Federal Unemployment Insurance
– theory and an application to Europe –

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This version: October 5, 2017,
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Abstract

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, 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 federal unemployment insurance program is much reduced. A federal unemployment insurance scheme can provide insurance only in severe circumstances.

Keywords: labor-market policy mix, fiscal federalism, search and matching

JEL-Codes: E32, E24, J64

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1 Introduction

Federally-financed unemployment insurance (UI) is a keystone of industrialized economies' automatic stabilizers. On the one hand, transfer-based automatic stabilizers smooth aggregate demand and the business cycle, McKay and Reis (2016). On the other, a federal component of UI insulates against asymmetric regional shocks. Such transfers play a particularly vital role in monetary unions, Farhi and Werning (forthcoming). In practice, the scope of the federal component in industrialized country's UI systems varies markedly from country to country,[1] regional moral hazard being one explanation, Persson and Tabellini (1996). The current paper lays out when federal UI is a good idea. Based on the theory, the paper then provides a quantitative exploration of federal UI for the European Monetary Union (EMU).[2]
We study the labor-market policy mix in a union of countries that jointly finance (part of or all) unemployment benefits afforded to unemployed workers. The labor market in each of the countries is subject to Mortensen and Pissarides-type (1994) search and matching frictions. Asymmetric shocks to the regions that are observable only to the regional government, demand externalities as in Krueger et al. (2016), and incomplete international financial markets give rise to a role for a federal component of UI. Member states retain control over all (or some) domestic labor-market policies; in particular, hiring subsidies, layoff restrictions, and their own UI system. The scope of federal UI is limited by the classic trade-off between federally-provided insurance and regional moral hazard.
As to the theory, the paper first resorts to a one-period version of the full model so as to develop analytical intuition. The member state's optimal policy responds to the introduction of federal UI. We show how this shapes the latter's scope. The exercise extends Landais et al. (forthcoming) by a federal dimension, demand externalities, and a mix of labor-market instruments. If member states resort to optimal labor-market policy over the cycle, a federal UI system that starts providing benefits already at normal levels of unemployment will unambiguously induce a higher steady-state unemployment rate. This is so unless member state's instruments are heavily restricted or if federal UI can be conditioned on shocks. The reason is simple. There are two benefits of federal UI. One is to – for fixed regional instruments – help stabilize the business cycle, which can have first-order effects on welfare. The other is to provide insurance against regional shocks, itself a second-order welfare effect. Once member states optimally use their labor-market instruments, they – on their own – can make sure that jobs no longer are hard to come, a line of reasoning highlighted by Jung and Kuester (2015), for example. This removes the first-order benefits of federal UI. The first-order moral

[1] At one end, the U.S. mainly rests on states to provide UI. A federal component is activated only after severe shocks, U.S. Department of Labor (2017). In other economies (such as Germany), instead, UI is administered exclusively at the federal level.

[2] UI in EMU to date relies exclusively on member states. The limited extent of cross-state risk-sharing (documented, for example, in Furceri and Zdzienicka, 2015) has prompted calls for further fiscal integration Jean-Claude Juncker (2015) and European Commission (2017).

hazard effect of federal UI then outweighs the remaining second-order gain. Unless regional instruments can be restricted, federal UI should only be provided in severe recessions.

If member states have a limited set of instruments, or cannot respond to cyclical fluctuations, instead, federal unemployment benefits become less distortive. Still, benefits should remain limited to severe-enough labor-market states so as to prevent member state's moral hazard in good times. In other words, with sufficient sovereignty of member states federal UI benefits best have features of strict conditionality that are familiar from the US UI system.[3]

Having established intuition, we provide a quantitative exploration for a stylized euro area. The calibration entails considerable fluctuations in unemployment that arise from wage rigidity, a feature that has been pointed out as being of first-order importance in the European crisis, Schmitt-Grohé and Uribe (2016). These fluctuations are socially inefficient. In line with Jung and Kuester (2015), the optimal domestic response of the member-state government is to use its policy instruments with a view toward reducing the size of unemployment fluctuations. Still, there remains scope for international insurance. In line with the intuition developed earlier, the optimal federal UI scheme provides such insurance in states of high unemployment.

That is, quantitatively, the cutoff before federal UI is provided is relatively large. This result may hinge on our baseline having no first-order gains from providing federal UI, while federal policy may induce first-order losses from moral hazard. We explore several scenarios that highlight the importance of each of these dimensions. First, we explore demand externalities through a link between aggregate demand in a member state and each states' labor productivity, Krueger et al. (2016). Federal UI transfers, then, increase domestic aggregate demand and stabilize potential output in the member state. If local governments conduct optimal policy, quantitatively, we find that our results do not deviate much from the baseline. The reason for this finding is simple again: demand externalities give member states a strong incentive to focus on employment-focused policies in the first place. These policies are distorted by European UI just the same way that they are in the baseline. Then, we explore the case of limited instruments at the level of the member state. Toward this end, we let member states select steady-state policies, but not cyclical policies. Federal UI transfers, then, are the only countercyclical policy at the level of the region. With instruments fixed over the cycle, such transfers have the potential to have first-order welfare gains. We find that, quantitatively, the generosity of federal UI increases – but the federal component still remains limited to severe recessions. We highlight the importance of the labor-market policy mix at the level of the member state.

We wish to be very clear that the exercise we conduct is a first pass at a European UI scheme. One reason is that we abstract from a number of features that may make optimal European UI more generous. For example, we model simple, implementable European UI schemes

[3]The extent to which member states would actually implement optimal labor-market policies certainly is disputable. Our paper provides a clear cutoff.

that condition on unemployment rates rather than spelling out the optimal mechanism. It is clear that – in theory – a sufficiently complicated mechanism could make country-specific shocks measurable, and thus ensure more insurance. At the same time, there are a number of constraints that may further reduce the scope for European UI. One is that EMU member states to date are characterized by considerable heterogeneity in labor-market institutions. A fact we are fully aware of, though we abstract from it entirely.[4] In the current paper, we wish to explore the scope for federal insurance and its determinants when member states retain sovereignty over labor-market regulation. Our main finding is that the scope for federal insurance may be limited as long as member states retain the right and the ability to make sovereign decisions with respect to labor-market policies. Our hunch is that allowing for heterogeneity and its complications will hardly weaken those incentives. At the same time, a reader may well see the institutional heterogeneity in EMU as a sign that member states currently have the right, but not the political ability to set labor-market policies optimally– for example, due to political constraints. Our paper speaks to this view as well, through the constant-instrument case that we nest in our analysis.

The paper is organized as follows: next, we review the related literature. Section 2 spells out the quantitative dynamic model and the member states' and federal governments' problems. Section 3 provides intuition as to the optimal design of federal UI using a one-period simplification of the full model. Section 4.3 calibrates the full model to EMU and, then, shows the quantitative implications for the optimal federal unemployment policy. A final section concludes. An extensive appendix provides derivations as well as proofs to the propositions.

Related literature

To the best of our knowledge, our paper is the first to study quantitatively the optimal design of a cross-country unemployment insurance scheme that allows for moral-hazard distortions at the level of local governments.

On the theory-side, our paper is related to a burgeoning literature on the optimal provision of unemployment benefits over the business cycle. For our simplified model in Section 3, the analytical derivations build on Landais et al. (forthcoming). They argue, in a closed economy, that the provision of unemployment benefits should become more generous in recessions if unemployment temporarily is not very elastic to benefits — for example, due to wage rigidities, or hiring freezes. What we add to this is the trade-off between insurance and moral hazard of a federal UI scheme, and we consider the overall policy mix and not only unemployment benefits as an instrument. This strikes us as particularly important for a *permanent* federal

[4]Even focusing on only one dimension of labor-market policies, national UI systems, there is notable heterogeneity Esser et al. (2013). Also see the data presented in Árpád Ábrahám, João Brogueira de Sousa, Ramon Marimon, Lukas Mayr (2017).

UI scheme, in response to which member states could permanently adapt policies.

For the modeling of member states in the quantitative part, we start from Jung and Kuester (2015). These authors, in a closed economy characterize analytically and computationally the optimal mix of unemployment benefits, hiring subsidies and layoff taxes, both over the business cycle and in steady state. The current paper extends the individual state's problem by demand externalities, decreasing returns to scale, and a more general form of wage rigidities. We do so so as to be able to nest different views as to how changes in unemployment benefits in isolation transmit to the aggregate economy, for example, Chodorow-Reich and Karabarbounis (2016) and Hagedorn et al. (2013). A contribution of our paper is to highlight that differences in such views are not of particular import for the question at hand, namely, in the following sense. To the extent that there are microeconomic rigidities that impact on the transmission of policies to macro-economic outcomes, and to the extent that a member state's policy is aware of the frictions and acts optimally (for its constituents), a member state's labor-market policies can go a long way of ameliorating the microeconomic frictions.

The current paper, as mentioned, abstract from permanent cross-country heterogeneity. Moyen et al. (2016), instead, focus on precisely this dimension of a European unemployment scheme. They provide an insightful analysis of federal unemployment insurance amid permanently heterogenous member states. Making recourse both analytically to Landais et al. (forthcoming) and simulations New Open Macroeconomics two-country model, they find considerable scope for a European UI scheme. What sets their paper apart from ours is the modelling of the sovereignty of member states. Their federal planner has far-reaching authority, being able to set the level of benefits in each member state. The planner does not face the risk of member states adjusting other policy parameters such as hiring subsidies or layoff taxes. Our analysis nests this as a special case. What we show is that the federal planner's authority – or the converse, the member states' sovereignty over the policy mix – has far-reaching implications for the insurance that can be provided federally.

Our study abstracts from heterogeneity not only across member states, but also limits heterogeneity within countries to a bare minimum. Dolls et al. (2015), instead, provide a micro simulation-based assessment of stabilization channels for a European unemployment insurance scheme for EMU member states. The results suggest that European UI could be a powerful instrument for regional insurance. A maintained assumption of their work is that the macroeconomic environment is not affected by the presence of federal UI. The starting point of our paper, instead, is that the motive for interregional risk-sharing may need to be balanced against regional moral hazard. We document that, quantitatively this, indeed, is a powerful proviso.

Árpád Ábrahám, João Brogueira de Sousa, Ramon Marimon, Lukas Mayr (2017), provide an ambitious quantitative exploration of a European UI mechanism that accounts for cross-country heterogeneity. Toward this end, they build a model of heterogeneous workers that can flow between un-/non-/ and employment and allow persistent idiosyncratic risk and self-insurance. The authors exert great effort to capture the heterogeneity of labor-market flow rates across the different countries. An important result of the paper is the scope for country-specific UI schemes that are welfare improving (administered at the central level or not). What this highlights to us, is that state-level labor-market policies (and not only UI benefits) may not best be treated as constant when considering a federal UI scheme.

? The current paper contributes to the body of literature on the optimal fiscal institutions within a common currency area, Mundell (1961); McKinnon (1963). The optimal fiscal policy in currency unions in micro–founded open economy models has been studied by Beetsma and Jensen (2005); Galí and Monacelli (2008); Ferrero (2009), among others. A common theme is the need for local fiscal policies to complement a common area-wide monetary policy. In the current paper paper, we abstract from modeling monetary policy explicitly and, instead, allow for demand externalities as in Krueger et al. (2016) that capture demand-side effects on aggregate output. With such effects, and a limited set of national fiscal instruments, Farhi and Werning (forthcoming) characterize the optimal fiscal transfers within a monetary union and points out the potentially large gains from international risk sharing when a lack of demand can have first-order effects on welfare. In a modern guise, this echoes Kenen (1969). We study quantitatively the optimal design and scope of a particular dimension of fiscal integration.

Next to these, our work builds on an influential body of literature on fiscal federalism. Persson and Tabellini (1996) study the optimal insurance of aggregate risk in a federation of states, in which individual states retain authority over the provision of insurance against idiosyncratic shocks, taxation, as well as public investment programs aimed at reducing aggregate risk. International risk pooling induces local governments to under–invest in programs alleviating local risk. We contribute to this strand of the literature by extending the analysis to a quantitative business cycle setting that helps to move to the discussion of a concrete set of labor-market policies. What we find is that fiscal risk sharing leads to over-insurance (instead of underinsurance of idiosyncratic employment risk). Bordignon et al. (2001) analyze optimal fiscal redistribution across regions when the central government has limited information on regional shocks. In order to signal that a region truly had a bad shock it has to engage in costly policies, in their case raising taxes in bad time. The transfer schemes that we analyze, instead, are simpler, in keeping with our aim as modeling federal UI as an automatic stabilizer. They condition on unemployment, but not on local government's actions. Oates (1999) for a review of the early literature.

Celentani et al. (2004) study how market incompleteness may arise from decentralized fiscal policies, where we take incompleteness as a primitive. The optimal risk-sharing arrangements within a union of countries have been studied in Bucovetsky (1998); Lockwood (1999) and Evers (2015), among others.

We study a particular set of policies that resemble some of the recent proposals of a European unemployment insurance schemes, for example, by commissioner Andor (2016). More generally, of course the debate on the need for a European welfare system is nearly as old as the European integration project itself, having started at least, with the call for harmonization of economic and social policies in the 1970 "Werner Report".[5] In light of the long history and the importance of the topic, we fear, that almost inevitably and without prejudice the above list of references is incomplete. this list of above references is incomplete.

2 The model

There is federal union that consists of a unit mass of atomistic member states. Variables that pertain to member states are marked by subscript $i \in [0, 1]$. Member states are linked through a federal unemployment insurance system. There is no international borrowing and lending, and there also is no trade across borders. That is, international insurance only occurs through the centralized fiscal authority. At the level of the member state, the model and exposition closely follow Jung and Kuester (2015). Next to the member states, there is a federal level, which raises taxes and provides federal transfers. In modeling the union, we abstract from international insurance through financial markets (both trade in state-contingent securities, and self-insurance through borrowing and lending) and international trade. These assumptions facilitate the exposition and they give a clear role for international insurance.[6] We also abstract from international labor-mobility. Each member state retains authority regarding domestic public policy.

In terms of notation, for clarity we use parentheses whenever we wish to highlight the argument(s) of a function. We use square brackets to gather terms.

We describe the model in three steps. First, we only describe the technological constraints faced by each member state, that is, those that would bind a planner. Then, we introduce the elements of the decentralized economy including member states' policy instruments, the federal UI plan and private-sector decisions. Last, we describe the policy problems at the level of the member state and the federal level.

2.1 Technological constraints for each member state

Each member state is populated by a continuum of measure one of workers, an infinite mass of potential one-worker firms that produce labor services, and a unit mass of representative

[5]Negotiations of the Maastricht Treaty that ultimately implemented monetary union, instead, largely sidestepped the issue of the welfare state, instead agreeing on fiscal rules for overall fiscal deficits and debt, Bini-Smaghi et al. (1994). Brunnermeier et al. (2016) summarize the struggle between different views on European economic policy.

[6]International financial markets clearly are not complete, and the European fiscal crisis has shown the limits to international borrowing and lending as well. To the extent that we wish to model federal insurance at business cycle frequency, our assumption on trade may be tenable as well. The reason is that, in the short run trade elasticities tend to be small. In any case, these assumptions stack the cards in favor of federal insurance.

firms that use labor services to produce a final consumption good. Workers are homogeneous in regard to their *ex ante* efficiency of working. Firms produce a homogeneous good that cannot be stored. Time is discrete.

2.1.1 Labor market flows

We denote the measure of workers who are employed in a particular member state at the *beginning* of period t by e_t^i. Employment at the beginning of the next period evolves according to

$$e_{t+1}^i = [1 - \xi_t^i] \cdot e_t^i + m_t^i, \tag{1}$$

where m_t^i are new firm-worker matches formed in period t. ξ_t^i is the rate of separation of existing firm-worker matches in period t. The government cannot observe the search effort of workers. All workers who are not employed at the beginning of the period are counted as "unemployed:" $u_t^i = 1 - e_t^i$. A worker can be recruited after posting a vacancy at resource cost $\kappa_v > 0$. New matches are created according to the matching function

$$m_t^i = A_t^i \left[v_t^i\right]^\gamma \cdot \left[[\xi_t^i e_t^i + u_t^i] s_t^i\right]^{1-\gamma}. \tag{2}$$

Here, A_t^i are fluctuations in match efficiency. $\gamma \in (0,1)$ is the elasticity of matches with respect to the number of vacancies v_t^i posted by firms. The last term, in turn, is explained as follows: The mass of workers who are potentially searching during period t equals $\xi_t^i e_t^i + u_t^i$. That mass comprises the workers laid off at the beginning of the period, $\xi_t^i e_t^i$, and the mass of workers who entered the period unemployed, u_t^i. s_t^i is the share of those workers who search for a job. Match efficiency follows an autoregressive process

$$\log(A_t^i/\chi) = \rho_A \, \log(A_{t-1}^i/\chi) + \varepsilon_{A,t}^i, \quad \rho_A \in [0,1), \; \varepsilon_{A,t}^i \sim N(0, \sigma_A^2).$$

Parameter $\chi > 0$ governs the steady-state matching-efficiency It is the heterogenous realizations of the shocks that generate scope for cross-country insurance.

For subsequent use, we define labor-market tightness as $\theta_t^i := v_t^i/([\xi_t^i e_t^i + u_t^i] s_t^i)$, the job-finding rate as $f_t^i := m_t^i/([\xi_t^i e_t^i + u_t^i] s_t^i) = A_t^i [\theta^i]^\gamma$, and the job-filling rate as $g_t^i := m_t^i/v_t^i = A_t^i [\theta^i]^{\gamma-1} = f_t^i/\theta_t^i$.

2.1.2 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.[7] $\beta \in (0,1)$ is the time-discount factor. Workers who are not employed enjoy an additive

[7]Observe the difference between u_t^i and $\mathtt{u}$. u_t^i marks the unemployment rate at the beginning of the period, whereas $\mathtt{u}$ marks the utility function.

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

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

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 future use, define the surplus of the currently employed worker from employment as $\Delta^i_t := V^i_{e,t} - V^i_{u,t}$.

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, $\iota \sim F_\iota(0, \sigma^2_\iota)$. For tractability, these costs are independently and identically distributed both across workers and across time. $F_\iota(0, \sigma^2_\iota)$ marks the logistic distribution with mean 0 and variance $\sigma^2_\iota := \pi\frac{\psi_s^2}{3}$, where a lower-case π refers to the mathematical constant. All workers whose disutility of search falls below a certain cutoff value $\iota^{s,i}_t$ 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:

$$\iota^{s,i}_t = f^i_t \, \beta \, E_t \left[\Delta^i_{t+1}\right]. \tag{4}$$

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

$$s^i_t = Prob(\iota \leq \iota^{s,i}_t) = 1/[1 + \exp\{-\iota^{s,i}_t/\psi_s\}]. \tag{5}$$

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.

2.1.3 Production and separation

There are two sets of firms: "employment-services firms" and "final-goods firms."

Employment-services firms.

There is an infinite mass of potential one-worker firms that produce employment services. Each firm j of these 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

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

Each firm-worker match, that does not separate, produces.
Total production of labor services is given by

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

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

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

Final-goods firms.

Final goods are produced by a representative firm using employment services as an input. The final goods firm may operate under decreasing returns to scale, its output being

$$y_t^i = [L_t^i]^\alpha [c_t^i]^\varsigma, \quad \alpha \in (0,1], \varsigma > 0. \tag{9}$$

We allow for decreasing returns to scale so as to be able to accommodate hiring freezes as in Michaillat (2012). In addition, we wish to allow for a demand-side channel, such that the provision of federal insurance can have stabilizing effects beyond the mere transfer. Toward this end, we follow Krueger et al. (2016) and assume that productivity is the product of two components: each match produces an amount $\exp\{a_t^i\}[c_t^i]^\varsigma$ of output, with $\varsigma \geq 0$. a_t^i is an exogenous shock to productivity. Productivity depends non-negatively on aggregate consumption, $c_t^i := e_t^i(1-\xi_t^i)c_{e,t}^i + e_t^i\xi_t^i c_{0,t}^i + (1-e_t^i)c_{u,t}^i$. Parameter ς captures the size of the spillovers between aggregate demand and productivity. The larger ς, the stronger the demand-side effects.

2.1.4 Resource constraint

Each member state'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 member state i be denoted by $\mathbb{B}_t^i$. These are given by

$$\mathbb{B}_t^i := B_{F,t}\left(u_t^i\right) - \tau_F. \tag{10}$$

Here $B_{F,t}\left(u_t^i\right)$ mark payments from the federal level to the individual member state. These payments are a function of u_t^i, that is, the mass of workers for which the member state pays unemployment benefits. Note that all member states, 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 member state to the federal level toward financing the federal insurance scheme.

With this notation at hand, the member state's resource constraint is

$$y_t^i + \mathbb{B}_t^i = e_t^i c_{e,t}^i + u_t^i c_{u,t}^i + e_t^i \int_{-\infty}^{\epsilon_t^{\xi,i}} \epsilon \, dF_\epsilon(\epsilon) + \kappa_v v_t^i. \tag{11}$$

2.2 Decentralized economy

The conditions spelled out above are technological constraints that would constrain the member state's planning problem. We now discuss those parts of the model that pertain to the decentralized economy only. We start with the government.

2.2.1 Member state government

The member state provides unemployment benefits and hiring subsidies in its constituency. It levels layoff taxes and production taxes. As documented in Jung and Kuester (2015) for the case with constant returns to scale and without the demand externality, this set of instruments allows the member state's government to implement the constraint-efficient planner's allocation. In addition, the local government receives net transfers from the central government. The member state government's budget constraint is given by

$$e_t^i\,[1-\xi_t^i]\,\tau_{J,t}^i + e_t^i\,\xi_t^i\,\tau_{\xi,t}^i + \mathbb{B}_t^i = u_t^i B_t^i + \tau_{v,t}^i v_t^i, \tag{12}$$

The left-hand side has revenue from the production and layoff, and the net transfers $\mathbb{B}_t^i$ from the central government. The right-hand side has unemployment benefits and the vacancy subsidy. The tax and subsidy rules, $\tau_{J,t}^i$, $\tau_{\xi,t}^i$, $\tau_{v,t}^i$, and UI benefit payments, B_t^i are specified further below. Note for now that, as long as the member state government can set its own unemployment benefits freely, it is entirely inconsequential if federal UI payments are channeled through the member state government's budget constraint or are paid directly to unemployed workers.

2.2.2 Consumption

Firms are owned in equal proportion by each worker located in the member state. Ownership of firms is not traded. Π_t^i marks the dividends that the firms pay. Consumption of the worker is given by

$$\begin{array}{llll} c_{e,t}^i & := & w_t^i + \Pi_t^i & \text{if} \quad \text{employed at the beginning of } t \text{ and working in } t, \\ c_{0,t}^i & := & w_{eu,t}^i + \Pi_t^i & \text{if} \quad \text{employed at the beginning of } t \text{ but laid off in } t, \\ c_{u,t}^i & := & B_t^i + \Pi_t^i & \text{if} \quad \text{unemployed at the beginning of } t. \end{array} \tag{13}$$

Here w_t^i marks the wage. $w_{eu,t}^i$ marks severance payments from the firm to a worker who has just been laid off. We assume that $w_{eu,t}^i = w_t^i$, that is, the laid-off worker still receives one-period's worth of wages. This would be an equilibrium outcome if there was Nash-bargaining over wages and severance payments, compare Jung and Kuester (2015). In order to accommodate other wage-setting mechanisms as well, here we introduce the level of severance payments as a (rather natural) assumption. In every period that the worker enters unemployed, he receives an amount B_t^i of unemployment benefits. For future reference also define the replacement rate as $b_t^i = c_{u,t}^i / c_{e,t}^i$.

2.2.3 Production and the value of the firm

Firms rebate their profits to all workers in their member state. The decisions made by final-goods firms are static, so all worker agree on the final goods firms' decisions. Final goods firms purchase labor services in a competitive market at price x_t^i. The first-order condition for hiring labor services then is

$$\alpha [L_t^i]^{\alpha-1}[c_t^i]^{\varsigma} = x_t^i. \tag{14}$$

Our notation already imposes that, in equilibrium demand for employment services needs to equal supply, with price x_t^i clearing the market.

The decisions made by employment-services firms are dynamic, instead, and involve discounting future profits. We assume that employment-services firms discount the future using discount factor $Q_{t,t+s}^i$, where $Q_{t,t+s}^i := \beta \frac{\lambda_{t+s}^i}{\lambda_t^i}$, with λ_t^i is the weighted marginal utility of the firm's owners:

$$\lambda_t^i := \left[\frac{e_t^i(1-\xi_t^i)}{\mathtt{u}'(c_{e,t}^i)} + \frac{e_t^i \xi_t^i}{\mathtt{u}'(c_{0,t}^i)} + \frac{u_t^i}{\mathtt{u}'(c_{u,t}^i)} \right]^{-1}. \tag{15}$$

Ex ante, namely, before the idiosyncratic shock ϵ_j is realized, the value of a firm that has a worker is given by

$$\begin{aligned} J_t^i \quad = \quad & -\int_{\epsilon_t^{\xi,i}}^{\infty} \left[\tau_{\xi,t}^i + w_{eu,t}^i \right] dF_\epsilon(\epsilon_j) \\ & + \int_{-\infty}^{\epsilon_t^{\xi,i}} \left[x_t^i \exp\{a_t^i\} - \epsilon_j - w_t^i - \tau_{J,t}^i + \mathbb{E}_t Q_{t,t+1}^i J_{t+1}^i \right] dF_\epsilon(\epsilon_j). \end{aligned} \tag{16}$$

The firm separates from the worker (first line) whenever the idiosyncratic cost shock, ϵ_j, is larger than a state-dependent threshold $\epsilon_t^{\xi,i}$, the determination of which will be discussed in Section 2.2.5. Doing so, it is mandated to pay layoff tax $\tau_{\xi,t}^i$ to the government and a previously negotiated severance payment $w_{eu,t}^i$ to the worker. The match will produce (second line) if ϵ_j does not exceed the threshold. In that case, the firm produces $\exp\{a_t^i\}$ units of labor services which it sells at price x_t^i, and the firm will pay wage w_t to the worker and a production tax $\tau_{J,t}^i$ to the government. A match that produces this period continues into the next. The last item in square brackets on the second line is the continuation value.

2.2.4 Matching and vacancy posting

An employment services firm that does not have a worker can post a vacancy at cost $\kappa_v - \tau_{v,t}^i > 0$, taking as given the hiring subsidy. In equilibrium, employment services firms post vacancies until the after-tax cost of posting a vacancy equals the prospective gains from hiring:

$$\kappa_v - \tau_{v,t}^i = q_t^i E_t \left[Q_{t,t+1}^i J_{t+1}^i \right], \tag{17}$$

where q_t^i is the probability of filling a vacancy.

2.2.5 Wage setting

The wage is determined by wage rule $w_t^i \equiv w(A_t^i, a_t^i, \eta_t^i, \theta_t^i, \Delta_t^i)$. The wage rule is twice continuously differentiable in all arguments. The arguments of the wage rule are the aggregate shocks, a_t^i and A_t^i, a "wage shock" (think of a shock to the bargaining power of the firm η_t^i, market tightness θ_t^i, and the surplus from being employed Δ_t^i.

The form of the wage rule follows Landais et al. (forthcoming) and nests several of the cases entertained in the literature. Most importantly, perhaps, the case of constant wages as an extreme form of wage rigidity and the case of Nash bargaining, the latter being discussed in Appendix **??**.

2.2.6 Dividends

Aggregate profits in each member state are given by the sum of profits of final goods firms and employment services firms

$$\Pi_t^i = \Pi_{F,t}^i + \Pi_{L,t}^i. \tag{18}$$

These are distributed in equal amount as dividends to all workers in the economy.

Profits by final-goods firms are given by

$$\Pi_{F,t}^i = (1-\alpha) L_t^\alpha c_t^\varsigma. \tag{19}$$

Profits of all employment-services firms aggregated are

$$\begin{aligned} \Pi_{L,t}^i = \quad & e_t^i \left[\int_{-\infty}^{\epsilon_t^{\xi,i}} \left[x_t^i \exp\{a_t^i\} - \epsilon - w_t^i - \tau_{J,t}^i \right] dF_\epsilon(\epsilon) - \int_{\epsilon_t^{\xi,i}}^{\infty} \left[w_t^i + \tau_{\xi,t}^i \right] dF_\epsilon(\epsilon) \right) \\ & - (\kappa_v - \tau_{v,t}^i) v_t^i. \end{aligned} \tag{20}$$

2.2.7 Federal government

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. The federal government in each period has to balance the budget of the federal UI system, so that $\int_0^1 \mathbb{B}_t^i \, \mathrm{d}i = 0$.

Net benefits $\mathbb{B}_t^i$ have two components.

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

Payments of transfers to each country $B_{F,t}\left(u_t^i\right)$, which are based on the member state's unemployment rate, and a constant transfer τ_F from member states to the federal level, τ_F, that is levelled in order to balance the federal UI budget.

Since we consider only country-specific shocks and countries are atomistic, the law of large numbers implies

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

where $\mathbb{E}$ marks unconditional expectations.

2.2.8 The individual member member state'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 member state, we consider a utilitarian Ramsey planner who gives equal weight to all workers in that member state. 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 $c_{0,t}^i = c_{e,t}^i$.
Using the assumptions laid out above, and using the properties of the logistic distribution, the planner's objective can be written as

$$\max_{\{\tau_{v,k}^i, \tau_{\xi,k}^i, \tau_{J,k}^i, B_k^i\}_{k=t}^{\infty}} E_t \sum_{k=t}^{\infty} \beta^k \left[e_k^i \mathrm{u}(c_{e,k}^i) + u_k^i \mathrm{u}(c_{u,k}^i) + \ (e_k^i \xi_k^i + u_k^i)(\Psi_s(s_k^i) + \overline{h}) \right], \tag{21}$$

subject to the laws of motion of the economy, and taking the federal UI scheme as given. Some of the results that we will show will allow the planner to only set a subset of the instruments. The first term in the objective is the consumption-related utility of employed workers. 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.[8]

2.2.9 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 member states' governments. The federal planner also ensures that the federal unemployment-insurance budget is balanced.

3 The main trade-offs in a one-period model

The current section resorts to a simplified, one-period version of the model, so as to build intuition for the quantitative results that follow. As for the individual country, the structure will largely resemble the insightful analysis of Landais et al. (forthcoming).[9] What we add

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

[9]Landais et al. (forthcoming) analyze optimal unemployment benefits over the business cycle when benefits are the only policy instrument of a closed economy.

are the two central ingredients for discussing federal unemployment insurance: a federal dimension that gives rise to moral hazard at the country level, and self-interested local labor-market policies, where the latter can extend beyond unemployment benefits.[10]

We start by describing the simplified model. Then, we discuss the federal authority's problem. Last, we discuss the optimal policy setting at the member state level.

3.1 The simplified model

The general setup resembles the full model spelled out earlier. Here, we keep the exposition short and focus only on those elements that change relative to the full model.

We consider one period. At the beginning of the period, all workers are unemployed. They may be hired within the period and, then, will produce. Otherwise, they are unemployed. Time ends afterward. For the sake of exposition, we abstract from an endogenous separation margin. Consequently, we also drop layoff taxes from the member state's policy instruments. We also abstract from demand externalities, setting $\varsigma = 0$.

3.1.1 Labor market

Initially, all workers are unemployed. Firms post vacancies, while workers decide on the search effort they exert. Firms and workers are matched and production takes place. Employed workers receive their wage. The government cannot observe search effort, so all non-employed workers receive unemployment benefits.

Since all workers are unemployed to start with, the matching function takes the form (2), which under our assumptions implies

$$m^i = A^i \left[v^i\right]^\gamma \cdot \left[s^i\right]^{1-\gamma}.$$

Define labor market tightness as $\theta^i = \frac{v^i}{s^i}$, the job-finding probability per unit of search effort as $f(\theta^i) \equiv A^i \left[\theta^i\right]^\gamma$. A vacancy is filled with probability $q(\theta^i) = A^i[\theta^i]^{\gamma-1} = \frac{f(\theta^i)}{\theta^i}$.

Employment evolves according to

$$e^i = s^i f(\theta^i). \tag{22}$$

3.1.2 Firms

The representative firm produces output according to

$$y^i = \exp(a^i)[e^i]^\alpha,$$

e marks the number of workers that the firm seeks to employ. $\alpha \in (0, 1]$ which allows for decreasing returns to scale, so as to allow for endogenous hiring freezes as in Michaillat (2012).

[10]Moyen et al. (2016) provide a related exercise, but abstract from local labor-market policy.

The firms' profits are given by $\Pi^i = y^i - w^i e^i - (\kappa - \tau_v^i)v^i$, reflecting that the local government may subsidize hiring. Profits can be rewritten as[11]

$$\Pi^i = y^i - w^i e^i - (\kappa - \tau_v^i)\frac{e^i}{q^i},$$

Firms will post vacancies until marginal profits are zero. We abstract from a possible interaction of the number of workers with the wage outcome; for example, Stole and Zwiebel (1996). The vacancy posting first-order condition, then, is

$$\exp(a^i)\alpha[e^i]^{\alpha-1} = w^i + (\kappa - \tau_v^i)\frac{1}{q^i}.$$

Bearing this in mind, the dividends that firms will rebate to the households, in equilibrium, will be:

$$\Pi^i = (1-\alpha)\exp(a^i)[e^i]^\alpha.$$

3.1.3 Workers

The expected utility of a worker reads

$$W^i = s^i f(\theta^i)\mathtt{u}(c_e^i) + (1 - s^i f(\theta^i))\mathtt{u}(c_u) - \Psi(s), \tag{23}$$

The first term captures that upon exerting effort s, the probability of finding a job is $sf(\theta)$. The second term takes into account that, with the opposite probability the worker will not find a job, in which case the worker has the consumption level of an unemployed worker. The final term is the utility cost from search. We assume Ψ is increasing, convex and twice continuously differentiable.

The budget constraint of the employed is

$$c_e = w + \Pi - \tau,$$

where τ taxes that the government levels to finance benefits and subsidies.[12] The budget constraint of the unemployed is given by

$$c_u = B + \Pi.$$

Here, B are the unemployment benefits provided by the local government. Note that, in terms of notation, we model unemployment benefits B as the total net flow of benefits that accrues to the worker (state-level and federal UI, net of taxes).

[11] $v = \theta s = sf(\theta)\theta/f(\theta) = sf(\theta)/q(\theta) = e/q(theta)$, where the last step follows from the labor-flow equation.

[12] In the simple model we tax workers rather than firms. Due to the static setup, taxes on firms would be identical to negative hiring subsidies.

The optimal search effort exerted by all workers is satisfies

$$\Psi_s(s^i) = f(\theta^i)\Delta^i, \tag{24}$$

where $\Delta^i = \mathtt{u}(c_e^i) - \mathtt{u}(c_u^i)$ marks the gain from search. As the gain from being search increases, so is the search effort. Similarly, a tighter labor market (tight from the perspective of firms) all else equal encourages search.

3.1.4 Wages

The wage is determined by wage rule $w^i \equiv w(A^i, a^i, \theta^i, \Delta^i)$. We assume the wage is twice continuously differentiable in all arguments.

3.1.5 State-level government

In setting the level of unemployment benefits, vacancy subsidies and taxes, the state-level government has to balance its budget so that

$$B^i \cdot [1 - e^i] + \tau_v^i \frac{e^i}{q^i} = \tau^i \cdot e^i + \mathbb{B}^i.$$

On the left-hand side are state-level unemployment benefits, and vacancy subsidies ($\tau_v \cdot v$). On the right-hand side are the taxes raised from the employed $\tau \cdot e^i$ and the net transfers that the local government receives from the federal level.

3.1.6 Federal government

The the federal government is to administrate the federal unemployment insurance system under a balanced-budget constraint:

$$\int_0^1 \mathbb{B}^i di = 0,$$

where $\mathbb{B}$ marks the net transfers paid to country i.

3.1.7 Equilibrium

In equilibrium the resource constraint has to be satisfied in each member state:

$$y^i - \kappa_v \frac{l}{q(\theta^i)} + \mathbb{B}^i = e^i c_e^i + [1 - e^i] \cdot c_u^i. \tag{25}$$

3.2 Elasticities

The following elasticities prove useful in the analysis of the model that follows. The definition of these follows Landais et al. (forthcoming).

Definition 1 *The "discouraged worker elasticity" is defined as*

$$\epsilon^s \equiv \frac{f(\theta^i)}{s} \frac{\partial s}{\partial f(\theta^i)},$$

it measures the elasticity of the search effort of a worker with respect to the job-finding rate. The larger ϵ^s, the more elastically does search effort respond to the job-finding rate.

Definition 2 *The "partial-equilibrium elasticity of unemployment" with respect to the generosity of the UI scheme, Δ, is defined as*

$$\epsilon^m \equiv -\frac{\Delta}{u} \frac{\partial(u)}{\partial \Delta} = \frac{\Delta}{u} \frac{\partial e}{\partial \Delta}.$$

It measures the percentage increase in unemployment when the utility gain from employment decreases by one percent, given that the job finding rate does not change. In other words, it accounts for the job search margin but does not include equilibrium adjustment of the market tightness.

Definition 3 *The "general-equilibrium elasticity of unemployment" with respect to the generosity of the UI scheme is defined as*

$$\epsilon^M \equiv -\frac{\Delta}{u} \frac{du}{d\Delta} = \frac{\Delta}{u} \frac{de}{d\Delta} = \frac{\Delta}{u} \left(\frac{\partial e}{\partial \theta} \frac{d\theta}{d\Delta} + \frac{\partial e}{\partial \Delta} \right).$$

It measures the percentage increase in unemployment when the utility gain from employment decreases by one percent, taking into account the equilibrium response of the market tightness. The key determinant of the macroelasticity is the response of wages to the generosity of the UI, Δ

Remark 1 *The general equilibrium elasticity is the partial equilibrium response augmented with the benefits impact on the equilibrium value of the market tightness:*

$$\epsilon^M = \epsilon^m + \frac{\Delta}{u} \frac{\partial e}{\partial \theta} \frac{d\theta}{d\Delta}$$

Whenever $\frac{d\theta}{d\Delta} = 0$, there is no general equilibrium effects of UI generosity and $\epsilon^M = \epsilon^m$

3.3 A limited set of instruments

Here we discuss the optimal policies with a limited set of instruments, namely if the member state government's labor-market policies are restricted to unemployment benefits and taxes.

We do so first for the member state and, then, for the federal government. Thereafter, Section 3.4 will discuss the case in which the member state has access to a broader range of labor-market policies, including hiring subsidies.
For the sake of exposition, we let net transfers be a function of $\mathbb{B}^i = \mathbb{B}(u^i)$ of the unemployment rate in the respective member state.

3.3.1 The member states' optimal response

First, we start with the case in which the member states have access only to unemployment benefits, but do not choose any other labor-market policies. Define the relevant replacement rate as $b^i := (B^i + \tau^i)/w^i$, that is the replacement rate is computed as unemployment transfers plus the labor taxes that an unemployed worker saves.

Proposition 1 *Suppose there is a federal government that provides unemployment-based transfers $\mathbb{B}(u^i)$. Consider a member state that chooses the level of benefits for its unemployed constituents so as to maximize* ex-ante *welfare,* (23)*. Then the optimal policy mix set by the member state can be characterized as follows:*
The replacement rate is given by

$$\begin{aligned} b^i = \quad & \frac{e^i}{\epsilon^{m,i}} \frac{\Delta^i}{w^i} \left(\frac{1}{\mathtt{u}_c(c_e^i)} - \frac{1}{\mathtt{u}_c(c_u^i)} \right) \\ + & \left(1 - \frac{\epsilon^{M,i}}{\epsilon^{m,i}}\right) \frac{1}{1+\epsilon^{s,i}} \left(\frac{\Delta^i}{\phi^i w^i} + b^i(1+\epsilon^{s,i}) - \frac{(1-\gamma)}{\gamma} \frac{\kappa_v}{q(\theta^i) w^i} \right). \\ + & \frac{d\mathbb{B}^i}{du^i} \frac{1}{w^i} \cdot \frac{\epsilon^{M,i}}{\epsilon^{m,i}} \\ \textit{with} \quad & \frac{1}{\phi^i} := \frac{e^i}{\mathtt{u_c}(c_e^i)} + \frac{u^i}{\mathtt{u_c}(c_u^i)}. \end{aligned} \tag{26}$$

And the payroll tax that balances the member state's budget is given by

$$\begin{aligned} \tau = & \frac{d\mathbb{B}^i}{du^i} \frac{\epsilon^{M,i}}{\epsilon^{m,i}} u^i + \frac{e^i \cdot u^i}{\epsilon^{m,i}} \Delta^i \left(\frac{1}{\mathtt{u}_c(c_e^i)} - \frac{1}{\mathtt{u}_(c_u^i)} \right) + \\ & \left(1 - \frac{\epsilon^{M,i}}{\epsilon^{m,i}}\right) \frac{u^i}{1+\epsilon^{s,i}} \left(\frac{\Delta^i}{\phi^i} + b^i w^i (1+\epsilon^{s,i}) - \frac{1-\gamma}{\gamma} \frac{\kappa_v}{q(\theta^i)} \right) - \mathbb{B}^i \end{aligned} \tag{27}$$

The Proposition summarizes the member state's welfare-maximizing policy for a given transfer rule $\mathbb{B}$ if the member states only have access to benefits. The first two rows are familiar from Landais et al. (forthcoming): The first row is a version of the Baily-Chetty formula.[13] The second row gives is a correction for the state of the economy. Whenever, the general-equilibrium elasticity of unemployment $\epsilon^{M,i}$ is smaller than the microeconomic elasticity $\epsilon^{m,i}$,

[13] Under which, absent macroeconomic effects of benefits, benefits are provided up to the point where the marginal utility gain for the unemployed equals the marginal utility loss of the employed, bearing in mind that higher benefits will increase unemployment duration.

the member state will provide more generous UI benefits. Term ϕ^i is a weighted average of the employed's and unemployed's utilities. The details are described in Landais et al. (forthcoming).

What is new is the third row of the benefit formula (the term starting with $\frac{\mathrm{d}\mathbb{B}^i}{\mathrm{d}u^i}$).The formula has the following interpretation. All other things equal, that is for a given gain from work Δ^i and given market tightness θ^i, the optimal replacement rate b^i for the country i depends only on the *marginal payment* from the federal level for the last unemployed worker. That is, at the optimum the marginal increase in transfers incentivizes member states to increase benefits in the same amount for inframarginal workers as well. The replacement rate is the greater, the greater is the marginal payment from the federal insurance for the last unemployed worker.

The following proposition formalizes the impact of the federal transfer scheme on the local policy choice.

Proposition 2 *Consider the same assumptions as in Proposition 1. Consider a change in a slope of the federal insurance payouts* $\frac{d\mathbb{B}^i}{du^i}$ *such that the aggregate resources in a given country remain intact. Then, the utility gain from work chosen by the local government decreases with the slope of the payouts. Formally,*

$$\frac{d\Delta^i}{d\frac{d\mathbb{B}^i}{du^i}} \propto -\epsilon^{M,i}\left[\frac{\epsilon^{m,i}}{\phi^i} + e^i\left(\frac{1}{\mathrm{u}_c(c_e^i)} - \frac{1}{\mathrm{u}_c(c_u^i)}\right)\right]^{-1} \leq 0$$

Proposition 2 indicates that the utility gain from employment shrinks with the generosity of the federal insurance provided. The intuition is the following. The local government would like to equalize the consumption of unemployed and employed workers. The unobservable search effort, however, forces the local government to keep a positive utility gain from the employment. When a country receives funds per each unemployed worker, having more unemployment is effectively cheaper and hence the local government can decrease the utility gain from work towards the desired level of zero. The response is the more significant, the greater is the macroeconomic elasticity of unemployment with respect to UI, $\epsilon^{M,i}$. To understand this relationship, consider the extreme case of $\epsilon^{M,i} = 0$. Then the government cannot influence the level of unemployment at all. Therefore, the provision of resources by the federal level does not distort the local government's incentives. The larger the control of the government over unemployment, *i.e.* the greater is $\epsilon^{M,i}$, the more severe is the free-riding motive. The larger $\epsilon^{M,i}$, the more resources the local government is able to extract from the federal level by shrinking the gain from work, Δ. The term in the inner parentheses stems from the concavity of the utility function. It indicates that the temptation to shrink the gain from employment is the smaller, the more consumption rich is the country to begin with.

3.3.2 Additional simplifying assumptions

In order to be able to derive a tractable representation of the optimal choice of federal policies, we make two further simplifying assumptions. Assume that there are only two shock states, a state in autarky associated with a "boom" (the H-state, high output) and a state associated with a "recession" (the L-state, low output). With probability π_H, a country will be in a boom, with probability π_L in a recession. In addition, we restrict ourselves to linear schemes, in which $\mathbb{B}(u^i) = \mathcal{B} \cdot u^i - \tau_F$. $\mathcal{B} > 0$, thus, is the payment per unemployed worker that the member-state government receives after having paid federal taxes.

3.3.3 The federal government

With these simplifying assumptions, we can derive a representation for the optimal policy of the federal government. Anticipating the above response of member states, the government chooses the generosity of the federal UI system (slope $\mathcal{B}$) and federal taxes τ_F so as to maximize *ex-ante welfare* of the union while balancing the federal budget:

$$\max_{\mathcal{B},\tau_F} \; \pi_H W(A^H, a^H, \theta^H, \Delta^H; \mathbb{B}) + (1-\pi) W(A^L, a^H, \theta^L, \Delta^L; \mathbb{B}),$$

where W is the value function of local Ramsey planner, as defined in (23). Then we have the following.

Proposition 3 *Consider the same assumptions as in Proposition 1. In addition, apply the assumptions spelled out in Section 3.3.2 (linear UI scheme and two states). Let superscript H mark the high output state, and L the low output state. Let* $\frac{1}{\phi^H} = \frac{e^H}{\mathrm{u}_c(c_e^H)} + \frac{1-e^H}{\mathrm{u}_c(c_u^H)}$ *and* $\frac{1}{\phi^L}$ *defined analogously. Then the optimal federal insurance scheme satisfies*

$$\mathcal{B} = \pi_H \cdot \pi_L \cdot \left[e^H - e^L\right] \cdot \left[\frac{\phi^L - \phi^H}{\pi\phi^H + (1-\pi)\phi^L}\right] \cdot \left[\pi_H \frac{du^H}{d\mathcal{B}} + \pi_L \frac{du^L}{d\mathcal{B}}\right]^{-1}$$

$\mathcal{B}$ are the federal transfers that a member state receives per unemployed worker. The more balanced the distribution between boom and recession countries is, the larger the transfer (the term $\pi_H \pi_L$ is maximized at $\pi_H = \pi_L = .5$). The bigger the employment difference between member states, the bigger the transfers as one would expect from a scheme that insurance against regional risks. In the extreme, if $e^H = e^L$, there would be no feasible way of redistributing resources based on unemployment as an indicator. The third term, $\frac{\phi^L - \phi^H}{\pi\phi^H + (1-\pi)\phi^L}$, captures the difference between marginal social values of resources in boom and bust country. Absent incentive considerations, the federal agency would transfer resources away from boom to bust countries up to the point where the marginal value of resources is equalized within the federation. The desire to equalize marginal utilities of consumption is traded off, however, against the need to mitigate the free-riding incentives of member states.

Member states' moral hazard is captured by the last term. By increasing $\mathcal{B}$, the federal UI scheme induces local governments to raise the replacement rate, and – thus – shrink the utility gains from unemployment, compare (26), that is, the terms $\left[\frac{du}{d\mathcal{B}}\right]$ are positive (or, at least, non-negative). The more responsive unemployment rates are to federal benefits, that is, the larger the moral hazard, the lower are the federal benefits provided.

It is instructive to dissect the moral-hazard term further:

$$\left[\pi_H \frac{\mathrm{d}u^H}{\mathrm{d}\mathcal{B}} + \pi_L \frac{\mathrm{d}u^L}{\mathrm{d}\mathcal{B}}\right] = \pi_H \left[-\frac{\mathrm{d}\Delta^H}{\mathrm{d}\mathcal{B}}\right] \frac{u^H}{\Delta^H} \epsilon^{M,H} + \pi_L \left[-\frac{\mathrm{d}\Delta^L}{\mathrm{d}\mathcal{B}}\right] \frac{u^L}{\Delta^L} \epsilon^{M,L}$$

The larger this term is, the less generous is the federal insurance scheme. The magnitude of the term, in turn, depends positively on the the impact of the unemployment benefits on equilibrium unemployment, $\epsilon^{M,i}$. If the local government can hardly affect the unemployment rate, $\epsilon^{M,i}$ is small, there is little scope for the free-riding motive. To the extent that $\epsilon^{M,i}$ is larger in boom states than in recession states, this suggests that a linear federal UI transfer scheme may unduly restrict the level of transfers provided. This suggests that a threshold scheme, such that no payouts are provided for boom countries, welfare-dominates the linear insurance scheme.

3.4 A full set of instruments

A central point above was that the provision of UI benefits distorted local governments' incentives least if the macro elasticity of unemployment with respect to benefits was small. This reasoning took the latter as outside the control of the local government. Next, instead, we discuss the case that the government has access to a wider set of labor-market instruments, namely unemployment benefits *and* vacancy subsidies. With this, the local government could work to make sure that jobs never are hard to come by. In other words, the macro-elasticity will never be small. As for the case with unemployment benefits only, we first discuss the optimal policies that the individual member state adopts and, then, discuss how these choices influence the optimal policy at the federal level.

3.4.1 The member state's optimal response

Proposition 4 characterizes the member states' optimal choice of instruments. One can show that – under autarky – these policies would implement the constrained-efficient planner's allocation.

Proposition 4 *Suppose there is a federal government that provides unemployment-based transfers $\mathbb{B}(u^i)$. Consider a member state that chooses the level of benefits and the level of vacancy subsidies for its unemployed constituents so as to maximize* ex-ante *welfare, (23). Then the optimal policy mix set by the member state can be characterized as follows:*

The hiring subsidy is characterized by

$$\tau_v^i = \left(w - y_e(e^i)\right) \frac{(1-\gamma)}{\gamma} \frac{\kappa_v}{\Delta^i} \left[\frac{1}{\phi^i} + (1+\epsilon^{s,i}) \frac{e^i}{\epsilon^{m,i}} \left(\frac{1}{\mathrm{u}_c(c_e^i)} - \frac{1}{\mathrm{u}_c(c_u^i)} \right) \right]^{-1} + \kappa_v \tag{28}$$

The optimal replacement rate is characterized by the Baily-Chetty formula, adjusted for a term that involves federal UI payments,

$$b^i = \frac{d\mathbb{B}^i}{du^i} \frac{1}{w^i} + \frac{e^i}{\epsilon^{m,i}} \frac{\Delta^i}{w^i} \left(\frac{1}{\mathrm{u}_c(c_e^i)} - \frac{1}{\mathrm{u}_c(c_u^i)} \right) + \frac{\tau_v^i}{q(\theta^i) w^i} \tag{29}$$

The payroll tax follows

$$\tau^i = u^i b^i w^i + \frac{e^i}{q(\theta^i)} \tau_v^i - \mathbb{B}^i.$$

Proof. See appendix. ■

These results are familiar from the existing literature for closed economies, for example Jung and Kuester (2015). Namely, the autarkic government sets vacancy subsidies so as to ensure that the Hosios condition is satisfied. Absent a federal intervention, in autarky, the government would set unemployment benefits according to the Baily-Chetty formula: Baily (1974) and Chetty (2006).

It is instructive to compare the characterization for benefits in equation (29) with that in equation (26). Focus on the respective first terms that concern the impact of the federal UI scheme on the replacement rate. Note that the terms differ only in the ratio $\frac{\epsilon^{M,i}}{\epsilon^{m,i}}$ that appears in (26) but not with the larger set of instruments. When the member state only had access to benefits, the pass-through from federal UI benefits to member state's benefits can be small, so that the federal benefits do not considerably distort search incentives; the case when the macro-elasticity was small relative to the micro-elasticity. Observe that this ratio no longer appears when the country has access to the full set of instruments. As spelled out in (29) the pass-through of federal benefits to a member state's unemployment benefits is constant, and never small.

The reason is as simple as it is important: if the member state government provides for the optimal labor-market policy mix, then jobs will never be hard to come by. Therefore, an increase in benefits will always distort the search incentives of workers to such an extent that firms post fewer vacancies. More generally, observe that the macro-elasticity does not appear anywhere in (26) nor, indeed, in the entire Proposition 4.

3.4.2 The federal government

If the member states have the full set of labor-market instruments, the optimal (linear) policy of the federal government can be characterized as follows:

Proposition 5 *Consider the same assumptions as in Proposition 4. In addition, apply the assumptions spelled out in Section 3.3.2 (linear UI scheme and two states). Then the optimal federal insurance system satisfies:*

$$\mathcal{B} = \pi_H \pi_L \left(e^H - e^L\right) \left(\frac{\phi^L - \phi^H}{\pi_H \phi^H + \pi_L \phi^L}\right) \cdot$$
$$\cdot \left[\pi_H \left[\left(-\frac{d\Delta^H}{d\mathcal{B}}\right) \frac{u^H}{\Delta^H} \epsilon^{m,H} - \frac{d\theta^H}{d\mathcal{B}} \frac{e^H}{\theta^H} (1 + \epsilon^{s,H})\gamma\right] + \pi_L \underbrace{\left[\left(-\frac{d\Delta^L}{d\mathcal{B}}\right) \frac{u^L}{\Delta^L} \epsilon^{m,L} - \frac{d\theta^L}{d\mathcal{B}} \frac{e^L}{\theta^L} (1 + \epsilon^{s,L})\gamma\right]}_{\textit{only micro-economic elasticities}}\right]^{-1}$$

The first three terms in the formula for $\mathcal{B}$ are analogous to those present in Proposition 3. The availability of the hiring subsidy alters only one term: the last term, that is related to member states' moral hazard. It is useful to contrast it with the moral hazard term in Proposition 3, repeated here for convenience.

$$\left[\pi_H \left[-\frac{\mathrm{d}\Delta^H}{\mathrm{d}\mathcal{B}}\right] \frac{u^H}{\Delta^H} \epsilon^{M,H} + \pi_L \left[-\frac{\mathrm{d}\Delta^L}{\mathrm{d}\mathcal{B}}\right] \frac{u^L}{\Delta^L} \underbrace{\epsilon^{M,L}}_{\text{macro elasticity}}\right]^{-1}$$

When the government has access only to the benefits, there are circumstances under which it cannot manipulate the local unemployment level and free-ride on the insurance scheme. This occurs whenever ϵ^M is small, that is whenever the response of labor demand leads to higher finding rates, for instance in the labor rationing model of Michaillat (2012). However, if the local government has at its disposal the full set of labor market policy instruments and makes optimal use of it, the extent to which it can affect unemployment is given by the micro elasticities, always. In particular, labor is never rationed, as the hiring subsidy helps to keep the marginal cost of labor at the social optimum. In general, the response of market tightness is now controlled directly, rather only indirectly through the transmission of UI on wages. This translates into more severe moral hazard distortions and, hence, a less generous insurance scheme.

4 A quantitative assessment for the euro area

This paper focuses on the design of federal unemployment insurance in unions of sovereign states. While the theory presented above is general, the application will be specific. Toward this end, we calibrate the model of Section 2.1 to one concrete example: a stylized euro area. The euro area is an important case for three reasons. First, to date EMU is a currency union without fiscal risk sharing. A "European unemployment insurance scheme" has the potential to ameliorate cyclical disparities and has, therefore, repeatedly been been mentioned as a policy option Werner (1970), Andor (2016). Second, what sets the euro area apart is that labor markets are considerably less fluid than, for example, in the US, see Elsby et al. (2013b).

This *a priori* makes federal insurance appear particularly worthwhile. Third, EMU is special in that it is a union of sovereign states. That is, member states to date have full sovereignty over *all* policy decisions related to their domestic labor markets. As our analytical results have highlighted, depending on elasticities, it is this dimension that may limit the scope of fiscal risk sharing through a federal UI system. What we wish to find out is: by how much? And what limits on domestic policies may be needed to provide meaningful cross-country insurance?

We wish to be clear as regards on issue upfront: As of the time of writing, there is notable heterogeneity in social insurance systems in the euro member states. We deliberately abstract from these differences, and therefore also from any asymmetric benefits or costs, or permanent unilateral (positive or negative) transfers associated with a European unemployment insurance scheme. Our view is that taking account of such heterogeneity is certainly important, but that accounting for the existing heterogeneity can only be the second step in evaluating a European unemployment insurance scheme. Rather, here we wish to do what we consider the first step, namely, to ask under which circumstances a meaningful federal UI scheme can be implemented among sovereign member states in the first place, and what the quantitative properties of such federal UI schemes are.

4.1 Calibration

Our strategy, therefore, is to calibrate our model to resemble a union of generic euro area member states. In the baseline, there is no federal UI scheme. Member states set constant labor-market policy instruments, that is the replacement rate, layoff tax and vacancy–posting subsidy. The instruments are fixed at the level that decentralizes the constrained-efficient steady state in each member state absent the federal scheme.

We calibrate parameters to match euro area averages and "typical" cyclical fluctuations of the labor market. We then calibrate the model's parameters such that it matches key properties of the euro-area business cycle. We do not currently 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 **??**, we treat the resulting parameters as structural and ask what the feasible labor market policy mix *should* look like.

4.1.1 Data used for the calibration

One period in the model is a month. We calibrate the model to the period 1991M1 to 2015M12.[14] Where applicable, the data series are seasonally adjusted. The sample period

[14] 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 labor market tightness in the euro area.

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 member states. 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 et al. (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 vacancies 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.[15]

We target the standard deviation of the unemployment rate of the AWM database. Since we study the international transfers with unemployment as the driving indicator, this is a central statistic to be matched. As regards job-finding and separation rates, Elsby et al. (2013b) 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. In our calibration strategy we target the relative volatility of job-finding and job-separation rates documented by Elsby et al. (2013b).

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. The table reports the log deviations of these quarterly averages from an HP trend with a smoothing parameter of 1600. The business cycle properties of the data are well-known. Unemployment and vacancies, u_t and v_t, are volatile and so is 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.

4.1.2 Calibrated parameters

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

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. Many of the data series that we compare the model to have a quarterly frequency.

[15] These are Austria, Belgium, Finland, Germany, Luxembourg, Portugal and Spain. In some years, only data for a subset of those countries are available. In such years, the series we used is scaled accordingly to account for the missing observations.

Table 1: Business cycle properties of the data

		y	$Lprod$	$urate$	v	f	ξ	w	θ
Standard deviation		1.98	0.91	11.04	23.85	9.20	11.28	0.97	24.63
Autocorrelation		0.96	0.88	0.98	0.97	0.77	0.85	0.95	0.91
	y	1.00	0.49	-0.92	0.18	0.57	-0.66	0.03	0.33
	$Lprod$	-	1.00	-0.16	0.22	0.38	-0.31	-0.13	0.40
	$urate$	-	-	1.00	-0.16	-0.47	0.40	-0.06	-0.27
Correlation	v	-	-	-	1.00	0.13	-0.42	0.63	0.56
	f	-	-	-	-	1.00	-0.55	-0.07	0.36
	ξ	-	-	-	-	-	1.00	0.26	-0.53
	w	-	-	-	-	-	-	1.00	0.07
	θ	-	-	-	-	-	-	-	1.00

Notes:

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(10^5) 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. For the sake of comparison, the presented labor market flows concern the German economy as documented in Hartung et al. (2016). 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.

calibrate the monthly discount factor β to .996. We set the value of leisure to $\Psi_s(s) + \overline{h} = 0.369$, in order to match the average unemployment rate in AWM data, 9.5 percent.[16]
We set $\psi_s = .118$ to replicate the elasticity of the average duration of unemployment with respect to UI benefits of 0.8, which is in line with the empirical micro literature, for example, Meyer (1990).[17] The coefficient of relative risk aversion is set to $\sigma = 1$, implying log utility. We set a vacancy posting cost of $\kappa_v = 0.95$ so as to obtain an average value of the monthly job finding rate of 0.7 percent, the euro area average in Elsby et al. (2013a). This results in an average cost per hire net of hiring subsidy, $\frac{v(\kappa_v - \tau_v)}{m}$ of one monthly wage, in line with a broader notion of recruiting costs, (Silva and Toledo, 2009). We set the elasticity of the matching function with respect to vacancies to $\alpha = .3$, within the range of estimates deemed reasonable by Pissarides and Petrongolo (2001). We set the firm's bargaining power to $\eta = \alpha = .3$ 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

[16]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 did actively search for work.

[17]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.

Table 2: Parameters for baseline

Preferences		
β	time–discount factor.	0.996
$\Psi_s(s) + \bar{h}$	value of leisure.	0.369
ψ_s	scaling parameter dispersion utility cost of search.	0.118
γ	relative risk aversion.	1
Vacancies, matching and bargaining		
κ_v	vacancy posting cost.	1.14
α	match elasticity with respect to vacancies.	0.3
χ	scaling parameter for match-efficiency.	0.103
η	steady–state bargaining power of firm.	0.3
γ_w	degree of cyclicality of bargaining power of worker.	19.3
Production and layoffs		
μ_ϵ	mean idiosyncratic cost.	0.4
ψ_ϵ	scaling parameter dispersion idiosyncratic cost shock.	2.22
ρ_a	autocorrelation of the aggregate productivity.	0.98
$\sigma_a \cdot 100$	std. dev. of innovation to aggregate productivity.	0.182
Labor market policy		
b	replacement rate.	0.526
τ_v	vacancy posting subsidy.	0.67
τ_ξ	layoff tax.	7.23

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

quarterly job-filling rate of 71 percent as in Walsh (2000) . This results in $\chi = .103$. The finding of rather low match efficiency is consistent with other observations for Europe, for example Jung and Kuhn (2014).

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), and Pissarides (2009). 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. Concretely, we specify the following law of motion of the bargaining power

$$\eta_t = \eta \cdot \exp\{\gamma_w \cdot a_{t-1}\}, \gamma_w \geq 0.$$

Note that related assumptions are common in the literature.[18] We choose the value of γ_w

[18]For example, Landais et al. (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.

that generates an amount of volatility in the unemployment rate, f_t, that is comparable to the data summarized in Table 1. This implies $\gamma_w = 19.3$. As a result, for a 1 percent negative productivity shock the bargaining power of firms falls by 19 percent, from a steady state value of .3 to .24.

We calibrate $\mu_\epsilon = .4$, equal to the capital share. We interpret this as a reduced form of capturing the cost of capital used in a match in the production process. We set the dispersion parameter for the idiosyncratic cost shock to $\psi_\epsilon = 2.22$. This ensures that the model replicates the ratio of the volatility of the job-finding and separation rate as in the data for the euro area Elsby et al. (2013a), see Table 1.

We set the serial correlation of the productivity shock to $\rho_a = 0.96$ and the standard deviation of the shock to $\sigma_a = 0.0018$. With these values, the model replicates the volatility and persistence of measured labor productivity in the data.

The layoff tax, the vacancy–posting subsidy, and the replacement rate are fixed at those values that decentralize the constraint-efficient steady-state allocation in each member state prior to the introduction of a European UI scheme. In the following section, we will study the difference between optimal federal insurance in an economy with fixed policy instruments, i.e. absent moral hazard, with the optimal insurance when the member state follow Ramsey policy. Our calibration strategy ensures that under both specifications the steady state absent a European UI scheme coincides. The optimal vacancy subsidy amounts to 1 monthly wage, whereas the optimal layoff tax equals approximately 11 monthly wages, in line with the long average duration of unemployment spells in the euro area.[19] The replacement rate is 52 percent, a value that is not unreasonable for the euro area average, compare (Christoffel et al., 2009)[20].

Table 3 reports business cycle statistics in the baseline model based on a first-order approximation of the model. The calibrated model does a reasonably job of replicating the fluctuations in the data. Unemployment and vacancies are considerably more volatile than 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.

We wish to close this section by highlighting that our choice of resolution of the Shimer (2005) puzzle is important not only for bringing the model's second moments close to the ones in the

[19]We lack knowledge regarding the precise values of all the policy instruments for our composite European economy. 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 comes in the form of a prohibition to separate, or mandated severance payments, but not layoff taxes *per se*.

[20]The OECD "Benefits and Wages" report calculates the average net replacement rates across family situations, income levels, for all euro area countries. The net replacement rate includes social assistance and housing benefits that the unemployed are entitled to. The average net replacement rate in the initial period of unemployment amounts to about 70% for a family that does not qualify for cash housing assistance or social assistance, and 73% for a family that do qualify. The respective net replacement rate over the first 5 years of unemployment read 33% and 56%.

Table 3: Business cycle properties of the model

		y	$Lprod$	$urate$	v	f	ξ	w	θ
Standard deviation		2.09	0.91	11.04	23.31	9.64	3.96	0.66	32.14
Autocorrelation		0.99	0.96	1.00	0.93	0.96	0.97	0.99	0.96
Correlation	y	1.00	0.95	-0.97	0.87	0.96	-0.99	0.92	0.96
	$Lprod$	-	1.00	-0.86	0.98	1.00	-0.99	0.75	1.00
	$urate$	-	-	1.00	-0.73	-0.87	0.92	-0.98	-0.87
	v	-	-	-	1.00	0.97	-0.94	0.59	0.97
	f	-	-	-	-	1.00	-0.99	0.77	1.00
	ξ	-	-	-	-	-	1.00	-0.84	-0.99
	w	-	-	-	-	-	-	1.00	0.77
	θ	-	-	-	-	-	-	-	1.00

Notes: 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.

data, but also for the results that we derive next. In particular, our calibration means that to a large extent unemployment fluctuations in the baseline economy are socially inefficient. The member state's planner, therefore, would ideally use the policy instruments, setting different values at different stages of the cycle, so as to implement much smoother employment than witnessed in the baseline. (Recall, the baseline assumes constant instruments) If allowed to optimize over the cycle, in the decentralized economy, the government will, therefore, choose the optimal policy mix to first and foremost stabilize employment. That is, with optimal domestic labor-market policy over the cycle, the local government on its own could go a long way in reducing the welfare cost of business cycles.

4.1.3 Aggregate Demand Externality

The baseline model does not specify a demand externality. As one of the extensions, we consider an economy in which productivity is subject to an externality from aggregate consumption (see section 2.1.3). We set $\varsigma = .3$ as in Krueger et al. (2016). We then calibrate the model in the same way as we do in the baseline case, replicate the same moments, and target the same steady state values. We set policies as follows. The vacancy subsidy and layoff taxes are set at the values for the case without aggregate demand externalities. We choose the value of the replacement rate so that the steady state employment chosen by the Ramsey planner in the demand externality economy is equal to the employment prevailing in the steady state in the baseline environment.

4.2 Parameterized Non-linear Payout Function

Currently, we do not solve for the optimal Mirrleesian federal unemployment insurance scheme. Rather, we resort to simple, implementable schemes, that is, parameterized forms of a federal UI scheme, the parameters of which we optimize so as to maximize *ex-ante* welfare of the member states. We discuss the choice of functional form next.

The theory and propositions presented in section 3 suggest the following properties for an optimal federal UI scheme. First, as long as member states enjoy sovereignty over labor-market policies, federal unemployment insurance must not be designed as a standing system. That is, the federal level should not take over administration of national UI schemes entirely. Rather federal benefits are to be paid only if member states suffer from severe shocks. That is, federal UI must be contingent. Second, payouts of the scheme should be insensitive to unemployment at low levels of unemployment. Third, there is a threshold, beyond which federal UI can be generous.

Motivated by the above observation we study the optimal design of the EUI in a class of functions with these properties. We specify the insurance payouts as a flexibly parameterized nonlinear function of the unemployment rate, potentially flat on some of the domain and increasing at higher values of unemployment. We, then, search for the welfare-maximizing parameterization of this scheme.

Concretely, let us assume that the payout from the insurance scheme, $G^{EUI}(u,;\nu\omega,\mathcal{B})$, is a function of the unemployed population u parameterized by $\nu,\omega,\mathcal{B}\geq 0$ such that

$$B_{F,t}(u;\nu,\omega,\mathcal{B})=\frac{\exp\left(\nu\cdot(u-u_{\text{aut}}-\omega)\right)}{1+\exp\left(\nu\cdot(u-u_{\text{aut}}-\omega)\right)}\cdot\mathcal{B}\cdot u, \qquad (30)$$

where ν is a positive scalar and u_{aut} is the autarkic steady state unemployment rate.

We postulate that a member state receives

$$\mathbb{B}(u^i;\nu,\omega,\mathcal{B})\equiv B_{F,t}(u^i;\nu,\omega,\mathcal{B})-\tau_F$$

units of the consumption good in period t. Federal taxes are set so as to balance the federal budget. Since there is no risk at the aggregate level (no union-wide shocks), federal taxes are constant over time.

4.3 A European Unemployment Insurance Scheme

This sections presents the results of the quantitative exercise in which we aim to determine the optimal design of the European UI scheme (in the confine of the rules outlined in (30)). In our model, we have abstracted from any private source of international insurance (trade in financial markets or goods). This means that – absent a response of member states' policies – there is notable scope for welfare-improving federal insurance. Our main result is that the scope heavily depends on the extent to which member states can respond to a federal scheme, though, both in the long-run (with the average level of instruments) and over the business cycle. In the extreme, our simulations suggest that if member states can and do use their instruments optimally always (a proposition that, in this extreme form, one may doubt to be of practical relevance), the potential of moral hazard induced by the scheme means that the optimal federal UI scheme virtually replicates autarky. The numerical results reported below are based on a second-order perturbation of the model.

4.3.1 Optimal Insurance Absent Moral Hazard

For comparison, we start with a baseline in which the member states can never react to the federal UI scheme. Rather, member states are assumed to keep their policies exactly at the autarkic, constant level – even after the introduction of the federal insurance scheme.

The solid line on Figure 3 illustrates the federal payouts delivered by the welfare-maximizing design of the federal unemployment insurance in the baseline economy. The optimal parameterization reads $\omega = -u_{\text{aut}}, \mathcal{B} = 1.5$. Note that $\omega^* = -u_{\text{aut}}$ implies a linear contract, without any threshold. In other words, in each period, member states receive gross transfers amounting to of one and a half times the unemployment figure.

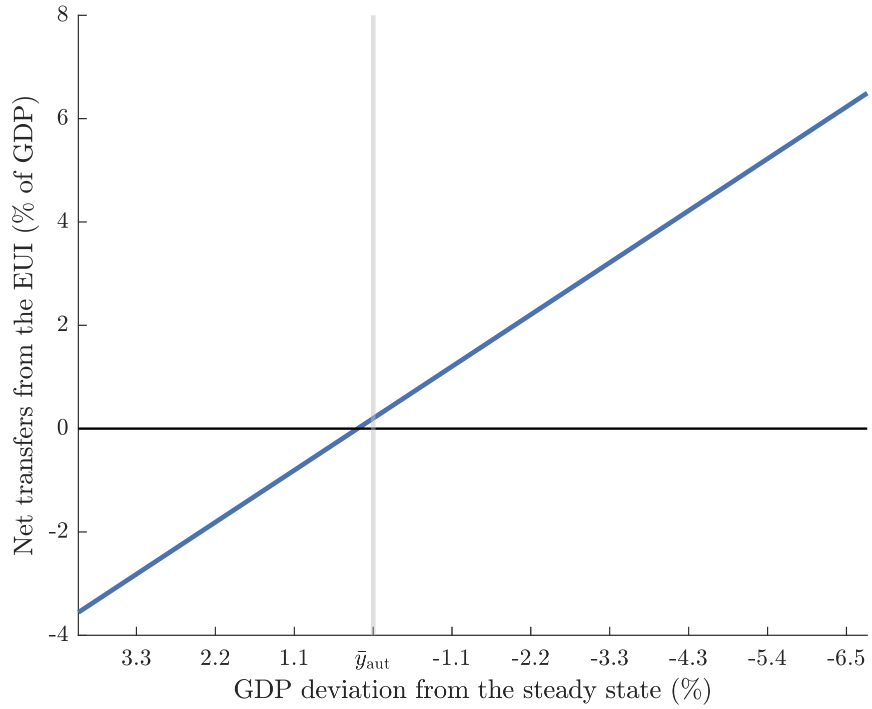
Not surprisingly, the federal transfers track closely the response of GDP to the unemployment shock. A one standard deviation shock reduces the employment rate by 1.3 percent GDP falls by 2.17 percent (see table 1). The transfers received from the federation rise by 2.07 percent of a steady state GDP.

The autarkic costs of the business cycle, in terms of consumption equivalent, amounts to 0.09 percent and the EUI reduces the costs of fluctuation to .06 percent. Note that the federal UI scheme, for constant domestic instruments can eliminate some of the welfare costs of business cycles, but not all. The reason is that constant domestic labor-market instruments mean that the model euro area as a whole uses its human capital inefficiently: there is too much employment in boom countries, and too little in recession countries.

4.3.2 Optimal Federal Insurance if Member States Adjust Long-run Policies

Absent moral hazard distortions, the above section showed that a European unemployment insurance scheme has the potential to provide welfare-improving insurance against business cycle shocks. Still, one may expect that local policies adjust to the introduction of a federal scheme. Precisely, a distinguishing feature of the European setup to date is that member states retain full sovereignty over their own labor-market policies. An important question, thus, is to what extent a welfare-improving transfer scheme can improve international insurance if that sovereignty is left untouched. The current section asks: what if local policymakers can once and for all adjust their labor market policies in response to a federal scheme, but (have

Figure 1: Net federal benefits $B^{EUI}(u; -u_a ut, 1.5)$ under the contract that is optimal absent moral hazard.



Notes: The payouts from the European UI under the contract that is optimal given that the local government cannot adjust local labor market policy in response. Federal transfers are expressed in terms percent of the GDP prevailing absent the insurance scheme.

to) keep policies constant over the business cycle? How does this change the shape of federal UI, and the scope of insurance.

To set the stage, Table 4 summarizes the prevailing steady state if a linear scheme as in Section 4.3.1 is implemented, to which member states react. We report results for less generous schemes than witnessed there, with slope $\mathcal{B} = .1$ or $\mathcal{B} = 1$. The reason for showing less generous federal schemes will become apparent instantly.

Table 4: Steady-state values – member states respond to linear federal UI scheme

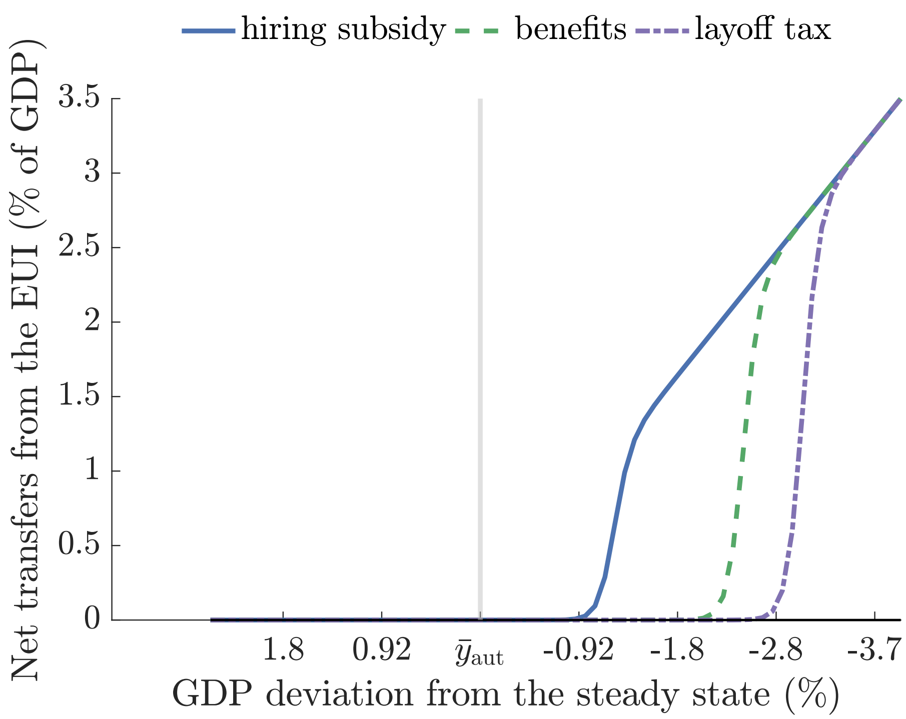
Variable	Description	autarky $\mathcal{B} = 0$	Federal insurance $\mathcal{B} = .1$	$\mathcal{B} = 1$
y	output.	0.895	0.809	0.310
u	unemployment rate.	0.095	0.171	0.625
v	vacancies.	0.017	0.025	0.034
f	job–finding rate.	0.062	0.059	0.046
s	fraction of job seekers.	0.899	0.873	0.748
ξ	layoff rate.	0.006	0.012	0.070
b	replacement rate	0.526	0.532	0.512
τ_ϵ	separation tax.	7.228	6.094	3.702
τ_v	vacancy posting subsidy.	0.670	0.645	0.632
τ_J	lump–sum production tax.	0.003	0.023	0.343
τ_F	lump–sum contribution to the EUI.	0.000	0.018	0.333

Notes: The table reports the steady-state values of selected endogenous variables when member states conduct Ramsey-optimal policy in response to the linear federal UI scheme of Figure **??**. The first column refers to the steady state absent a federal UI scheme. Column two and three refer to the federal UI scheme of Figure **??** but with different levels of generosity, indexed by $\mathcal{B} = 0.1$ and $\mathcal{B} = 1$ (the scheme underlying Figure **??** featured $\mathcal{B} = 1.5$).

Table 4 shows that once countries are allowed to react to the scheme, the steady state changes markedly. Employment falls by 10 percent (for $\mathcal{B} = 0.1$) or 65 (!) percent (for $\mathcal{B} = 1$). The main culprit of this is not the replacement rate. Indeed, virtually identical results would emerge if the member states were not allowed to adjust benefits after the introduction of federal UI. Rather, what makes the difference is that member states can change *the other* labor-market policies. In particular, ember state no longer bear the full marginal fiscal cost of unemployment. As a result, they are is inclined to reduce layoff taxes, in particular, which in turn raises unemployment. The burden that the countries impose on each other leads to a significant drop of the economic activity. In other words, in order to make generous cross-country insurance implementable through federal UI benefits, it is not sufficient – nor even needed, in the current model, at least – to restrict only the member state's benefit policies. Rather, member states would also have to forfeit *a wide range of labor-market policies.*

Member states' responses to the introduction of federal UI will, thereby, notably change the optimal federal UI scheme. This is shown in Figure 2 The algorithm underlying the

Figure 2: Net federal benefits $B^{EUI}(u;\omega^*,\mathcal{B}^*)$ under the optimal contract given that the member states adjust only long term (steady state) policy in response to the federal insurance.



Notes: The payouts from the European UI under the contract that is optimal given that the local government adjusts local labor market policy in response but only in the long term. Federal transfers are expressed in terms percent of the GDP prevailing absent the insurance scheme. Each line represents a setup with different restriction on which local instruments can be adjusted in response to the federal insurance.

figure solves for the insurance scheme that is optimal under the assumption that the local labor-market policy instruments are fixed at the steady-state level throughout the business cycle, but at levels that are influenced by the federal UI scheme. The resulting optimal federal contract (in the class that we consider) resembles a trigger scheme.[21] Numerically, the resulting optimal contracts in Figure 2 resemble a threshold scheme. There are, usually, no payouts. Only once the recession is deep enough, the federal level does provide UI based transfers. What is important to observe is that the Figure shows three different cases. The green dashed line marks the case that the member state can only adjust unemployment benefits in response to the scheme (with production taxes balancing the budget), but not the other labor-market instruments. The cutoff is at a 2 percent drop in output

The blue solid line marks the case when the country only can adjust the vacancy subsidy. The threshold falls to a recession commensurate with about a percent drop in GDP. The purple dashed-dotted line, instead, shows what happens to the optimal federal insurance scheme if member states adjust layoff taxes in response to the federal scheme (with, again, production taxes balancing the budget) but do not adjust any other labor-market policy. The cutoff moves toward 1.5 standard-deviation drop in output (by 3 percentage points). These figures underscore two implications: first, member states sovereignty reduces the scope for federal insurance. Second, it is not necessarily sufficient to restrain one dimension of labor-market policy (for example, benefits) – rather one may have to restrain the entire labor-market mix to some extent.

Whereas the introduction of the optimal federal UI scheme absent a response by the member states implied a gain equivalent to 0.026 percent of life-time consumption, gains are smaller when member states can react. When only the hiring subsidy reacts, the welfare gain still amounts to 0.0086 percent of life-time consumption. With a response of benefits, the gain is halved again to, namely, 0.0043 of life-time consumption. The scenario with a response of layoff taxes implies a gain still, but only of 0.0011 percent of life-time consumption. The welfare gains from a federal UI system (in the close of schemes considered here) does heavily depend on the policy options left to member states.

4.3.3 What if Member States have Access to Stabilization Policy?

The previous section analyzed the scope for a federal UI scheme if member states adjust long-run policies optimally. Next, we assess what happens to the state of federal UI if member states not only adjust policies in the long-run (keeping instruments fixed over the business cycle), but if they also adjust their policies in response to cyclical fluctuations. That is, the current section asks to what extent does federal UI have the potential to crowd out efforts by member states to stabilize their own business cycles? Of course, one may have the view

[21] The algorithm, for comparability, fixes $\mathcal{B} = 1.5$ as was found optimal in Figure 3, for entirely constant instruments. We optimize over ν and ω.

that member states simply cannot engage in cyclical stabilization policy. Then, the results of Section 4.3.2 highlight the scope for federal UI. Alternatively, one may bear in mind that member states might have some scope left for stabilization policy, in line with the fact that various member states of the euro area did implement labor-market stabilization policies in the recent recession (such as the German short-term work program). In any case, here we wish to highlight how a federal UI scheme should be designed that accounts for such efforts. We use the same algorithm as in Section 4.3.1, with the only difference being that the local instruments $\tau_v, \tau_\xi, \tau_J, b$ are no longer fixed, but follow the individual member state's Ramsey plan.

We solve the second order approximation to the model for different values of $\omega, \mathcal{B}$, calculate the resulting welfare for a typical household and choose the values of parameters for which the highest welfare is attained. The results are summarized in Figure 3. We consider three setups: with unrestricted instruments, with only layoff taxes and the hiring subsidy (and production taxes) allowed to adjust and only benefits allowed to adjust.

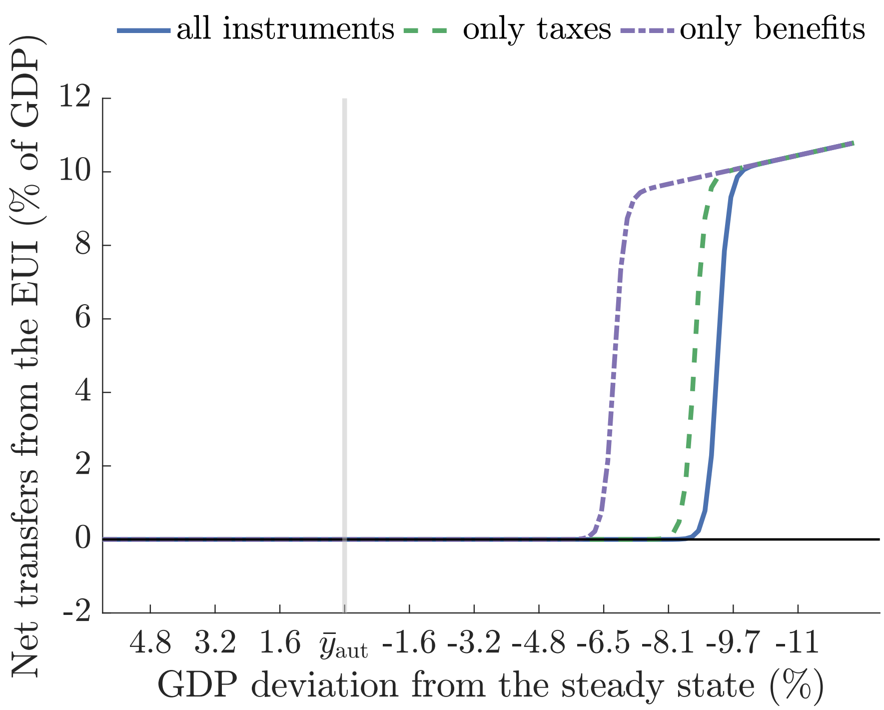
Figure 3 presents the results. What is noteworthy is that the threshold of the federal UI system moves markedly to the right. Federal UI is switched on only pays in truly large recessions, when output falls by at least 6 percent (when only benefits adjust), or by at least 10 percent (when all instruments are allowed to adjust). More flexibility of member-state governments severely reduces the scope for federal insurance.

The lump-sum taxes required to balance the federal budget are economically insignificant in all three scenarios, suggesting that the probability of ever crossing the threshold is negligible.

4.3.4 Aggregate Demand Externalities

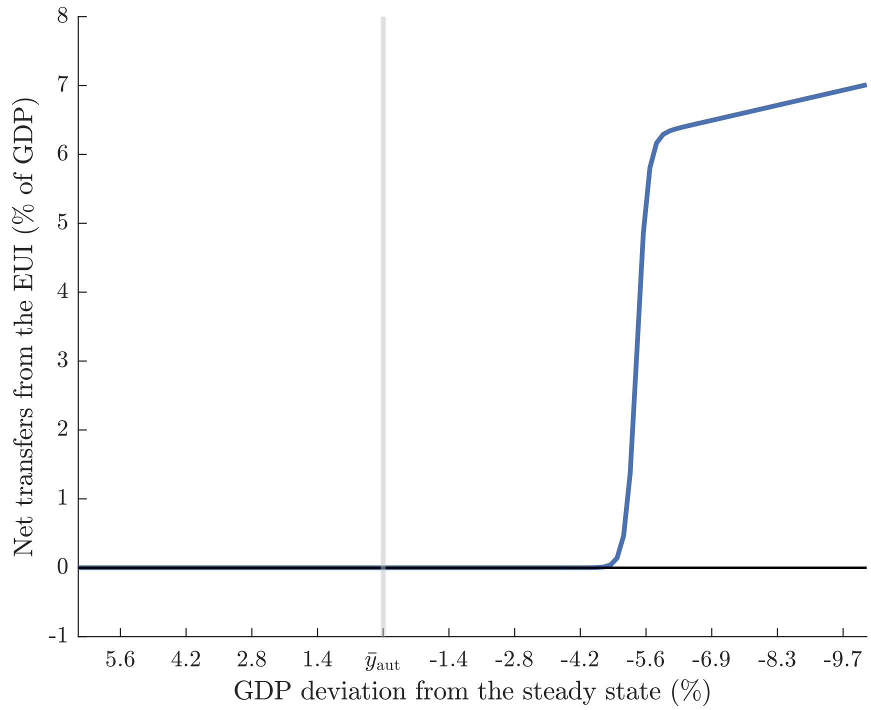
In this section we study how the optimal scope of international insurance changes in an economy that exhibits larger costs of business cycles. Demand externalities are a prominent case in point (see Section 2.1.3 for details). Such demand externalities mean that business cycles can have first-order welfare effects. They, therefore, could be one reason for implementing a fiscal union in the first place, compare Farhi and Werning (forthcoming). With demand externalities, consumption stabilization provided by a federal UI scheme, not only stabilizes consumption, but it also limits a costly (endogenous) further drop in labor productivity in a recession, which exacerbates the initial recessionary impulse. We have performed analogous quantitative exercises as in the case of the baseline model, that is, as in Section 4.3.1, Section 4.3.2, and Section 4.3.3. Figure 4 reports the scenario comparable to Section 4.3.3, the section that studied the case when member states used Ramsey-optimal policies in both the steady state and over the business cycle. The optimal insurance contract under demand externalities preserves the threshold-like structure that alleviates free-riding motive. The insurance is steeper than the baseline case and is triggered already at a less severe recession. Figure 4 plots the payouts under the optimal contract. Still, insurance is provided only in rather deep

Figure 3: Net federal benefits $B^{EUI}(u; \omega^*, \mathcal{B}^*)$ under the optimal contract given that member states adjust local labor market policy in response.



Notes: The payouts from the European UI under the contract that is optimal given that the local government adjusts local labor market policy in response. Federal transfers are expressed in terms percent of the GDP prevailing absent the insurance scheme. Each line represents a setup with different restriction on which local instruments can be adjusted in response to the federal insurance.

Figure 4: Gross federal benefits $B^{EUI}(u; \omega^*, \mathcal{B}^*)$ under the optimal contract in the economy with demand externalities.



Notes: The payouts from the European UI under the contract in the economy with demand externalities that is optimal given that the local government adjusts local labor market policy in response. Federal transfers are expressed in terms percent of the GDP prevailing absent the insurance scheme.

recessions (being phased in only when output drops by five percent).

5 Conclusions

How shall one design a federal unemployment insurance scheme in a union of member states that retain some sovereignty? In the current paper, sovereignty was taken to be the member states' room for manoeuvre with respect to local labor-market policies. The paper has provided intuition based on pencil-and-paper propositions and it has provided a quantitative exploration for a stylized euro area. The model was stylized in that it did not specify any scope for federal delegation. Optimally, the federal level would coordinate all policies. Indeed, in the model, if this were so, a federal UI scheme could easily insure countries against idiosyncratic business cycle risks and provide notable welfare gains.

Results are preliminary, but the following conclusions appear to emerge. First, relative to this baseline, we find that member states' sovereignty is very important for the scope of a federal UI benefit system. There are three central results. First, federal unemployment insurance must not be designed as a standing system, in which the federal level takes over administration of national UI schemes. Unless that is, member states give up their sovereignty. For implementing a standing federal UI system, it will not be enough, second, to restrict/regulate local unemployment benefit systems. Rather, all local labor-market instruments would need to be restricted. Instead, federal benefits are to be paid only if member states suffer from sufficiently severe shocks. That is, federal UI must be contingent on observing a severe-enough recession. Third, beyond such a threshold, federal UI can be generous. Quantitatively, we found that the thresholds were high, implying that federal insurance was possible only against truly severe recessions. Once accounting for an effect of federal UI provision on member states' own incentives to engage in stabilization policy, the scope for federal insurance was reduced further still. Demand externalities reduced the thresholds.

In closing, we wish to emphasize that our results have abstracted from a number of dimensions that may make implementability of a federal UI scheme in Europe either more desirable or more complicated. On the one hand, we have modeled a group of atomistic economies. To the extent that actual economies have some weight, the incentives to free ride would be smaller since countries share in the costs of the schemes. Still, for small countries or if there are regions within countries, the general mechanism should be stand up to scrutiny. On the other, we have abstracted from heterogeneity across countries. This would make implementing a generous standing European UI scheme difficult. What our paper shows is that even abstracting from heterogeneity, implementation of a generous federal UI scheme is not desirable as long as countries retain sovereignty. Insurance against extreme risks, in turn, may be politically easier to implement. Last, and perhaps most important, we have abstract from productivity-enhancing effects that a federal component of UI may have. For example, a federal scheme would automatically imply some portability of benefits, which could foster mobility, and enhance productivity. These effects may well be of first-order importance. Still, even if we miss some of the microeconomic long-term benefits of a joint EUI system/welfare system, we believe our central result will stand: unless member states cede sovereignty, a generous federal UI scheme will be counterproductive.

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A Derivations and intermediate results

A.1 Autarky, full instruments

Lemma 6

$$\left.\frac{\partial SW}{\partial \theta}\right|_{\Delta} = \frac{l}{\theta}(1-\eta)\phi w\left(\frac{\Delta}{\phi w} + (1+\epsilon^f)\left(b - \frac{\tau_v}{q(\theta)w}\right) - \frac{\eta}{1-\eta}\frac{\kappa_v}{q(\theta)w}\right)$$

Proof. We proceed as in the proof of Lemma 9. First, note that $\frac{\partial SW}{\partial \theta} = \frac{\partial s}{\partial f} f' f \Delta + s f' \Delta + u'(c_u)\frac{\partial c_u}{\partial \theta} - \Psi'(s)\frac{\partial s}{\partial f} f'$. By the envelope theorem the changes in search effort have not first-order impact on welfare. $s f' \Delta = \frac{l}{\theta}(1-\eta)\Delta$. The market tightness affects consumption thorough the resource constraint. Using $c_e = u^{-1}\left(u(c_u) + \Delta\right)$, the constraint can be rewritten as

$$y(l(\theta,\Delta)) - \kappa_v \frac{l(\theta,\Delta)}{q(\theta)} = l(\theta,\Delta)u^{-1}\left(u(c_u(\theta,\Delta)) + \Delta\right) + (1 - l(\theta,\Delta))c_u(\theta,\Delta)$$

The wage now is redefined as $w = y' - \kappa_v/q + \tau_v/q$. The implicit differentiation wrt θ yields

$$\begin{aligned}
y'(l)\frac{\partial l}{\partial \theta} + \kappa_v \frac{q'(A,\theta)}{(q(\theta))^2} l - \kappa_v \frac{1}{q(\theta)}\frac{\partial l}{\partial \theta} &= \frac{\partial l}{\partial \theta} c_e + l\frac{u'(c_u)}{u'(c_e)}\frac{\partial c_u}{\partial \theta} - \frac{\partial l}{\partial \theta} c_u + (1-l)\frac{\partial c_u}{\partial \theta} \\
\frac{\partial l}{\partial \theta}\left(y'(l) - \frac{\kappa_v}{q(\theta)} - c_e + c_u\right) - \kappa_v \frac{\eta}{q(\theta)}\frac{l}{\theta} &= \left(\frac{l}{u'(c_e)} + \frac{1-l}{u'(c_u)}\right) u'(c_u)\frac{\partial c_u}{\partial \theta} \\
\frac{l}{\theta}(1-\eta)(1+\epsilon^f)\left(w - \frac{\tau_v}{q} - c_e + c_u\right) - \kappa_v \frac{l}{\theta}\frac{\eta}{q(\theta)} &= \left(\frac{l}{u'(c_e)} + \frac{1-l}{u'(c_u)}\right) u'(c_u)\frac{\partial c_u}{\partial \theta} \\
\frac{l}{\theta}(1-\eta)(1+\epsilon^f)\left(bw - \frac{\tau_v}{q}\right) - \kappa_v \frac{l}{\theta}\frac{\eta}{q(\theta)} &= \left(\frac{l}{u'(c_e)} + \frac{1-l}{u'(c_u)}\right) u'(c_u)\frac{\partial c_u}{\partial \theta},
\end{aligned}$$

Taken together this yields

$$\begin{aligned}
\frac{\partial SW}{\partial \theta} &= \frac{l}{\theta}(1-\eta)\Delta + \phi\frac{l}{\theta}(1-\eta)(1+\epsilon^f)\left(bw - \frac{\tau_v}{q}\right) - \phi\kappa_v \frac{l}{\theta}\frac{\eta}{q(\theta)} \\
&= \frac{l}{\theta}(1-\eta)\phi w\left(\frac{\Delta}{w\phi} + (1+\epsilon^f)\left(b - \frac{\tau_v}{q(\theta)w}\right) - \frac{\eta}{1-\eta}\frac{\kappa_v}{q(\theta)w}\right)
\end{aligned}$$

■

Proposition 7 *Optimal policy sets hiring so as to keep market tightness at the welfare maximizing value. The optimal hiring subsidy satisfies*

$$\tau_v = q(\theta)\frac{\Delta}{\phi(1+\epsilon^f)} + q(\theta)bw - \frac{\eta}{(1-\eta)(1+\epsilon^f)}\kappa_v$$

Proof. The FOC for the market tightness delivers $\frac{\partial SW}{\partial \theta}\big|_\Delta = 0$. Solving the expression in Lemma 6 for market tightness yields the result. ■

Proposition 8 *The optimal replacement rate follows Baily-Chetty formula,*

$$b = \frac{l}{\epsilon^m}\frac{\Delta}{w}\left(\frac{1}{u'(c_e)} - \frac{1}{u'(c_u)}\right)$$

Proof. The first order conditions for the optimal gain from employment reads

$$\left.\frac{\partial SW}{\partial \Delta}\right|_\theta = 0$$

It follows that $\frac{\partial SW}{\partial \Delta} = sf + u'(c_u)\frac{\partial c_u}{\partial \Delta}$. Differentiation of the resource constraint yields

$$\begin{aligned}
\frac{\partial l}{\partial \Delta}\left(y'(l) - \frac{\kappa_v}{q(\theta)} - c_e + c_u\right) &= l\frac{1}{u'(c_e)}\left(1 + u'(c_u)\frac{\partial c_u}{\partial \Delta}\right) + (1-l)\frac{\partial c_u}{\partial \Delta} \\
\frac{\partial l}{\partial \Delta}\left(w - \Delta_c - \frac{\tau_v}{q(\theta)}\right) - \frac{l}{u'(c_e)} &= \left(l\frac{u'(c_u)}{u'(c_e)} + 1 - l\right)\frac{\partial c_u}{\partial \Delta} \\
\epsilon^m \frac{1-l}{\Delta}\left(bw - \frac{\tau_v}{q(\theta)}\right) - \frac{l}{u'(c_e)} &= \left(\frac{l}{u'(c_e)} + \frac{1-l}{u'(c_u)}\right) u'(c_u)\frac{\partial c_u}{\partial \Delta}
\end{aligned}$$

Hence

$$\begin{aligned}
\frac{\partial SW}{\partial \Delta} &= l + \phi\left[\epsilon^m \frac{1-l}{\Delta}\left(bw - \frac{\tau_v}{q(\theta)}\right) - \frac{l}{u'(c_e)}\right] \\
&= (1-l)\phi\left[\epsilon^m \frac{w}{\Delta}\left(b - \frac{\tau_v}{q(\theta)w}\right) - \frac{l}{1-l}\left(\frac{1}{\phi} - \frac{1}{u'(c_e)}\right)\right] \\
\Rightarrow \qquad b &= \frac{\tau_v}{q(\theta)w} + \frac{\Delta}{\epsilon^m w}\frac{l}{1-l}\left(\frac{1}{\phi} - \frac{1}{u'(c_e)}\right)
\end{aligned}$$

■

This appendix contains proofs of all statements in the paper.

A.2 Proofs of Statements in Section ??

Proof. [Proof of Proposition **??**] The proof rests on the following three lemmas.

Lemma 9 *The partial derivative of welfare with respect to the market tightness reads*

$$\frac{\partial W}{\partial \theta} = \frac{l}{\theta}(1-\eta)\phi w\left(\frac{\Delta}{\phi w} + b(1+\epsilon^f) - \frac{\eta}{1-\eta}\frac{\kappa_v}{q(\theta)w}\right)$$

Lemma 10 *The effect of the generosity of the UI scheme Δ on the market tightness is*

$$\frac{d\theta}{d\Delta} = -\frac{\theta}{\Delta}\frac{1-l}{l}\frac{1}{1-\eta}\frac{\epsilon^m}{1+\epsilon^f}\left(1 - \frac{\epsilon^M}{\epsilon^m}\right)$$

Lemma 11 *The partial derivative of welfare with respect to the generosity of the UI scheme Δ is given by*

$$\frac{\partial W}{\partial \Delta} = (1-l)\phi\frac{w}{\Delta}\epsilon^m\left(b - \frac{l}{\epsilon^m}\frac{\Delta}{w}\left(\frac{1}{u'(c_e)} - \frac{1}{u'(c_u)}\right)\right)$$

Given the above lemmas, the proof is proceeds as follows. The first order condition of the Ramsey problem is

$$\frac{\partial W}{\partial \theta}\frac{\partial \theta}{\partial \Delta} + \frac{\partial W}{\partial \Delta} = 0$$

The three expressions on the left–hand side are characterized in turn by the three lemmas. Plugging the formulas delivers

$$0 = \left\{ \frac{l}{\theta}(1-\eta)\phi w \left(\frac{\Delta}{\phi w} + b(1+\epsilon^f) - \frac{\eta}{1-\eta}\frac{1}{q(\theta)w} \right) \right\} \cdot \left\{ -\frac{\theta}{\Delta}\frac{1-l}{l}\frac{1}{1-\eta}\frac{\epsilon^m}{1+\epsilon^f}\left(1-\frac{\epsilon^M}{\epsilon^m}\right) \right\}$$
$$+ \left\{ (1-l)\phi \frac{w}{\Delta}\epsilon^m \left(b - \frac{l}{\epsilon^m}\frac{\Delta}{w}\left(\frac{1}{u'(c_e)} - \frac{1}{u'(c_u)} \right) \right) \right\}$$

$$0 = -(1-l)\phi \frac{w}{\Delta}\epsilon^m \left(\frac{\Delta}{\phi w} + b(1+\epsilon^f) - \frac{\eta}{1-\eta}\frac{1}{q(\theta)w} \right) \frac{1}{1+\epsilon^f}\left(1-\frac{\epsilon^M}{\epsilon^m}\right)$$
$$+ (1-l)\phi \frac{w}{\Delta}\epsilon^m \left(b - \frac{l}{\epsilon^m}\frac{\Delta}{w}\left(\frac{1}{u'(c_e)} - \frac{1}{u'(c_u)} \right) \right)$$

$$b = \underbrace{\frac{l}{\epsilon^m}\frac{\Delta}{w}\left(\frac{1}{u'(c_e)} - \frac{1}{u'(c_u)} \right)}_{\text{Baily–Chetty formula}} + \underbrace{\left(1-\frac{\epsilon^M}{\epsilon^m}\right)\frac{1}{1+\epsilon^f}\left(\frac{\Delta}{\phi w} + b(1+\epsilon^f) - \frac{\eta}{1-\eta}\frac{\kappa_v}{q(\theta)w} \right)}_{\text{general equilibrium correction term}}$$

■ We complete the proof of the proposition with the proofs of the lemmas. **Proof.** [Proof of Lemma 9] It follows that

$$\frac{\partial W}{\partial \theta} = \frac{\partial s}{\partial f(\theta)} f'(A,\theta) f(\theta)\Delta + s f'(\theta)\Delta + u'(c_u)\frac{\partial c_u}{\partial \theta} - \Psi'(s)\frac{\partial s}{\partial f(\theta)} f'(A,\theta)$$

Please note that the envelope theorem implies that $\frac{\partial s}{\partial f(\theta)} = 0$ when it comes to the direct impact on welfare. Furthermore, $sf'(\theta)\Delta = \frac{sf}{\theta}\frac{\theta f'}{f}\Delta = \frac{l}{\theta}(1-\eta)\Delta$. Lastly, we need to calculate $\frac{\partial c_u}{\partial \theta}$ such that the change in consumption is consistent with the budget constraint. To this end, we implicitly differentiate the balanced budget requirement (25). Using $c_e = u^{-1}(u(c_u) + \Delta)$, the constraint can be rewritten as

$$y(l(\theta,\Delta)) - \kappa_v \frac{l(\theta,\Delta)}{q(\theta)} = l(\theta,\Delta)u^{-1}(u(c_u(\theta,\Delta)) + \Delta) + (1 - l(\theta,\Delta))c_u(\theta,\Delta)$$

The implicit differentiation wrt θ yields

$$y'(l)\frac{\partial l}{\partial \theta} + \kappa_v \frac{q'(A,\theta)}{(q(\theta))^2} l - \kappa_v \frac{1}{q(\theta)}\frac{\partial l}{\partial \theta} = \frac{\partial l}{\partial \theta}c_e + l\frac{u'(c_u)}{u'(c_e)}\frac{\partial c_u}{\partial \theta} - \frac{\partial l}{\partial \theta}c_u + (1-l)\frac{\partial c_u}{\partial \theta}$$
$$\frac{\partial l}{\partial \theta}\left(y'(l) - \frac{\kappa_v}{q(\theta)} - c_e + c_u \right) - \kappa_v \frac{\eta}{q(\theta)}\frac{l}{\theta} = \left(\frac{l}{u'(c_e)} + \frac{1-l}{u'(c_u)} \right) u'(c_u)\frac{\partial c_u}{\partial \theta}$$
$$\frac{l}{\theta}(1-\eta)(1+\epsilon^f)(w - c_e + c_u) - \kappa_v \frac{l}{\theta}\frac{\eta}{q(\theta)} = \left(\frac{l}{u'(c_e)} + \frac{1-l}{u'(c_u)} \right) u'(c_u)\frac{\partial c_u}{\partial \theta},$$

where we used $\epsilon^f = \frac{f(\theta)}{s}\frac{\partial s}{\partial f(\theta)}$, $-\frac{q'(A,\theta)}{(q(\theta))^2} = -\frac{1}{\theta q(\theta)}\frac{\theta q'(A,\theta)}{q(\theta)} = \frac{\eta}{\theta q(\theta)}$ and

$$\frac{\partial l}{\partial \theta} = \frac{\partial(sf(\theta))}{\partial \theta} = \frac{\partial s}{\partial f(\theta)} f'(A,\theta) f + s f'(A,\theta) = f'(A,\theta) s \left(\frac{f(\theta)}{s}\frac{\partial s}{\partial f(\theta)} + 1 \right) = \frac{l}{\theta}\left(1+\epsilon^f\right)(1-\eta).$$

Let us define $\frac{1}{\phi} = \frac{l}{u'(c_e)} + \frac{1-l}{u'(c_u)}$ and $\Delta_c = c_e - c_u$. Furthermore, please note that the replacement rate satisfies $bw = w - \Delta_c$. With all the above results at hand, we can write the partial derivative of welfare wrt the market tightness as follows.

$$\frac{\partial W}{\partial \theta} = \frac{l}{\theta}(1-\eta)\phi w \left(\frac{\Delta}{\phi w} + b(1+\epsilon^f) - \frac{\eta}{1-\eta}\frac{\kappa_v}{q(\theta) w} \right) \tag{31}$$

■ **Proof.** [Proof of Lemma 10] Please note that

$$\epsilon^M = \epsilon^m + \frac{\theta}{1-l}\frac{\partial l}{\partial \theta}\frac{\Delta}{\theta}\frac{\mathrm{d}\theta}{\mathrm{d}\Delta} = \epsilon^m + \left[\frac{l}{1-l}\left(1+\epsilon^f\right)(1-\eta)\right]\frac{\Delta}{\theta}\frac{\mathrm{d}\theta}{\mathrm{d}\Delta}$$

Rearranging the terms and dividing by ϵ^m yields the desired result

$$\frac{\Delta}{\theta}\frac{\mathrm{d}\theta}{\mathrm{d}\Delta} = -\left(1 - \frac{\epsilon^M}{\epsilon^m}\right)\frac{1-l}{l}\frac{\epsilon^m}{1+\epsilon^f}\frac{1}{1-\eta} \tag{32}$$

■ **Proof.** [Proof of Lemma 11] Please observe that

$$\frac{\partial W}{\partial \Delta} = l + u'(c_u)\frac{\partial c_u}{\partial \Delta}$$

We need to derive the change $\frac{\partial c_u}{\partial \Delta}$ that is implied by the balanced budget requirement. Implicit differentiation of the resource constraint yields

$$y'(l)\frac{\partial l}{\partial \Delta} - \frac{\kappa_v}{q(\theta)}\frac{\partial l}{\partial \Delta} = \frac{\partial l}{\partial \Delta}c_e + l\frac{\partial c_e}{\partial \Delta} - \frac{\partial l}{\partial \Delta}c_u + (1-l)\frac{\partial c_u}{\partial \Delta}$$

Please recall that $\frac{\partial l}{\partial \Delta} = \epsilon^m \frac{1-l}{\Delta}$. Furthermore, since $c_e = u^{-1}\left(u(c_u) + \Delta\right)$, it follows that $\frac{\partial c_e}{\partial \Delta} = \frac{1}{u'(c_e)}\left(1 + u'(c_u)\frac{\partial c_u}{\partial \Delta}\right)$. Hence, one obtains

$$\begin{aligned}
\frac{\partial l}{\partial \Delta}\left(y'(l) - \frac{\kappa_v}{q(\theta)} - c_e + c_u\right) &= l\frac{1}{u'(c_e)}\left(1 + u'(c_u)\frac{\partial c_u}{\partial \Delta}\right) + (1-l)\frac{\partial c_u}{\partial \Delta} \\
\frac{\partial l}{\partial \Delta}(w - \Delta_c) - \frac{l}{u'(c_e)} &= \left(l\frac{u'(c_u)}{u'(c_e)} + 1 - l\right)\frac{\partial c_u}{\partial \Delta} \\
\epsilon^m\frac{1-l}{\Delta}(w - \Delta_c) - \frac{l}{u'(c_e)} &= \left(\frac{l}{u'(c_e)} + \frac{1-l}{u'(c_u)}\right)u'(c_u)\frac{\partial c_u}{\partial \Delta}
\end{aligned}$$

Using the definition of $\frac{1}{\phi} = \frac{l}{u'(c_e)} + \frac{1-l}{u'(c_u)}$ and plugging the above formula to the expression for $\frac{\partial W}{\partial \Delta}$ we obtain

$$\frac{\partial W}{\partial \Delta} = l + \phi\left(\epsilon^m \frac{1-l}{\Delta}(w - \Delta_c) - \frac{l}{u'(c_e)}\right) = (1-l)\phi\left(\frac{w}{\Delta}\epsilon^m b + \frac{l}{1-l}\left(\frac{1}{\phi} - \frac{1}{u'(c_e)}\right)\right)$$

The proof is concluded by noting that $\frac{1}{\phi} - \frac{1}{u'(c_e)} = -(1-l)\left(\frac{1}{u'(c_e)} - \frac{1}{u'(c_u)}\right)$ ■

Proof. [Proof of Proposition 1] The proof is analogous to the proof of Proposition **??**, with the Lemmas 1 to 3 augmented with the federal benefits $B^{EA}(1-l)$.

Lemma 12 *The partial derivative of welfare with respect to the market tightness reads*

$$\frac{\partial W}{\partial \theta} = \frac{l}{\theta}(1-\eta)\phi w\left(\frac{\Delta}{\phi w} + b(1+\epsilon^f) - \frac{1+\epsilon^f}{w}\frac{dB^{EA}}{d(1-l)} - \frac{\eta}{1-\eta}\frac{1}{q(\theta)w}\right)$$

Lemma 13 *The effect of the generosity of the UI scheme Δ on the market tightness is the same as in the economy without insurance.*

$$\frac{d\theta}{d\Delta} = -\frac{\theta}{\Delta}\frac{1-l}{l}\frac{1}{1-\eta}\frac{\epsilon^m}{1+\epsilon^f}\left(1 - \frac{\epsilon^M}{\epsilon^m}\right)$$

Lemma 14 *The partial derivative of welfare with respect to the generosity of the UI scheme Δ is given by*

$$\frac{\partial W}{\partial \Delta} = (1-l)\phi\frac{w}{\Delta}\epsilon^m\left(b - \frac{1}{w}\frac{dB^{EA}}{d(1-l)} - \frac{l}{\epsilon^m}\frac{\Delta}{w}\left(\frac{1}{u'(c_e)} - \frac{1}{u'(c_u)}\right)\right)$$

Under federal insurance scheme, the first order condition for the local government reads

$$\begin{aligned}\frac{l}{\theta}(1-\eta)\phi w\left(\frac{\Delta}{\phi w} + b(1+\epsilon^f) - \frac{\mathrm{d}B^{EA}}{\mathrm{d}(1-l)}\frac{1+\epsilon^f}{w} + \frac{\eta}{1-\eta}\frac{1}{qw}\right)\frac{-\theta}{\Delta}\frac{1-l}{l}\frac{1}{1-\eta}\frac{\epsilon^m}{1+\epsilon^f}\left(1-\frac{\epsilon^M}{\epsilon^m}\right)\\ + (1-l)\phi\frac{w}{\Delta}\epsilon^m\left(b - \frac{1}{w}\frac{\mathrm{d}B^{EA}}{\mathrm{d}(1-l)} - \frac{l}{\epsilon^m}\frac{\Delta}{w}\left(\frac{1}{u'(c_e)} - \frac{1}{u'(c_u)}\right)\right) = 0\end{aligned}$$

$$\begin{aligned}0 = -(1-l)\phi\frac{w}{\Delta}\epsilon^m\left(\frac{\Delta}{\phi w} + b(1+\epsilon^f) - \frac{\mathrm{d}B^{EA}}{\mathrm{d}(1-l)}\frac{1+\epsilon^f}{w} - \frac{\eta}{1-\eta}\frac{1}{q(\theta)w}\right)\frac{1}{1+\epsilon^f}\left(1-\frac{\epsilon^M}{\epsilon^m}\right)\\ + (1-l)\phi\frac{w}{\Delta}\epsilon^m\left(b - \frac{\mathrm{d}B^{EA}}{\mathrm{d}(1-l)}\frac{1}{w} - \frac{l}{\epsilon^m}\frac{\Delta}{w}\left(\frac{1}{u'(c_e)} - \frac{1}{u'(c_u)}\right)\right)\end{aligned}$$

$$\begin{aligned}b = \frac{l}{\epsilon^m}\frac{\Delta}{w}\left(\frac{1}{u'(c_e)} - \frac{1}{u'(c_u)}\right) + \left(1-\frac{\epsilon^M}{\epsilon^m}\right)\frac{1}{1+\epsilon^f}\left(\frac{\Delta}{\phi w} + b(1+\epsilon^f) - \frac{\eta}{1-\eta}\frac{1}{q(\theta)w}\right)\\ - \left(1-\frac{\epsilon^M}{\epsilon^m}\right)\frac{\mathrm{d}B^{EA}}{\mathrm{d}(1-l)}\frac{1}{w} + \frac{\mathrm{d}B^{EA}}{\mathrm{d}(1-l)}\frac{1}{w}\end{aligned}$$

$$b = \underbrace{\frac{\epsilon^M}{\epsilon^m}\frac{\mathrm{d}B^{EA}}{\mathrm{d}(1-l)}\frac{1}{w}}_{>0} + \underbrace{\frac{l}{\epsilon^m}\frac{\Delta}{w}\left(\frac{1}{u'(c_e)} - \frac{1}{u'(c_u)}\right) + \left(1-\frac{\epsilon^M}{\epsilon^m}\right)\frac{1}{1+\epsilon^f}\left(\frac{\Delta}{\phi w} + b(1+\epsilon^f) - \frac{\eta}{1-\eta}\frac{1}{q(\theta)w}\right)}_{\text{autarkic benefits}}$$

■

Proof. [Proof of lemma 12] The only change with respect to the proof o lemma 9 is that the budget constraint now reads

$$y(l(\theta,\Delta)) - \kappa_v \frac{l(\theta,\Delta)}{q(\theta)} + B^{EA}(1-l) = l(\theta,\Delta)u^{-1}\left(u(c_u(\theta,\Delta)) + \Delta\right) + (1-l(\theta,\Delta))c_u(\theta,\Delta)$$

and hence

$$\frac{\partial c_u}{\partial \theta}u'(c_u) = \phi\frac{l}{\theta}\left((1-\eta)(1+e^f)\left(bw - \frac{\mathrm{d}B^{EA}}{\mathrm{d}(1-l)}\right) - \frac{\eta}{q}\right)$$

This leads to

$$\frac{\partial W}{\partial \theta} = \frac{l}{\theta}(1-\eta)\phi w\left(\frac{\Delta}{\phi w} + b(1+\epsilon^f) - \frac{1+\epsilon^f}{w}\frac{\mathrm{d}B^{EA}}{\mathrm{d}(1-l)} - \frac{\eta}{1-\eta}\frac{1}{q(\theta)w}\right)$$

■

Proof. [Proof of Lemma 13] The only impact of federal unemployment insurance is through $\frac{\partial c_u}{\partial \theta}$ implied by the local budget constraint and hence absent in the derivation of $\frac{\mathrm{d}\theta}{\mathrm{d}\Delta}$ ■ **Proof.** [Proof of Lemma 14] Please note that under federal insurance the the implicit differentiation of the local budget constraint with respect to utility gain from working reads

$$y'(l)\frac{\partial l}{\partial \Delta} - \frac{\kappa_v}{q(\theta)}\frac{\partial l}{\partial \Delta} - \frac{\mathrm{d}B^{EA}}{\mathrm{d}(1-l)}\frac{\partial l}{\partial \Delta} = \frac{\partial l}{\partial \Delta}c_e + l\frac{\partial c_e}{\partial \Delta} - \frac{\partial l}{\partial \Delta}c_u + (1-l)\frac{\partial c_u}{\partial \Delta}$$

and thus

$$\frac{\partial c_u}{\partial \Delta}u'(c_e) = \phi\left(\epsilon^m\frac{1-l}{\Delta}w\left(b - \frac{1}{w}\frac{\mathrm{d}B^{EA}}{\mathrm{d}(1-l)}\right) - \frac{l}{u'(c_e)}\right)$$

This leads to the following expression for partial derivative of wealth wrt the utility gain

$$\frac{\partial W}{\partial \Delta} = (1-l)\phi\frac{w}{\Delta}\epsilon^m\left(b - \frac{1}{w}\frac{\mathrm{d}B^{EA}}{\mathrm{d}(1-l)} - \frac{l}{\epsilon^m}\frac{\Delta}{w}\left(\frac{1}{u'(c_e)} - \frac{1}{u'(c_u)}\right)\right)$$

■

Proof. [Proof of Corollary **??**] We multiply both sides of the formula for optimal replacement rate in Porposition 1 by $\epsilon^m w$ and rearrange to obtain

$$\Delta = \left[-\frac{\mathrm{d}B^{EUI}}{\mathrm{d}(1-l)}\epsilon^M + \epsilon^M bw + (\epsilon^m - \epsilon^M)\frac{1}{1+\epsilon^f}\frac{\eta}{1-\eta}\frac{\kappa_v}{q}\right]$$
$$\cdot\left[\frac{l}{u'(c_e)} - \frac{l}{u'(c_u)} + \left(\epsilon^m - \epsilon^M\right)\frac{1}{1+\epsilon^f}\frac{1}{\phi}\right]^{-1}$$

The see that the distortions always lead to shrinking gain from employment note that concavity of u implies $\frac{l}{u'(c_e)} - \frac{l}{u'(c_u)} > 0$ and our assumption on wages weakly increasing in benefits yields $\left(\epsilon^m - \epsilon^M\right)\frac{1}{1+\epsilon^f}\frac{1}{\phi} > 0$. ■

Proof. [Proof of Proposition **??**] Let us define the social welfare in a boom country as

$$W^H(A^H, \theta^H, \Delta^H; B^{EUI}) = s^H \cdot f^H \cdot \Delta^H + u(c_u^H) - \Psi(s^H).$$

$W(A^L, \theta^L, \Delta^L; B^{EUI})$ is defined analogously.
The social welfare for a union as a whole can be written as

$$\begin{aligned}
V(B^{EUI}) =& \pi \max_{\Delta^H, c_u^H} \Big\{ W(A^H, \theta(\Delta^H), \Delta^H; B^{EUI}) \\
&\qquad + \phi^H \left[y(l^H) - \kappa_v \frac{l^H}{q^H} - l^H u^{-1}(u(c_u^H) + \Delta^H) - (1 - l^H) c_u^H + B^{EUI}\left(1 - l^H\right) \right] \Big\} \\
&+ (1 - \pi) \max_{\Delta^L, c_u^L} \Big\{ W(A^L, \theta(\Delta^L), \Delta^L; B^{EUI}) \\
&\qquad + \phi^L \left[y(l^L) - \kappa_v \frac{l^L}{q^L} - l^L u^{-1}(u(c_u^L) + \Delta^L) - (1 - l^L) c_u^L + B^{EUI}\left(1 - l^L\right) \right] \Big\}
\end{aligned} \tag{33}$$

Optimal insurance in class of linear contracts $B^{EUI}(1 - l) \equiv (1 - l)\mathcal{B} - \tau^{EUI}$ solves

$$\begin{aligned}
&\max_{\mathcal{B}} V(\mathcal{B}) \\
&\text{s.t.} \\
&\Delta(\mathcal{B}) \text{ given by Poposition 1} \\
&\tau^{EUI}(\mathcal{B}) = \mathcal{B}\left[\pi(1 - l^H) + (1 - \pi)(1 - l^L)\right]
\end{aligned}$$

FOC is

$$\begin{aligned}
0 &= \phi^H \pi \left(1 - l^H - \frac{\mathrm{d}\tau}{\mathrm{d}\mathcal{B}}\right) + (1 - \pi)\phi^L \left(1 - l^L - \frac{\mathrm{d}\tau}{\mathrm{d}\mathcal{B}}\right) \\
&= \pi\phi^H(1 - l^H) + (1 - \pi)\phi^L(1 - l^L) - \frac{\mathrm{d}\tau}{\mathrm{d}\mathcal{B}}\left(\pi\phi^H + (1 - \pi)\phi^L\right)
\end{aligned}$$

Note

$$\begin{aligned}
\frac{\mathrm{d}\tau^{EUI}}{\mathrm{d}\mathcal{B}} &= \pi(1 - l^H) + (1 - \pi)(1 - l^L) \\
&\quad + \mathcal{B}\left(-\pi \frac{\mathrm{d}\Delta^H}{\mathrm{d}\mathcal{B}} \left[\frac{\partial l^H}{\partial \theta^H}\frac{\partial \theta^H}{\partial \Delta^H} + \frac{\partial l^H}{\partial \Delta^H}\right] - (1 - \pi)\frac{\mathrm{d}\Delta^L}{\mathrm{d}\mathcal{B}}\left[\frac{\partial l^L}{\partial \theta^L}\frac{\partial \theta^L}{\partial \Delta^L} + \frac{\partial l^L}{\partial \Delta^L}\right]\right)
\end{aligned}$$

It holds that

$$\frac{\partial l}{\partial \theta}\frac{\mathrm{d}\theta}{\mathrm{d}\Delta} + \frac{\partial l}{\partial \Delta} = \frac{1 - l}{\Delta}\epsilon^M$$

Hence

$$\frac{\mathrm{d}\tau^{EUI}}{\mathrm{d}\mathcal{B}} = \pi(1 - l^H) + (1 - \pi)(1 - l^L) - \mathcal{B}\left(\pi \frac{\mathrm{d}\Delta^H}{\mathrm{d}\mathcal{B}}\frac{1 - l^H}{\Delta^H}\epsilon^{HM} + (1 - \pi)\frac{\mathrm{d}\Delta^L}{\mathrm{d}\mathcal{B}}\frac{1 - l^L}{\Delta^L}\epsilon^{LM}\right)$$

So that the FOC is

$$\frac{\pi\phi^H(1-l^H)+(1-\pi)\phi^L(1-l^L)}{\phi^H+\phi^L} = \pi(1-l^H)+(1-\pi)(1-l^L) \\ - \mathcal{B}\left(\pi\frac{\mathrm{d}\Delta^H}{\mathrm{d}\mathcal{B}}\frac{1-l^H}{\Delta^H}\epsilon^{HM} + (1-\pi)\frac{\mathrm{d}\Delta^L}{\mathrm{d}\mathcal{B}}\frac{1-l^L}{\Delta^L}\epsilon^{LM}\right)$$

Solving for optimal generosity $\mathcal{B}$ delivers

$$\mathcal{B} = \pi(1-\pi)\left(l^H - l^L\right)\left(\frac{\phi^L-\phi^H}{\pi\phi^H+(1-\pi)\phi^L}\right)\left(-\pi\frac{\mathrm{d}\Delta^H}{\mathrm{d}\mathcal{B}}\frac{1-e^H}{\Delta^H}\epsilon^{HM} - (1-\pi)\frac{\mathrm{d}\Delta^L}{\mathrm{d}\mathcal{B}}\frac{1-e^L}{\Delta^L}\epsilon^{LM}\right)^{-1}$$

■