# Incentive-Compatible Unemployment Reinsurance for the Euro Area*

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**Abstract**

We model a reinsurance mechanism for the national unemployment insurance programs of euro area member states. The proposed risk-sharing scheme is designed to smooth country-level unemployment risk and expenditures around each country's median level, so that participation and contributions remain incentive-compatible at all times, and there is no permanent redistribution across countries. We show that, relative to the status quo, such a scheme could have provided nearly perfect insurance of the euro area states' unemployment expenditure risk in the aftermath of the 2009 sovereign debt crisis if allowed to borrow up to 2.5 percent of the euro area GDP. Limiting or not allowing borrowing by the scheme would have still provided significant smoothing of surpluses and deficits in the national unemployment insurance programs over the period 2000–2019.

**Keywords**: unemployment insurance, risk sharing, reinsurance, euro area, fiscal policy, mechanism design, limited commitment
**JEL codes**: E62, J65, F32

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# 1 Introduction

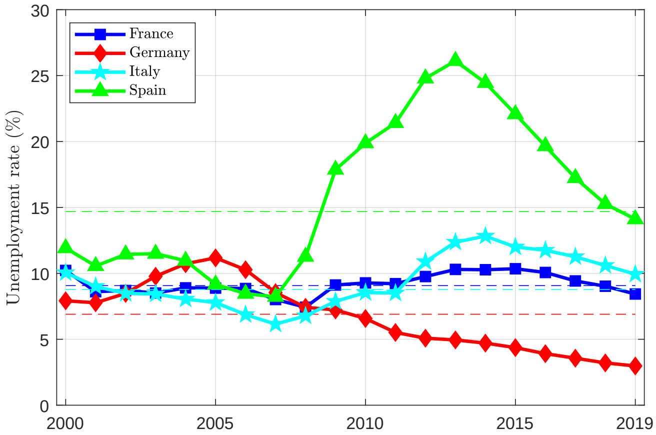
The 2009-2014 euro area sovereign debt crisis demonstrated that national economies can be subject to pro-cyclical financial constraints (Bénassy-Quéré et al. (2018)). Countries in the euro area periphery had to scale down their social safety nets and implement various austerity measures under pressure from creditors. These pro-cyclical fiscal rules could have been avoided if member states had not been subject to rising sovereign debt spreads.

There have been numerous proposals aiming to increase cross-country risk sharing in the euro area (EA) in the form of a common reinsurance mechanism for national unemployment insurance (UI) programs, see the reviews in Dolls (2024), Beblavy and Lenaerts (2017) and Section 2. Using historical data, several authors have shown that relatively small contributions to a reinsurance scheme could fund transfers to member countries subject to large adverse macroeconomic shocks. While these proposals contain extensive institutional detail, they often rely on statistically derived or ad hoc contribution and payout rules.

We complement and extend this literature by modeling a euro area unemployment reinsurance scheme (thereafter EA-URS) from mechanism-design first principles. Specifically, we conceptualize, solve, and simulate using historical data, a hypothetical common reinsurance platform in which EA countries participate. The EA-URS is designed so that member countries co-insure one another, both within and across time periods, in terms of their own *relative* variations in unemployment over time around an anchor rate (the country's median unemployment rate for the studied period). A country contributes (pays an insurance premium) into the common fund when its unemployment rate is low relative to the country's median unemployment rate and receives a payout (indemnity) from the fund when its unemployment rate is relatively high. The contribution and payout amounts are optimally determined from the solution of a dynamic mechanism design problem. Net redistributionary transfers or subsidies from countries with persistently low unemployment to countries with persistently high unemployment are ruled out by design. Each country's net expected contributions and payouts with respect to the scheme are nil over a long-time horizon by construction. This implies that the scheme is balanced over a sufficiently long period and does not require external financing to operate.

The EA-URS that we model is based on the presence of asymmetric idiosyncratic (cyclical or other) fluctuations in country-level unemployment, which we document in the data, and on the ability of euro area countries to borrow jointly through the reinsurance scheme at equal or better conditions compared to having to issue their own debt in downturns. Figure 1 plots the unemployment rates of the four largest euro area countries – France, Germany, Italy and Spain. The Figure shows that country-level unemployment fluctuations are significant in magnitude and, importantly, imperfectly correlated. For example, there is no year in which the unemployment rates in all four countries were simultaneously above or below their respective median rates.

Figure 1: Unemployment rates in the euro area 'big four'




Notes: the figure plots the unemployment rate (in percent) in the four largest euro area economies over 2000-2019. The horizontal dashed lines show each country's median unemployment rate over the period.

Our main contribution is the design of a reinsurance scheme that is incentive-compatible and robust to limited commitment. This means that the risk-sharing contributions and payouts are such that, given the countries' intertemporal smoothing preferences, no country has an incentive to leave the scheme at any time and in any unemployment state. To give a concrete example, even if a member country goes through several consecutive years of low unemployment, it would still prefer to continue to contribute to the reinsurance scheme because, in expectation, it would benefit from receiving payouts from the platform in future years when its unemployment rate would be high relative to its median value. Second, by appropriately normalizing the countries' unemployment rates and unemployment insurance revenues, we explicitly address and avoid concerns about possible persistent one-way redistributionary transfers, focusing instead on smoothing idiosyncratic fluctuations around each country's median economic conditions.

We simulate the model reinsurance scheme for 17 euro area countries, using data on their unemployment rates and unemployment insurance revenues from 2000 to 2019. We show that the countries' national unemployment insurance programs could have shared risk with each other nearly perfectly if the reinsurance scheme was able to borrow up to €320 billion (about 2.5 percent of the 2019 euro area GDP). Not allowing borrowing by the scheme still achieves significant unemployment risk smoothing in the periods 2000-2009 and 2017-2019, however, without ability to borrow the scheme's risk-sharing ability is diminished between 2010 and 2016 (the sovereign debt crisis), when most euro area countries experienced above-median unemployment rates at the same time.

We also use the calibrated structural model to evaluate the welfare gains from the proposed euro area risk-sharing scheme, versus the alternative of each country smoothing unemployment risk on its own via buffer stock savings. Within-sample, for the actually realized country unemployment shocks in the 2000-2019 data, we estimate the average consumption supplement measuring the gain from joining the risk-sharing scheme, to be equivalent to a 10 percent increase in saving-only consumption (ranging between 1.7% to 19.3% across the 17 countries). We also compute the *expected* welfare gain (i.e., not specific to the realized shocks) between the saving-only and the risk-sharing settings via a Monte-Carlo simulation based on 1,000 hypothetical unemployment shock paths and find it to be 5.5% of saving-only consumption.

The paper proceeds as follows. In Section 2 we review the policy and academic literature discussing a European Unemployment Benefits Scheme (EUBS), focusing on the main potential benefits and proposed design elements. Section 3 describes our theoretical model of cross-country risk-sharing with limited commitment and outside option the saving-only setting. Section 4 describes the data used, the mapping of the data to the model, and the model calibration and simulation approach. Section 5 contains the main results. Section 6 compares our EUBS scheme with a leading representative alternative from the literature. The final section concludes.

## 2 European Unemployment Benefits Scheme (EUBS)

The idea of establishing a common unemployment insurance scheme has featured prominently in the broader debate on fiscal stabilization instruments for the euro area. Many authors and policymakers have argued that the currency union remains institutionally incomplete and vulnerable to macroeconomic shocks; e.g., Bénassy-Quéré et al. (2018), Berger et al. (2019), Pasmeni (2015) and Allard et al., (2013). The 2007-08 financial crisis reinforced calls for expanded fiscal capacity to complete the Economic and Monetary Union (EMU) architecture (Burriel et al. (2020)). Key structural features of the euro area—low labor mobility, sticky prices and wages (Chortareas (2013)), and the limited integration of member states' financial markets—further support the case for fiscal centralization. At the same time, there is reluctance and caution against moving toward a full fiscal union if it would result in persistent one-way transfers across member states.

While the European Stability Mechanism (ESM) established in 2012 plays a significant role in providing loans to member states in financial distress, broader risk-sharing mechanisms operating through the financial markets or fiscal instruments remain limited. The policy discussion has focused on fiscal tools that can function as automatic stabilizers. For example, drawing on the concept of US state 'rainy day funds' (RDFs)[1], Lenarčič and Korhonen (2018) explore a euro area fiscal stabilization mechanism designed to limit

[1]Rainy day funds (RDFs) are state-level financial reserves that allow states to accumulate savings during periods of economic growth and provide a financial buffer in times of revenue shortfalls or unforeseen expenses. RDFs vary in their design and operation but share the common goal of enhancing fiscal resilience.

moral hazard and permanent transfers through upfront eligibility criteria and restricting payouts to instances of severe economic shocks.

The existing literature can be grouped in two broad strands: (i) assessing the potential benefits of an EUBS and (ii) describing the institutional design of an EUBS, including contribution and payout rules and financing. While having the advantage of including high level of institutional detail, most proposed designs are not explicitly grounded in economic theory with respect to incentive-compatibility of the countries' contributions and participation. In contrast, we explicitly endogenize and model countries' incentives and characterize the optimal payouts and contributions over time and across different economic states. Our model EUBS scheme also avoids permanent transfers by design, by only smoothing fluctuations around country-specific anchor levels of unemployment and expenditures.

## EUBS Benefits

Chortareas (2013) discusses the possible ways in which an EUBS can contribute to fiscal policy management and help stabilize business cycle fluctuations, especially in contexts where monetary policy alone cannot cope with shocks that affect member states asymmetrically, see Andor (2016). Claveres and Strasky (2018) argue that centralized fiscal capacity in the form of a European unemployment reinsurance scheme can result in potentially high stabilization effects and show that relatively small contributions from member states (around 0.2% of GDP) would go a long way toward effective risk sharing via transfers to national unemployment insurance funds when in deficit. The paper further shows that a common unemployment benefits scheme would have provided additional macroeconomic stabilization during the financial crisis of 2009-2013, both at the euro area and the member state level.

On the capacity of an EUBS to stabilize output over the business cycle, Gros (2016) argues that assessing the potential benefits is hard because of the many ways in which an EUBS could be implemented. Dolls (2024) finds that an unemployment reinsurance scheme would have cushioned on average 7% to 14% of employment income losses through inter-regional smoothing and 3% to 6% through intertemporal smoothing, consistent with the presence of large asymmetries in labor market shocks in the euro area.

There also exists related theoretical work exploring the benefits of an EUBS. For example, Abraham et al. (2023) study the welfare and incentive effects of unemployment insurance policies at the worker level using a multi-country dynamic general equilibrium model and find that a payroll tax funded common pool scheme designed to mitigate excessive unemployment benefits expenses in a severe economic crisis could yield sizable welfare gains. While we reach a similar overall conclusion, our approach differs by focusing on the country level and explicitly modeling the scheme members' incentives to contribute and participate.

In summary, while a broad agreement appears to exist about the potential benefits of an EUBS, a successful implementation would crucially depend on how such scheme is designed. Importantly, to ensure its viability, the consensus in the literature is that the scheme must be incentive-compatible and politically feasible. Specifically, member countries must have an incentive to maintain their required contributions and voluntary participation, and the scheme should not involve permanent one-way redistributionary transfers. These conditions are fully met in our proposed EUBS.

## EUBS Design

Related work explores the design and feasibility of an EUBS as a mechanism to mitigate the impact of country-level economic shocks. In 2015, at the request of the European Commission's Directorate-General for Employment, Social Affairs and Inclusion, a comprehensive feasibility study (Beblavy and Lenaerts (2017)) assessed alternative EUBS designs and key functions, their legal bases, and implementation options without treaty change.[2] Below we summarize the key EUBS features outlined in the report.

- *Trigger*: this feature refers to the exact conditions that cause a country to be asked to make a contribution (pay an insurance premium) or to receive a payout (insurance indemnity). Brandolini et al. (2016) consider different possible triggers: one in which the unemployment scheme is always active, one in which the EUBS is active only for countries experiencing a variation in the output gap exceeding a certain threshold,[3] and one in which it is only active for countries experiencing a decrease in employment above a threshold.[4] Alternatively, Dolls (2024) proposes a scheme triggered by an increase of 2% of the difference between the unemployment rate and the NAWRU (non-accelerating wage rate of unemployment). Both Claveres and Strasky (2018) and Arnold et al. (2018) propose an automatic trigger based on deviations of the unemployment rate from its average.

- *Pay-in*: this feature refers to how contributions to the common scheme insurance fund are defined. Most authors model contributions to the scheme as a percentage of the country's GDP, e.g., Beblavy and Maselli (2014) and Dolls (2024). Contributions can be fixed or variable, depending on the context. For instance, Beblavy and Lenaerts (2017) suggest a fixed contribution until the fund accumulates 0.5%

[2]The proposed 18 variants have different features (e.g., trigger, pay-in, caps, etc.), see Beblavy and Lenaerts (2017) for details.

[3]The proposed threshold is one half of the standard deviation of the output gap calculated across all considered countries.

[4]A fall in employment greater or equal to 20 percent of the standard deviation of the changes in employment levels calculated across all countries.

of the EU GDP, then contributions are stopped. If the fund's balance falls below the 0.5% threshold, contributions are restarted. Others have suggested taxes on employers and employees collected in a similar way to how national unemployment insurance funds operate, e.g., Dullien (2014).

- *Experience rating*: this feature aims to ensure that the reinsurance scheme does not lead to permanent transfers across countries and limits member state contributions based on a moving average of past contributions over several years. The experience rating acts as a slow-moving memory mechanism accounting for labor market trends. Most papers propose some variant of experience rating to limit net redistributive transfers across countries, e.g., see Claveres and Strasky (2018).

- *Cap*: this feature complements the experience rating by imposing an exogenous cap on yearly contributions usually defined as a percentage of GDP. Beblavy and Lenaerts (2017) propose different cap variants and range. Naturally, the higher is the cap the larger are the cross-country risk-sharing benefits, however, larger redistributive effects can arise. Many authors, including the present paper, apply a long-term cap of zero, meaning that over a sufficiently long time horizon each country needs to be in balance with the scheme. Beblavy and Lenaerts (2017) suggest that moral hazard can be addressed by the use of caps and experience rating.

The four EUBS design features discussed above determine the incentives of the member states to contribute and participate. The schemes discussed in the literature typically address incentives in the form of intuitive 'rules of thumb' to illustrate why countries would be willing to contribute given the potential benefit from being insured. The main idea is that, with sufficiently small contributions and sufficiently large payouts/indemnities when unemployment peaks, member states would be willing to participate, but the exact amounts or rates of contributions and payouts are exogenously fixed or statistically determined based on historical data.

In contrast, our main contribution is analyzing and quantitatively assessing a euro area reinsurance scheme in which the demand for insurance, the optimal contributions and payouts, and the incentive compatibility constraints are all derived from an explicit mechanism-design theoretic economic model. The notions corresponding to experience rating, triggers, pay-in rate, and caps are all endogenously determined by the model solution obtained from solving a dynamic optimization problem. Specifically, promised utility and its updating over time depending on the realized shocks serves the function of experience rating. The optimal state- and history-contingent risk-sharing transfers combine the functions of trigger, pay-in, and caps. Naturally, as in all theory-based work, these strengths of our approach should be evaluated keeping in mind the modeling assumptions and abstractions. We provide a detailed discussion in the conclusions section.

# 3 Model

We consider a multiperiod setting in which countries face economic shocks affecting their unemployment rates and unemployment insurance (UI) revenues and expenditures and which the countries would like to smooth out. We quantitatively evaluate and compare two settings: (i) each country smoothing out unemployment risk on its own using current UI revenues and savings, and (ii) a mutual reinsurance scheme in which the countries participate voluntarily.

In each period $t$, each country faces an economic shock process with a finite number of discrete states $s_i$, $i = 1...I$. To allow for persistence (serial correlation), we assume that the shock process is first-order Markov with transition probability matrix $P(s'|s)$, where $s$ (one of $\{s_i\}_{i=1}^I$) is the current state and $s'$ is the next period's state, also one of $\{s_i\}_{i=1}^I$. The state transition probability matrix $P$ is calibrated from the data (see Section 4.1) and is assumed to be stable, known, and common to all countries. When simulating the model, we feed the actual state realizations for each country. We handle heterogeneity in unemployment levels and in UI revenue levels across countries in the data by performing a double normalization (see Section 4.1 for details). First, the country's unemployment in state $s_i$, $n(s_i)$ is normalized relative to the country's median unemployment rate. Second, all model resource units (income, consumption, savings, etc.) are expressed in terms of (normalized by) each country's median UI revenues for the sample period taken from the data. We abstract from heterogeneity across the countries in preferences, the shock process, or debt access. This allows us to use a structural model of enhanced risk sharing subject to limited commitment and perform welfare comparisons.

We focus on the sub-problem of national governments of financing and smoothing UI expenditures given their actual UI revenues, as observed in the data,[5] and abstract from, or take as given, other government expenditures and the rest of the economy. The welfare criterion we use is smoothing normalized UI expenditure per normalized unemployed (see Section 4.1) over time and across states of the world, that is, smoothing *relative* fluctuations in the countries' UI revenues (and hence UI expenditures) that arise from economic shocks affecting unemployment relative to the countries' 'structural' (median) unemployment rate.[6]

[5]We calibrate UI revenues by calculating annual revenue flows from the data, given the countries' existing tax codes and UI programs, see Table B1. We acknowledge that in extraordinary times, e.g., the COVID pandemic, governments can re-purpose other revenues or use debt to address unemployment, but we do not model this in the current paper.

[6]Smoothing public finances is a political goal in the euro area, as demonstrated by existing and proposed stabilization tools such as the European Stability Mechanism, the NextGenerationEU recovery package launched in response to the COVID pandemic, or the proposed European Investment Stabilization Function.

## 3.1 Saving only

We first describe a 'saving only' setting in which each country manages unemployment insurance on its own. The country can save UI revenues in a risk-free asset at a gross interest rate $R$ but cannot borrow. The saving-only setting allows countries to self-insure by accumulating and running down a buffer stock of savings. This allows for more consumption smoothing than autarky (consumption equal to income each period) but less smoothing compared to if borrowing were also possible.

The country maximizes the present discounted value of a concave function, $U$ of normalized UI expenditure ('consumption') $c_i$, given its normalized UI revenues ('income') $q_i$ taken from the data. This maximization can be interpreted as smoothing UI expenditures over time and across unemployment states. All unemployed within a country are assumed to be identical. Heterogeneity across the countries in the level of UI revenues or unemployment is incorporated and handled through appropriate data normalizations; see Section 4.1. Denote by $d$ the current-period savings, normalized in the same way as revenue $q$. The country's optimization problem can be written as a recursive dynamic program with state variables current savings, $d$ and the current unemployment state, $s$ and choice variables normalized consumption $c_i$ and next-period savings $d'_i$ for each next-period state $s' = s_i$:

$$V(d, s) = \max_{\{d'_i, c_i\}} \sum_i P(s_i|s) \left(U(c_i) + \beta V(d'_i, s_i)\right) \tag{1}$$

$$s.t. \quad c_i + d'_i = Rd + q_i \quad \forall i = 1 \dots I \tag{2}$$

In our baseline results we restrict $d$ and $d'_i$ to be non-negative in all states $s_i$, ruling out borrowing. Alternatively, a borrowing limit $\bar{d} < 0$ can be imposed and we also compute a version of the model in which countries could both save and borrow up to a limit, see Section 5.2 and Figure A4. Initial UI program assets, $d_0$, are set to zero in the simulation.[7]

## 3.2 Risk-sharing reinsurance scheme

Next, we consider a common risk-sharing scheme with voluntary participation for unemployment reinsurance across the countries. Specifically, we use a dynamic mechanism-design model of *limited commitment*, e.g., Thomas and Worrall (1988) or Karaivanov and Townsend (2014). In each period, each participating country must have an incentive to remain in the scheme and not renege on any due contributions.

We model the reinsurance scheme as the solution to a multi-period mechanism design problem in which a risk-neutral insurance scheme can transfer funds across the participat-

[7] We make this assumption for data availability reasons, as in the model the state variable $d$ corresponds to the national UI programs' assets (normalized) on which we have no data.

ing countries' national UI programs and can save and borrow funds at a gross interest rate $R$, subject to participation and commitment constraints for the countries. The scheme does not control each country's UI revenues, but the latter are observable and taken into account when computing each country's optimal payout or contribution. This can be written as the following dynamic program:

$$\Pi(w,s) = \max_{\{w',c_i,\tau_i\}} \sum_i P(s_i|s)\left(-\tau_i + R^{-1}\Pi(w'_i,s_i)\right) \tag{3}$$

$$s.t. \quad c_i = q_i + \tau_i \quad \forall i = 1...I \tag{4}$$

$$U(c_i) + \beta w'_i \geq U(q_i) + \beta V^o(s_i) \quad \forall i = 1...I \tag{LC}$$

$$\sum_i P(s_i|s)\left(U(c_i) + \beta w'_i\right) = w \tag{5}$$

where $s$ is the current unemployment state, $s_i$ is the next-period's state, and $V^o(s_i)$ is the country's outside option at state $s_i$. The gains from risk sharing depend on the outside option. In our baseline simulation we assume that the outside option equals the saving-only present value $V(0, s_i)$ from equation (1), that is, if a country considers reneging it would leave the scheme with zero savings.[8]

The promised utility state variable $w$ reflects the present-value utility of future transfers, given the history of unemployment shocks experienced by the country. It can be interpreted as an 'experience score', assigned and updated given the experienced sequence of shocks. Such history-dependence is optimal when full insurance is infeasible because of the limited commitment friction. The risk-sharing platform uses cross-country transfers, $\tau_i$ to smooth expenditure per unemployed (consumption), $c_i = q_i + \tau_i$. The function $\Pi(w, s)$ captures the present-value deficit (if negative) or surplus (if positive) of the scheme with a country in state $(w, s)$.

Constraint (LC) is the limited commitment constraint, which ensures that the country has no incentive to renege on the risk-sharing arrangement and switch to saving only.[9] Constraint (5) is the promise keeping constraint, reflecting the reinsurance platform's commitment to deliver present discounted value $w$ to the country via future transfers.

The model solution corresponds to the constrained-efficient (subject to the commitment problem) risk sharing contract between a risk-averse agent (the country) and a risk-neutral principal (the scheme), see Thomas and Worrall (1988) and Ljungkvist and Sargent (2000). The optimal consumption level and insurance transfers depend on the

[8]We also ran a version allowing both borrowing and saving as the outside option, see Section 5.2.

[9]In our baseline simulation the outside option does not allow borrowing. Note, however, that in the limited commitment model a country would optimally consider reneging (not making a due contribution) when revenue $q$ is high, not when it is low and the country would like to borrow. In addition, if a country would have incurred "debt" with the scheme (i.e., received more payouts than contributions made) and can be obligated to pay that upon leaving, this would make staying in the scheme more attractive.

current income realization and the history of previous realizations.

# 4 Data and simulations

We use unemployment rate data sourced from the IMF International Financial Statistics database for 17 euro area countries in the period 2000 to 2019 (see Table A1). We construct UI revenue series for each country as the product of the percentage of gross salary income withheld by the government for unemployment insurance (source: OECD), the average gross wage income (source: OECD), and the total number of employed persons (source: IMF International Financial Statistics). All data sources and definitions are listed in Table B1.

## 4.1 Data normalization and model calibration

For each country we normalize (standardize) the observed unemployment rates over the period of analysis, 2000-2019, by dividing each observation by the country's median unemployment rate for the period.[10] The rationale for this normalization is that we want to abstract from structural differences in unemployment across the euro area countries and focus on smoothing deviations around a country-specific 'anchor' unemployment rate (the median rate for the period), thus avoiding permanent redistributionary transfers.[11] We also normalize the UI revenue data for each country by dividing each observation by the country's median UI revenue over the period of analysis. This addresses the large differences in country size or GDP per capita in the data. The resulting double normalization of the unemployment and revenue data, explained in detail below, homogenizes the countries and allows us to treat them as ex-ante identical agents facing a common standardized income process with known distribution, as assumed in the theoretical model. This allows us to use the Karaivanov and Townsend (2014) approach to solve for the optimal consumption and insurance transfers (contributions/premia or payouts/indemnities) and to quantify the gains from improved risk sharing.

Specifically, we first use the observed unemployment rates for each country $j$ and year $t$ from the data and normalize each observation by the country's median unemployment rate over the period 2000 to 2019. We define the *normalized unemployment rate* $\bar{u}_{jt}$ for

[10]This normalization implicitly assumes that the data generating process is invariant and well represented by the sample period. An implementation of the scheme could require periodic re-assessment unemployment state process calibration, e.g., due to demographic, social and technological changes or structural reforms. For instance, many euro area countries have had a lower unemployment rate since the COVID pandemic compared to the previous two decades.

[11]In our simulations we chose each country's median unemployment rate for the period 2000–2019 as the anchor rate because of its robustness to outliers and extreme values, but other anchor rates can be easily used. A simulation using the mean rate as the anchor produced very similar results.

country $j$ in year $t$ as

$$\bar{u}_{jt} = \frac{u_{jt}}{u_j^{median}} \tag{6}$$

where $u_{jt}$ is the actual unemployment rate for country $j$ and year $t$ in the data and $u_j^{median}$ is the median unemployment rate in country $j$ for the sample period 2000–2019.

We discretize the distribution of the normalized unemployment rates $\{\bar{u}_{jt}\}$ on the 9-point grid $\{n(s_i)\}$, $i = 1...9$, where the grid points $n(s_i)$ are set equal to the first to ninth deciles of the $\{\bar{u}_{jt}\}$ data, pooled over all countries $j$ and years $t$ in our sample.[12] By construction, state $s_5$ corresponds to the median unemployment rate in each country during the 2000–2019 period (e.g., 5.2% for Austria; 9.1% for France, etc.) and $n(s_5) = 1$. State $s_1$ corresponds to the lowest normalized unemployment level in the model, $n(s_1)$, while state $s_9$ corresponds to the highest unemployment level in the model, $n(s_9)$, each defined relative to the country's median unemployment rate. See Table A1 for the correspondence between the $\{n(s_i)\}$ grid in the model (normalized unemployment rate deciles) and the actual unemployment rates in the data for each country.

For each country-year pair $(j, t)$, the discretized unemployment state distribution $\{n(s_i)\}$ maps the (normalized) data values $\bar{u}_{jt}$ to the nearest grid point $n(s_i)$. We use this mapping to define

$$\Gamma(j, t) = s_i \tag{7}$$

as the unemployment state $s_i$, $i \in \{1, .., 9\}$ in which country $j$ is in year $t$. We then calibrate the implied discrete Markov state transition probability matrix $P(s'|s)$, with elements $\{s' = s_k, s = s_l\}$ for all possible $k, l = 1...I$, using the observed fraction (frequency) of all country-year observations for which $\Gamma(j, t) = s_l$ and $\Gamma(j, t + 1) = s_k$, for each possible $k, l = 1...I$. The feasible grid dimensionality ($I = 9$ grid points) in the model simulation is determined by the number of data points we have (17 countries times 20 years), since this number affects how precisely we can calibrate the distribution and state transition matrix of the unemployment shocks.[13]

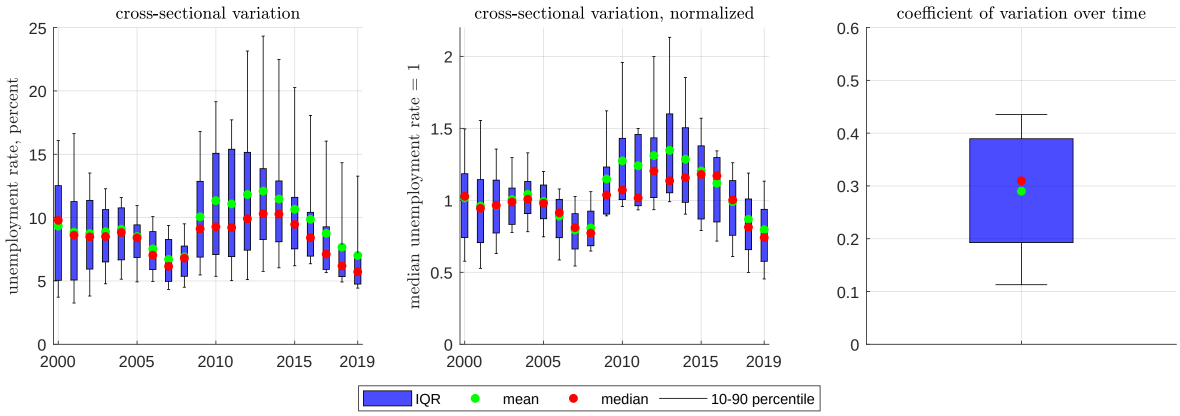
The unemployment rate normalization allows the countries to have different structural unemployment levels and ensures that the reinsurance scheme does not make redistributionary transfers based on structural differences. Instead, the optimal insurance transfers (contributions or payouts) are only based on the country's *relative*, e.g., business-cycle state of unemployment, that is, on how large the country's current unemployment rate is relative to the country's median unemployment rate. In the simulations in the next

[12] We use a histogram function to map each normalized unemployment rate $\bar{u}_{jt}, \forall j, t$ in the data (see equation (6)) to the nearest grid point $n(s_i)$ for some $i = 1, ..., 9$. This procedure yields the normalized unemployment grid $\{n(s_i)\}_{i=1}^{9} = \{0.67, 0.77, 0.88, 0.96, 1, 1.06, 1.14, 1.28, 1.50\}$

[13] A simulation using 5 states for $s_t$ produced very similar results.

section, we assume that all countries face the same underlying stochastic process for the normalized unemployment rate, that is, the unemployment levels $n(s_i)$ defined relative to the country median rate and the transition probabilities $P(s'|s)$. The countries and the reinsurance scheme know and use this common stochastic unemployment process (derived from the data, as described) to solve the dynamic optimization problems in Section 3.

Figure 2: Unemployment rates variation



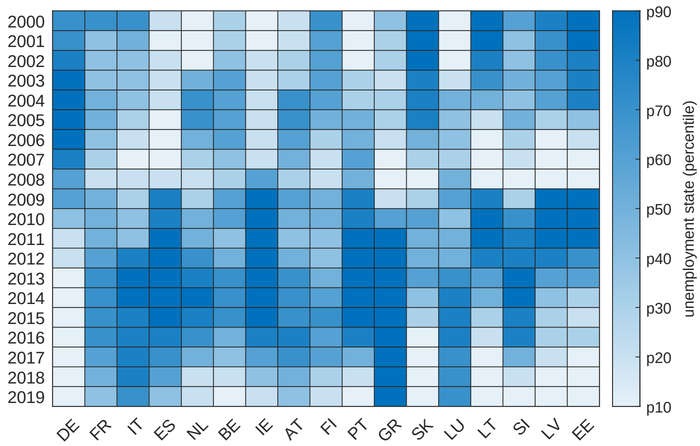

Notes: the left-hand panel plots the cross-sectional distribution (inter-quartile range IQR, mean, median, 10th and 90th percentile) of the unemployment rates in the 17 euro area countries in our data. The centre panel plots the cross-sectional distribution of normalized unemployment rates, defined as the actual rate divided by the country's median unemployment rate for the period 2000–2019. The right-hand panel plots the distribution of the countries' coefficients of variation of unemployment over time (2000–2019).

Figure 2 plots the cross-sectional variation (left and centre panel) and the time variation (right panel) in the unemployment rates of the 17 euro area countries in our data. We see that there exists a large variation across the countries' unemployment rates in each year, ranging from one half to twice the median rate over the period 2000–2019 (the median rate is normalized to 1 in the centre panel). While there is partial co-movement (e.g., an overall increase in unemployment in the period 2008 to 2012 followed by a decrease), the correlation between the different countries' relative unemployment states is imperfect, as shown in Figure 3, which leaves scope for potentially large gains from sharing unemployment risk and smoothing UI expenditures across countries and over time, as we quantify and illustrate below.[14] Figure 3 also shows instances where an implementation of the scheme may face political economy challenges. For instance, at the beginning of the sample period, Spain contributes while Germany receives a payout even though the unemployment rate in Spain was higher than that in Germany, see Figure 1. We address this issue in the conclusions.

To account for differences in country size or economic development in the data, we construct *normalized UI revenue*, $\overline{r}_{jt}$ for country $j$ and year $t$, defined as the actual UI revenue $r_{jt}$ in bln euros in the data divided by the median revenue, $r_j^{median}$ for country $j$

[14] A perfectly positive correlation between the countries' unemployment states would result in all cells in each row of Figure 3 to have the same color.

Figure 3: Unemployment relative to the country median




Notes: the figure displays the normalized unemployment state $s_i$, defined in equation (7), for each country (in the columns) and each year (in the rows). The median unemployment level for each country is denoted by p50 and corresponds to state $s_5$. Darker colors mean higher unemployment relative to the country median. See Table A1 for the mapping between unemployment states and unemployment rates for each country.

computed over the years 2000 to 2019,

$$\bar{r}_{jt} = \frac{r_{jt}}{r_j^{median}} \tag{8}$$

The UI revenue for each country $j$ and year $t$ in the model is thus expressed in common normalized units, as a fraction or multiple of the country's median UI revenue.

Using the unemployment and revenue normalizations described above, we define the 'income' grid values, $q_i$ in the model (common for all countries) corresponding to the normalized UI revenue per normalized unemployed in each state $s_i$ as

$$q_i = \frac{\kappa(s_i) median\{\bar{r}_{jt}\}}{n(s_i)} \text{ for all } i \tag{9}$$

where $median\{\bar{r}_{jt}\}$ is the median of normalized UI revenues computed over all country-time observations $jt$ and equals 1 using equation (8). Higher unemployment, $n(s_i)$ implies lower UI revenue per unemployed $q_i$, that is, less resources to finance UI expenditure.[15] The coefficients $\kappa(s_i)$ allow for normalized total UI revenue, $n(s_i)q_i$ in the model to vary with the unemployment state $s_i$, relative to its median value of 1. For example, when there is high unemployment, total UI tax revenue can be lower.[16] That is, we do not assume constant national UI revenue across economic states.

[15] For our data we obtain: $\{q_i(s_i)\}_{i=1}^9 = \{1.65, 1.31, 1.15, 1.04, 1, 0.95, 0.89, 0.78, 0.63\}$.

[16] We construct $\kappa(s_i)$ using the median of the countries' normalized UI revenues expressed in constant CPI-adjusted units for each state $s_i$; for our data we obtain $\{\kappa(s_i)\}_{i=1}^9 = \{1.10, 1.02, 1.01, 0.99, 1, 1.00, 1.02, 1.00, 0.94\}$.

The unemployment and UI revenue normalizations allow us to convert model units (consumption, transfers, savings) into euros by multiplying the model quantities (measured in normalized resources per normalized unemployed) by the normalized unemployment level $n(s_i)$ in the respective state $s_i$, and by the median UI revenue (in euros) for each respective country. For example, suppose that in the risk-sharing scheme the optimal transfer per normalized unemployed in state $s_i$ is $\tau_i = 0.05$ (that is, since $\tau_i > 0$, a payout is due from the reinsurance scheme to the country) and suppose that normalized unemployment in that state is $n(s_i) = 1.14$ (the 70th percentile, see Table A1). Then, the total payout which the country would receive from the platform equals $n(s_i) \times \tau_i = 0.057$ model units, which in turn converts to $n(s_i) \times \tau_i \times r_j^{median}$ bln euros. To pick a specific country, for Austria $r_j^{median} = 8.68$ bln and hence the payout in this example would be $0.057 \times 8.68 = 0.49$ bln, to be distributed among the 5.9% unemployed from the country population.[17]

## 4.2 Model simulation

We assume strictly concave utility of the CRRA form, $U(c) = \frac{c^{1-\sigma}}{1-\sigma}$, with the baseline simulations performed using log utility ($\sigma \to 1$). We calibrate the gross interest rate $R$ used to compute the models to $R = 1.0156$, which equals 1 plus the average interest rate in the data for the period, 1.56%.[18] We set the discount factor to $\beta = 1/R$. The discrete distribution (grid) for normalized unemployment with values $n(s_i)$ and the transition probabilities $P(s'|s)$ are constructed from the countries' unemployment rates data, as explained in Section 4.1. The normalized UI revenues $q_i$ ('income' in the model) for each country are also constructed from the data, see Section 4.1.

The initial state $s_0$ used to initialize the Markov process for each country is constructed from 1999 unemployment rate data, mapped to the grid $n(s)$ as described in Section 4.1. We set initial savings, $d_0$ to zero in the saving only model. In the risk-sharing (limited commitment) model we set the initial state $w_0$ to yield zero ex-ante expected present-value profits for the reinsurance platform, i.e., such that $\Pi(w_0, s_0) = 0$. For any time period, the value $n(s_i)\Pi(w)$ is the current balance of the reinsurance scheme with a country with history of unemployment summarized by $w$. This balance may be a surplus or a deficit, however, the chosen initialization ensures that on average, over the long run, the scheme breaks even with respect to each country and therefore with respect to all member countries overall.

To simulate the saving-only model in equations (1)–(2), we also need to track the evolution of total UI savings for the country over time, since all model variables ($q_i$, $c_i$,

[17]See Table A1 for the mapping between normalized (used in the model) and actual unemployment rates and Table A2 for the median UI revenue in bln euros for each country.

[18]We calculated this average using data on the euro short-term repo interest rate from 2000 to 2019 sourced from the European Central Bank.

$d$, $d'_i$) and the budget constraint are defined per current normalized unemployed, the magnitude of which, $n(s_i)$, varies over time. Specifically, if current total savings for the country are $D$ model units and current normalized unemployment is $n(si)$, we set the value of the state variable $d$ in the saving-only model to $d = \frac{D}{n(s_i)}$. Given $d$ and unemployment state realization $s_i$, the model solution determines the next-period savings per normalized unemployed, $d'_i$. We then compute the total savings $D'$ for the country's UI program carried into the next period as $D' = n(s_i)d'_i$, and use the value $D'$ and next-period's normalized unemployment state to determine the new UI savings-per-unemployed state, and so on.

We solve each of the two models numerically, feeding the actual unemployment and revenue series from the data (normalized as explained above) for each country. The respective model solutions determine the optimal path for savings and consumption expenditure in the saving-only model and the optimal insurance transfers (positive or negative), consumption, and promised utility in the risk-sharing model, for each year 2000 to 2019. We then convert back the model units into euros (see Tables A1 and A2 in Appendix A) and add up the resulting monetary values to compute the yearly total insurance payment flows (contributions or payouts) and the cumulative balance (surplus or deficit) for the risk-sharing platform in any year (see the next section for details). The simulation results allow us to quantify how much consumption smoothing results from having access to the risk-sharing scheme compared to the saving-only baseline where each country self-insures on its own.

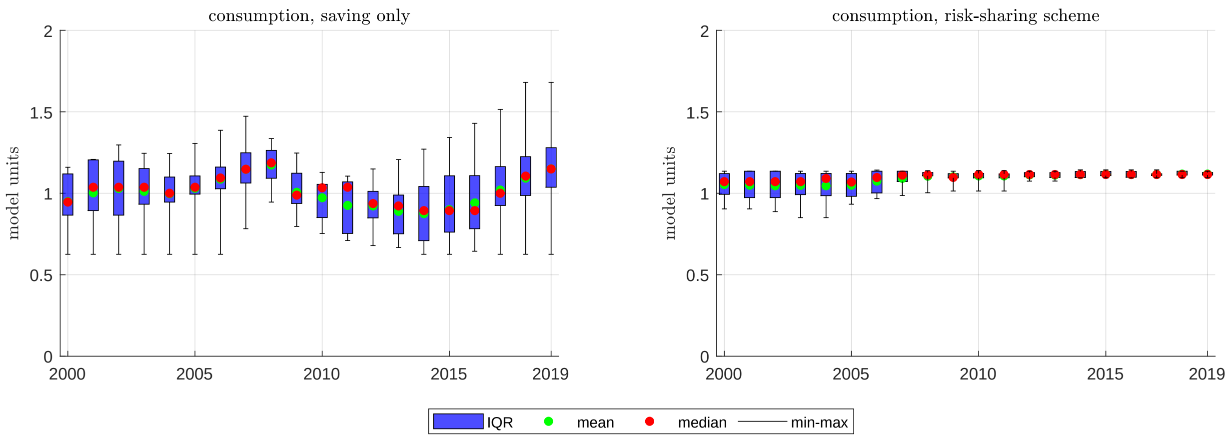
# 5 Results

## 5.1 Main results

We use the computed model solutions, together with the countries' (normalized) unemployment and UI revenue data for the period 2000 to 2019, to quantify the gains from insuring unemployment-related risk across the euro area countries. Specifically, we compare the consumption (UI expenditure) smoothing in each country in the saving-only setting, in which each country can only smooth expenditures by accumulating or running down savings on its own, versus in the risk-sharing setting, in which all countries pool the risk and co-insure each other by contributing (paying an insurance premium) into a common fund when their unemployment is low relative to their median unemployment rate, or receiving a payout (indemnity) from the fund when their unemployment is high relative to the median.

In Figure 4 we plot the simulated consumption (UI expenditure per unemployed) in model units for the saving only setting (the left panel) and for the risk-sharing scheme with limited commitment and voluntary participation (the right panel). The Figure

Figure 4: Gains from risk-sharing – consumption smoothing




Notes: the figure plots the cross-sectional distribution of consumption (UI expenditure per unemployed) in model units. Model units are measured in normalized resources per normalized unemployed (see Section 4.1). The left-hand panel plots the inter-quartile range (IQR), the mean, the median, and the minimum and maximum normalized consumption in the saving-only setting. The right-hand panel plots the consumption cross-sectional distribution for the risk-sharing scheme.

demonstrates that the insurance scheme achieves a very high level of consumption (UI expenditure per unemployed) smoothing. In contrast, for the same model parameters, in the saving only setting there remains sizable unsmoothed variation in consumption, both across the countries and over time.

In Table 1 we quantify the degree of consumption smoothing achieved in the risk-sharing scheme vs. in the saving only alternative for each country. Column (1) displays the coefficient of variation of model income (normalized UI revenue), which is the exogenous variation being smoothed in the model. Columns (2) and (3) display the coefficient of variation in consumption (normalized UI expenditure), respectively in the saving-only and risk-sharing settings. We use the coefficient of variation (CoV) as a standardized measure of variability allowing comparisons across countries and across the two model settings. In column (4) of Table 1 we also compute the percentage consumption-equivalent supplement quantifying the welfare gains for each country from joining the risk-sharing scheme relative to staying in the saving only setting. These gains are computed for the actually realized unemployment state history over the sample period 2000-2019. For each country $j$ the percentage supplement is defined as the value $\xi^j$ by which consumption in the saving only (S) setting must be raised to match the level of welfare (present-value discounted utility) in the risk-sharing scheme, that is, $\xi^j$ solves:

$$\sum_{t=2000}^{2019} \beta^{t-2000} u((1+\xi^j)c^S(s_t^j)) = \sum_{t=2000}^{2019} \beta^{t-2000} u(c^{RS}(s_t^j)) \tag{10}$$

where $c^S$ and $c^{RS}$ denote simulated consumption in the saving-only and risk-sharing models, respectively, and $\{s_t^j\}$ is the observed history of unemployment states in the data for country $j$ and years $t = 2000$ to 2019.

Table 1: Consumption smoothing

| Country | CoV income (1) | CoV consumption* <br> **reduction from CoV income in brackets* <br> saving only, S (2) | risk sharing, RS (3) | consumption supplement RS vs. S, $\xi^j$ (4) |
|---|---|---|---|---|
| Austria, AT | 0.140 | 0.092 (−34%) | 0.004 (−97%) | 12.7% |
| Belgium, BE | 0.170 | 0.079 (−54%) | 0.009 (−95%) | 9.5% |
| Estonia, EE | 0.375 | 0.235 (−37%) | 0.100 (−73%) | 9.0% |
| Finland, FI | 0.131 | 0.077 (−41%) | 0.063 (−52%) | 1.7% |
| France, FR | 0.099 | 0.070 (−29%) | 0.049 (−51%) | 4.9% |
| Germany, DE | 0.368 | 0.326 (−11%) | 0.057 (−85%) | 5.3% |
| Greece, GR | 0.371 | 0.258 (−30%) | 0.008 (−98%) | 19.3% |
| Ireland, IE | 0.355 | 0.237 (−33%) | 0.005 (−99%) | 15.2% |
| Italy, IT | 0.255 | 0.167 (−35%) | 0.053 (−79%) | 10.4% |
| Latvia, LV | 0.335 | 0.172 (−49%) | 0.062 (−81%) | 6.5% |
| Lithuania, LT | 0.366 | 0.220 (−40%) | 0.050 (−86%) | 9.1% |
| Luxembourg, LU | 0.261 | 0.132 (−49%) | 0.004 (−98%) | 7.9% |
| Netherlands, NL | 0.272 | 0.134 (−51%) | 0.002 (−99%) | 8.0% |
| Portugal, PT | 0.362 | 0.227 (−37%) | 0.002 (−99%) | 18.4% |
| Slovenia, SI | 0.278 | 0.160 (−42%) | 0.015 (−95%) | 12.6% |
| Slovakia, SK | 0.337 | 0.230 (−32%) | 0.053 (−84%) | 10.1% |
| Spain, ES | 0.364 | 0.234 (−36%) | 0.008 (−98%) | 10.0% |
| sample average | 0.285 | 0.179 (−38%) | 0.032 (−86%) | 10.0% |
| *MC simulated* | *0.236* | *0.163 (−31%)* | *0.017 (−93%)* | *5.5%* |

Notes: Column (1) displays the coefficient of variation (CoV) of income, $q$ (normalized UI revenue) in the model. Columns (2) and (3) display the coefficient of variation (CoV) of consumption, $c$ (normalized UI expenditure), respectively in the saving-only and risk-sharing scheme settings. The numbers in brackets correspond to the percentage reduction relative to the CoV of income, see footnote 19. Column (4) reports the consumption-equivalent supplement which would make a country indifferent between the saving only and risk-sharing settings, given the realized unemployment state history for each respective country. The last row ("MC simulated") displays averages from a Monte Carlo simulation of 1,000 hypothetical generated paths for the unemployment state drawn from the calibrated transition matrix $P$.

Table 1 quantifies the income risk/variability (column 1) and its mitigated pass-through to consumption variability in the saving-only setting (column 2) and in the risk-sharing scheme (column 3). The simulation results imply that if the countries were only able to smooth UI revenue variability by saving on their own, they would have had, on average, 38 percent reduction (ranging from 11% to 54%) in the coefficient of variation (CoV) of consumption (normalized UI expenditure), $c$ compared to the CoV of income (normalized UI revenue), $q$.[19] Alternatively, if the countries participated in the common

[19] We compute the CoV reductions in columns (2) and (3) as $100 \times (\frac{\text{CoV consumption}}{\text{Cov income}} - 1)$ for each country and report the average reduction in the "sample average" row.

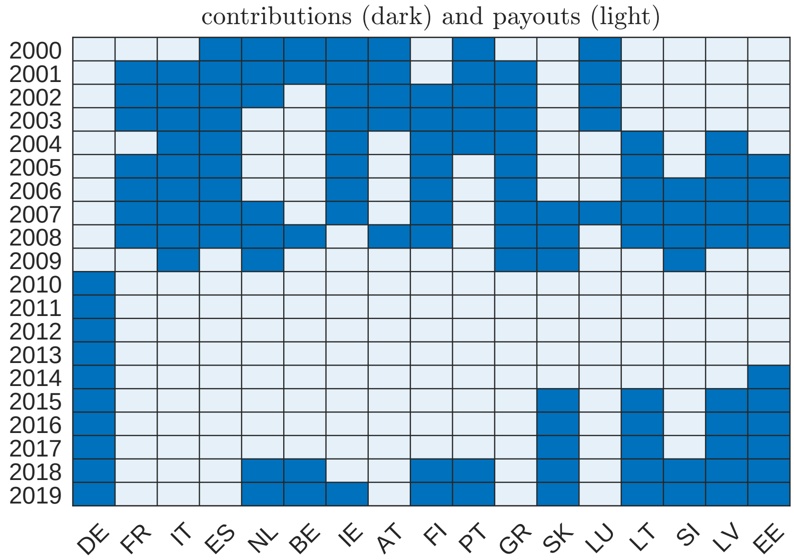
risk-sharing scheme, their consumption CoV (see column 3) would have been on average 86 percent lower than the CoV of underlying income in column (1), with a nearly 100% reduction (nearly perfect risk smoothing) for several countries, given their realized unemployment histories. Comparing head-to-head the coefficients of variation of consumption in columns (2) and (3), the average reduction in consumption variability moving from the saving-only setting to the risk-sharing scheme is 79 percent.

Column (4) of Table 1 quantifies the consumption smoothing gains for the assumed level of risk aversion (log utility). We compute welfare gains in two ways: within-sample and ex-ante. First, we compute the consumption supplement, $\xi^j$ that country $j$ in the saving-only setting would require to be indifferent to being in the risk-sharing scheme, see equation (10), given that country's realized (within-sample) unemployment state history from 1999 (initial condition) to 2019. The average consumption supplement (Table 1, the "sample average" row) is equivalent to a 10 percent increase in the saving-only consumption. Note that these within-sample consumption supplement magnitudes include the optimal borrowing by the scheme in the sample period (total payouts exceeding total contributions during and after the 2009-14 euro area crisis, see Figure 7), and thus represent a mix of risk sharing across states and smoothing over time. The estimated supplements range from 1.7% for Finland, around 5% for France and Germany, to 18.4% for Portugal and 19.3% for Greece, the two countries that would have benefited the most from having access to such risk sharing in the period 2000-2019.

Second, in the last row of Table 1 we compute the ex-ante expected welfare gain between the saving-only and the risk-sharing settings, using a Monte Carlo (MC) simulation of 1,000 randomly generated hypothetical paths for the unemployment state $s_t$ drawn from the calibrated state transition matrix $P$. In the MC simulation, by the Law of Large Numbers, the risk-sharing scheme is on average in balance in terms of inflows and outflows (no deficit/debt), i.e., the estimated gains correspond to the expected improvement in consumption smoothing between the saving-only and the risk-sharing model, which we find to be 5.5% of saving-only consumption in our calibration.

In Figure 5 we illustrate how consumption smoothing is achieved in the reinsurance scheme, by displaying when each country is asked to contribute (pay an insurance premium) or receives a payout (indemnity), as implied by the model solution. The Figure shows that before 2008 and after 2017 there is an approximate balance in the number of countries with positive (low unemployment) and negative (high unemployment) states. However, in the period 2009-2017 the majority of countries, with the notable exception of Germany, optimally draw from the scheme, as they simultaneously experience high unemployment relative to their anchor level. The main takeaway is that in most years, except around the sovereign debt crisis, the unemployment shocks are sufficiently uncorrelated across the euro area countries which, together with the risk-sharing scheme's ability to save and borrow on aggregate, enables the large gains from sharing the risk and

Figure 5: Risk-sharing contributions and payouts




Notes: each column corresponds to a country, each row corresponds to a year. Dark color means that the country is a net contributor to the risk-sharing scheme (pays an insurance premium) in a given year. Light color means that the country is a net recipient (receives an insurance payout/indemnity).

smoothing consumption displayed in Figure 4 and Table 1.

In Figure 6 we quantify the magnitude of the optimal risk-sharing transfers (contributions or payouts) by converting model units into monetary units (bln euro) and displaying the implied flows to or from the platform for each country as a percentage of its GDP. For most countries and years (Spain, Portugal, and Greece being the main exceptions), the transfers implied by the model solution (payouts in green and contributions in red) are within 1% of GDP.

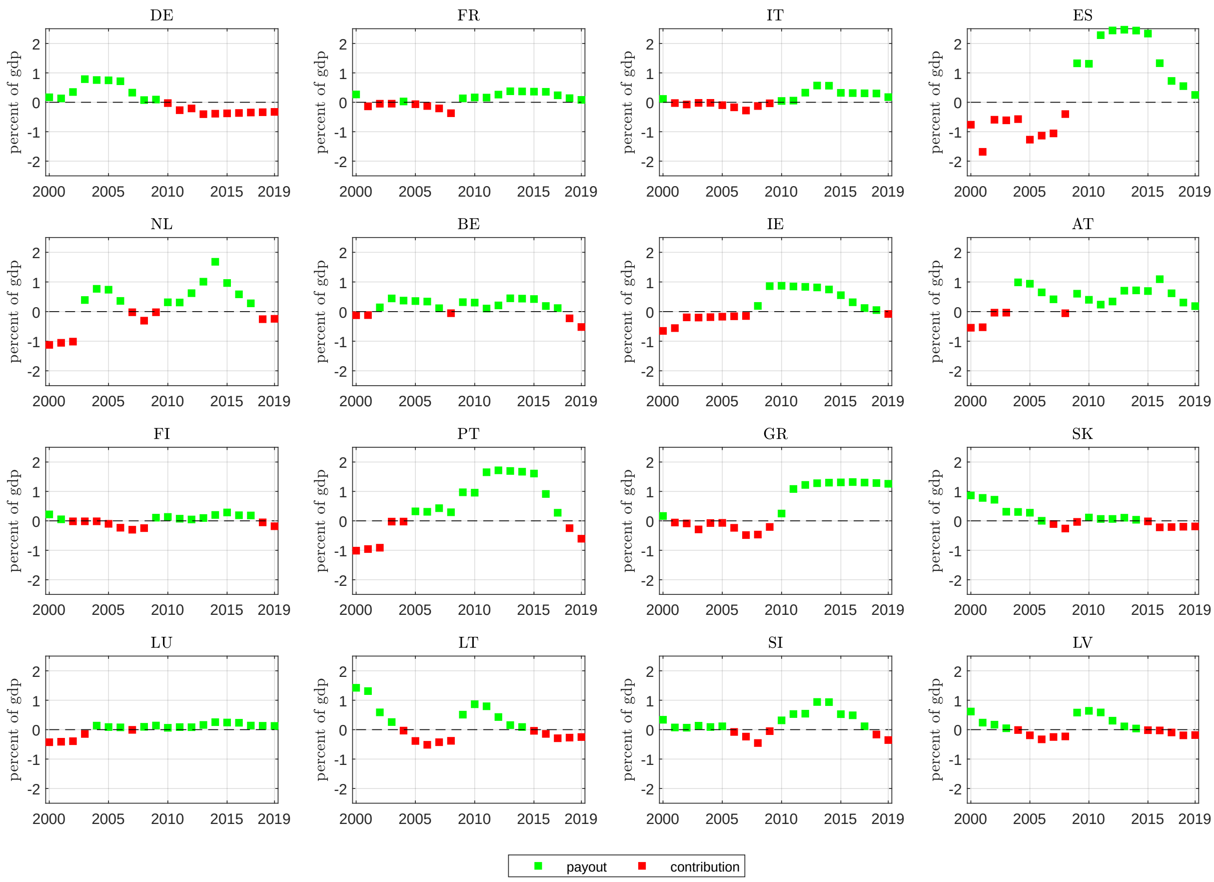
In Figure 7 we assess how the optimal risk-sharing transfers in the reinsurance scheme add up across all countries in terms of the total payouts received, total contributions made and the resulting net fund balance, for each year from 2000 to 2019. We compute the cumulative balance $B_t$ in the right-side panel using the ECB euro short-term interest rates $r_t$ for 2000–2019, see Table B1, as follows:

$$B_t = (1 + r_{t-1})B_{t-1} + F_t \tag{11}$$

where $F_t$ denotes total net flows (contributions minus payouts) in year $t$ and $B_0 = F_0$.

The left-side panel of Figure 7 plots the total contributions, total payouts, and the difference between the two ("net position"), for each year. The inflows and outflows are approximately balanced or in net surplus in 2000 to 2002, 2006 to 2008, and 2018 to 2019. In contrast, yearly net deficits are incurred in the periods 2003 to 2005 and 2009 to 2017, with maximum deficit of €54 bln in 2014. The reason for the deficits is that in those years more countries, or larger countries, receive payouts compared to

Figure 6: Risk-sharing transfers as share of GDP

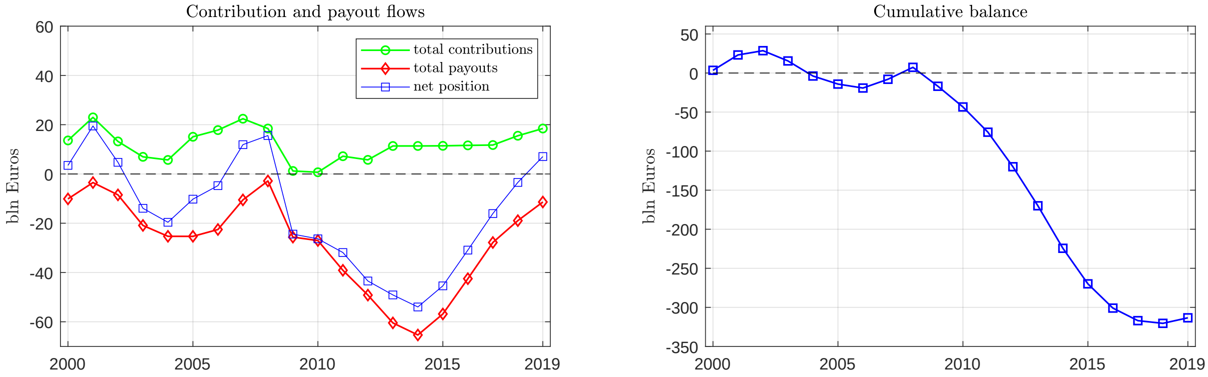



Note: each panel displays the optimal country contribution (in red) or payout (in green) as share of GDP in the risk-sharing scheme over the period 2000–2019.

those making contributions (see Figure 5). The platform's net cashflow position steadily improves after 2014 and reaches a surplus of 7 bln euro in 2019, the last year in our data. Cumulatively, see the right-side panel of Figure 7, the yearly net flows imply that the reinsurance fund is balanced or in surplus from 2000 to 2009, however, because of the common unemployment shocks affecting most euro area countries starting in 2009, the scheme's cumulative balance goes into deficit, reaching a maximum of €320 bln in 2018 before starting to be gradually reduced.

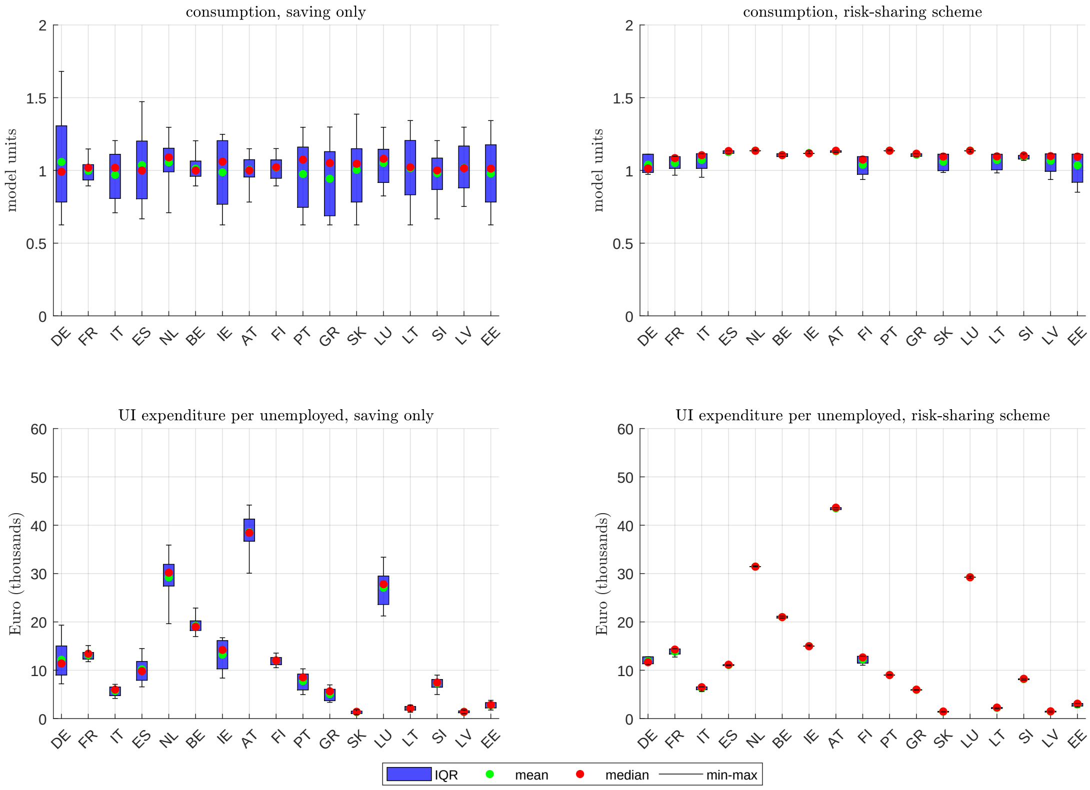
Finally, in Figure 8 we plot time variation of UI expenditure per unemployed in the saving only vs. in the risk-sharing scheme by country, both in model units (in the top panels) and in euros (in the bottom panels). The figure illustrates the nearly perfect smoothing over time achieved in the reinsurance scheme. The bottom-row panels clearly demonstrate how our proposed scheme only smooths UI expenditures around each country's own median level of unemployment and resources, as opposed to redistributing across countries with systematically different levels or unemployment or UI revenues.

Figure 7: Risk-sharing scheme - annual flows and cumulative balance




Notes: the left-hand panel plots the total annual fund flows into and out of the risk-sharing scheme and the resulting annual net surplus or deficit over the period 2000–2019. The right-hand panel plots the cumulative balance (total savings or debt) of the risk-sharing scheme in each year.

Figure 8: Consumption (UI expenditure per unemployed) smoothing by country




Notes: the top-row panels display the distribution of consumption over 2000–2019 for each country in model units (normalized resources per normalized unemployed) for the saving-only setting (left panel) and for the risk-sharing scheme (right panel). The bottom-row panels show the same results but expressed in monetary units (euros). We convert into euros by multiplying the model-unit values by the 2000–2019 median UI revenue (in bln EUR) per median unemployment (in mln) for each respective country.

## 5.2 Alternative specifications and robustness

Naturally, the numerical results depend on the parameters used to compute the model solution, namely the interest rate (1.56%, calibrated from ECB data as the average rate for the 2000–2019 period), the discount factor (1/1.0156), and the assumed CRRA risk-aversion value (log utility). A higher interest rate making borrowing for the scheme more costly, or lower risk aversion, would each lead to slightly less smoothing of the unemployment shocks but smaller deficits – see Figure A3 computed using CRRA risk-aversion parameter 0.5 where the maximum deficit is significantly lower, at €229 bln.

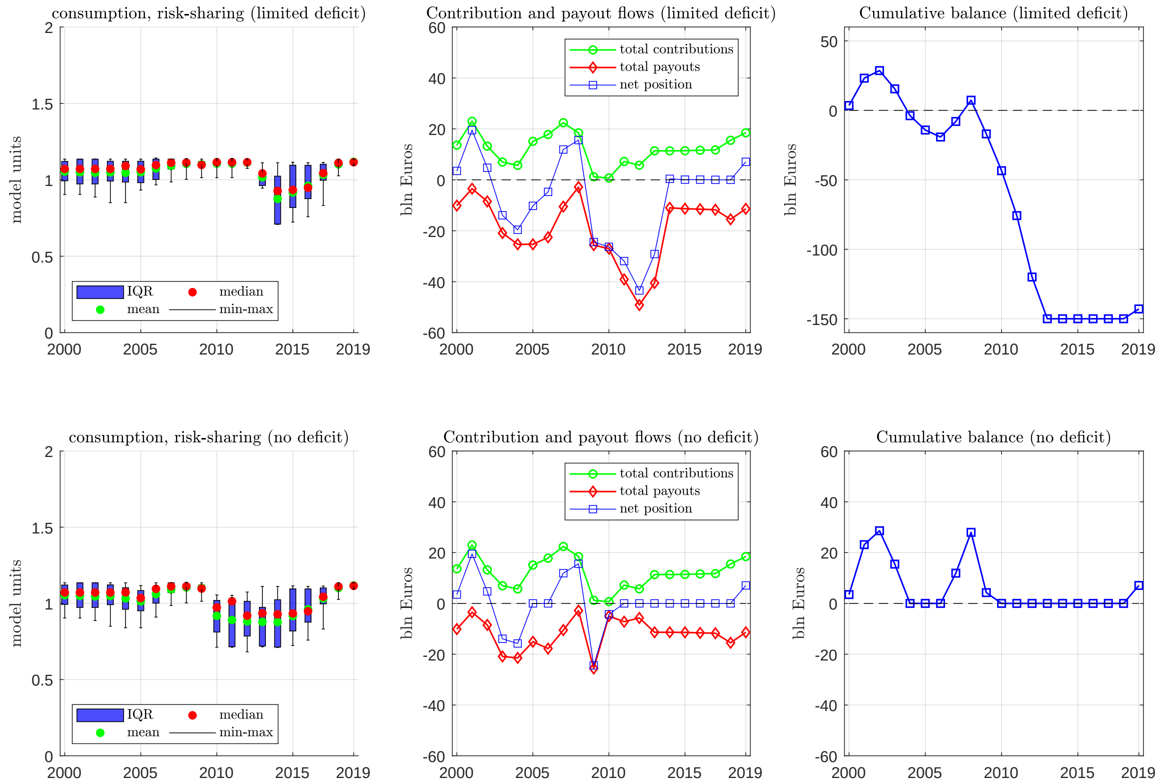
In Figure A4 in the Appendix we also compute and compare the consumption smoothing in the saving-only setting vs. in a borrowing and saving setting in which the country may borrow at the same interest rate $R$, up to an exogenous limit.[20] Allowing borrowing yields better smoothing of UI expenditure per unemployed than in the saving-only regime, however, the residual variation in consumption is still significantly larger compared to that in the risk-sharing scheme (compare Figure A4 with Figure 4). The reason is that individual country saving and borrowing is an imperfect substitute for insurance via pooling idiosyncratic risk. A country may suffer a sequence of negative shocks and reach the borrowing limit (see section 3.1) reducing its ability to smooth expenditures. In addition, debt is assumed to be non-contingent, thus a county which borrowed in an earlier period is required to repay, regardless of its current economic state. The maximum total borrowed amount by all 17 countries reaches just under €100 bln in 2016, which is lower than the aggregate borrowing in the reinsurance scheme (compare with Figure 7). We also computed the expected ex-ante welfare gains from joining the risk-sharing scheme for a country in the borrowing and saving model, averaging over the same 1,000 simulated Monte Carlo unemployment state histories used in the last row of Table 1. In this simulation, the outside option is going to the borrowing and saving setting with zero debt/savings. The estimated consumption supplement is 2.5% (compared to 5.5% for the saving-only setting in Table 1).[21]

In the period 2009-2014 most euro area countries experienced high unemployment at the same time, which (optimally) leads to yearly deficits and debt accumulation for the reinsurance scheme as a whole, as shown in Figure 7. If such deficits and negative fund balances are, however, politically (e.g., Germany finding itself on one side of the ledger) or economically infeasible, we also analyze scenarios in which we impose an exogenous limit on the cumulative deficit/debt that the reinsurance scheme can incur. The results are shown on Figure 9 for a cumulative deficit ceiling equal to either €150bln (in the top panels) or when no deficit is allowed and only surpluses can be accumulated (in the bottom panels). To compute these results, we use the true model solution with unlimited

[20]In Figure A4 the borrowing limit is set to 1, i.e., each country's UI program is assumed to be able to borrow (carry debt) up to the country's median yearly UI revenue.

[21]We also ran a simulation of the borrowing and saving model in which the gross interest rate $R$ is an increasing linear function of savings/debt, $d$ with net interest rate ranging between 1.56% (our baseline calibrated value) at maximum savings and 4% at maximum debt. Having to pay higher interest when borrowing significantly reduces the country's ability to smooth UI expenditures and the resulting distribution of consumption (normalized UI expenditure) across countries and time in that simulation is very similar to that in the saving-only setting in Figure 4.

Figure 9: Risk-sharing scheme with limited or no deficit




Notes: the left-hand panels plot the cross-sectional distribution of consumption (UI expenditure per unemployed) in model units. The center panels plot the annual flows in and out of the risk-sharing scheme, as well as the net position. The right-hand panels display the cumulative balance of the risk-sharing scheme over the studied period. The top row of panels shows the simulation results when the risk-sharing scheme is subject to a borrowing/debt limit of 150 bln EUR. The bottom row shows the results for the case in which the scheme is not permitted to run a deficit (no borrowing).

deficit, however, if in some year the total due payouts are such that the cumulative deficit limit would be exceeded, we reduce all payouts proportionally to match the limit. Since this ex-post adjustment is not optimal in general, these simulations are provided only for illustration and do not depict the optimal mechanism-design solution for a given permitted deficit level. In other words, the degree of consumption smoothing shown on Figure 9 is a lower bound for the consumption smoothing that can be attained in these limited-deficit settings.

The left-hand panels of Figure 9 show that imposing a deficit limit on the reinsurance scheme reduces its ability to smooth consumption (UI expenditure per unemployed) in the years for which the limit binds, specifically 2012–2017 for the 50 bln deficit limit scenario and 2005–2006 (a very small distortion) and 2011–2017 for the “no deficit” scenario. The imperfect smoothing of unemployment risk in the years when the deficit limit is binding resembles that in the saving only setting, when a country exhausts its savings after a sequence of negative shocks. Conversely, in the years when the deficit limit does not bind, consumption is almost perfectly smoothed unlike in the saving only setting - compare Figure 9 with Figure 4, left-hand panel or see Figure A5 in which we display head-to-head the smoothing in all four analyzed scenarios (saving only and optimal risk-sharing with unlimited deficit, limited deficit, and no deficit). We show the insurance transfers for the scenario without deficit in Figure A6.

# 6 Comparison with an alternative EUBS

We next compare our mechanism-design based unemployment risk reinsurance scheme with the reinsurance scheme proposed in Dolls (2019), (2024) which we use as a leading representative of the EUBS proposals with exogenously defined trigger, contribution and payout rates reviewed in Section 2.

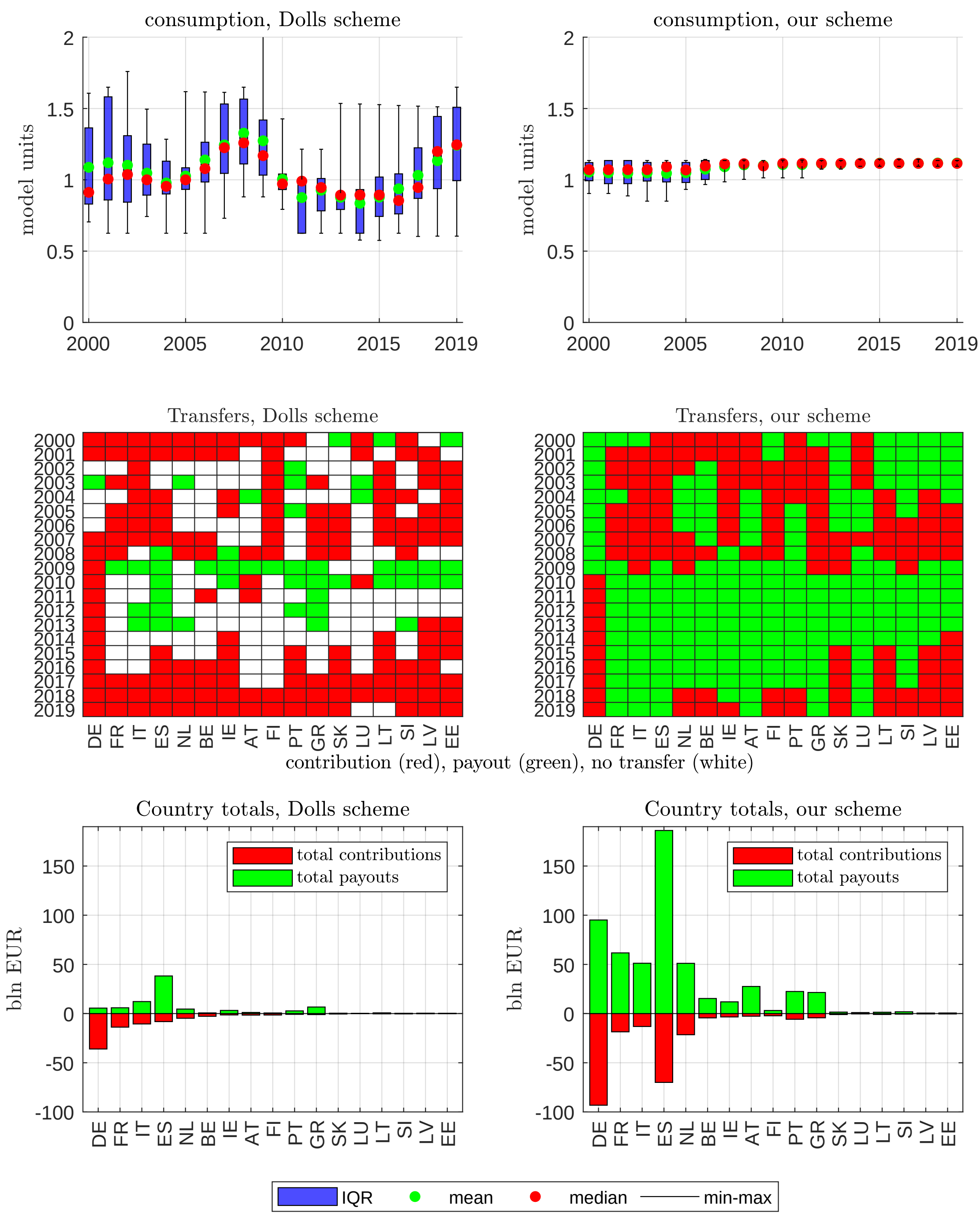
A contribution obligation in the Dolls scheme is triggered when the following two conditions hold simultaneously for the current unemployment rate $u_{j,t}$ of country $j$ in year $t$: (c1) there is a year-on-year decrease in the unemployment rate, i.e., $u_{j,t} < u_{j,t-1}$ and (c2) the current unemployment rate is below the country's 7-year moving average. A payout obligation is triggered when: (p1) the year-on-year increase in the unemployment rate exceeds 1 percentage point and (p2) the current unemployment rate is above the 7-year moving average. If the payout trigger for country $j$ and year $t$ is activated, then the payout amount $P_{j,t}$ is determined by the increase in the number of unemployed relative to the previous year and current gross wages.[22] The contribution rate is determined as a fraction of the country's total gross wages so that all triggered payout amounts are fully covered over the period of analysis (2000–2019 here) and the scheme is balanced ex post.

On Figure 10 we simulate the Dolls (2019, 2024) scheme using our data and compare it with our EA-URS reinsurance scheme. The top panels of Figure 10 illustrate the smoothing of consumption (normalized UI expenditure per normalized unemployed) in the Dolls' scheme and our scheme. Consumption in the Dolls scheme is expressed in model units to compare with our results and equals $c_i^{dolls} = q_i + \tau_i^{dolls}, \forall i$, where $\tau_i^{dolls}$ is the payout or contribution converted into model units, and $q_i$ is normalized UI revenue per normalized unemployed, as defined in Section 3. Compared to a scenario of no smoothing where consumption equals income in all states and times ($c_i = q_i, \forall i$), the Dolls scheme reduces the cross-country and time variability in consumption (UI expenditure per unemployed) and dampens the 2009–2010 sharp drop in income per unemployed. However, because of its relatively strict payout conditions and ex-post balanced budget requirement, the resulting consumption smoothing is lower than that in our EA-URS scheme, including, for most years, when no deficit is permitted (compare with Figure 9).

The centre panels of Figure 10 display the pattern of contributions and payouts by

[22] The payout formula is: $P_{j,t} = 0.7 \times \Delta Unemployed_{j,t} \times 0.5 \times GrossWages_{j,t}$, based on the additional resources needed to cover the unemployment benefits. The calculation assumes a 50% wage replacement rate and a 70% coverage rate, indicating that, on average, 70% of newly unemployed individuals are eligible for benefits which replace 50% of their annual gross salary.

Figure 10: Comparison with an alternative EUBS




Notes: The top panels display the smoothing of normalized consumption in the Dolls' scheme (top-left panel), compared to in our scheme (top-right panel), expressed in model units (normalized revenue per normalized unemployed). The centre panels show the years for each country in which contributions (in red) or payouts (in green) are made. The bottom-row panels compare the total contributions and total payouts by country, added over the 2000–2019 period, in the Dolls scheme vs. our reinsurance scheme.

country and year in the Dolls scheme versus our scheme. We observe that payouts in the Dolls scheme are less frequent, which is because the trigger condition requires a continuing year-on-year increase in unemployment of at least 1 percentage point, compared to in our mechanism-design scheme where payouts are optimally triggered when unemployment remains high (even if decreasing year-on-year) relative to the country's median level. Because of how the payout trigger is defined, the Dolls scheme also features many years in which a country is neither a contributor, nor receives a payout (marked in white on the figure).

In the bottom-row panels of Figure 10 we display and compare the total contributions and payouts by country in the Dolls scheme vs. our EA-URS scheme. We see that the implied transfers in the Dolls scheme are smaller in magnitude. While Spain (ES) is the main net payout recipient over the analyzed period in both schemes, in our scheme this is financed primarily through borrowing by the scheme (see Figure 7), while in Dolls Germany is the largest net contributor, as the scheme is required to be balanced ex-post.

We also ran a simulation in which we set the scheme's debt limit to 7.5bln euro, calibrated so that the EA-URS is balanced ex-post (it has zero cumulative deficit in 2019), as assumed in Dolls. In this simulation, displayed on Figure A7, Spain receives lower total payouts over the period of analysis (about 54bln, compared to 150bln in the unconstrained scheme), due to payout reductions in the years for which the scheme's debt limit binds. Naturally, as in Figure 9, the level of consumption smoothing in the EA-URS scheme is reduced in the period 2010–2016 when the debt limit binds but remains high in the remaining years.

We draw two main takeaways from these comparisons. First, requiring the reinsurance scheme to be balanced over a relatively short or exogenously fixed time period reduces its ability to smooth out the unemployment risk. Instead, allowing the EUBS scheme to borrow in years in which many countries experience high unemployment is optimal, while requiring each country (and hence the scheme as a whole) to achieve balance over a sufficiently long time horizon. Second, better UI expenditure smoothing is obtained if the contribution and payout triggers are defined relative to an anchor rate (in our scheme, the country median unemployment rate), without requiring year-on-year increases or decreases in unemployment.

# 7 Conclusions

The euro area sovereign debt crisis has reinvigorated the debate on establishing additional fiscal instruments for the euro area. A common European unemployment benefits scheme has been one of the proposed solutions to strengthen the automatic fiscal stabilizing capacity of the European Monetary Union. Existing proposals to set up an unemployment reinsurance mechanism for the euro area aim to exploit the observed asymmetry in the fluctuations of unemployment rates of member countries, which we also document here. However, most of these studies, while featuring rich institutional details and empirical payout and contribution rules, do not engage in an explicit treatment of the participants' preferences, incentives, or optimal choices. We complement these approaches with a formal mechanism design model in which member states have an economic incentive to join, remain, and contribute to the proposed risk-sharing scheme over a long horizon.

Building on our previous work on mechanism design, safety nets, and dynamic financial constraints in Karaivanov and Townsend (2014) and Karaivanov et al. (2023), we model and simulate an incentive-compatible reinsurance scheme for euro area states' unemployment risk (EA-URS). Our results using data from 17 euro area countries in the period 2000-2019, show that a euro area wide platform could have provided nearly perfect sharing of unemployment risk if allowed to borrow up to 2.5% of the 2019 euro area GDP. In 'normal times', i.e., the years before 2008 and after 2017, the scheme features an approximate balance in the number of countries which pay in a contribution (those where the unemployment rate is below the country median) and the countries which receive a payout/indemnity (those where the unemployment rate is above the country median), as unemployment shocks in the euro area are sufficiently uncorrelated. Conversely, in a period of synchronized economic downturns and high unemployment, such as the years between 2009 and 2016, most countries would optimally draw from the scheme to help supplement their national UI programs.

To solve and simulate the dynamic mechanism design model with the available data, we have made several simplifying assumptions about the scheme's design. These are potential limitations in light of which our results should be interpreted. We assume that the countries face a common stable probability distribution for unemployment risk (normalized relative to the median) that we calibrate from historical data. The country-specific anchor rates around which the reinsurance scheme smooths the risk and the countries' median UI revenues are also assumed stable at their historical levels. While these conditions are likely to hold in the short to medium term, if an implementation is considered, a transparent framework can be put in place for periodic adjustment so that the calibration determining the insurance payouts or contributions reflects structural changes or trends in the countries' unemployment dynamics over time, especially if such changes may impair the scheme's long-term financial balance with a given country or overall. Since our model and simulations use economic variables that are available with a relatively short lag, contemporaneous data can be incorporated. Second, the model abstracts from heterogeneity in preferences or resources among the unemployed within countries, focusing instead on smoothing normalized UI expenditures around a country-specific anchor level. Data availability and sample size limitations prevent us from allowing initial UI assets, the risk process, or the interest rate to differ across countries.

Finally, political-economy or fiscal considerations can matter for the scheme's practical implementability, such as the size of payouts or contributions in the context of other national expenditures, the potential of governments to re-allocate revenues from other sources, or the "optics" of a country A, with higher absolute but low relative to its median unemployment contributing to the scheme, while a country B with lower absolute unemployment is receiving a payout. We do not consider the latter a major problem since the perception of economic activity in country A during such periods is likely to be strong, making it less politically and economically costly to contribute to the scheme. In addition, the scheme is balanced over time by design, thus no country would perceive itself or others as systematically (over-)contributing or (over-)receiving. Ultimately, the feasibility of the scheme relies on whether governments see value in smoothing their UI revenues and expenses and sharing risk beyond what they can achieve on their own. This is the key aspect of our analysis.

The EA-URS we model is robust to limited commitment, so that a member country would not gain from leaving the scheme or reneging on a contribution. We focus on limited commitment as the main obstacle to risk sharing, as we believe that other obstacles, e.g., private information or hidden actions, are less relevant in the euro area institutional setting.[23] For example, we consider that it would be unlikely for a euro area country to misreport or deliberately engage in policies resulting in higher unemployment after joining the scheme, as such actions are likely to incur large economic and political costs compared to any gains from a small increase in payouts or reduction in contributions. Furthermore, such deviations would only have a short-term effect if the anchor unemployment rate is periodically adjusted. Similarly, a country would not have an incentive to reduce its UI revenue intake (e.g., by lowering the tax rate) after joining the scheme, since its contributions and payouts would be adjusted accordingly so that the scheme remains in balance with the country over the long run. The balance over a long horizon feature also allows for entry of new members into the scheme, as all payouts and contributions are based on each country's own anchor level and unemployment history.

Our findings suggest that an incentive-compatible unemployment reinsurance for the euro area could be feasible in terms of the required resources and could significantly contribute to reducing the fluctuations in euro area members' national unemployment expenditures. Since unemployment and economic activity are counter-cyclical, the EA-URS we model would further benefit the member states by allowing them to allocate scarce resources during economic downturns to alternative fiscal policies rather than having to cover for increased unemployment benefit expenses.

**Declaration of funding**

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**Declaration of interests**

The authors declare that they have no competing interests.

[23]Future work could, however, explicitly extend the mechanism-design problem by adding other contractual frictions such as moral hazard.

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# Appendix A

Table A1: Normalized and actual unemployment rates by country

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| **Normalized rate, $\mathbf{n(s_i)}$** | **0.67** | **0.77** | **0.88** | **0.96** | **1** | **1.06** | **1.14** | **1.28** | **1.50** |
| Country \ percentile | p10 | p20 | p30 | p40 | p50 | p60 | p70 | p80 | p90 |
| Austria, AT | 3.5 | 4.0 | 4.6 | 5.0 | 5.2 | 5.5 | 5.9 | 6.7 | 7.8 |
| Belgium, BE | 5.2 | 6.0 | 6.8 | 7.4 | 7.7 | 8.2 | 8.8 | 9.9 | 11.6 |
| Estonia, EE | 5.5 | 6.4 | 7.2 | 7.9 | 8.2 | 8.7 | 9.4 | 10.5 | 12.3 |
| Finland, FI | 5.7 | 6.5 | 7.4 | 8.1 | 8.5 | 8.9 | 9.6 | 10.8 | 12.7 |
| France, FR | 6.1 | 7.0 | 8.0 | 8.7 | 9.1 | 9.6 | 10.3 | 11.6 | 13.6 |
| Germany, DE | 4.6 | 5.3 | 6.1 | 6.6 | 6.9 | 7.3 | 7.8 | 8.8 | 10.3 |
| Greece, GR | 8.1 | 9.3 | 10.6 | 11.6 | 12.1 | 12.8 | 13.7 | 15.4 | 18.1 |
| Ireland, IE | 4.2 | 4.8 | 5.5 | 6.0 | 6.3 | 6.6 | 7.1 | 8.0 | 9.4 |
| Italy, IT | 5.9 | 6.8 | 7.7 | 8.4 | 8.8 | 9.3 | 10.0 | 11.2 | 13.1 |
| Latvia, LV | 7.5 | 8.7 | 9.9 | 10.8 | 11.2 | 11.9 | 12.8 | 14.4 | 16.8 |
| Lithuania, LT | 7.2 | 8.3 | 9.5 | 10.3 | 10.8 | 11.4 | 12.3 | 13.8 | 16.2 |
| Luxembourg, LU | 3.3 | 3.8 | 4.3 | 4.7 | 4.9 | 5.2 | 5.6 | 6.3 | 7.4 |
| Netherlands, NL | 4.0 | 4.6 | 5.2 | 5.7 | 6.0 | 6.3 | 6.8 | 7.6 | 9.0 |
| Portugal, PT | 6.2 | 7.2 | 8.1 | 8.9 | 9.3 | 9.8 | 10.5 | 11.8 | 13.9 |
| Slovenia, SI | 4.4 | 5.1 | 5.8 | 6.3 | 6.6 | 6.9 | 7.5 | 8.4 | 9.8 |
| Slovakia, SK | 9.1 | 10.5 | 11.9 | 12.9 | 13.5 | 14.3 | 15.4 | 17.3 | 20.3 |
| Spain, ES | 9.8 | 11.3 | 12.9 | 14.0 | 14.7 | 15.5 | 16.7 | 18.7 | 22.0 |

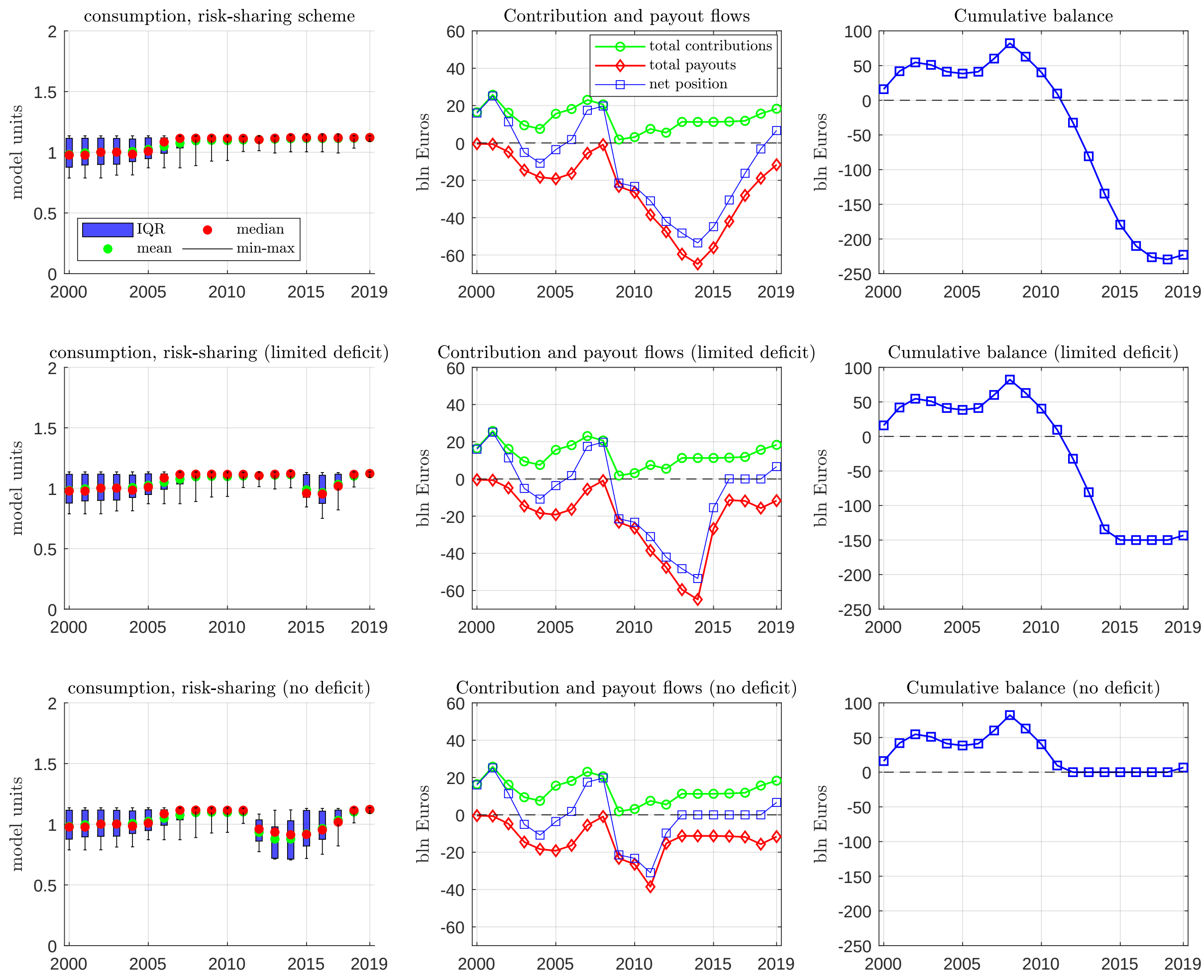
Notes: the table displays the normalized unemployment rates (the top row) used in the model simulations and their mapping to actual unemployment rates (in percent) for each country. The normalized unemployment rate for each country is defined as the actual unemployment rate divided by the country's median unemployment rate for the period 2000-2019, see Section 4.1 for details. The median (p50 percentile) unemployment rate for each country, corresponding to normalized rate of 1, is shown in column (5). The numbers in columns (2)–(4) and (6)–(9) are obtained by multiplying the corresponding normalized rate in row 1 by the median unemployment rate for each country from column (5).

Table A2: Unemployment insurance (UI) revenue and tax rate

| **Country** | **median revenue**<br>bln EUR<br>(1) | **tax rate**<br>percent<br>(2) |
|---|---|---|
| Austria, AT | 8.68 | 6.00 |
| Belgium, BE | 6.99 | 4.03 |
| Estonia, EE | 0.16 | 2.40 |
| Finland, FI | 2.64 | 3.00 |
| France, FR | 34.78 | 4.05 |
| Germany, DE | 31.60 | 2.40 |
| Greece, GR | 3.14 | 4.52 |
| Ireland, IE[1] | 1.98 | 2.40 |
| Italy, IT | 12.52 | 2.00 |
| Latvia, LV | 0.16 | 1.84 |
| Lithuania, LT[2] | 0.34 | 2.40 |
| Luxembourg, LU[1] | 0.28 | 2.40 |
| Netherlands, NL | 14.79 | 4.19 |
| Portugal, PT | 3.78 | 5.00 |
| Slovenia, SI[2] | 0.48 | 2.40 |
| Slovakia, SK | 0.50 | 2.00 |
| Spain, ES | 33.09 | 7.05 |

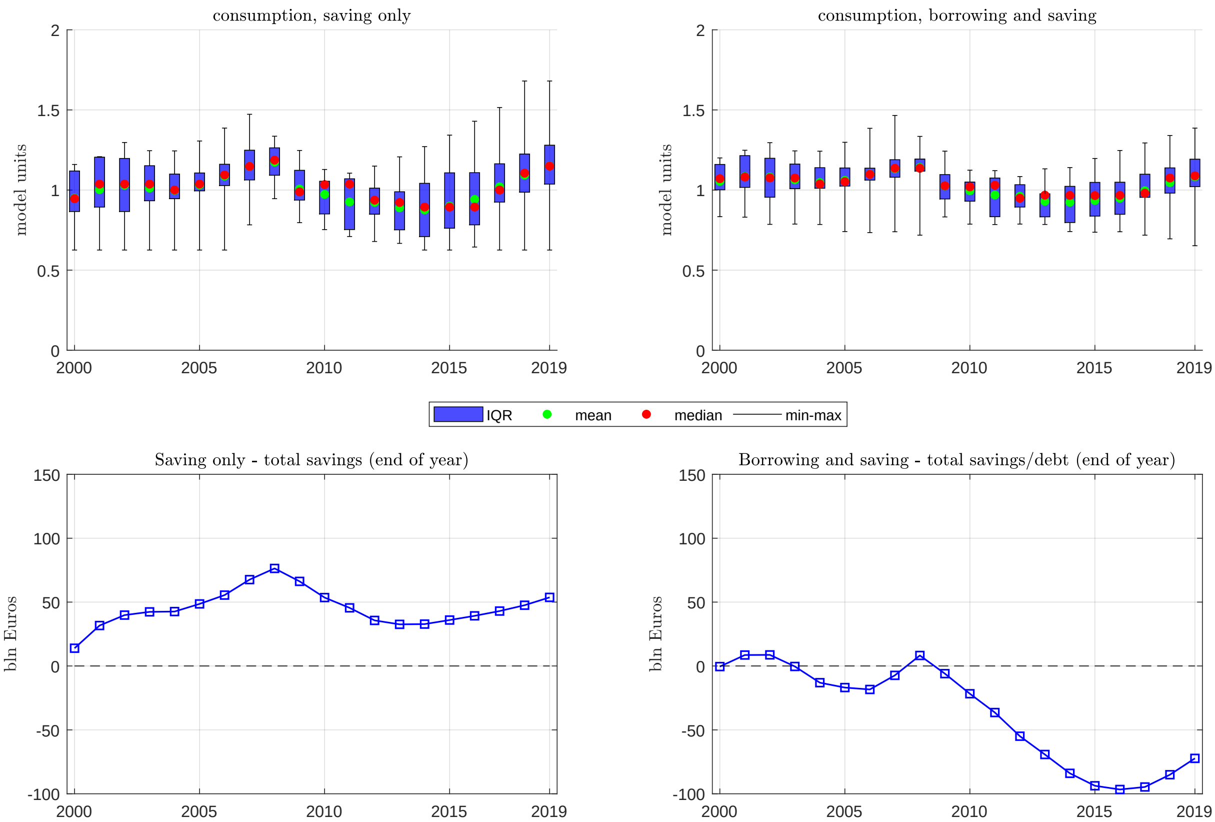
Notes: column (1) displays the median unemployment insurance (UI) revenue for each country over the period 2000–2019, used to compute normalized resource units in the model simulation. The UI revenue is calculated as the product of three data variables: (A) the percent of average gross wages withdrawn as contribution to unemployment insurance, (B) the average gross annual wage, and (C) the total number of employed. Column (2) displays the national UI contribution/tax rate, (A) used to calculate UI revenue. See Table B1 for all data sources and definitions.
[1]Absent an official UI tax rate, we use the sample median (2.4%). [2]Assuming that the official UI-specific tax rate (0.16% for LT and 0.21% for SI) is supplemented from other budget sources, we use the sample median rate as proxy for the actual UI contribution rate in these countries.

Figure A3: Risk-sharing scheme, consumption, flows and cumulative balance (lower risk aversion, CRRA parameter 0.5)



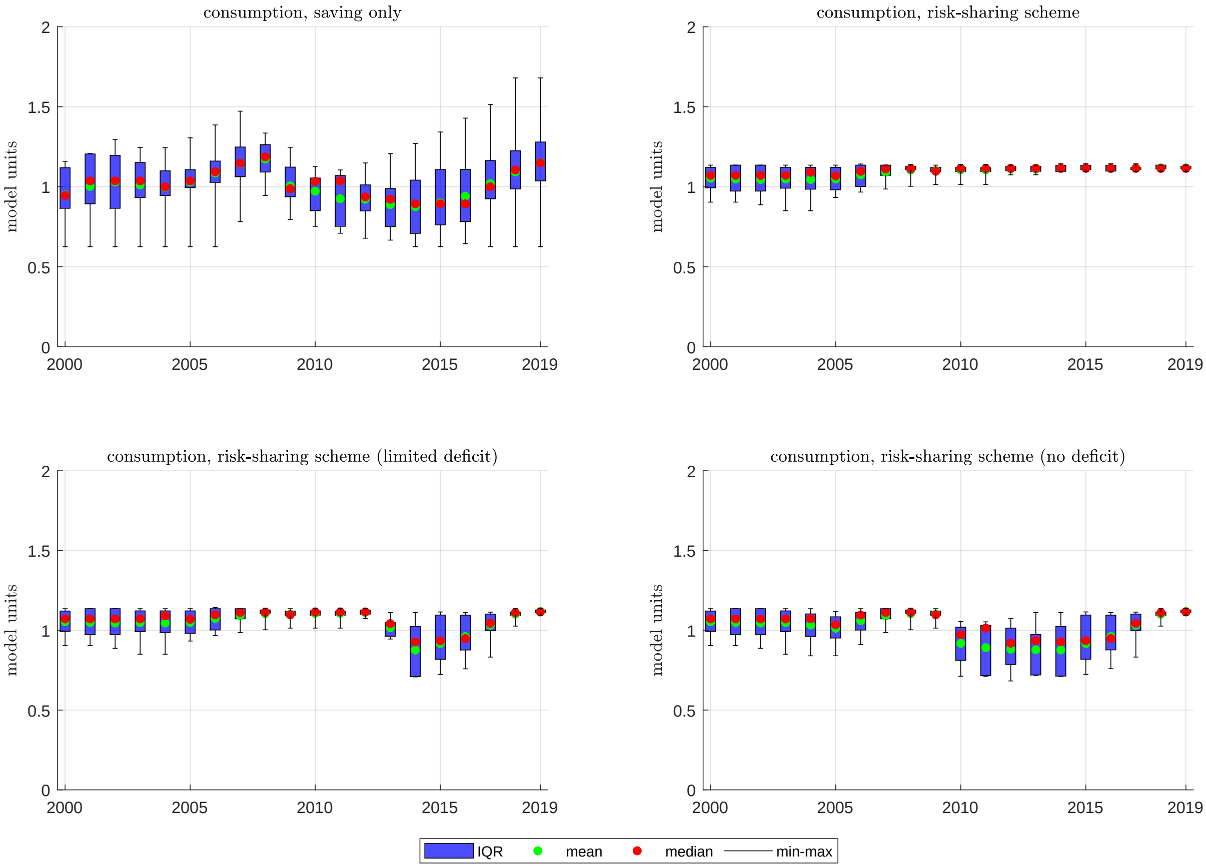

Notes: The figure displays simulation results for CRRA risk aversion parameter 0.5. The top row of panels shows the results when the risk-sharing scheme is not subject to a borrowing limit; the center row shows the results when the risk-sharing can run a limited deficit up to 50 bln EUR, and the bottom row shows the results for the case when the scheme is not permitted to run a deficit. The left-hand panels plot the cross-sectional distribution of model consumption (UI expenditure per unemployed). The center panels plot the annual flows into and out of the risk-sharing scheme and the scheme's net position (surplus or deficit) by year. The right-hand panels show the cumulative balance of the risk-sharing reinsurance scheme over the period 2000-2019.

Figure A4: Saving only vs. Borrowing and saving



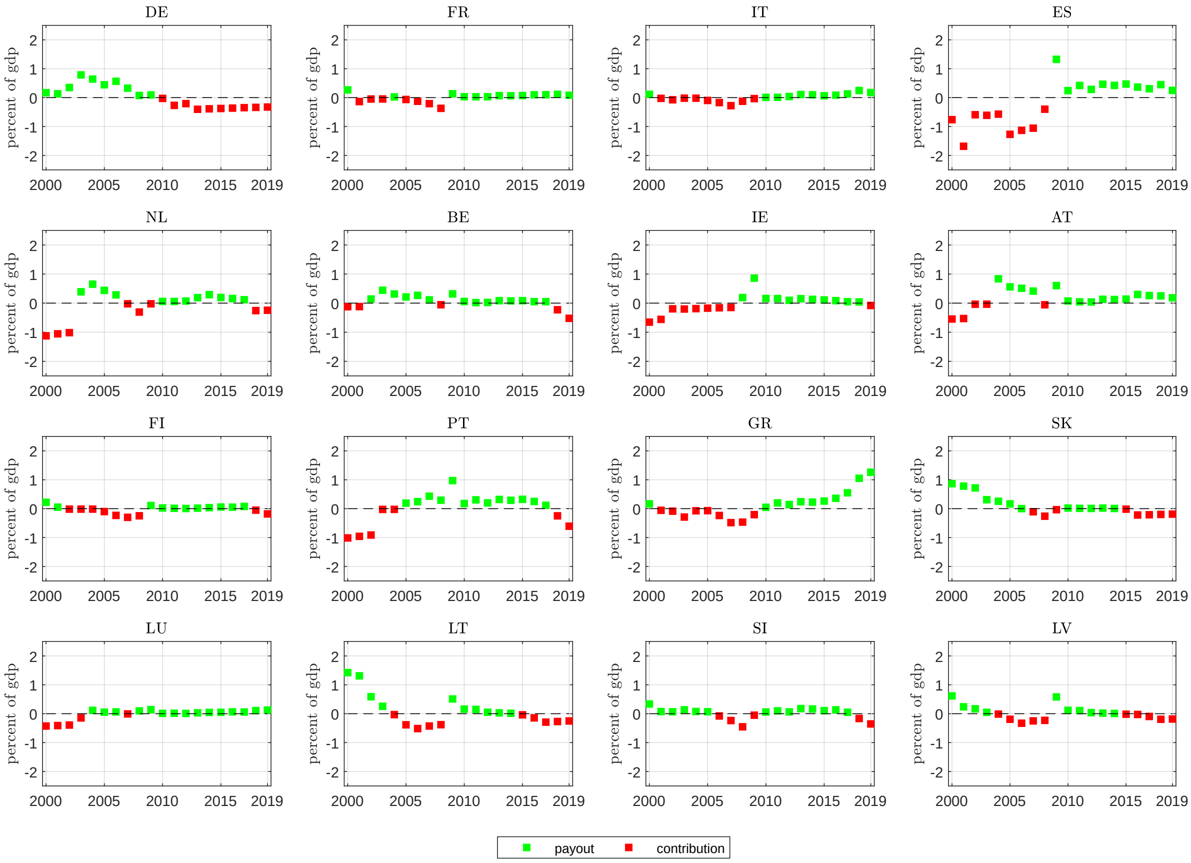

Notes: the top row of panels compares the cross-country distribution of consumption (UI expenditure per unemployed) in model units in the saving only setting (left-hand panel) and in the borrowing and saving setting (right-hand panel) for each year from 2000 to 2019. The bottom row compares the annual net balance (total savings or debt aggregated over all countries) in bln euros in the saving-only setting (left-hand panel) and in the borrowing and saving setting (right-hand panel).

Figure A5: Consumption smoothing – comparison



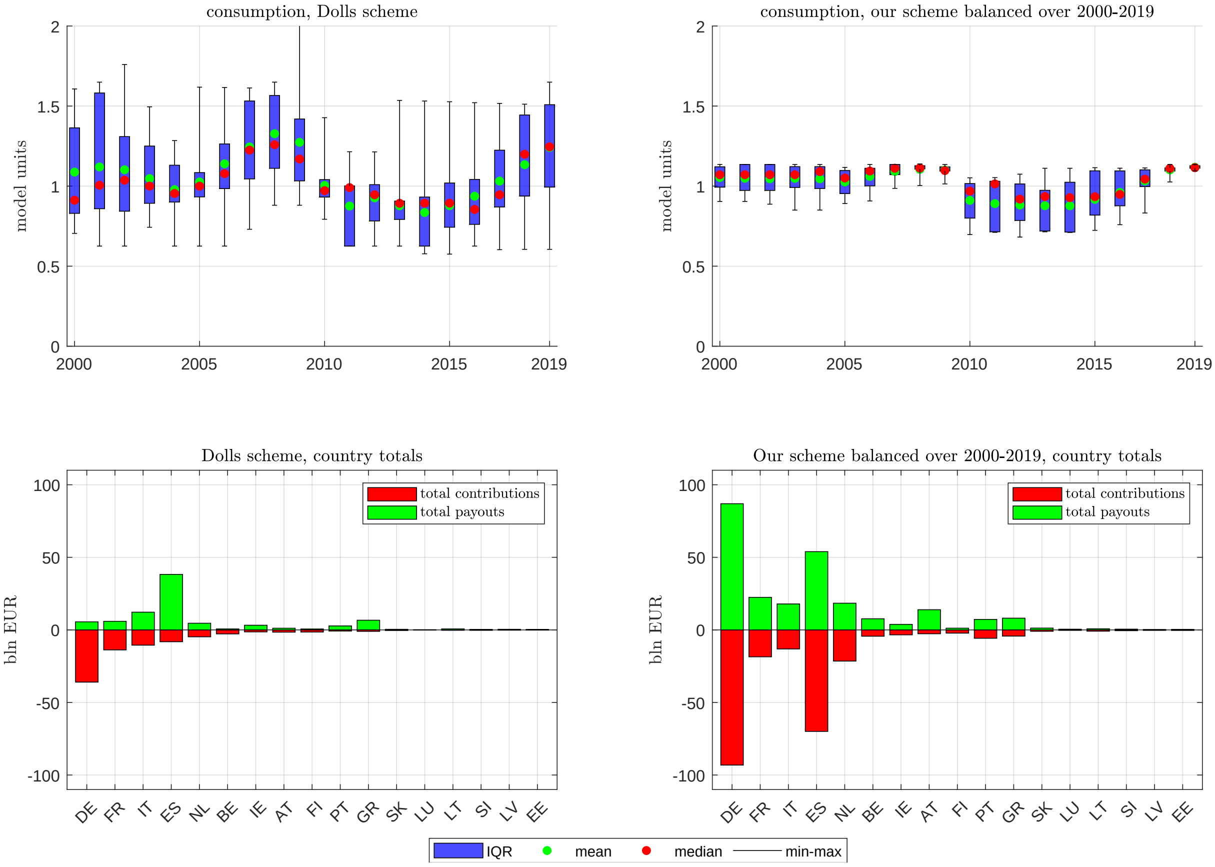

Notes: each panel shows the cross-sectional distribution of consumption (UI expenditure per unemployed) in model units for a different setting: saving only (top left), risk-sharing scheme with unlimited borrowing capacity (top right), risk-sharing scheme with maximum 50 bln EUR limited deficit (bottom left), and risk-sharing scheme with no permitted deficit (bottom right).

Figure A6: Risk-sharing transfers as fraction of GDP (zero deficit scenario)




Note: each panel shows the size, expressed as share of GDP, of the reinsurance contribution/premium to the scheme (in red) or payout/indemnity from the scheme (in green) for each country in the risk-sharing scheme under zero permitted deficit.

Figure A7: Comparison with Dolls (2019), balanced over 2000–2019



# Appendix B

Table B1: Data Sources and Definitions

| Data variable | Definition | Source | Link |
|---|---|---|---|
| Unemployment (mln people) | Unemployment comprises all persons of working age who were: a) without work during the reference period, i.e. were not in paid employment or self-employment; b) currently available for work, i.e. were available for paid employment or self-employment during the reference period; and c) seeking work, i.e. had taken specific steps in a specified recent period to seek paid employment or self-employment. | IMF, *International Financial Statistics* | unempl_IMF |
| Unemployment rate (percent) | The unemployment rate is calculated by expressing the number of unemployed persons as a percentage of the total number of persons in the labor force. | IMF, *International Financial Statistics* | unemp_rate_IMF |
| Employment (mln people) | Employment comprises all persons of working age who during a specified short period, such as one week or one day, were in the following categories: a) paid employment; or b) self-employment (whether at work or with an enterprise but not at work). | IMF, *International Financial Statistics* | employment_IMF |
| Average gross wages (EUR) | Average annual wages per full-time and full-year equivalent employee. | OECD | wages_OECD |
| Unemployment insurance revenues (bln EUR) | Calculated as the product of three data variables: (i) the percentage of average gross wages contributed to unemployment insurance, (ii) average gross annual wages, and (iii) total number of employed (employment). | authors' calculations | |
| GDP (bln EUR) | National accounts, expenditure, gross domestic product, nominal and seasonally adjusted. | IMF, *International Financial Statistics* | nGDP_IMF |
| Interest rate (percent) | Euro short-term Main Refinancing Operations (MRO) rate for 2000–2019. | European Central Bank (ECB) | ECB_rate |
| UI tax rate (percent) | Contribution to unemployment insurance by employers and employees. | OECD | OECD_TaxRate |