in the data for the euro area; compare Elsby, Hobijn and Sahin (2013). In regard to aggregate productivity, we set the serial correlation of the productivity shock to $\rho_a = 0.982$ and the standard deviation of the shock to $\sigma_a = 0.00171$. With these values, the model replicates the volatility and serial correlation of labor productivity in the data.

Next, we turn to calibrating the policy variables. In calibrating unemployment benefits, we follow Christoffel, Kuester and Linzert (2009) and set benefits b such that the replacement rate $b = c_{u,t}/c_{e,t}$ is equal to 6%. This is in line with the average of net replacement rates across family situations, income levels, and euro area countries that one can deduce from the OECD

[11] It is well–documented that the flexible–wage search and matching model fails to generate the magnitude of the cyclical fluctuations that one observes in the labor market; see Shimer (2005), Hall (2005), Hagedorn and Manovskii (2008), and Pissarides (2009).

[12] For example, Landais, Michaillat and Saez (2010) directly specify that $w_t = \overline{w} \exp\{\varrho a_t\}$, with $\varrho = 0.5$ as an exogenous wage rule. In our framework, workers and firms bargain about the wage. Due to the shifting bargaining powers, however, the resulting equilibrium wage will be less responsive to productivity than under a Nash-bargaining protocol with a constant bargaining power. In sensitivity analysis, we also explore a completely exogenous wage rule.

reports on "Benefits and Wages."

We set layoff taxes to recoup roughly 100% of the fiscal costs of unemployment benefits over the average duration of an unemployment spell. This parameterization is a compromise between two extremes. On the one hand, legislation in the majority of euro-area member states does protect incumbent workers from being laid off, on the other hand, typically this does not come in the form of a prohibition to separate, or mandated severance payments, but not layoff taxes proper. We set vacancy subsidies to $\tau_{v,t} = 0$.

In regard to the cyclical properties, the calibrated model does a reasonably good job of replicating the fluctuations in the data; see Table 3, which reports statistics based on a first-order approximation of the model. Unemployment and vacancies are considerably more volatile than

Table 3—Business cycle properties of the model

		y	*Lprod*	*urate*	v	f	ξ	w	θ
Standard deviation		2.16	0.91	11.31	19.12	8.77	4.25	0.97	29.24
Autocorrelation		0.99	0.96	0.99	0.93	0.97	0.98	0.99	0.97
Correlation	y	1.00	0.98	-0.99	0.92	0.98	-0.99	1.00	0.98
	Lprod	-	1.00	-0.93	0.98	1.00	-0.99	0.96	1.00
	urate	-	-	1.00	-0.85	-0.94	0.97	-1.00	-0.94
	v	-	-	-	1.00	0.98	-0.96	0.89	0.98
	f	-	-	-	-	1.00	-1.00	0.97	1.00
	ξ	-	-	-	-	-	1.00	-0.99	-1.00
	w	-	-	-	-	-	-	1.00	0.97
	θ	-	-	-	-	-	-	-	1.00

Note: The table reports second moments in the model. *Lprod* is labor productivity per worker. *urate* is the unemployment rate. All data are quarterly aggregates, in logs and multiplied by 100 in order to express them in percent deviation from the steady state. We report unconditional standard deviations from the model. The first row reports the standard deviation. The next row reports the autocorrelation. The following rows report the contemporaneous correlation matrix. Table 1 reports the corresponding business cycle statistics in the data.

productivity and so are the job-finding and separation rates. Vacancies and unemployment are negatively correlated, thus preserving the Beveridge-curve relationship. The job-finding rate is procyclical, the separation rate countercyclical.

IV. Quantitative Results

This section presents the results of the quantitative exercise in which we aim to determine the optimal design of a European Unemployment Insurance scheme. The results suggest that under incomplete international financial markets, abstracting from a response by the member states, a rather generous European Unemployment Insurance system would notably increase welfare, and would be able to almost eradicate the costs of idiosyncratic business cycle shocks. Consequently, we discuss which of the instruments would need to be restricted at the European level to recoup the welfare gains from pan-European insurance.

A. Parameterized Non–linear Payout Function

The European Unemployment Insurance scheme, that we study, is a rules-based scheme that follows a reasonably simple parametric form. We believe that this will be necessary in order to translate an international insurance contract into law. The European level, therefore, chooses a payout function from a parameterized family of functions. Concretely, let us assume that the payout from the insurance scheme, $G(1-e,;\omega,\nu)$, is chosen from the (rather flexible) class of generalized logistic distribution functions. Let G be function of the non–employed population $1-e$ parameterized by $\omega,\nu \geq 0$ such that

$$G(1-e;\omega,\nu) = \frac{B_H}{\left[1+q\exp\{-\omega x\}\right]^{1/\nu}} \tag{13}$$

$$x = -\log\left(\frac{1}{1-e} - \frac{1}{u_H}\right) \tag{14}$$

G has support on $(0, u_H)$, the latter being the maximum permissible level of unemployment.[13] Parameters $q > 0$ and ν govern the slope of transfers. The parameter ω captures the threshold level of unemployment above which significant insurance is paid.

In light of the discussion in Section II, the non–linear formulation of the insurance payout allows to mitigate the incentive distortions induced by the scheme without the need to significantly reduce to degree of the insurance provided. Intuitively, as the payout rises steeply only above a certain level of unemployment, the federal funds allow for insurance against a the worst–case scenario of a severe recession. At the same time, in the neighborhood of the steady=state, the benefit function is flat enough so as to disincentive the planner to permanently increase the unemployment level.

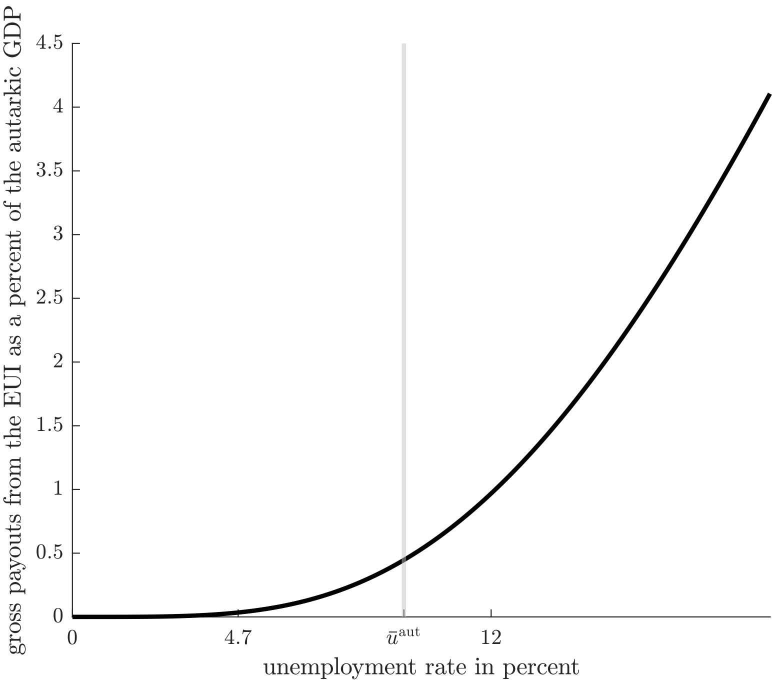
B. Optimal Federal Insurance Scheme – Fixed Instruments at the country level

We start by showing the optimal European Unemployment Insurance Scheme when the individual country cannot adjust its labor-market instruments. That is, we abstract from country-level moral hazard by assumption.

The solid line on Figure 1 indicates the optimal design of the federal unemployment insurance for this case. The optimal parameterization has that in the deterministic steady state, the net transfers are slightly positive. A shock that moves the unemployment rate up by one standard deviation, from the steady state value of 9.5 percent towards 10.57 percent, results in a net

[13]To see this, note that $\lim_{1-e\to 0} G(1-e;\omega,\nu) = 0$ and $\lim_{1-e\to u_H} G(1-e;\omega,\nu) = B_H$.

FIGURE 1. FEDERAL REPLACEMENT RATE $G(1-e;\omega^*,B_H^*)$, WHERE ω^*,B_H^* DENOTE THE WELFARE–MAXIMIZING CHOICE OF PARAMETERS.



Notes: The vertical line indicates the steady state level of unemployment equal to 9.5 percent that we choose as a calibration target. The optimal parameterization reads $\omega^* = 3.5, B_H^* = .3$. The other parameters are $q = (.025)^2, \nu = 1/2, B_L = 0, u_L = 0, u_H = .4$

transfer of .4 percent of the steady state GDP (in this parameterization the constant, lump–sum EUI contribution is 0.72 percent of the autarkic GDP each period).

The transfer scheme reduces the welfare costs of business cycles by about a quarter (from 0.026 percent to 0.02 percent of steady-state consumption). Households would be willing to give up 0.0034 percent of their life-time consumption to live under this scheme. Unemployment is barely affected by the scheme, compare Table 4.

The autarkic costs of business, in terms of consumption equivalent, amounts to .026 percent and the EUI reduces the costs of fluctuation to 0.0061 percent.

Table 4—Steady state values of selected endogenous variables under autarky and the optimal non–linear EUI.

Variable	Descritpion	Autarky	EUI
y	output.	0.9	0.9
c_e	consumption of the employed.	0.927	0.926
c_u	consumption of the unemployed.	0.557	0.557
w	wage.	0.924	0.924
f	job–finding rate.	0.1	0.1
ξ	layoff rate.	0.0104	0.0104
θ	labor market tightness.	0.296	0.296
b	replacement rate	0.601	0.601
Δ_u	utility difference.	1.82	1.82
J	firm value.	0.725	0.724
Π	dividends.	0.00264	0.00264
τ_ϵ	sepration tax.	4.25	4.25
τ_v	vacancy posting subsidy.	0	0
u	unemployment rate.	0.095	0.095
e	employment.	0.909	0.909
s	fraction of job seekers.	0.945	0.945
v	vacancies.	0.0279	0.0279
τ_J	lump–sum production tax.	0.0112	0.0114
ζ	optimal tax wedge.	3.88	3.88

*Notes:*The table reports comparison of the steady state values in the baseline under autarky and under the optimal non–linear EUI scheme.

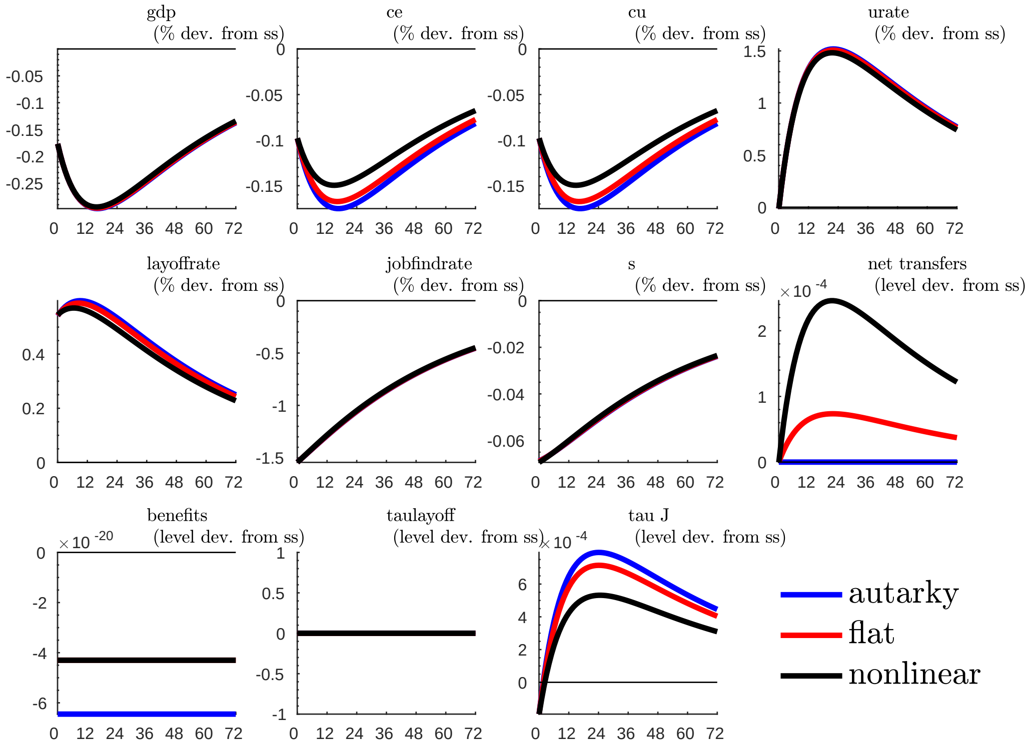
The essential feature of the scheme is its non-linearity. For a counterfactual, consider a "flat insurance" scheme under which the European policy maker would pay a fixed sum for each unemployed worker. We consider an (otherwise arbitrary) flat insurance scheme in which the federal tax rate is identical to the one implied by the optimal scheme. In order to exhaust those funds, under the "flat insurance" scheme, the replacement rate is 5.6 percent.[14]. Such a scheme is detrimental to welfare.

Figure IV.B compares impulse responses for different setups of European Unemployment In-

[14]The "flat" scheme is a special case of a nonlinear replacement rate obtained when $\omega = 0, q = 0, B_H - .056$ and arbitrary $\nu > 0$.

surance: autarky, flat with each country receiving a fix amount of resources per each unemployed and "nonlinear" denoting the optimal benefits scheme $\mathcal{B}_F(\omega^*, \nu^*)$.

Figure 2. Impulse responses for different types of insurance scheme in the baseline economy.



Notes:

As can be witnessed from Figure IV.B, absent a response of the member states' governments, the European Unemployment Insurance Scheme notably smoothes the response of consumption without affecting much the response of GDP or employment.

C. Allowing for a policy response by member states

We have shown above that the European Insurance system has the potential to improve welfare by providing insurance against business cycle shocks. This result was derived under the assumption that the individual governments do not adjust their labor-market instruments in response to the scheme. Now, we allow the domestic governments to react to the federal insurance system.

As a starting point, we implement the optimal European UI scheme that was derived above in Section IV.B. Once we allow member countries to react to that scheme, it becomes highly undesirable. The countries' planner would like to sacrifice as much as 7 percent of the present value of lifetime consumption in his country in order to leave the union and live in the autarkic economy.

V. Sensitivity Analysis

This section examines the robustness of our finding to two alternative ways of modeling the business cycle. In particular, here we entertain alternative ways of modeling the source of fluctuations in the baseline economy. In particular, we assess entirely exogenous wages, as in Landais, Michaillat and Saez (2010) and demand externalities as in Krueger, Mitman and Perri (2016).

VI. Conclusions

To be completed.

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THE DETAILS OF THE SOLUTION ALGORITHM. — In solving the model we proceed as follows.

Let $\boldsymbol{\Omega}, \boldsymbol{B_H}$ be the vectors considered in the grid search algorithm.

for each pair $(\omega, B_H) \in \boldsymbol{\Omega} \times \boldsymbol{B_H}$ **do**

$\tau_F \leftarrow \mathcal{B}_F(\bar{u}; \omega, B_H)$

$C \leftarrow 1$

$\epsilon \leftarrow 10^{-8}$

while $C > \epsilon$ **do**

find the steady state level implied by (ω, B_H) and τ_F.

solve second order approximation around that steady state

calculate convergence criterion $C = \text{abs}\left(\tau_F - \mathbb{E}_0\left\{\mathcal{B}_F(u_t; \omega, B_H)\middle|\tau_F\right\}\right)$

$\tau_F \leftarrow \mathbb{E}_0\left\{\mathcal{B}_F(1 - e_t; \omega, B_H)\middle|\tau_F\right\}$

end while

save the budget–balancing taxes $\tau_F^*(\omega, B_H) \leftarrow \tau_F$

store the welfare $W(\omega, B_H)$, where

$$W(\omega, B_H) = \mathbb{E}_0\left\{\sum_{t=0}^{\infty} \beta^t \left(e_t u(c_{e,t}) + (1 - e_t)u(c_{u,t}) + (\xi e_t + u_t)(\Psi(s_t) + \bar{h})\right) \middle|\omega, B_H, \tau_F^*(\omega, B_H)\right\}.$$

end for

return the welfare maximizing pair ω^*, B_H^*, s.th. $\forall_{\omega, B_H} W(\omega^*, B_H^*) \geq W(\omega, B_H)$