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Abstract

The growing asymmetry in the size of fiscal imbalances poses a serious challenge to the macroeconomic stability of the Euro Area (EA). We show that following a contractionary shock, the current monetary and fiscal framework weakens economic growth even in low-debt countries because of the zero lower bound (ZLB) constraint. At the same time, the current framework also exposes the EA to the risk of fiscal stagflation if one country were to refuse to implement the necessary fiscal consolidations. We study a new framework that allows EA policymakers to separate the need for short-run macroeconomic stabilization from the issue of long-run fiscal sustainability. Following a contractionary shock, the central bank tolerates the increase in inflation needed to stabilize the amount of Eurobonds issued in response to a large EA recession. National governments remain responsible to back their country-level debt by fiscal adjustments. The policy acts as an automatic stabilizer that benefits both high-debt and low-debt countries, generating a moderate increase in inflation that mitigates the recession and allows the central bank to move away from the ZLB. At the same time, the proposed policy lowers the risk of fiscal stagflation because it endows EA countries with effective stabilization policies.

Keywords: Monetary and fiscal policy coordination, monetary union, Eurobonds, zero lower bound, government debt.

JEL Classification: E50, E62, E30.

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1 Introduction

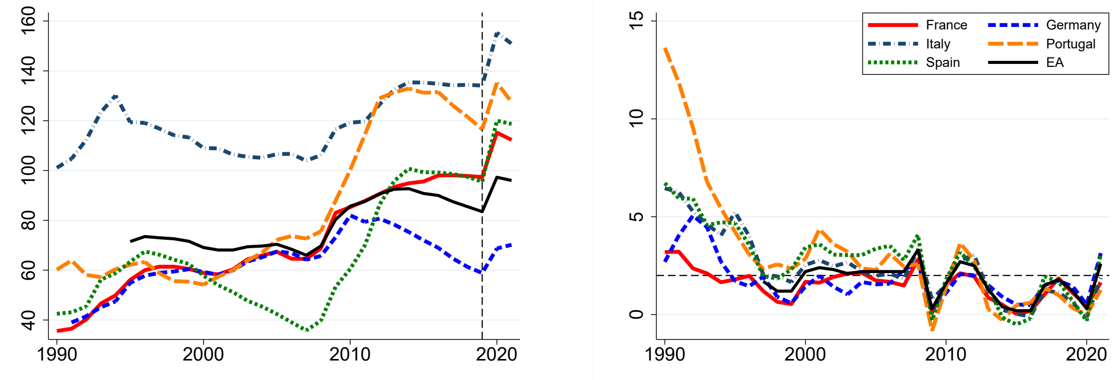
The fiscal position of several countries of the Euro Area (EA) has considerably deteriorated over the last decade. After the Pandemic Recession, a larger number of EA countries, including France and Spain, will have a public debt larger than the size of their GDP (left panel of Figure 1). Against this backdrop of rising fiscal imbalances, the debate about the design of new fiscal rules is likely to be high priority in the political agenda of EA policymakers as the pandemic wanes. The debate will arguably be more polarized than in the past since more countries have now a large public debt. At the same time, with nominal interest rates at their historical low for a prolonged period of time, monetary policy has had little room to alleviate the economic costs of the pandemic. In fact, for more than 10 years, the European Central Bank (ECB) has been struggling with the risk of deflation (right panel of Figure 1).

Paradoxically, this inability of the central bank to act during a recession and the constraints on fiscal policy leave the EA exposed to the risk of elevated inflation if one or more of the high debt countries were to move away from fiscal sustainability or if agents became convinced that this might happen in the future. This is because the narrow monetary space in response to negative shocks, combined with the need to correct large fiscal imbalances, is likely to leave high-debt countries without effective policy tools to stabilize the economy in the next recession. We show that the lack of coordination between the ECB and the fiscal authorities of the single countries can generate stagflation dynamics that have a fiscal nature.

We build a two-agent New Keynesian (TANK) model of a monetary union with a high-debt country and a low-debt country to evaluate three post-pandemic scenarios for the EA. Similarly to pre-pandemic arrangements, in the first scenario the national governments of the EA agree on a set of fiscal rules requiring large national debts to be stabilized through distortionary fiscal adjustments. In the second scenario, we study the possibility that the polarization of the fiscal debate will cause a high-debt country to refuse to comply with the common fiscal rules. The third scenario is a novel type of coordination between monetary and fiscal policies in which the central bank accommodates the moderate rise in inflation necessary to stabilize the amount of Eurobonds debt needed to combat the consequences of large area-wide recessions. Under this new monetary and fiscal arrangement, national governments remain fiscally responsible to stabilize their own debt as in the past.

We calibrate the model to two EA countries with a substantially different level of debt-to-GDP ratios: Italy and Germany. To evaluate the ability of the three monetary and fiscal arrangements to stabilize the EA economy, we consider a demand-driven recession that causes the ZLB constraint to become binding.

In the first scenario, the national fiscal imbalances are expected to be entirely corrected by higher distortionary taxes and lower expenditures – a scenario that we call *Fiscal Discipline*.



(a) Debt-to-GDP

(b) CPI Inflation

Figure 1 – Panel (a): Debt is reported in percentage of GDP. The vertical dashed line marks the year 2019. Source: IMF. Panel (b): Inflation is reported in percentage points. Source: OECD.

Under Fiscal Discipline, the recession is particularly deep for the high-debt country, but the low-debt country also suffers a severe contraction in real activity. This result emerges for two reasons. First, in the calibrated model, the two EA economies are characterized by a large degree of interdependence due to their strong trade links. Second, the low interest rate environment turns out to critically limit the central bank's ability to alleviate the adverse effects of recessionary shocks and of the large fiscal adjustments implemented in the high-debt country on the EA economy and on the low-debt country's economy.

In the second scenario, the high-debt country refuses to implement the necessary fiscal adjustments and a *Conflict* with the centralized monetary authority arises. If the central bank is expected to lose this conflict and to eventually accommodate the increase in inflation needed to stabilize the large debt of the defiant country, inflation rises during the conflict between the two authorities. Consequently, the central bank tightens monetary policy during the conflict, aggravating the recession and the fiscal situation of the defiant country. Since the private sector expects the central bank to eventually accommodate the rise in inflation needed to stabilize the fiscal imbalance of the defiant country, inflationary pressure in the whole area intensifies as a result of the larger debt-to-GDP ratio in the high-debt country. The resulting spiral of monetary tightening-deeper recession-higher inflation causes serious harm to both the high- and low-debt countries. The low-debt country ends up being affected by a higher inflation rate needed to stabilize the fiscal imbalance of the high-debt country. Finally, this scenario is shown to usher in a prolonged period of heightened macroeconomic volatility for the EA after the conflict, as the EA enters a Fiscally-led policy mix.

The third scenario based on using Eurobonds to combat the consequences of severe EA-wide recessions is dubbed *Emergency Budget*. During regular times, the common budget is backed by future primary surpluses to be raised symmetrically across the EA countries.

However, when an exceptionally large area-wide recession occurs, the resulting increase in Eurobonds is ascribed to an emergency budget that will be addressed by the coordinated monetary and fiscal policy mix. In this coordinated scenario, the monetary authority stands ready to tolerate the moderate increase in inflation needed to stabilize the amount of Eurobonds issued in response of the large recession. This moderate reflation of the EA economy raises the long-term nominal interest rate, restoring monetary policy as an important stabilization tool for the EA economy.

It is important to note that the amount of Eurobonds to be issued is not a discretionary choice of national governments. Rather, the fiscal and the monetary authorities of the EA agree on a fiscal rule to establish ex-ante how much Eurobonds are to be issued in response to large area-wide recessionary shocks. Moreover, this common budget clarifies that country-specific fiscal imbalances resulting from past and future decisions of national governments will be covered by the taxpayers in the respective countries.

The Emergency Budget works as an automatic stabilizer that functions by moderately increasing inflation expectations at the onset of a recession. These effects on inflation expectations are particularly helpful in mitigating the severity of a recession because they allow the EA to avoid or shorten the duration of the zero lower bound. In the meantime, the national fiscal authorities remain responsible to stabilize their own debt using their national fiscal instruments as required by the EA fiscal rules, which are inspired by fiscal discipline. This preserves long-run macroeconomic stability.

The Emergency Budget improves upon Fiscal Discipline along several dimensions. First, the Emergency Budget is more effective in mitigating the recession in both the high-debt country and the low-debt country. Adopting an Emergency Budget at the EA level raises inflation expectations as EA agents understand that the increase in Eurobonds will be worn away by higher future prices. These beliefs boost the efficacy of Eurobonds-backed fiscal stimulus because they contribute to lowering real interest rates in both countries. Furthermore, agents understand that under the new policy coordination the common budget, not the national ones, will bear the brunt of the large recession. Consequently, agents anticipate less dramatic distortionary fiscal adjustments at the national level, leading to a milder recession and a more robust recovery. In summary, the new coordinated monetary and fiscal strategy improves upon the other two scenarios because it successfully separates the need for short-run economic stabilization from the issue of long-run fiscal sustainability of national debts.

Second, even if Fiscal Discipline is still maintained at national level, the faster rebound of the economies lowers national debt-to-GDP ratios. While this result is particularly valuable for those countries that start with a high level of debt when the recession hits, low-debt country's economies also benefit from it due to the large degree of economic integration in the EA.

Third, the rise in inflation needed to repay Eurobonds turns out to be fairly modest because of a general equilibrium effect. By mitigating the recession, the emergency budget leads to less Eurobonds debt accumulation, calling for a smaller increase in the inflation rate. At the same time, given that fiscal discipline is preserved at the national level, the presence of Eurobonds eliminates the risk of high inflation and the possibility of stagflation dynamics because the individual countries, through the actions of the ECB and the centralized Treasury, preserve the ability to react to adverse shocks. This arguably lowers the risk that a country refuses to follow fiscal discipline.

Fourth, in response to a large negative shock, in which the ZLB risk is elevated and inflation dynamics are affected by a downward bias (Bianchi, Melosi, and Rottner 2021), the persistent rise in inflation is beneficial as it brings about a controlled reflation of the EA economy. The resulting increase in long-term nominal interest rates causes ZLB periods to become less frequent and less likely, thereby improving the central bank's ability to stabilize the economy.

The proposed policy strategy is shown to be welfare improving for both high-debt and low-debt countries, because it reduces the frequency and severity of zero-lower-bound episodes without jeopardizing the commitment to long-term fiscal sustainability. When monetary policy is not constrained, a high debt country experiences a slower recovery than a low-debt country, because it needs to implement a larger fiscal adjustment. The spillover effects for the low debt country are relatively modest, because the central bank is able to neutralize the headwinds due to the large fiscal adjustments. Thus, when monetary policy is unlikely to become constrained during a recession –as it was the case when the current monetary and fiscal EA framework was designed– the low debt country has no interest in moving away from fiscal discipline. However, in a low interest rate environment, recessions are more severe in both countries because monetary policy is constrained by the ZLB. In this case, rethinking the policy framework becomes attractive for the low-debt country too. Against this scenario, our proposed coordinated strategy reduces the need for fiscal stabilization for both countries by creating a moderate increase in inflation in the EA and by lowering real interest rates. As a result the recession is considerably smaller in both high-debt and low-debt countries and monetary policy does not become constrained by the ZLB.

This paper contributes to the topical debate on the interactions between monetary and fiscal policy (Bartsch et al., 2020), by studying how issuing Eurobonds gives rise to new avenues of interactions, which would be substantially less viable when fiscal policy is set at national level. Studying different policy setups in the context of a currency union adds a novel perspective to the body of research on fiscal-monetary interaction (Sargent and Wallace, 1981; Leeper, 1991; Sims, 1994; Woodford, 1994, 1995, 2001; Cochrane, 1999, 2001; Schmitt-Grohé and Uribe, 2000; Bassetto, 2002; Benhabib et al., 2002; Reis, 2016; Billi and Walsh, 2021, among many others).

Bianchi and Melosi (2019) show how the lack of policy coordination in response to a large shock can have dire consequences, leading to an economic meltdown. They argue that the policy trade-offs implied by a large recession can be solved with a coordinated strategy. This paper extends the analysis to confront the specific challenges arising in a currency union. Two close studies to ours are Jarocinski and Mackowiak (2018) who discuss potential fiscal-monetary interactions to address the EA malaise, and Mackowiak and Schmidt (2022) who analytically study the price level determination in a monetary union. Finally, our paper contributes to the literature on monetary and fiscal policy in currency unions (Bergin, 2000; Beetsma and Jensen, 2005; Gali and Monacelli, 2008; Ferrero, 2009; Nakamura and Steinsson, 2014, Farhi and Werning, 2017, Andrés et al., 2022), by specifically studying the implications of attributing a significant stabilization role to a centralized fiscal authority.

The rest of the paper is organized as follows. Section 2 describes the EA model. Section 3 presents our empirical strategy. Section 4 presents the main results. First, we describe the dire consequences of a deep recession when fiscal discipline applies to both the EA and the national level irrespective of the origin of the debt accumulation. Second, we show how the presence of a EA emergency budget can help alleviate the dire effects of a deep recession. Section 5 discusses how to think about a new EA monetary and fiscal framework that both high and low debt countries should find desirable. Section 6 presents the case of a conflict between the central bank and the fiscal authority of the high-debt country. Section 7 concludes.

2 A TANK Model of the Euro Area

In this section, we present a TANK model of a monetary union, which we will call Euro Area (EA). The model builds upon Leeper et al. (2017), who study fiscal multipliers in the US. We extend that model by introducing a centralized monetary authority and a centralized fiscal authority that issues Eurobonds.

The EA is composed of two countries. Each country is populated by two types of households: savers and non-savers. Savers consume and invest in assets (financial assets and physical capital), whereas non-savers only consume, but cannot invest. Both savers and non-savers supply labor to labor packers in a monopolistically competitive market. Labor packers aggregate all the varieties of labor into a homogeneous labor service that they sell to domestic intermediate firms producers in a competitive market. Intermediate firms rent capital from savers of the same country in a competitive market. In each country, there are infinitely many intermediate firms. By combining labor and capital, these firms produce intermediate goods to be sold to the final goods producers of both countries. Final goods producers aggregate all the varieties of the domestic and foreign intermediate goods into a non-tradable homogeneous final good that the producers sell to households in a perfectly competitive market. Labor and capital are country-specific and cannot be traded across country. We assume nominal rigidities in wage and price settings. Profits of firms are rebated to domestic households.

In each country, savers buy three types of financial assets: a set of state-contingent securities, the debt issued by their respective national government, and Eurobonds. State-contingent claims can be traded by households across countries. Eurobonds are issued by a centralized fiscal authority for the EA and, like the national government bonds, have a maturity structure. The debt issued by the national fiscal authorities is held domestically by savers and is stabilized by raising distortionary taxes and lowering transfers and government consumption. Eurobonds are issued to savers in both countries and how the EA policymakers stabilize them depends on the monetary and fiscal framework in place, as we will explain later.

There is a centralized monetary authority that sets the price of a one-period risk free bond, which is obtained as a portfolio of state-contingent securities that pays off one unit of the numeraire in every state of the world with certainty.

The size of two countries is identical and the structure of their economy (markets, agents, etc.) is symmetric. For this reason, in what follows we will just describe the decision problems faced by agents in one of the countries, which we dub home country. Aggregate shocks (namely, risk premium shocks and technology shocks, which we will define below) hit both countries symmetrically.

2.1 Households

Each country's economy is populated by a continuum of households on the interval $[0, 1]$ of which a fraction μ is non-savers and a fraction $1 - \mu$ is savers. Superscript S indicates a variable associated with savers, and N to non-savers.

Savers. An optimizing saver household that supplies the differentiated labor input of type j, $L_t^S(j)$, derives utility from composite consumption $\tilde{C}_t^S(j) \equiv C_t^S(j) + \alpha_G G_t$, where $C_t^S(j)$ is private consumption and G_t is public consumption. Parameter α_G governs the degree of substitutability of the consumption goods: when $\alpha_G < 0$, private and public consumption are complements; when $\alpha_G > 0$, they are substitutes. The household values consumption relative to a habit stock defined in terms of lagged aggregate consumption of savers, $\tilde{C}_{t-1}^S$. Thus, savers' period utility function is given by $\mathcal{U}_t^S = \left[\ln\left(\tilde{C}_t^S(j) - \tilde{C}_{t-1}^S\right) - \frac{L_t^S(j)^{1+\xi}}{1+\xi}\right]$, where ξ is the inverse of the Frisch labor elasticity.

Savers accumulate a stock of physical capital $\bar{K}_t^S$. This stock of capital depreciates at rate δ and accrues with investment I_t^S, net of adjustment costs. It follows the law of motion $\bar{K}_t^S(j) = (1-\delta)\bar{K}_{t-1}(j) + \left[1 - s\left(\frac{I_t^S(j)}{I_{t-1}^S(j)}\right)\right] I_t^S(j)$, where s indicates an investment adjustment cost function that satisfies the properties $s(e^\gamma) = s'(e^\gamma) = 0$ and $s''(e^\gamma) \equiv s > 0$. Effective capital K is the share of physical capital stock that households decide to rent to the domestic intermediate firms at price R_t^K and is denoted by $\bar{K}$. In symbols, $K_t^S(j) = v_t(j)\bar{K}_{t-1}^S(j)$, where $v_t(j)$ is the utilization rate of capital. This utilization incurs a cost of $\Psi(v_t)$ per unit of physical capital. Given the steady-state utilization rate v =1 and $\Psi(1) = 0$, the function Ψ has the following properties: $\Psi'(1) = 0$ and $\frac{\Psi''(1)}{\Psi'(1)} = \frac{\psi}{1-\psi}$, where $\psi \in [0, 1)$. Rental income on effective capital is taxed at the rate τ_t^K.

Savers have access to a complete set of contingent claims, $B_{s,t+1}$, traded across the currency union, and priced using the stochastic discount factor $Q_{t,t+1}$, which is common across the union. Notice that $E_t[Q_{t,t+1}] = \frac{1}{R_t}$, where R_t is the interest rate used by the central bank as its monetary policy instrument and is the gross return on a one-period risk-free bond.[1]

The long-term debt issued by the national government is a zero-coupon bond whose maturity decays at the constant rate $\rho \in [0, 1]$ to yield the duration $(1 - \beta\rho)^{-1}$, where β is the discount rate. Analogously, Eurobonds are modeled as zero coupon bonds whose maturity decays at the constant rate $\rho^{EA} \in [0, 1]$ to yield the duration $(1 - \beta\rho^{EA})^{-1}$.

Savers receive after-tax wage and rental income, lump-sum transfers from the national government, Z^S, lump-sum transfers from the EA fiscal authority, $Z^{S,EA}$ and profits from firms, D. Wage and rental income are taxed at rate τ_t^L and τ_t^K, respectively, by the national government. The centralized fiscal authority taxes these incomes at rates $\tau_t^{EA,L}$ and $\tau_t^{EA,K}$. Consumption is also taxed by the he national governments and the EA fiscal authority at rate τ_t^C and $\tau_t^{EA,C}$, respectively. They spend income on consumption C^S, investment in future capital, I^S, state-contingent assets, national bonds, and Eurobonds. The nominal flow budget constraint for saver j in the state l is

$$\begin{aligned} &P_t^C(1 + \tau_t^C + \tau_t^{EA,C})C_t^S + P_t^C I_t + E_t\left(\frac{Q_{t,t+1}B_{t+1}^{SC}(j)}{\epsilon_t^{rp}}\right) + P_t^B B_t + P_t^{B,EA}B_t^{EA} \\ &= B_t^{SC}(j) + (1 + \rho P_t^B)B_{t-1} + (1 + \rho P_t^{B,EA})B_{t-1}^{EA} + (1 - \tau_t^L - \tau_t^{EA,L})W_t(j)L_t^S(j) \\ &+(1 - \tau_t^K - \tau_t^{EA,K})R_t^K v_t \bar{K}_{t-1}^S - \psi(v_t)\bar{K}_{t-1}^S + P_t^C Z_t + P_t^C Z_t^{EA} + D_t. \end{aligned} \tag{1}$$

where the variable P_t^B denotes the price of domestic long-term nominal government bonds B_t and the variable $P_t^{B,EA}$ denotes the price of Eurobonds B_t^{EA}. $B_{t+1}^{SC}(j)$ is a random variable that denotes the state contingent payoff of the portfolio of financial securities held by households of type j at the beginning of period $t + 1$ and $Q_{t,t+1}$ is the stochastic discount factor that prices these payoffs in period t.

The shock ϵ_t^{rp} is called risk premium shocks as in Smets and Wouters (2007). It follows an AR(1) process and is meant to capture a wedge between the interest rate controlled by the central bank and the return to the assets held by the households. P_t^C is the competitive

[1]Under the assumed structure for financial markets, a one-period risk free bond is obtained as a portfolio of state-contingent securities that pays off one unit of currency in each state of the world with certainty.

price of the final good consumed in the country.

Savers maximize lifetime discounted utility $E_t \sum_{t=0}^{\infty} \beta^t \mathcal{U}_t^S$ subject to the sequence of budget constraints in equation (1).

Non-Savers. Non-savers have the same preferences as savers but, since they cannot trade assets, they end up consuming all their disposable income in every period, which consists of after-tax labor income, lump-sum transfers Z^N from the national government, and lump-sum transfers from the EA fiscal authority, $Z^{N,EA}$. It is assumed that the hand-to-mouth households supply differentiated labor services, and set their wage to be equal to the average wage that is optimally chosen by the savers, as described below. Using the superscript N to indicate the non-saving, hand-to-mouth households, their budget constraint can be written as follows:

$$P_t^C(1+\tau_t^C+\tau_t^{EA,C})C_t^N = (1-\tau_t^L-\tau_t^{EA,L}) \int_{\mu}^{1} W_t(j)L_t^N + P_t^C Z_t + +P_t^C Z_t^{EA},$$

where it is assumed that both savers and non-savers face the same tax rates on consumption and labor income. We drop the subscript j because nonsavers solve the same decision problem. Note that transfers from the national government and the EA fiscal authority are assumed to be the same across types of households.

2.2 Final goods producers

Final goods producers produce a non-tradable consumption good Q_t^C by combining a bundle of domestically produced intermediate goods C_t^H with a bundle of imported foreign intermediate goods C_t^F via the technology:

$$Q_t^C = \left[(1-\nu_c)^{\frac{1}{\mu_c}} C_t^{H\frac{\mu_c-1}{\mu_c}} + \nu_c^{\frac{1}{\mu_c}} C_t^{F\frac{\mu_c-1}{\mu_c}}\right]^{\frac{\mu_c}{\mu_c-1}}, \tag{2}$$

where $\mu_C > 0$ is the elasticity of substitution between home and foreign goods, while $\nu_C \in [0,1]$ determines the relative preference that a country has for foreign goods over domestic ones. Home and foreign intermediate goods bundles are combined using CES technologies:

$$C_t^H = \left[\int_0^1 C_t^H(i)^{\frac{1}{1+\eta_p}} di\right]^{1+\eta_p} \quad \text{and} \quad C_t^F = \left[\int_0^1 C_t^F(i^*)^{\frac{1}{1+\eta_{p,x}}} di^*\right]^{1+\eta_{p,x}}$$

where i and i^* are indices of intermediate goods produced domestically or abroad, respectively, and $\eta_p > 0$ is the elasticity of substitution between the differentiated goods, which is assumed to be the same in both countries.

The final good producers first choose the optimal mix of differentiated output from firms

i and i^* via cost minimization. This implies the following demands for the domestically produced and imported intermediate goods i and i^* by the final goods producer:

$$C_t^H(i) = \left(\frac{p_t(i)}{P_t}\right)^{-\frac{1+\eta_p}{\eta_p}} C_t^H \quad \text{and} \quad C_t^F(i^*) = \left(\frac{p_t(i^*)}{P_t^*}\right)^{-\frac{1+\eta_p}{\eta_p}} C_t^F,$$

where $p_t(i)$ and $p_t(i^*)$ denote the price set by the intermediate goods firms producing the variety i and i^*, respectively. P_t and P_t^* denote the price index of the the intermediate goods produced domestically and abroad, respectively.

Final goods producers then choose the mix of domestically produced and imported intermediate goods by minimizing costs subject to the technology in equation (2). We obtain

$$C_t^H = (1-\nu_C)\left(\frac{P_t}{P_t^C}\right)^{-\mu_C} Q_t^C \quad \text{and} \quad C_t^F = \nu_C\left(\frac{P_t^*}{P_t^C}\right)^{-\mu_C} Q_t^C,$$

where

$$P_t^C = \left[(1-\nu_c){P_t}^{1-\mu_c} + \nu_c {P_t^*}^{1-\mu_c}\right]^{\frac{1}{1-\mu_c}}.$$

2.3 Intermediate goods firms

Firm i's intermediate output $y_t^H(i)$ is demanded by the domestic final goods producer and the foreign final goods producer. Since the intermediate good is sold to these producers in the same market, the producers will pay the same price. This market structure presumes that the the law of one price holds, so that the price of a given variety (i or i^*) is the same in both countries.[2] It then follows that the total demand for domestically produced intermediate good i is

$$y_t(i) = \left(\frac{p_t(i)}{P_t}\right)^{-\frac{1+\eta_p}{\eta_p}} (Y_t^H + Y_t^{H^*}), \tag{3}$$

where $\eta_p > 0$, $p_t(i)$ is the price charged by firm i, Y_t^H is the aggregate domestic demand for domestically produced intermediate goods and $Y_t^{H^*}$ is the aggregate foreign demand of domestically produced intermediate goods (i.e., export of domestically produced intermediate goods), and P_t is the aggregate index of all the domestically produced intermediate goods.

Each firm i produces with a Cobb-Douglas technology, $Y_t(i) = K_t(i)^\alpha (A_t L_t(i))^{1-\alpha} - A_t\Omega$,

[2] This assumption is known as Producer Currency Pricing (PCP) in contrast with the Local Currency Pricing (LCP), where each variety's price is set separately for each country and quoted (and potentially sticky) in that country's local currency. Thus, the law of one price does not necessarily hold. It has been shown by Devereux and Engel (2003) that LCP and PCP may have different implications for monetary policy, but since we study a currency union, the type of pricing should not matter.

where $\alpha \in [0,1]$ and $\Omega > 0$ represents fixed costs of production that grow at the rate of the technological progress. The term A_t is a permanent shock to technology. The logarithm of its growth rate, $u_t^a = \ln A_t - \ln A_{t-1}$, follows the stationary AR(1) process $u_t^a = (1-\rho)\gamma + \rho u_{t-1}^a + \epsilon_t^a$, $\epsilon_t^a \sim N(0, \sigma_a^2)$, where γ defines the logarithm of the steady-state gross growth rate of technology.

Price setting in the intermediate goods markets is subject to a lottery a la Calvo. This assumption implies that only a fraction $(1-\omega_p)$ of intermediate firms are allowed to reoptimize their price. Firms that cannot reoptimize partially index their last period's price $p_{t-1}(i)$ to past inflation according to the weighted geometric average of past inflation in the domestically-produced intermediate goods, $\pi_{t-1} \equiv \frac{P_{t-1}}{P_{t-2}}$, and the steady-state inflation rate in the domestically-produced intermediate goods, π. The weight associated with the past inflation rate controls the degree of price indexation and is denoted by χ_p. Intermediate goods firms that are allowed to reoptimize, choose their price in period $\tilde{p}_t(i)$ so as to maximize the expected discounted stream of profits. Formally,

$$E_t \sum_{s=0}^{\infty} (\beta\omega_p)^s \frac{\lambda_{t+s}}{\lambda_t} \left[\left(\Pi_{k=1}^{s} (\pi_{t+k-1})^{\chi_p} (\pi)^{1-\chi_p} \right) \left(\tilde{p}_t(i) - MC_{t+s} \right) Y_{t+s}(i) \right],$$

subject to equation (3), where λ_t denotes savers' marginal utility of consumption.

2.4 Wage setting

We assume that both savers and non-savers households are monopoly suppliers of a unit measure of differentiated labor service, indexed by l. In every period, a fraction $(1-\omega_w)$ of saver households get the opportunity to optimally readjust the wage rate at which they sell their differentiated labor service. If the wage cannot be reoptimized, it will be increased at the geometric average of the steady-state rate of inflation and of last period inflation according to the rule: $W_t(l) = W_{t-1}(l)(\Pi_{t-1}e^{\gamma})^{\chi_w}(\Pi e^{\gamma})^{1-\chi_w}$, where χ_w captures the degree of nominal wage indexation. Each differentiated labor service is supplied by both savers and non-savers, and demand is uniformly allocated among households. Non-savers set their wage to be the average wage of the savers.

A perfectly competitive labor packer purchases the differentiated labor inputs, $L_t(l)$, sold by savers and nonsavers households and assembles them to produce a composite homogeneous labor service, L_t, using the packaging technology $L_t = \left[\int_0^1 L_t(l)^{\frac{1}{1+\eta_w}} dl \right]^{1+\eta_w}$, where η_w denotes the degree of substitutability among labor types. The labor packer sells the composite homogeneous labor input to the intermediate goods firms at the competitive price W_t. The static cost minimization problem yields the demand function for each type of labor $L_t(l) = L_t \left(\frac{W_t(l)}{W_t} \right)^{-\frac{1+\eta_w}{\eta_w}}$.

2.5 Policymakers

We denote the debt-to-GDP ratio of each country as the market value of outstanding national debt divided by the national GDP: $s_{b,t} = \frac{P_t^B B_t}{P_t^C Y_t}$. Similarly, we denote the debt-to-GDP ratio of the EA as the market value of outstanding Eurobonds divided by the EA GDP: $s_{b,t}^{EA} = \frac{P_t^{B,EA} B_t^{EA}}{P_t^{EA} Y_t^{EA}}$. In what follows, hatted variables denote percentage deviations from the steady state.

National fiscal authority. Each national government collects tax revenues from capital, labor, and consumption taxes, and sells the nominal bond portfolio, B_t, to finance its interest payments and expenditures, G_t, Z_t^S, Z_t^N. The budget constraint of the national government in the home economy (i.e., the economy of the country we have described in the previous sections) is:[3]

$$P_t^B B_t + \tau_t^K R_t^K K_t + \tau_t^L W_t L_t + P_t^C \tau_t^C C_t = (1 + \rho P_t^B) B_{t-1} + P_t^C G_t + P_t^C Z_t. \tag{4}$$

The foreign country national government's budget constraint is analogously defined. The home country national fiscal authority follows the fiscal rules below, which we linearize around the steady state – hatted variables denote log-deviations from steady state:

$$\hat{\tau}_t^J = \rho^J \hat{\tau}_{t-1}^J + (1 - \rho^J)\gamma^J \hat{s}_{b,t-1}, \tag{5}$$

$$\hat{g}_t = \rho^G \hat{g}_{t-1} - (1 - \rho^G)\gamma^G \hat{s}_{b,t-1} \tag{6}$$

$$\hat{z}_t = \rho^Z \hat{z}_{t-1} - (1 - \rho^Z)\gamma^Z \hat{s}_{b,t-1} - (1 - \rho^Z)\phi^Y \hat{y}_{t-1} \tag{7}$$

where $J \in \{C, L, K\}$ and $\hat{s}_{b,t}$ is the debt-to-GDP ratio of the home country. The fiscal rules for the national government of the foreign country is analogously defined. The rule for fiscal transfers, $\hat{z}_t$, incorporates an automatic stabilizer component as it also reacts to output. The parameters $\gamma^J, \gamma^G, \gamma^Z, \phi^Y \geq 0$ capture the strength of the fiscal response to debt ratios and output.

EA policymakers. The EA fiscal authority collects tax revenues from capital, labor, and consumption taxes in both countries and issues Eurobonds, B_t^{EA}, to finance its interest payments and its expenditures, $Z_t^{EA} + G_t^{EA}$. The budget constraint of the EA fiscal authority is

[3] In this draft fiscal and monetary rules are shown in log-linear deviations from steady state. But this is done for convenience of exposition. It is straightforward to back out the nonlinear rules.

as follows:

$$
\begin{aligned}
P_t^{B,EA} B_t^{EA} + \tau_t^{EA,K}(R_t^K K_t + R_t^{K*} K_t^*) + \tau_t^{EA,L}(W_t L_t + W_t^* L_t^*) \\
+\tau_t^{EA,C}(P_t^C C_t + P_t^{C*} C_t^*) = (1 + \rho P_t^{B,EA}) B_{t-1}^{EA} + P_t^C Z_t^{EA} + P_t^{C*} Z_t^{EA*},
\end{aligned} \tag{8}
$$

where $C_t = \int_0^1 C_t(j)dj = (1-\mu)C_t^S + \mu C_t^N$ denotes aggregate consumption in the home economy (i.e., the economy of the country we have described in the previous sections) and the variable with the superscript $*$ denotes variable in the foreign economy (i.e., the economy that is symmetrical to the one we have described in the previous sections). The EA fiscal authority has four fiscal instruments that can be used to stabilize the debt: transfers, Z_t^{EA}, consumption taxes, $\tau_t^{EA,C}$, labor income taxes $\tau_t^{EA,L}$, and capital income taxes, $\tau_t^{EA,K}$. As shown in the households' budget constraints, the EA taxes are also distorsive and are additive to national taxes.

How the EA fiscal authority adjusts its fiscal tools to repay the stock of Eurobonds depends on the fiscal arrangements as it will be clarified in the next sections. Assuming that the EA authority has the power of levying taxes on households is not critical for our results. We could have assumed that the national government transfers part of their tax revenues to the EA fiscal authority to repay Eurobonds. What is critical is that the fiscal regime used to stabilize Eurobonds may be different from that used to stabilize the national government.

The EA monetary authority sets the EA interest rate R_t, which is the interest rate of the risk-free asset, so as to respond to the EA inflation rate $\pi_t^{EA} = \pi_t^{\frac{1}{2}} \pi_t^{*\frac{1}{2}}$ and the EA output $y_t^{EA} = y_t^{\frac{1}{2}} y_t^{*\frac{1}{2}}$. The EA monetary policy may be constrained by the ZLB. The exact specification of the EA monetary authority's reaction function depends on the monetary framework in place, on which more details will be provided in what follows.

2.6 Monetary and Fiscal Arrangements

We study three different scenarios for the monetary and fiscal policy mix. First, we study *Fiscal Discipline*. National governments raise taxes and cut expenditures to stabilize their national debt and Eurobonds are also backed by future fiscal adjustments.[4] Monetary authority is active. *Fiscal Discipline* describes quite closely the pre-pandemic monetary and fiscal framework with the addition of the Eurobonds. The second case is the *Emergency Budget*, in which the national fiscal authorities are still responsible for the national debts, but a share of Eurobonds resulting from a large recession is not backed by future fiscal adjustments. The monetary authority follows passive policy with respect to the increase in inflation needed to

[4]We assume that the EA fiscal authority makes these adjustments. However, this is not essential. We could write a model in which Eurobonds are repaid with fiscal adjustments decided by the national fiscal authorities and our results would be unchanged.

stabilize the amount of Eurobonds accumulated in response to the large recession, while it is otherwise active. Third, we consider a situation in which the fiscal authority of the high-debt country refuses to comply with fiscal discipline and unilaterally disregards debt stabilization. This scenario, which we call *Conflict*, could arise if fiscal discipline were not economically or politically sustainable.

Fiscal Discipline. Under the *Fiscal Discipline* scenario, all three fiscal authorities, i.e. the two national and the EA fiscal authorities, are committed to stabilize the debt-to-GDP ratios by raising taxes and cutting expenditures. Specifically, the national governments follow the rules in equations (5)-(7) with the parameters that govern the response to last period's debt (γ^G, γ^Z, and $\gamma^J > 0$) satisfying the stability of the national debt in both countries.

At the EA level, the rules governing the fiscal tools are the same as those followed by the two national governments; that is,

$$\hat{z}_{EA,t} = \rho^Z \hat{z}_{EA,t-1} - (1-\rho^Z)\gamma^{EA,Z} \hat{s}^{EA}_{b,t-1} - (1-\rho^Z)\phi^Y \hat{y}^{EA}_{t-1} \tag{9}$$

$$\hat{\tau}^J_{EA,t} = \rho^J \hat{\tau}^J_{EA,t-1} + (1-\rho^J)\gamma^{EA,J} \hat{s}^{EA}_{b,t-1}, \tag{10}$$

where $J \in \{C, L, K\}$. Under *Fiscal Discipline* the parameters governing the response to last period's debt ($\gamma^{EA,Z}$ and $\gamma^{EA,J} > 0$) satisfy the stability of the EA debt.

At the same time, the monetary authority follows the rule

$$\hat{R}_t = \max\left\{ -\ln R^*, \rho_r \hat{R}_{t-1} + (1-\rho_r)\left[\phi_\pi \hat{\pi}^{EA}_t + \phi_y \hat{y}^{EA}_t\right] \right\}, \tag{11}$$

where $\hat{\pi}^{EA}_t = \frac{1}{2}\hat{\pi}_t + \frac{1}{2}\hat{\pi}^*_t$ and $\hat{y}^{EA}_t = \frac{1}{2}\hat{y}_t + \frac{1}{2}\hat{y}^*_t$.[5] Under *Fiscal Discipline*, the Taylor principle is satisfied, $\phi_\pi > 1$. However, the monetary authority's ability to maneuver the nominal interest rate can become constrained by the zero lower bound.

Emergency Budget. Under the *Emergency Budget* scenario, EA policymakers modulate their policy mix to weather the adverse consequences of a recessionary shock. The recessionary shock in question is the risk-premium shock ϵ^{rp}_t, which typically plays a leading role in explaining recessions in estimated DSGE models (e.g., Smets and Wouters 2007). This shock hits both countries of the EA symmetrically.

The core of this strategy is that the EA fiscal authority does not commit to carry out any fiscal action to stabilize the increase in Eurobonds resulting from the economic contraction

[5] We assume that the two countries are equally sized, hence the EA inflation and output are an equally weighted average of the two countries' CPI inflation and output.

owing to this large recessionary shock. At the same time the EA monetary authority is not committed to raise the interest rate to fight the increase in inflation needed to stabilize the increase in Eurobonds resulting from the economic contraction owing to this large recessionary shock. They, however, do not change their policy mix in response to the economic consequences of any of the other shocks. Thus, with respect to all other shocks a monetary-led policy mix is in place, as under Fiscal Discipline. National fiscal authorities are committed to stabilize their fiscal imbalances pursuing Ricardian policies in all contingencies.

The *Emergency Budget* policy mix causes an increase in inflation expectations commensurate to the need to stabilize the share of Eurobonds issued to combat the recession. Higher inflation expectations lower the real interest rate, making the *Emergency Budget* strategy particularly appealing to combat a recession in which monetary policy is constrained by the ZLB.

Under the *Emergency Budget* policy mix, the EA fiscal authority adjusts its fiscal instruments according to the following rules:

$$\hat{z}_{EA,t} = \rho_Z \hat{z}_{EA,t-1} - (1-\rho_Z)\left[\gamma_Z^P\left(\hat{s}_{EA,t-1}^P\right) + \gamma_Z^A\left(\hat{s}_{EA,t-1} - \hat{s}_{EA,t-1}^P\right)\right] - (1-\rho_Z)\,\gamma_{ZY}\hat{y}_{EA,t-1} \tag{12}$$

$$\hat{\tau}_{EA,t}^J = \rho_J \hat{\tau}_{EA,t}^J + (1-\rho_J)\left[\gamma_J^P\left(\hat{s}_{EA,t-1}^P\right) + \gamma_J^A\left(\hat{s}_{EA,t-1} - \hat{s}_{EA,t-1}^P\right)\right] \tag{13}$$

where $0 \leq \gamma_Z^A < \beta^{-1} - 1 \leq \gamma_Z^P$ and $0 \leq \gamma_J^A < \beta^{-1} - 1 \leq \gamma_J^P$. These fiscal rules imply that the EA fiscal authority is fiscally responsible only to stabilize the amount of Eurobonds denoted by $\hat{s}_{EA,t}^P$. The EA fiscal authority is not fiscally responsible for the share of Eurobonds exceeding that amount; that is, $\hat{s}_{EA,t} - \hat{s}_{EA,t}^P$. This share of unfunded Eurobonds corresponds to the amount of Eurobonds issued in response to economic consequences of the recessionary shocks, ϵ_t^{rp}. The exact characterization of this share can be obtained by constructing a shadow economy as we will show later. Note that EA transfers, $\hat{z}_{EA,t}$, respond to changes in the EA output, $\hat{y}_{EA,t-1}$. This is one channel through which a recession leads to an increase in the Eurobonds.

The monetary authority agrees to accommodate the increase in inflation necessary to stabilize the emergency budget, $\hat{s}_{EA,t} - \hat{s}_{EA,t}^P$. The monetary rule in this scenario is

$$\hat{R}_t = \max\left\{-\ln R_*, \rho_R \hat{R}_{t-1} + (1-\rho_R)\left[\phi_\pi^A \hat{\pi}_{EA,t}^P + \phi_\pi^P\left(\hat{\pi}_t - \hat{\pi}_{EA,t}^P\right) + \phi_y \hat{y}_{EA,t}\right]\right\}$$

with $0 \leq \phi_\pi^P \leq 1 < \phi_\pi^A$. This rule rests on two additive components defining the rate of inflation in the EA ($\hat{\pi}_{EA,t}$). The first component, $\hat{\pi}_{EA,t}^P$, originates from the typical business cycle shocks and from the shocks to fiscal spending that single countries are committed to stabilize with their fiscal tools. With respect to this component, the Taylor principle applies. The second component, $\hat{\pi}_t - \hat{\pi}^P_{EA,t}$, is the amount of inflation originating from a recessionary shock, ϵ^{rp}_t that affects the EA countries symmetrically. Under the *Emergency Budget* framework, the monetary authority accommodates the rise in this component of inflation with passive policies. It can be shown that the accommodative monetary policy triggers the increase in inflation needed to stabilize the share of Eurobonds the EA fiscal authority is not fiscally responsible for, $\hat{s}_{EA,t} - \hat{s}^P_{EA,t}$.

To sum up, EA policymakers respond to the recession triggered by a symmetric risk-premium shock by increasing spending financed with Eurobonds. No fiscal provision is made by the EA fiscal authority with regard to this share of Eurobonds. Furthermore, with respect to the stabilization of this share of Eurobonds, the monetary authority allows inflation to rise as needed.

From a technical point of view, the *Emergency Budget* scenario requires modeling a shadow economy that keeps track of what the fiscal burden and inflation would have been absent recessionary risk-premium shocks, which trigger the emergency budget (Bianchi and Melosi (2019), Bianchi et al. (2021a)). The shadow economy is by construction identical to the economy (henceforth, the actual economy) except that (i) the risk-premium shocks, ϵ^{rp}_t, are shut down and (ii) the ZLB constraint is not enforced. Both the national fiscal authorities and the EA fiscal authority are assumed to follow Ricardian fiscal policies to stabilize their respective debt in the shadow economy. The EA monetary authority conducts active monetary policy in the shadow economy. Thus, the EA fiscal rules in this shadow economy read:

$$
\begin{aligned}
\hat{z}^P_{EA,t} &= \rho_Z \hat{z}^P_{EA,t-1} - (1-\rho_Z)\,\gamma^P_Z \hat{s}^P_{EA,t-1} - (1-\rho_Z)\,\gamma_{ZY} \hat{y}^P_{EA,t-1} \\
\hat{\tau}^{J,P}_{EA,t} &= \rho_J \hat{\tau}^{J,P}_{EA,t} + (1-\rho_J)\,\gamma^P_J \hat{s}^P_{EA,t-1}
\end{aligned}
$$

where the superscript P denotes variables determined in the shadow economy.

The monetary rule in the shadow economy reads:

$$
\hat{R}_t = \rho_R \hat{R}_{t-1} + (1-\rho_R)\left[\phi^A_\pi \hat{\pi}^P_{EA,t} + \phi_y \hat{y}^P_{EA,t}\right].
$$

Note that the ZLB constraint is not enforced in the shadow economy. This implies that the Eurobonds issued in response to the further deterioration of the economic outlook due to the binding ZLB are not backed by future fiscal adjustments. Rather, this amount of Eurobonds is stabilized through higher inflation accommodated by passive monetary policy.

It should be noted that the shadow economy is an accounting device to keep track of the stock of Eurobonds and inflation that would have arisen if risk-premium recessionary shocks, requiring the activation of an emergency budget, had never hit the economy. In regard to the shadow economy's stock of debt $\hat{s}^P_{EA,t}$ and to the shadow economy's inflation rate, $\hat{\pi}^P_{EA,t}$, EA policymakers follow a mix of Ricardian fiscal policies and active monetary policy.

Conflict. In the third and final scenario, labelled *Conflict* scenario, we consider a situation in which the fiscal authority of the high-debt country refuses to comply with the required fiscal discipline and starts disregarding debt stabilization. This scenario could arise because following fiscal discipline is not economically or politically feasible. We model this deviation from fiscal discipline as a temporary regime change in which the central bank is committed to the Taylor principle, while fiscal policy in the high debt country is active. This situation cannot last forever because it would lead to explosive dynamics. However, this conflict can persist for a while, leading to *temporarily* explosive dynamics, as described in more detailed below.

2.7 Market Clearing

Market clearing in the final-good markets implies $Q_t^C = C_t$. The home country's aggregate resource constraint is $Y_t = C_t^H + I_t + G_t + \psi(v_t)\bar{K}_{t-1} + C_t^{H*}$, where C_t^{H*} indicates the foreign import of domestically produced intermediate goods.

2.8 Zero Lower Bound Constraint and Model Solution

The model is log-linearized around the steady state (transfers and primary surplus are linearized). The zero lower bound constraint is modeled as in Faccini and Melosi (2020). This method allows us to find the certainty-equivalence solution to the temporary non-linear dynamics introduced by the zero lower bond. After having observed past and current shocks, agents update their rational expectations about the duration of the zero lower bound over time. This method entails appending a sequence of anticipated shocks (ZLB shocks) to the unconstrained Taylor rule. These anticipated shocks are known by agents in the current period, but will hit the economy in future periods. The sequence of these shocks is computed so as to ensure that agents expect that the zero lower bound constraint will be satisfied for the next 40 quarters in every period. When the constraint is never expected to become binding, these anticipated shocks are set to zero.

When we simulate the economy under *Fiscal Discipline* or under the *Emergency Budget* case, we check in every period if the ZLB binds. If it does, we solve the fix point over the sequence of current and anticipated ZLB shocks appended to the monetary policy reaction functions. It should be noted that since the ZLB is not enforced in the shadow economy, no fixed point is computed in that economy and the ZLB shocks to enforce the ZLB in the actual economy do not enter the block of equations describing the shadow economy.

Parameter	Description	Value	Target/Source
Preferences			
β	Discount factor	0.999	Annual SS real rate of 1.35%
ξ	Inverse Frisch elasticity	2	Coenen et al. (2013)
θ	Habit in formation	0.59	Coenen et al. (2013)
α^G	Substitutability of private vs. gov. consumption	-0.24	Leeper et al. (2017)
Frictions and technology			
100γ	Steady-state log growth rate of technology	0.25	Leeper et al. (2017)
μ	Share of hand-to-mouth households	0.11	Leeper et al. (2017)
α	Elasticity in production function	0.33	SS share of labour income in total output of 70%
δ	Capital depreciation rate	0.025	Implies annual depreciation of 10%
s	Investment adjustment cost	5.56	Coenen et al. (2013)
ψ	Capital utilization cost	0.16	Leeper et al. (2013)
ω_p	Price Calvo parameter	0.93	Coenen et al. (2013)
ω_w	Wage Calvo parameter	0.78	Coenen et al. (2013)
χ_p	Price indexation	0.38	Coenen et al. (2013)
χ_w	Wage indexation	0.54	Coenen et al. (2013)
η_p	Elasticity of substitution between intermediate goods	0.163	Leeper et al. (2013)
η_w	Elasticity of substitution between labor inputs	0.286	Leeper et al. (2013)
$\nu_{C,IT}$	Degree of openness for IT	0.205	Albonico et al. (2019)
$\nu_{C,DE}$	Degree of openness for DE	0.261	Albonico et al. (2019)
$\mu_{C,IT}$	Elasticity of sub. between IT & DE	1.130	Albonico et al. (2019)
$\mu_{C,DE}$	Elasticity of sub. between DE & IT	1.300	Albonico et al. (2019)

Table 1 – Calibrated values for model parameters.

3 Calibration

Our two-country model is calibrated to Italy and Germany at quarterly frequency. Table 1 reports the calibrated parameters for preferences, technology, and nominal and real frictions. The calibration of these parameters mainly relies on Coenen et al. (2013) and Albonico et al. (2019), which estimate dynamic stochastic general equilibrium models for the EA.

Table 2 reports steady-state calibration targets and policy parameters. The steady-state values of national debt-to-GDP ratios are set to 60%, according to the Maastricht Treaty rules. As Eurobonds have not been issued yet, we calibrate the EA debt-to-GDP ratio to match an annualized value of 7%, in line with the latest proposals of the European Council. Steady state government expenditure-to-GDP ratio is calibrated to match each country quarterly average in 2019, which is 0.187 and 0.205 for Italy and Germany respectively. Debt maturity decay rates are calibrated to target the average maturity of government debt, which is 6.87, 5.94, and 6.6 in Italy, Germany, and the EA respectively.

Parameters related to tax rates are calibrated using the European Commission database on taxes in the EA as described in Appendix B.1. This implies steady-state tax rates on labor, capital and consumption of 19.71%, 29.2%, and 22% for Italy, and 25.2%, 30.6%, and 19% for Germany. The EA values of steady-state tax rates on labor, capital and consumption are set to the value of 3% – as the EA has no power to levy taxes so far, we have calibrated

Parameter	Description	Value	Target/Source
Steady-state calibration targets			
$s_{b,IT}$	Quarterly debt-to-GDP in IT	2.4	Annualized 60%, Maastricht Treaty parameter
$s_{b,DE}$	Quarterly debt-to-GDP in DE	2.4	Annualized 60%, Maastricht Treaty parameter
$s_{b,EA}$	Quarterly debt-to-GDP in EA	0.28	Annualized 7%
$s_{gc,IT}$	Gov. expenditure-to-GDP ratio IT	0.187	Quarterly average in 2019, Eurostat
$s_{gc,DE}$	Gov. expenditure-to-GDP ratio DE	0.205	Quarterly average in 2019, Eurostat
τ^L_{IT}	Steady-state tax rate on labor IT	19.7%	EC, DG Taxation and Customs Union, 2018
τ^L_{DE}	Steady-state tax rate on labor DE	25.2%	EC, DG Taxation and Customs Union, 2018
τ^L_{EA}	Steady-state tax rate on labor EA	3%	
τ^K_{IT}	Steady-state tax rate on capital IT	29.2%	EC, DG Taxation and Customs Union, 2018
τ^K_{DE}	Steady-state tax rate on capital DE	30.6%	EC, DG Taxation and Customs Union, 2018
τ^K_{EA}	Steady-state tax rate on capital EA	22.8%	EC, DG Taxation and Customs Union, 2018
τ^K_{EA}	Steady-state tax rate on capital EA	3%	
τ^C_{IT}	Steady-state tax rate on cons. IT	22%	EC, DG Taxation and Customs Union, 2018
τ^C_{DE}	Steady-state tax rate on cons. DE	19%	EC, DG Taxation and Customs Union, 2018
τ^C_{EA}	Steady-state tax rate on cons. EA	3%	
Debt maturities			
ρ_{IT}	Debt maturity decay rate IT	0.854	Target average maturity of 6.87 in 2019
ρ_{DE}	Debt maturity decay rate DE	0.831	Target average maturity of of 5.94 in 2010
ρ_{EA}	Debt maturity decay rate EA	0.833	Target average maturity of 6.6 in 2010
Fiscal authorities			
ρ^L_{IT}	Persistence of τ^L in IT	0.735	Estimated 2004-2020, EC, DG Taxation & Customs Union
ρ^L_{DE}	Persistence of τ^L in DE	0.735	Estimated 2004-2020, EC, DG Taxation & Customs Union
ρ^L_{EA}	Persistence of τ^L in EA	0.726	Estimated 2004-2020, EC, DG Taxation & Customs Union
ρ^K_{IT}	Persistence of τ^K in IT	0.606	Estimated 2006-2018, EC, DG Taxation & Customs Union
ρ^K_{DE}	Persistence of τ^K in DE	0.662	Estimated 2006-2018, EC, DG Taxation & Customs Union
ρ^K_{EA}	Persistence of τ^K in EA	0.502	Estimated 2006-2018, EC, DG Taxation & Customs Union
ρ^C_{IT}	Persistence of τ^C in IT	0.884	Estimated 2000-2020, EC, DG Taxation & Customs Union
ρ^C_{DE}	Persistence of τ^C in DE	0.833	Estimated 2000-2020, EC, DG Taxation & Customs Union
ρ^C_{EA}	Persistence of τ^C in EA	0.895	Estimated 2000-2020, EC, DG Taxation & Customs Union
ρ^G_{IT}	Persistence of G in IT	0.659	Estimated over 2007-2019, Eurostat
ρ^G_{DE}	Persistence of G in DE	0.365	Estimated over 2007-2019, Eurostat
ρ^Z_{IT}	Persistence of transfers rule	0.785	Estimated over 1996-2019, Eurostat
ρ^Z_{DE}	Persistence of transfers rule	0.636	Estimated over 2002-2019, Eurostat
ρ^{EA}_Z	Persistence of transfers rule	0.880	Estimated over 2002-2019, Eurostat
γ^G	Debt response for G	0.11	IT debt-to-GDP to SS in 15 years
γ^Z	Debt response for transfers	0.11	IT debt-to-GDP to SS in 15 years
γ^L	Debt response for τ^L	0.11	IT debt-to-GDP to SS in 15 years
γ^K	Debt response, for τ^K	0.11	IT debt-to-GDP to SS in 15 years
γ^C	Debt response for τ^C	0.11	IT debt-to-GDP to SS in 15 years
ϕ_Y	Automatic stabilizers	0.11	IT debt-to-GDP to SS in 15 years
Monetary authority			
ϕ_π	Interest rate response to EA inflation	1.89	Coenen et al. (2013)
ϕ_y	Interest rate response to EA output	0.07	Albonico et al. (2019)
ρ_r	Interest rate smoothing	0.88	Coenen et al. (2013)
$\bar{\pi}$	Inflation target	1.90	ECB's target below but close to 2%
Risk Premium Shock			
ρ	Persistence of shock	0.96	Match average EABCN peak-to-trough
σ	Volatility of shock	0.011	Match output volatility over 1999Q1-2019Q4

Table 2 – Calibrated values for model parameters and steady-state targets.

EA steady state tax rates to a low, but not negligible value.[6] The persistence of tax rates is set by estimating their serial autocorrelation over the available time span of the taxation database. The persistence of government expenditure and transfers is estimated in a similar fashion by using data from the European Commission as described in Appendix B.2. As for the parameters that control the response of fiscal variables to debt-to-GDP, we assume that all fiscal instruments are used to stabilize debt. We calibrate γ^G, γ^Z, γ^L, γ^K, γ^C, and ϕ_Y so that the Italian debt-to-GDP ratio, which initially is 134.8%, can be brought back to a level of 60% in fifteen years. Parameters that characterize the behavior of the monetary authority are set following Coenen et al. (2013) and Albonico et al. (2019). The interest rate response to EA inflation and output are set to 1.89 and 0.07 respectively, while the interest rate smoothing parameter is set to 0.88.

The parameters that control the risk premium shock are calibrated as follows. The persistence is set to match the average length of peak-to-trough following the chronology of EA business cycles as identified by the Euro Area Business Cycle network, which corresponds to 5.8 quarters.[7] This results in setting the persistence to 0.96. The volatility of the shock is calibrated so that the volatility of the first principal component of the two countries' output in the model matches the volatility of the first principal component of the Italian and German output over the period 1999Q1-2019Q4.

4 Facing a Recession

We use the model to show how the fiscal/monetary policy mix employed in response to an exceptionally large recessionary shock affects the depth and the length of the recession. In particular, we study how the economy responds to the recessionary shock under the two monetary/fiscal policy mixes described above. The first, which we call *Fiscal Discipline*, assumes that Eurobonds are backed by fiscal provisions, which the currency union fiscal authority credibly commits to. The second, which we call *Emergency Budget*, assumes that no provision is made to back the Eurobonds issued in response to the large recession. Under this scenario, fiscal policy is therefore active at the currency union level. In both fiscal setups, national debt-to-GDP is always assumed to be stabilized by the national fiscal authorities. Thus, fiscal policy is always passive at the national budget level. This implies that countries that want generous welfare programs are still responsible for providing fiscal backing and cannot rely on inflation stabilization. The central bank is generally active, but it accommodates the increase in inflation necessary to stabilize the increase in Eurobonds caused by the recession.

[6]Tax rate on consumption refers to VAT tax rate; tax rate on capital to the implicit tax rate on capital; and tax rate on labor to two components of the implicit tax rate on labor, which are personal income tax and employees' social security contribution.

[7]The chronology can be found at the following link: Euro Area Business Cycles.

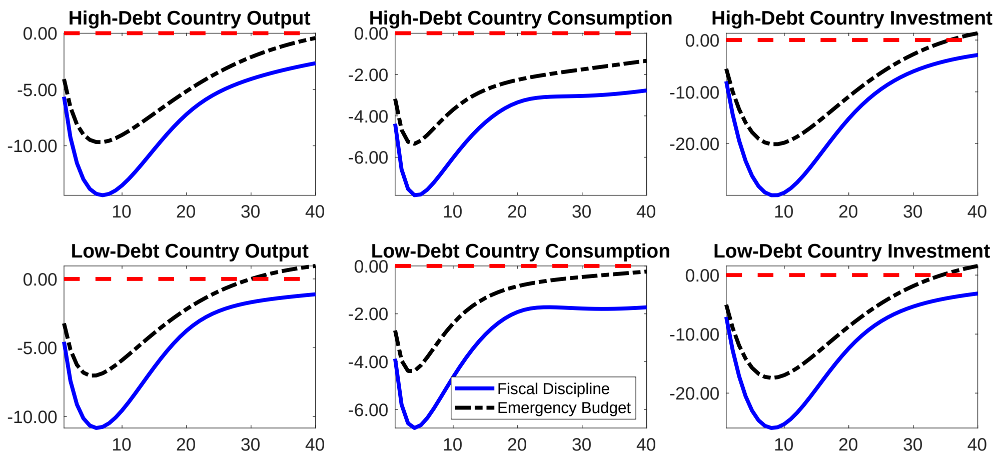


Figure 2 – Output dynamics for the high-debt and the low-debt country under *Fiscal Discipline* or the *Emergency Budget*. GDP is real output expressed in percentage log deviations from its steady state. The periods on the x-axis are quarters.

As explained in the model description above, we maintain the assumption that a Monetary-led policy mix is always in place with respect to small shocks that do not push the economy against the zero lower bound. This means that with respect to these shocks the economy behaves in the same way across the scenarios considered here. The two scenarios only differ in terms of the response to the large contractionary risk shock. Thus, if no large risk shocks were to occur, welfare would be invariant across the two policy combinations. However, as we shall see, the presence of large shocks that can push the economy to the zero lower bound implies that welfare deeply differs across the two policy scenarios. These large contractionary shocks limit the ability of the central bank to effectively stabilize the economy.

Modelling the Recession We initialize the model economy at its steady-state equilibrium, except for the initial values of national debts. These are calibrated to the 2019 level of debt-to-GDP of Italy (134.8%) and Germany (61.9%) respectively. The asymmetry in debt-to-GDP ratios plays an important role in the dynamic response of the economy to the recessionary shock. The recession is modelled as an exogenous risk premium shock to the return on the state-contingent bonds as in Smets and Wouters (2007). This shock is meant to capture a wedge between the interest rate controlled by the central bank and the return to the assets held by households.[8] We will study the dynamic responses to a one and a half standard deviation risk premium shock that hits both countries contemporaneously.

[8]Under given assumptions, this risk premium shock can be microfounded as a liquidity preference shock as shown by Fisher (2015).

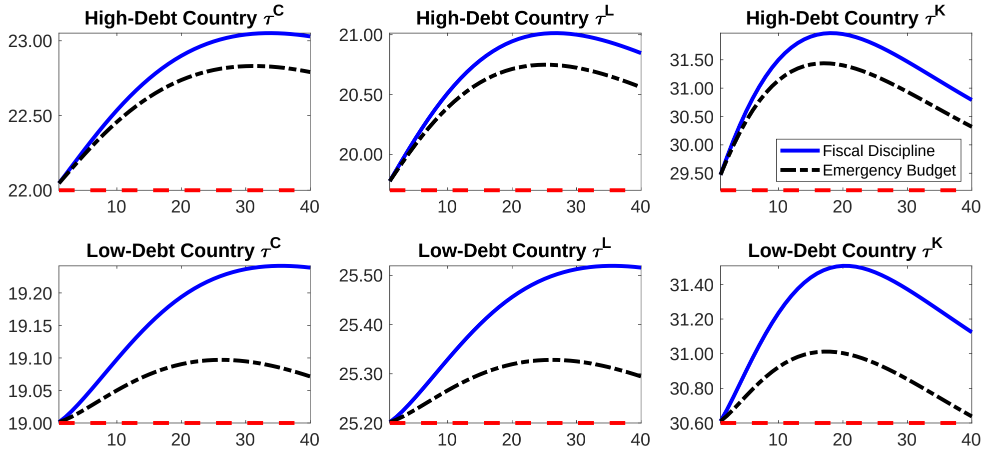


Figure 3 – Fiscal instruments for the high-debt and the low-debt country under *Fiscal Discipline* or the *Emergency Budget*. Tax rates are in percentage points. The periods on the x-axis are quarters.

Fiscal Discipline The responses of the economy to the recessionary shock are shown in Figure 2 – Figure 4. We first describe the dynamics of the model in the case of fiscal discipline (blue solid line). Figure 2 depicts the dynamics of output and its components for the high-debt and the low-debt country. The shock generates a stark recession in both countries, where consumption and investment fall dramatically. The contraction is stronger and more persistent for the high-debt country. These asymmetries are better understood by looking at Figure 3, which exhibits the responses of the fiscal instruments used by the national fiscal authorities to respond to the recession. Under fiscal discipline, the adjustment that the fiscal authority of the high-debt country has to carry out is more significant than the adjustment of the low-debt country. The strong fiscal adjustment of the high-debt country fiscal authority causes a more severe recession in the high-debt country. Nonetheless, the zero lower bound constraint, the presence of distortionary taxation, as well as the trade linkages between the two countries contribute to trigger a deep recession also in the low-debt country.

The required fiscal adjustment is particularly strong in both countries, as the nominal interest rate hits the zero lower bound and the monetary response is constrained, causing a large recession and large debt accumulation. This is what is shown in Figure 4, which depicts the dynamics of the EA variables. The fact that the central bank encounters the zero lower bound exacerbates the recession as the real interest rate is higher than it would be if the central bank could freely lower interest rates. This feature of the model would exist even if we were to introduce unconventional monetary policy as long as unconventional monetary policy is less effective than conventional monetary policy.

In response to the recessionary shock, the debt-to-GDP rises both at the national and

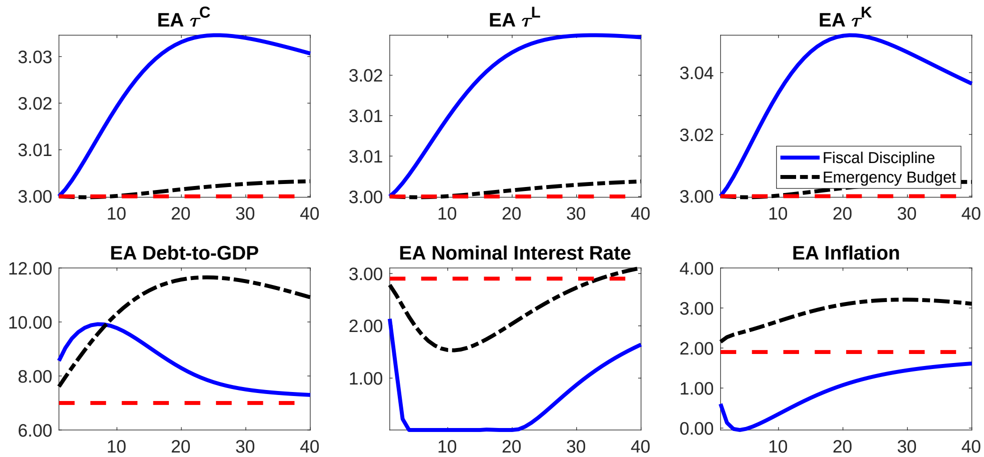


Figure 4 – Macroeconomic dynamics for the EA under *Fiscal Discipline* or the *Emergency Budget*. EA transfers are expressed as percentage of EA GDP. Tax rates are in percentage points. Inflation and the interest rate are expressed in percentage of annualized rates. EA debt-to-GDP ratio is the nominal Eurobonds at the end of the quarter divided by the annualized EA GDP in the quarter. The periods on the x-axis are quarters.

at the EA level. Under fiscal discipline the fiscal adjustment is carried out by stabilizing debt through fiscal adjustments. EA tax rates are raised and transfers are lowered. Both changes have important contractionary effects. The change in tax rates affects the incentives to work, accumulate capital, and consume. The change in transfers have a one-to-one effect on the non-savers consumers. Figure 5 shows the debt-to-GDP ratios of both countries. The recessionary shock generates an initial spike in debt ratios as GDP contracts. After the initial increase over the first quarters, the effects of fiscal stabilization start kicking in and debt ratios gradually fall. While the low-debt country is able to bring its debt ratio back to the steady state in less than ten years, it will take fifteen years and a deeper recession for the high-debt country to fully stabilize its debt.

Eurobonds and Emergency Budget Rules The possibility of issuing Eurobonds does not in itself help alleviating the dire consequences of a recession. If the EA fiscal authority backs Eurobonds by levying taxes and cutting transfers in the same way national fiscal authorities do, the option of issuing Eurobonds on top of the national debt does not make a substantial difference. The output dynamics in the presence or absence of Eurobonds are almost identical, meaning that if the EA fiscal authority mimics the fiscal response of the national fiscal authorities the mere presence of Eurobonds does not help mitigating the recession. In fact, if the cost of stabilizing the Eurobonds were redistributed on the different countries proportionally to their national debt, then the distinction between national and EA

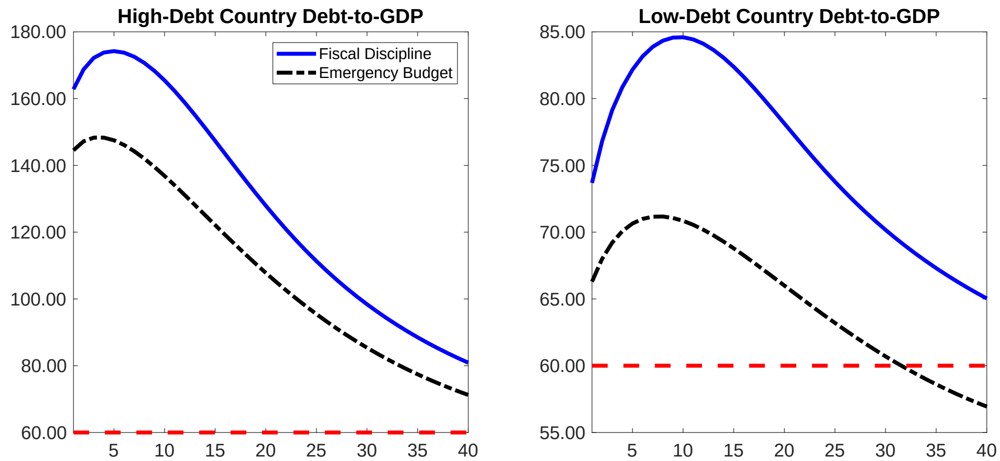


Figure 5 – Macroeconomic dynamics for the high-debt and the low-debt country under *Fiscal Discipline* or the *Emergency Budget*. National debt-to-GDP ratios are national nominal debts at the end of the quarter divided by the annualized national GDP in the quarter. The periods on the x-axis are quarters.

debt would be only a matter of labels.

What makes a substantial difference in addressing the recession is the possibility opened up by Eurobonds of running an EA emergency budget that separates the need for long-run fiscal sustainability from the desire of mitigating a sharp recession. Under the EA emergency budget, the EA fiscal authority does not commit to any provision to cover the increase in the amount of Eurobonds caused by an exceptionally large recession. This means that the increase in EA debt triggered by the recession is not backed by future tax revenues or lower transfers. In the model, this implies setting the parameters γ_J^A and γ_Z^A of the EA fiscal rules (12) and (13) to zero. At the same time, the central bank allows inflation to rise by responding less than one-to-one to the increase in inflation resulting from the need of stabilizing the emergency budget.

The black dotted lines in Figure 2 – Figure 5 show the dynamics of the economy under the EA emergency budget. As exhibited by Figure 2, output in both countries contracts by a lower amount and less persistently than under fiscal discipline. The smaller contraction is accounted for by a smaller decline in both consumption and investment, which is driven by a lower real interest rate. As shown by Figure 4, under the emergency budget inflation is allowed to increase, thus letting the real interest rate fall more than under fiscal discipline, where low inflation and the zero-lower bound on the nominal rate prevent the real interest rate from falling as much. This inflationary pressure allows the central bank to avoid the zero lower bound under the EA Emergency budget.

While the EA fiscal authority adopts an emergency budget, the national fiscal authorities are still committed to stabilize national debt by raising taxes and cutting spending and transfers. This allows the national fiscal authorities to keep national debt ratios at bay, while still relying on the EA emergency budget to face the costs of the recession. Importantly, the mitigation of the pandemic recession that the EA emergency budget is able to attain has some positive effects also on national debt ratios. As displayed in Figure 5, the less severe drop in output contributes to lower national debt ratios and allows for a quicker convergence toward the steady-state values. This result is particularly valuable for the high-debt country, for which a fiscal stabilization is especially painful.

5 A New Monetary and Fiscal Framework

In this section, we analyze more in detail why the traditional policy framework is ineffective in the current economic environment. To do so, we present a simulation exercise under four different scenarios. The goal of this exercise is to highlight that the shortcomings of the current policy framework depend on two key factors. First, the euro area countries do not have a homogeneous fiscal situation. Second, the central bank is constrained by the zero-lower bound. Importantly, we are going to show that in this environment, both low and high debt countries should be in favor of reforming the policy framework to achieve better coordination between the monetary and fiscal authorities.

Inspecting the channels Figure 6 shows the output dynamics in response to a contractionary risk shock under four different scenarios, together with the behavior of the monetary policy interest rate. The first scenario (light blue line with dots) plots the responses of output when the two countries face the same (low) debt ratios and monetary policy is unconstrained. In this case, both countries are implementing fiscal adjustments, but these are small and monetary policy is able to mitigate the recession. Note that we are allowing the nominal interest rate to become negative by a large amount, something that is arguably not possible in reality. The dynamics in the two countries are still slightly different because of different steady-state levels of distortionary taxation, but the differences are minimal.

The second scenario (magenta line with squares) shows the output outcomes when monetary policy is still unconstrained, but one country has a high debt ratio. The recession is more severe for the high debt country because this country needs to implement a larger fiscal adjustment. However, given that monetary policy is unconstrained, we do not observe a large difference with respect to the previous scenario. Importantly, the low debt country suffers a recession that is substantially equivalent to the one experienced in the previous case. Thus, we could argue that when monetary policy is unconstrained, the low debt country might have little interest in rethinking the current policy framework. This is consistent with the fact that

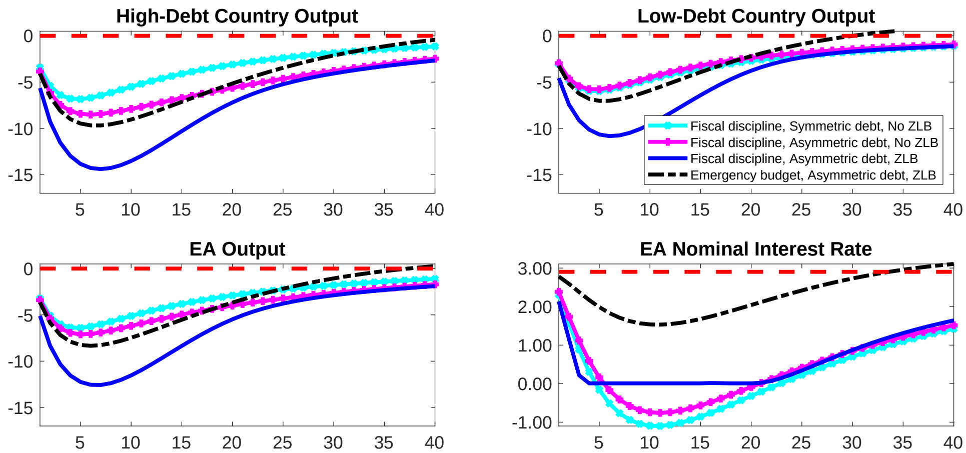


Figure 6 – Macroeconomic dynamics for the high-debt and the low-debt country under four scenarios: 1) *Fiscal Discipline*, symmetric debt, and no ZLB constraint; 2) *Fiscal Discipline*, asymmetric debt, and no ZLB constraint; 3) *Fiscal Discipline*, asymmetric debt, and ZLB constraint; 4) the *Emergency Budget*. The periods on the x-axis are quarters.

the current policy framework was designed during a period of time, the 1990s, during which the main concern was to obtain a convergence of the inflation rates across the different members of the euro area and strong fiscal fundamentals were perceived as necessary to achieve this goal. During those years, the risks of encountering the zero lower bound and of deflation were not at the center of the policy discourse.

The outcomes become quite different for both the low and high debt country once we impose the zero lower bound constraint. This is what is shown in the third scenario (dark blue solid line). Now both countries suffer a much larger recession because they both lose the accommodation of the central bank. The low debt country suffers a smaller recession, but still large nonetheless. In fact, the recession across the two countries is now more similar because the effects of the low interest rate environment dominate the effects of distortionary taxation. In this case, rethinking the policy framework becomes attractive for both countries.

The black dashed line considers our policy proposal. The coordinated policy creates an increase in inflation that lowers the real interest rate and allows the central bank to avoid the zero lower bound. As shown above, the resulting amount of inflation is modest because the goal is to stabilize the debt resulting from the recession, not the entire fiscal burden. Thus, both countries are better off implementing the emergency budget, even if only one of the two countries has a large debt. This is because the present economic environment, with persistently low interest rates, is quite different from the one that was in place when the current policy rules were designed. Both countries have an interest in regaining a fully-functioning monetary policy, especially in light of the constrains on the conduct of fiscal policy.

Welfare implications Table 3 computes inflation and output volatility for both countries and for EA as a whole. We consider the two policy approaches studied above. As explained earlier, these two policy approaches differ only with respect to the response to the risk shocks that can push the economy to the zero lower bound. Instead, policymakers react in the same way to the other shocks hitting the economy, including fiscal spending shocks. Thus, without loss of generality, we focus on the inflation and output volatility caused by the risk shocks.

The Emergency budget policy mix delivers better outcomes for both inflation and output volatility. Given that in NK models the welfare is decreasing in these two variables, we obtain the unambiguous result that welfare improves under the emergency budget policy mix. Thus, our findings differ from Schmitt-Grohé and Uribe (2007), who find that a Monetary-led regime gets closer to the optimal Ramsey solution in NK models, and from Bianchi and Ilut (2017), who show that Fiscally-led regimes generally lead to a more volatile economy because the economy is not insulated with respect to fiscal imbalances. This result might appear surprising at first, but it is in line with the results presented above. The Emergency budget regime acts as an automatic stabilizer that is activated in response to those shocks that make monetary policy ineffective. In the current policy environment a Monetary-led regime is in place with respect to the regular fluctuations, while a Fiscally-led regime, the Emergency budget, is activated only with respect to exceptional events, helping policymakers stabilize the economy once monetary policy reaches the zero lower bound. Thus, the Fiscally-led policy mix reduces the overall volatility because it reduces the severity of large recessions, while preserving the benefits of the Monetary-led policy mix during more modest business cycle fluctuations.[9]

This discussion also elucidates why both countries benefit from moving away from fiscal orthodoxy. The policy prescription is not to abandon long-term fiscal discipline. This policy change would lead to high volatility and a very large increase in inflation, given the current levels of debt for the high-debt countries. Instead, the policy prescription consists of separating the response to the large recession from the long-run policies meant to prevent a return to the high and volatile inflation that affected many European countries before the creation of the euro. This approach also benefits the low-debt country because it remedies the limits of monetary policy in a low interest rate environment.

Why a reform is necessary The recent deterioration of fiscal positions in many large economies has put the governments of the EA at a crossroads. They can follow the old approach of maintaining fiscal discipline irrespective of the causes behind the large fiscal imbalances. Alternatively, they can reform the monetary and fiscal framework of the EA in

[9]Leeper and Zhou (2013) also find that inflation is an effective stabilization tool in the presence of a maturity structure of debt and distortionary taxation.

Volatilities	Fiscal Discipline	Emergency Budget
Euro Area Output	16.797	11.707
Euro Area Inflation	0.617	0.427
High-Debt Country Output	18.103	12.273
High-Debt Country Inflation	0.640	0.426
Low-Debt Country Output	15.516	11.147
Low-Debt Country Inflation	0.640	0.426
ZLB Frequency	0.210	0.089

Table 3 – Volatilities of Output and Inflation for 1000 simulations of 40 periods under *Fiscal Discipline* and *Emergency Budget*.

light of the new challenges that they are facing. In this paper, we study a possible overhaul of the monetary and fiscal framework resting on the introduction of Eurobonds. These bonds play a twofold role. First, Eurobonds provide the EA with a novel stabilization tool to weather future area-wide recessions. This new tool is very valuable in the current low interest rate environment that limits considerably the room of maneuver of monetary policy. Second, Eurobonds allow policymakers to draw a clear line between the amount of debt due to stabilization policies that benefit all countries in the EA and the debt accumulated by national governments to address the specific welfare policies.

Our analysis suggests that for Eurobonds to play this much needed stabilization role for the EA economy, the traditional monetary framework has to be reformed. Monetary policy remains committed to keep inflation low following a normal recession. However, when large recessions happen and monetary policy becomes constrained by the effective lower bound, the monetary authority coordinates with the EA fiscal authority by tolerating a persistent increase of inflation. The size of the reflation is commensurate to the need of repaying the Eurobonds issued to support country members to weather the large recession. The rise in the long-term inflation expectations contrasts the deflationary pressure owing to the proximity to the effective lower bound (the so-called deflationary bias) and allows the monetary authority to have more room to stabilize the economy in the next recession.

The proposal studied in this paper rests on the notion of coordination between the monetary authority and the fiscal authorities of the EA. To avoid threats to the central bank's independence, the amount of Eurobonds that require the persistent increase in inflation should be limited to what strictly necessary to contrast an unusually large recession that limits the ability of the monetary authority to react.

6 Lack of Coordination

The EA emergency budget requires coordination between the EA monetary and fiscal authorities, to avoid an unpleasant scenario. Bianchi and Melosi (2019) show (for the United States) that the lack of coordination between the monetary and fiscal authorities can push the

Parameter	Description	Fiscal Discipline	Emergency Budget	Conflict
ϕ_π	Monetary response to π_{EA}	1.89	0.9	1.89
$\gamma_{J,IT}$	Fiscal response for IT	0.11	0.11	0.001
$\gamma_{J,DE}$	Fiscal response for DE	0.11	0.11	0.11
$\gamma_{J,EA}$	Fiscal response for EA	0.11	0.001	0.11

Table 4 – Parameters of the monetary and fiscal rules under *Fiscal Discipline*, *Emergency Budget*, and *Conflict*.

economy into a spiral of heightened instability and economic stagnation. Suppose that the fiscal authority does not commit to stabilize debt by raising future taxes or cutting transfers, while the central bank is adamant about keeping inflation under control, thus not giving up the Taylor principle. This lack of coordination between the fiscal authority and the central bank has dire consequences on the economy. Under this scenario, the debt-to-GDP grows substantially and the central bank loses control over inflation.

In a currency union the possibility that one single country refuses to implement the necessary fiscal adjustments can trigger similar dynamics. To see this, we model a situation in which the high debt country deviates from fiscal discipline, while the monetary authority remains committed to stabilize inflation. If this situation were to persist forever, no stable solution would exist. However, a solution exists if this conflict between the two authorities is only temporary. In this case, the equilibrium outcomes depend on the expected resolution of the conflict.

The lack of policy coordination between the EA monetary authority and the high-debt country fiscal authority is modeled here by solving a Markov-switching model. In our setup, there are four possible regimes: fiscal discipline, emergency budget, conflict with monetary-led resolution, and conflict with fiscally-led resolution. The first two regimes correspond to the fiscal discipline and the emergency budget cases. The latter two differ in their exit strategy after the period of conflict between the EA monetary authority and the high-debt country fiscal authority. The transition matrix Q between the four regimes is the following:

$$Q = \begin{pmatrix} p^{MM} & 1-p^{FF} & 1-p^{CC} & 0 \\ 1-p^{MM} & p^{FF} & 0 & 1-p^{CC} \\ 0 & 0 & p^{CC} & 0 \\ 0 & 0 & 0 & p^{CC} \end{pmatrix}.$$

Transition probabilities between regimes are calibrated as in Bianchi and Melosi (2019). Thus, $p^{MM} = 0.9902$, $p^{FF} = 0.9932$, and $p^{CC} = 0.9$. The conflict is assumed to last 10 quarters. During the period of conflict, the EA monetary authority remains active in fighting inflation, which implies that the Taylor principle holds. At the same time, the high-debt country fiscal

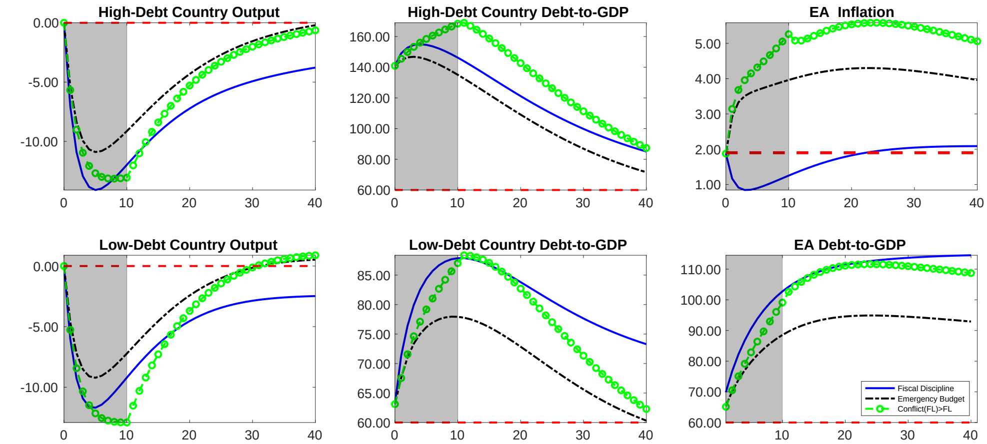


Figure 7 – EA inflation, Eurobonds, high-debt country and low-debt country output and debt dynamics under *Fiscal Discipline*, the *Emergency Budget*, and *Conflict* with fiscally-led resolution between the high-debt country fiscal authority and the EA monetary authority. GDP is real output expressed in percentage log deviations from its steady state. National debt-to-GDP ratios are national nominal debts at the end of the quarter divided by the annualized national GDP in the quarter. EA debt-to-GDP are the nominal Eurobonds at the end of the quarter divided by the annualized EA GDP in the quarter. Inflation is expressed in percentage of annualized rates. The periods on the x-axis are quarters. Shaded areas indicate periods of conflict between the high-debt country fiscal authority and the EA monetary authority.

authority gives up on debt stabilisation. This corresponds to a parameter of the fiscal rule below the stability threshold. We set this parameter to 0.001, which is below, but close to the stability threshold. Table 4 reports the parameters under fiscal discipline, emergency budget, and conflict between the monetary authority and the high-debt fiscal authority.

The macro dynamics under the conflict scenario are shown as the green line in Figure 7, together with the cases analyzed above. The conflict period is denoted with a a gray area and it is eventually followed by a policy change to the Fiscally-led policy mix. Suppose that because of political or economic constraints the high-debt country is unable to implement the necessary fiscal adjustments in response to a large recession. This determines a large increase in the debt-to-GDP ratio for the high-debt country. If markets expect that the central bank will eventually be forced to allow inflation to increase, inflationary pressure arises immediately. The central bank increases rates to contrast inflation, but this determines an economic slowdown with further increase in debt accumulation and inflationary pressure. Both economies experience a vicious spiral of stagnation and debt accumulation. In fact, for the low debt country this scenario is particularly damaging because the country is still following fiscal discipline, but now real interest rates are higher because of the attempt of the central bank to control the inflationary pressure stemming from the fiscal issues in the high-debt country.

Importantly, the possibility of this scenario arising in the future represents a drag on the economy today. The existence of the emergency budget is a way to avoid that beliefs coordinate on such inauspicious scenario. Countries that need fiscal stimulus in response to the recession would still be able to obtain it, while preserving a credible plan for long-run fiscal sustainability.

7 Conclusion

We have introduced a dynamic general equilibrium model to study the role of stabilization policies in a monetary union characterized by low-debt and high-debt countries and by decentralized fiscal policy. Following an adverse shock, the low interest rate environment critically limits the central bank's ability to stabilize the economy in recession. At the same time, the stabilization role of fiscal policy is greatly diminished in the debt-ridden countries by the expectations of future tax increases or expenditure cuts, which are needed to adjust their strained fiscal position. The lack of a stabilization policy in the high-debt country has severe repercussions on the economic performance of the low-debt countries.

We also study a scenario, in which a high-debt country unilaterally refuses to apply the fiscal rules to correct its fiscal position. This scenario is particularly gloomy because it can lead to a spiral of rising interest rate, deeper recession, and rising inflation in every countries of the area. The macroeconomic volatility of the entire area will also increase persistently.

As an alternative, we propose a novel strategy resting on the coordination between the monetary authority and the fiscal authorities. In the wake of a large recession that pushes the policy rate to the zero lower bound, the policy authorities agree on the size of an emergency budget that will be financed by issuing Eurobonds. The central bank tolerates the inflationary pressure resulting from the need to stabilize the stock of Eurobonds. In doing so, policymakers operate a controlled reflation of the EA economy. This strategy leads to a substantially better outcome than the two previous alternatives because it separates the issue of long-term fiscal consolidation from that of short-term need of economic stabilization. The moderate reflation of the economy makes zero lower bound episodes less frequent, restoring monetary policy as a leading economic stabilization tool, and leading to welfare improvements for both high- and low-debt countries.

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A The Log-Linear Model

We list the equilibrium equations of the log-linear model for country 1. The equilibrium equations for country 2 are symmetric unless explicitly stated.

- Production function

$$\hat{y}_{1,t} = \frac{Y_1 + \Omega_1}{Y_1} \left[\alpha \hat{k}_{1,t} + (1-\alpha)\hat{l}_{1,t} \right] \tag{1}$$

- Capital-labor ratio

$$\hat{r}^k_{1,t} - \hat{w}_{1,t} = \hat{l}_{1,t} - \hat{k}_{1,t} \tag{2}$$

- Marginal cost

$$\hat{mc}_{1,t} = \alpha \hat{r}^k_{1,t} + (1-\alpha)\hat{w}_{1,t} \tag{3}$$

- Phillips curve

$$\hat{\pi}^H_t = \frac{\beta}{1+\chi_p\beta} E_t \hat{\pi}^H_{t+1} + \frac{\chi_p}{1+\chi_p\beta}\hat{\pi}^H_{t-1} + \kappa_p(\hat{mc}_{1,t} - \hat{p}^H_t) \tag{4}$$

- Public/private consumption in utility of the household

$$\hat{c}^*_{1,t} = \frac{C^S_1}{C^S_1 + \alpha_G G_1}\hat{c}^S_{1,t} + \frac{\alpha_G G_1}{C^S_1 + \alpha_G G_1}\hat{g}_{1,t} \tag{5}$$

- Saver household's FOC for consumption

$$\hat{\lambda}_{1,t} = \hat{\eta}^p_{1,t} - \frac{e^\gamma}{e^\gamma - \theta}\hat{c}^*_{1,t} + \frac{\theta}{e^\gamma - \theta}\hat{c}^*_{1,t-1} - \frac{\tau^C_1}{1+\tau^C_1+\tau^C_{eu}}\hat{\tau}^C_{1,t} - \frac{\tau^C_{eu}}{1+\tau^C_1+\tau^C_{eu}}\hat{\tau}^C_{eu,t} \tag{6}$$

- Household's FOC for labor

$$\begin{aligned} \hat{w}_{1,t} = {} & \frac{1}{1+\beta}\hat{w}_{1,t-1} + \frac{\beta}{1+\beta}E_t\hat{w}_{1,t+1} \\ & -\kappa_w \left[\hat{w}_{1,t} - \xi \hat{l}_{1,t} + \hat{\lambda}_{1,t} - \frac{\tau^L_1}{1-\tau^L_1-\tau^L_{eu}}\hat{\tau}^L_{1,t} - \frac{\tau^L_{eu}}{1-\tau^L_1-\tau^L_{eu}}\hat{\tau}^L_{eu,t} \right] \\ & + \frac{\chi^w}{1+\beta}\hat{\pi}_{t-1} - \frac{1+\beta\chi^w}{1+\beta}\hat{\pi}_t + \frac{\beta}{1+\beta}E_t\hat{\pi}_{t+1} \end{aligned} \tag{7}$$

- Household's FOC for capacity utilization

$$\hat{r}^k_{1,t} - \frac{\tau^K_1}{1-\tau^K_1-\tau^K_{eu}}\hat{\tau}^K_{1,t} - \frac{\tau^K_{eu}}{1-\tau^K_1-\tau^K_{eu}}\hat{\tau}^K_{eu,t} = \frac{\psi}{1-\psi}\hat{v}_{1,t} + \hat{p}^I_t$$

- Household's FOC for capital

$$\begin{aligned}\hat{q}_{1,t} =& E_t\hat{\lambda}_{1,t+1} - \hat{\lambda}_{1,t} + \beta e^{-\gamma}(1-\tau^K_1-\tau^K_{eu})r^k_1 E_t\hat{r}^K_{t+1} \\ &- \beta e^{-\gamma}\tau^K_1 r^k E_t\hat{\tau}^K_{1,t+1} - \beta e^{-\gamma}\tau^K_{eu} r^k_1 E_t\hat{\tau}^K_{eu,t+1} + \beta e^{-\gamma}(1-\delta)E_t\hat{q}_{1,t+1}\end{aligned} \tag{8}$$

- Household's FOC for investment

$$\frac{1}{s(1+\beta)}\hat{p}^I_t + \hat{i}_{1,t} - \frac{1}{(1+\beta)se^{2\gamma}}\hat{q}_{1,t} - \frac{\beta}{1+\beta}E_t\hat{i}_{1,t+1} = \frac{1}{1+\beta}\hat{i}_{1,t-1} \tag{9}$$

- Effective capital

$$\hat{k}_{1,t} = \hat{v}_{1,t} + \hat{\bar{k}}_{1,t-1} \tag{10}$$

- Law of motion for capital

$$\hat{\bar{k}}_{1,t} = (1-\delta)e^{-\gamma}\hat{\bar{k}}_{1,t-1} + \left[1-(1-\delta)e^{-\gamma}\right]\hat{i}_{1,t} \tag{11}$$

- Euler equation of household

$$\lambda_{1,t} = \hat{R}_t + E_t\hat{\lambda}_{1,t+1} - E_t\hat{\pi}_{t+1} \tag{12}$$

- Risk sharing condition

$$\lambda_{1,t} - \lambda_{2,t} = rer_t \tag{13}$$

- Budget constraint of non savers

$$\begin{aligned}&\tau^C_1 C^N_1\hat{\tau}_{1,t} + \tau^C_{EA}C^N_1\hat{\tau}_{EA,t} + (1+\tau^C_1+\tau^C_{EA})C^N_1\hat{c}^N_{1,t} = (1-\tau^L_1-\tau^L_{EA})w_1L_1(\hat{w}_{1,t}+\hat{L}_{1,t}) \\ &- \tau^L_1 w_1L_1\hat{\tau}^L_{1,t} - \tau^L_{EA}w_1L_1\hat{\tau}^L_{EA,t} + Z_1\hat{z}_{1,t} + Z_{EA}(\hat{z}^{EA}_{1,t} - \hat{p}^{EA}_{1,t})\end{aligned} \tag{14}$$

- Household's aggregate consumption

$$C_1\hat{c}_{1,t} = C^S_1(1-\mu)\hat{c}^S_{1,t} + C^N_1\mu\hat{c}^N_{1,t} \tag{15}$$

- Aggregate resource constraint

$$Y_1\hat{y}_{1,t} = C^H\hat{c}_t^H + C^{H*}\hat{c}_t^{H*} + I_1\hat{i}_{1,t} + G_1\hat{g}_{1,t} + \psi'(1)K_1\hat{v}_{1,t} \tag{16}$$

- Maturity structure of debt

$$\hat{R}_t + \hat{P}_{1,t}^B = \frac{\rho}{R}E_t\hat{P}_{1,t+1}^B \tag{17}$$

- Budget constraint of national government

$$\begin{aligned}
&\frac{B_1}{Y_1}\hat{b}_{1,t} + \tau_1^K r^K\frac{K_1}{Y_1}\left[\hat{\tau}_{1,t}^K + \hat{r}_t^K + \hat{k}_{1,t}\right] + \tau_1^L w\frac{L_1}{Y_1}\left[\hat{\tau}_{1,t}^L + \hat{w}_t + \hat{l}_{1,t}\right] + \tau_1^C\frac{C_1}{Y_1}\left[\hat{\tau}_{1,t}^C + \hat{c}_{1,t}\right]\\
&= \frac{1}{\beta}\frac{B_1}{Y_1}\left[\hat{b}_{1,t-1} - \hat{\pi}_t - \hat{P}_{1,t-1}^B\right] + \frac{B_1}{Y_1}\frac{\rho}{e^\gamma}\hat{P}_{1,t}^B + \frac{G_1}{Y_1}\hat{g}_{1,t} + \frac{Z_1}{Y_1}\hat{z}_{1,t}
\end{aligned} \tag{18}$$

- Maturity structure of Eurobonds

$$\hat{R}_t + \hat{P}_{EA,t}^B = \frac{\rho}{R}E_t\hat{P}_{EA,t+1}^B \tag{19}$$

- EA budget constraint

$$\begin{aligned}
&\frac{B_{EA}}{Y}\hat{b}_{EA,t} + \tau_{EA}^K r^K\frac{K_1}{Y}\left[\hat{\tau}_{EA,t}^K + \hat{r}_{1,t}^K + \hat{k}_{1,t} + \hat{p}_{1,t}^{EA}\right] + \tau_{EA}^K r^K\frac{K_2}{Y}\left[\hat{\tau}_{EA,t}^K + \hat{r}_{2,t}^K + \hat{k}_{2,t} + \hat{p}_{2,t}^{EA}\right]\\
&+ \tau_{EA}^L w\frac{L_1}{Y}\left[\hat{\tau}_{EA,t}^L + \hat{w}_{1,t} + \hat{l}_{1,t} + \hat{p}_{1,t}^{EA}\right] + \tau_{EA}^L w\frac{L_2}{Y}\left[\hat{\tau}_{EA,t}^L + \hat{w}_{2,t} + \hat{l}_{2,t} + \hat{p}_{2,t}^{EA}\right]\\
&+ \tau_{EA}^C\frac{C_1}{Y}\left[\hat{\tau}_{EA,t}^C + \hat{c}_{1,t} + \hat{p}_{1,t}^{EA}\right] + +\tau_{EA}^C\frac{C_2}{Y}\left[\hat{\tau}_{EA,t}^C + \hat{c}_{2,t} + \hat{p}_{2,t}^{EA}\right]\\
=&\frac{1}{\beta}\frac{B_{EA}}{Y}\left[\hat{b}_{EA,t-1} - \hat{\pi}_t^{EA} - \hat{P}_{EA,t-1}^B\right] + \frac{B_{EA}}{Y}\frac{\rho}{e^\gamma}\hat{P}_{EA,t}^B\\
&+ \frac{Z_{EA}}{Y}\hat{z}_{1,t}^{EA}
\end{aligned} \tag{20}$$

- Fiscal rule for G

$$\hat{g}_{1,t} = \rho_G\hat{g}_{1,t-1} - (1-\rho_G)\gamma_G\hat{s}_{b1,t-1} \tag{21}$$

- Fiscal rule for Z

$$\hat{z}_{h,t} = \rho_h^Z\hat{z}_{h,t-1} - (1-\rho_h^Z)\gamma_h^Z\hat{s}_{b_h,t-1} - (1-\rho_h^Z)\phi_h^Y\hat{y}_{t-1} \tag{22}$$

- Fiscal rule for taxes

$$\hat{\tau}^J_{1,t} = \rho_J \hat{\tau}^J_{1,t-1} + (1-\rho_J)\gamma_J \hat{s}_{b1,t-1} \tag{23}$$

- EA fiscal rule for Z

$$\hat{z}_{EA,t} = \rho^Z \hat{z}_{EA,t-1} - (1-\rho^Z)\gamma^Z \hat{s}^{EA}_{b,t-1} - (1-\rho^Z)\phi^Y \hat{y}^{EA}_{t-1} \tag{24}$$

- EA fiscal rule for taxes

$$\hat{\tau}^J_{EA,t} = \rho_J \hat{\tau}^J_{EA,t-1} + (1-\rho_J)\gamma_J \hat{s}_{bEA,t-1} \tag{25}$$

- Monetary policy rule

$$\hat{R}_t = \rho_r \hat{R}_{t-1} + (1-\rho_r)\left[\phi_\pi \hat{\pi}^{EA}_t + \phi_y \hat{y}^{EA}_t\right] \tag{26}$$

- EA inflation

$$\hat{\pi}^{EA}_t = \frac{1}{2}\hat{\pi}_t + \frac{1}{2}\hat{\pi}^*_t \tag{27}$$

- EA output

$$\hat{y}^{EA}_t = \frac{1}{2}\hat{y}_{1,t} + \frac{1}{2}\hat{y}_{2,t} \tag{28}$$

- Final consumption good technology

$$\hat{c}_{1,t} = (1-\nu_C)\hat{c}^H_t + \nu_C \hat{c}^F_t \tag{29}$$

$$\hat{c}_{2,t} = \nu_C \hat{c}^{H*}_t + (1-\nu_C)\hat{c}^{F*}_t \tag{30}$$

- Consumption price index

$$(1-\nu_C)\hat{p}^H_t + \nu_C \hat{p}^F_t = 0 \tag{31}$$

$$\nu_C \hat{p}^{H*}_t + (1-\nu_C)\hat{p}^{F*}_t = 0 \tag{32}$$

- Home demand for imported consumption

$$\hat{c}_t^F = \mu_C \hat{p}_t^F + \hat{c}_{1,t} \tag{33}$$

$$\hat{c}_t^{H*} = \mu_C \hat{p}_t^{H*} + \hat{c}_{2,t} \tag{34}$$

- Home inflation link to the relative price

$$\hat{\pi}_t^H = \hat{\pi}_t + \hat{p}_t^H - \hat{p}_{t-1}^H \tag{35}$$

$$\hat{\pi}_t^{F*} = \hat{\pi}_t^* + \hat{p}_t^{F*} - \hat{p}_{t-1}^{F*} \tag{36}$$

- Combining LCP and foreign import inflation link to relative price

$$\hat{\pi}_t^H = \hat{\pi}_t^* + \hat{p}_t^{H*} - \hat{p}_{t-1}^{H*} \tag{37}$$

$$\hat{\pi}_t^{F*} = \hat{\pi}_t + \hat{p}_t^F - \hat{p}_{t-1}^F \tag{38}$$

- Relative investment price

$$\hat{p}_t^I = \hat{p}_t^H \tag{39}$$

$$\hat{p}_t^{I*} = \hat{p}_t^{F*} \tag{40}$$

- Definition of debt-to-GDP

$$\hat{s}_{1,t} = \hat{b}_{1,t} - \hat{y}_{1,t} \tag{41}$$

$$\hat{s}_{2,t} = \hat{b}_{2,t} - \hat{y}_{2,t} \tag{42}$$

$$\hat{s}_{EA,t} = \hat{b}_{EA,t} - \hat{y}_t^{EA} \tag{43}$$

- Price definitions

$$p_{1,t}^{EA} - p_{1,t-1}^{EA} = \hat{\pi}_t - \hat{\pi}_{EA,t} \tag{44}$$

$$p_{2,t}^{EA} - p_{t-1}^{2,EA} = \hat{\pi}_t^* - \hat{\pi}_{EA,t} \tag{45}$$

$$rer_t - rer_{t-1} = \hat{\pi}_t^* - \hat{\pi}_t \tag{46}$$

B Data Description for the Calibration of Fiscal Parameters

B.1 Taxes

We calibrate the data on tax rates using 'European Commission, DG Taxation and Customs Union, Taxes in Europe database and IBFD data'. This database is the one used to compile 'Taxation Trends in the European Union' (2020). Data on tax rates are available at annual frequency. We interpolate them to get them at quarterly frequency.

τ^C**.** Corresponds to VAT rates, in Table 1 of EC (2020). Sample period 2000-2020.

τ^L**.** Corresponds to the implicit tax rate on labor, Graph 12 in EC (2020). It is made of three components: personal income tax, employees' social security contribution and employers' social security contribution. We only take the first two components. Sample period 2004-2020.

τ^K**.** Corresponds to the overall implicit tax rate on capital, graph 16 for year 2018 and table 4 for years 2006-2018. EU-19 tax rates are simple averages of the tax rates in the EU-19 countries. Sample period 2006-2018.

Steady state values correspond to the tax rates in 2018. The persistence of the fiscal rules is computed to match the autocorrelation of tax rates at quarterly frequency.

B.2 Transfers and Government Expenditure

They are taken from the 'Quarterly non-financial accounts for general government' database in Eurostat.

Transfers. They are 'Social benefits other than social transfers in kind, payable'.

Government Expenditure. It is 'Final consumption expenditure of general government'.

The two series are in nominal terms (million euros). They are transformed in real terms using the GDP deflator. Moreover, to make them correspondent to the model variables they are converted in log per capita term as follows:

$$X = \ln\left(\frac{x}{Popindex}\right) * 100 \tag{47}$$

where

Popindex index of Pop, constructed such that 2015Q3 = 1;

Pop is population from 16 to 64.

The persistence of the fiscal rules is computed to match the autocorrelation of the transformed variables.