Who Is Afraid of Eurobonds?*

Francesco Bianchi† Leonardo Melosi‡ Anna Rogantini Picco§

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Abstract

We build a dynamic general equilibrium model of the Euro Area (EA) to study the consequences of the currently large fiscal imbalances. Stabilization via fiscal adjustments leads to a decade of weak or no economic growth. To avert this dismal scenario, we study a coordinated strategy that separates the need for short-run economic stabilization from the issue of long-run fiscal sustainability. This strategy entails a revision of the monetary framework aiming to achieve a moderate reflation of the EA economy. The magnitude of the reflation is commensurate with the need to stabilize the Eurobonds debt. The ensuing rise in the long-term inflation expectations allows the monetary authority to have more room to stabilize the economy in the next recession. By raising nominal interest rates, this reflation of the EA economy brings back monetary policy as a crucial stabilization tool. These new bonds are issued at the EA level to financially help national governments weather the pandemic crisis. National governments remain responsible to repay their debt through fiscal adjustments. Our analysis suggests that this coordinated strategy allows the EA to achieve several desirable objectives at once: it mitigates the severity of the pandemic recession, boosts the post-pandemic recovery, helps containing the increase in national debt-to-output ratios, preserves long-run fiscal discipline at national level, reduces the frequency and duration of periods in which monetary policy is constrained by the zero lower bound.

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

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*The views in this paper are solely those of the authors and should not be interpreted as reflecting the views of the Federal Reserve Bank of Chicago or any other person associated with the Federal Reserve System, or the Sveriges Riksbank.

†Duke University, CEPR and NBER. E-mail: francesco.bianchi@duke.edu.

‡FRB of Chicago, European University Institute, and CEPR. E-mail: lmelosi@frbchi.org.

§Sveriges Riksbank, Research Division. E-mail: anna.rogantini.picco@riksbank.se.

1 Introduction

The fiscal position of several countries of the Euro Area (EA) has considerably deteriorated in the last decade (Figure 1). The Pandemic crisis has only exacerbated these large national fiscal imbalances. As this crisis will come to an end, the issue of how to stabilize these large national debts is likely to be high in the political agenda. The debate will arguably be more polarized than in the past since more countries have now a large fiscal imbalance. On the other hand, with the nominal interest rates at their historical low, monetary policy has little room to alleviate the economic costs of fiscal adjustments in high-debt countries and in the EA as a whole. This narrow monetary space combined with the need to correct their fiscal imbalance is likely to leave high-debt countries without effective policy tools to stabilize the economy in the next recession.

In this paper, we build a dynamic general equilibrium model of the EA to evaluate three possible post-pandemic scenarios. In the first scenario, the national governments of the EA agree on a set of fiscal rules requiring the large national debts to be stabilized by their respective governments through (distortionary) fiscal adjustments. We show that this scenario is likely to lead to a decade of weak or no economic growth in the EA. Given the large degree of economic integration of the EA, we find that the lack of stabilization tools in debt-ridden EA countries will also significantly impair the ability of low-debt countries' governments to stabilize their economy.

In the second scenario, the polarization of the fiscal debate will reach a point to cause a high-debt country to walk away and refuse to enact the requested fiscal adjustments. In this case, the model predicts that inflation rises in every country even though the central bank tightens monetary policy aggressively in an unsuccessful attempt to combat this inflationary pressure. This scenario leads to the worst outcome for the EA with high-debt countries unilaterally breaking the common fiscal rules, low-debt countries bearing the costs of rising inflation, and the central bank losing control over inflation.

In the third scenario, we study a specific type of coordination between monetary and fiscal policies to achieve better and less risky outcomes. This coordinated strategy has two key elements. First, Eurobonds are issued to finance stabilization policies that benefit the EA as a whole (e.g., to finance the measures needed to combat the Pandemic crisis). Second, the central bank reforms its framework to accommodate the persistent but moderate rise in inflation due to the need to repay the stock of Eurobonds. National governments remain fiscally responsible to repay their own debt. We show that this strategy delivers a better outcome than the other two alternatives by separating the need for short-run economic stabilization from the issue of long-run fiscal sustainability of national debts. By reflating the economy, this strategy also gives monetary policy more room to stabilize the EA economy in recession.

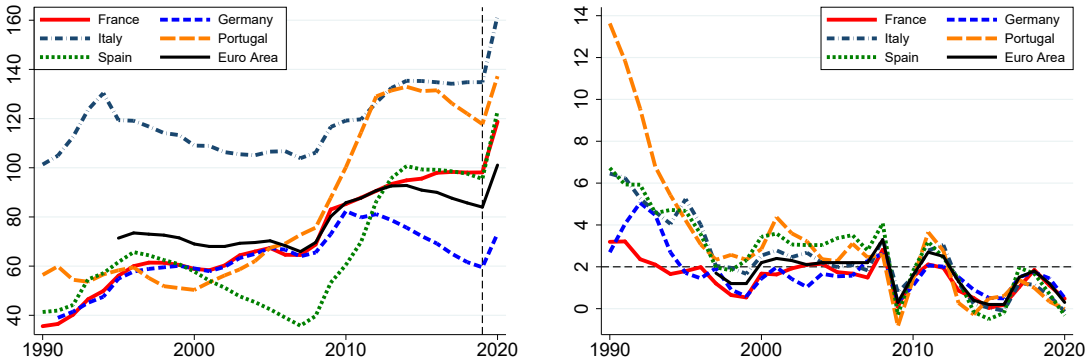
We calibrate the model to two EA countries with a substantially different level of debt-to-GDP ratios: Italy and Germany. The initial debt-to-GDP ratios are calibrated to

match the 2019 levels and we consider a demand-driven recession of typical magnitude for the EA area.

We use the model to evaluate the three scenarios previously discussed. 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*. Under Fiscal Discipline, while the recession is particularly deep for the high-debt country, the low-debt country's economy severely contracts too. This result emerges for two reasons. First, in the calibrated model, the EA economies feature a large degree of interdependence due to their strong trade links. Second, the central bank's inability to alleviate the adverse effects of these fiscal adjustments on the EA economy exacerbates the pass-through to the low-debt economies.

In the second scenario where the high-debt country refuses to implement the necessary fiscal adjustments, a *Conflict* scenario can arise. If the central bank is expected to lose the conflict and to eventually accommodate the increase in inflation needed to stabilize the large debt of the defiant country, inflation rises during the conflict. Consequently, the central bank tightens monetary policy aggressively during the conflict, aggravating the recession and the debt-to-GDP ratio 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. The resulting spiral of monetary tightening-deeper recession-higher inflation causes serious harm to both the high- and low-debt countries. It should be noted that the low-debt country ends up being affected by a higher inflation rate needed to stabilize the fiscal imbalance of the high-debt country. Moreover, this scenario is shown to usher in a prolonged period of heightened macroeconomic volatility for the EA after the conflict.

The third scenario based on using Eurobonds as a coordination device for monetary and fiscal policies is dubbed *Emergency Budget*. The central idea consists of creating a common budget for the EA via the emission of Eurobonds. The resulting debt is used to finance stabilization policies needed to respond to area-wide recessionary shocks (e.g., the pandemic crisis or a severe financial crises in the EA or overseas). Moreover, this common debt clarifies that country-specific fiscal imbalances resulting from past and future decisions of national governments to cut taxes or to increase spending will be repaid by the respective national tax payers. 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 the common budget, which we call the emergency budget, will be addressed by the coordinated monetary and fiscal policy mix. In this coordinated scenario, the monetary authority stands ready to tolerate a persistent increase in inflation needed to stabilize the stock of eurobonds. 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. Importantly, the national fiscal authorities remain responsible to stabilize their own



(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.

debt using their national fiscal instruments as required by the EA fiscal rules, which are inspired by fiscal discipline.

We show that the Emergency Budget improves upon Fiscal Discipline along several dimensions. First, the Emergency Budget mitigates the recession in both countries. Adopting an Emergency Budget at the EA level raises inflation expectations as EA agents understand that Eurobonds will be worn away by higher future prices. These beliefs contribute to lowering real interest rates in both countries, mitigating the recession. Furthermore, agents understand that under the new policy arrangement the common budget, not the national ones, will be the one to bear the brunt of the large recession. Consequently, agents will anticipate less dramatic distortionary fiscal adjustments at the national level, leading to a milder recession and a more robust recovery.

Second, we show that, even if Fiscal Discipline is still maintained at national level, the faster rebound of the economies lowers national debt-to-GDP ratios. This result is particularly valuable for those countries that start with high levels of debt when the recession hits.

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 debt accumulation, calling for a smaller increase in the inflation rate.

Fourth, in a low interest rate environment, in which the ZLB risk is elevated and inflation dynamics is affected by a downward bias, the persistent rise in inflation is beneficial as it brings about a controlled reflation of the EA economy. The resulting increase in the nominal interest rates causes ZLB periods to become less frequent and less likely, thereby improving the central bank's ability to stabilize the economy in the longer run.

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-Grohe and Uribe, 2000; Bassetto, 2002; Reis, 2016; Billi and Walsh, 2021, among many others).

Bianchi and Melosi (2019) have shown 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. A close study to ours is Jarocinski and Mackowiak (2018) who also discuss potential fiscal-monetary interactions to address the EA malaise. 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), by specifically studying the implications of attributing a significant stabilization role to a monetary union's fiscal authority.

The rest of the paper is organized as follows. Section 2 describes the EA model. Section 3 presents our empirical strategy discussing how we calibrate and estimate the model parameters. 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. Section 6 concludes.

2 A Model for the EA

In this section, we present a DSGE model of the EA. The EA is modelled as composed of two countries, which mainly differ for the government debt initially held. One country has an initially high debt-to-GDP ratio (*High Debt Country*), while the other has a close to steady state debt-to-GDP ratio (*Low Debt Country*). Monetary policy is set at EA level by a central bank, which aims at stabilizing the inflation and output gap of the EA. Fiscal policy is set at two levels. National fiscal authorities issue national debt that is stabilized by raising distortionary taxes and lowering transfers and government expenditure. In addition, a EA fiscal authority issues Eurobonds that are normally backed by EA distortionary taxes and changes in EA transfers. The rest of the model is a generalization to a two-country environment of a medium scale general equilibrium model similar to the one employed by Leeper et al. (2017) to study fiscal multipliers in the United States. The latter, in turn, builds on Christiano et al. (2005), featuring a detailed fiscal block with distortionary taxes and hand-to-mouth consumers.

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 j derives utility from composite consumption $C_t^{*S}(j) \equiv C_t^S(j)+\alpha_G G_t$, 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 $\alpha_G > 0$, the goods are substitutes. The household values consumption relative to a habit stock defined in terms of lagged aggregate consumption of savers ($\tilde{C}_{t-1}^{*S}$). Each household j supplies a continuum of differentiated labor inputs $L_t^S(j,l)$, $l \in [0,1]$. The aggregate quantity of these labor services is $L_t^S(j) = \int_0^1 L_t^S(j,l)dl$. Savers' period utility function is given by $\mathcal{U}_t^S = \left[(\ln C_t^{*S}(j) - \tilde{C}_{t-1}^{*S}) - \frac{L_t^S(j)^{1+\xi}}{1+\xi}\right]$, 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 related to the physical capital stock $\bar{K}$ by $K_t^S(j) = v_t(j)\bar{K}_{t-1}^S(j)$, 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]

Savers of each country have also access to a portfolio of long-term nominal government bonds of their country B_t, which sells at price P_t^B in t. Maturity of these zero-coupon bonds decays at the constant rate $\rho \in [0,1]$ to yield the duration $(1-\beta\rho)^{-1}$, where β is the discount rate.

Savers have also access to a portfolio of Eurobonds, B_t^{EA}, which sells at price $P_t^{B,EA}$ in t. Maturity of these zero-coupon bonds 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 government, Z^S , and profits from firms, D. They spend income on consumption C^S, investment in future capital, I^S, on state-contingent assets, national bonds, and Eurobonds. The

[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.

nominal flow budget constraint for saver j is

$$P_t^C(1+\tau_t^C+\tau_t^{EA,C})C_t^S(j)+P_t^I I_t(j)+E_t\left(\frac{Q_{t,t+1}B_{s,t+1}}{\epsilon_t^{rp}}\right)+P_t^B B_t(j)+P_t^{B,EA}B_t^{EA}(j) \quad (1)$$
$$=B_{s,t}(j)+(1+\rho P_t^B)B_{t-1}(j)+(1+\rho P_t^{B,EA})B_{t-1}^{EA}(j)+(1-\tau_t^L-\tau_t^{EA,L})\int_0^1 W_t(l)L_t^S(j,l)dl$$
$$+(1-\tau_t^K-\tau_t^{EA,K})R_t^K v_t(j)\bar{K}_{t-1}^S(j)-\psi(v_t)\bar{K}_{t-1}^S+P_t^C Z_t^S(j)+D_t(j).$$

ϵ_t^{rp} is an exogenous risk premium 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.

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. They have the same preferences as savers. They consume all their disposable income each period, which consists of after-tax labor income and lump-sum transfers Z^N from the government. Like savers, they supply all differentiated labor services. Their budget constraint is as follows:

$$P_t^C(1+\tau_t^C+\tau_t^{EA,C})C_t(j)^N=(1-\tau_t^L-\tau_t^{EA,L})\int_0^1 W_t(l)L_t^N(j,l)dl+P_t^C Z_t^N(j).$$

2.2 Firms and Price Settings

Intermediate goods firms. Each country consists of a continuum of monopolistically competitive intermediate goods firms indexed by $i\in[0,1]$. In the home market, the demand for firm i's output $y_t^H(i)$ is given by

$$y_t^H(i)=\left(\frac{p_t^H(i)}{P_t^H}\right)^{-\frac{1+\eta_p}{\eta_p}}(Y_t^H+Y_t^{H^*}), \quad (2)$$

where $\eta_p>0$, $p_t^H(i)$ is the output price charged by firm i, Y_t^H is the aggregate domestic demand, $Y_t^{H^*}$ is the aggregate foreign import, and P_t^H is the aggregate price index. This formulation presumes that the the law of one price holds, so that the price of a given variety is the same in both countries.[2]

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

[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.

Firms face perfectly competitive factor markets for capital and labor. Cost minimization implies that firms have identical nominal marginal costs per unit of output, given by $MC_t = (1-\alpha)^{\alpha-1}\alpha^{-\alpha}(R_t^k)^{\alpha}W_t^{1-\alpha}A_t^{-1+\alpha}$.

Prices evolve *à la* Calvo. An intermediate firm has a probability of $(1-\omega_p)$ each period to reoptimize its price. Firms that cannot reoptimize partially index their prices to past inflation according to the rule:

$$p_t^H(i) = (\pi_{t-1}^H)^{\chi_p}(\pi^H)^{1-\chi_p}P_{t-1}^H(i),$$

where $\pi_{t-1}^H = \frac{P_{t-1}^H}{P_{t-2}^H}$ and π^H is the steady-state producers' price inflation rate. Firms that are allowed to reoptimize their price in period t maximize expected discounted nominal profits

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

subject to equation 2, where λ_t is the marginal utility of saver households.

Final-good firms. Final-good firms 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:

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

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 combine differentiated output from each domestic firm i and foreign firm i^* via

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

where $\eta_p, \eta_{p,x} > 0$ are related to the intratemporal elasticities of substitution between the differentiated outputs supplied by the home and foreign intermediate firms. The consumption final good firm first chooses optimal amounts of each differentiated output from firms i and i^* via cost minimization, and then chooses the optimal bundles to maximize profits. This implies the following demands for the domestically produced and imported intermediate goods i and i^* by the final private consumption good firm:

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

as well as the following demand for the domestically produced and imported intermediate good bundles by the final private consumption good firm:

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

where

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

2.3 Wages

Households supply differentiated labor services to the intermediate goods producing firms. Each differentiated labor service is supplied by both savers and non-savers, and demand is uniformly allocated among households. A perfectly competitive labor packer purchases the differentiated labor inputs and assembles them to produce a composite labor service, L_t, according to the technology $L_t = \left[\int_0^1 L_t(l)^{\frac{1}{1+\eta_w}} dl\right]^{1+\eta_w}$, where η_w is the wage markup. The labor agency rents labor type $L_t(l)$ at price $W_t(l)$ and sells a homogeneous labor input to the intermediate producer at price W_t. The static profit maximization problem yields the demand function $L_t(l) = L_t\left(\frac{W_t(l)}{W_t}\right)^{-\frac{1+\eta_w}{\eta_w}}$.

It is assumed that savers optimally set their wage while non-savers simply set their wage to be the average wage of the savers. Every period, a saver household gets an opportunity to optimally readjust the wage rate that applies to all of its workers, $W_t(l)$, with probability ω_w. If the wage cannot be reoptimized, it will be increased at the geometric average of the steady state rate of inflation Π and of last period inflation Π_{t-1}, 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.

2.4 Fiscal Authorities

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. Lump- sum transfers are identical across households, so $Z_t = \int_0^1 Z_t(j)dj = Z_t^S = Z_t^N$. The national government budget constraint

is:

$$P_t^B B_t + \tau_t^K R_t^K K_t + \tau_t^L W_t L_t + P_t^C \tau_t^C C_t = (1 + \rho P_t^B) B_{t-1} + P_t^C G_t + P_t^C Z_t. \tag{3}$$

Each national fiscal authority $h \in \{1, 2\}$ follows the fiscal rules below:

$$\hat{\tau}_{h,t}^J = \rho_h^J \hat{\tau}_{h,t-1}^J + (1 - \rho_h^J)\gamma_h^J \hat{s}_{b_h,t-1}, \tag{4}$$

$$\hat{g}_{h,t} = \rho_h^G \hat{g}_{h,t-1} - (1 - \rho_h^G)\gamma_h^G \hat{s}_{b_h,t-1} \tag{5}$$

$$\hat{z}_{h,t} = \rho_h^Z \hat{z}_{h,t-1} - (1 - \rho_h^Z)\gamma_h^Z \hat{s}_{b_h,t-1} - (1 - \rho_h^Z)\phi_h^Y \hat{y}_{t-1} + u_t^Z \tag{6}$$

where $J \in \{C, L, K\}$, $\hat{s}_{b_h,t}$ is the debt-to-GDP ratio at national level, $u_t^Z = \rho_Z u_{t-1}^Z + \epsilon_t^Z$, and $\epsilon_t^Z \sim N(0, \sigma_Z^2)$. The rule for fiscal transfers incorporates an automatic stabilizer component as it also reacts to output. The parameters $\gamma_h^G, \gamma_h^Z, \gamma_h^J, \phi_h^Y \geq 0$ capture the strength of the fiscal response to debt ratios and consumption.

EA fiscal authority. The EA fiscal authority collects tax revenues from capital, labor, and consumption taxes in both countries and sells Eurobonds, B_t^{EA}, to finance its interest payments and expenditures, Z_t. Its budget constraint is as follows:

$$\begin{aligned} P_t^{B,EA} B_t^{EA} + \tau_t^{EA,K}(R_{1,t}^K K_{1,t} + R_{2,t}^K K_{2,t}) + \tau_t^{EA,L}(W_{1,t} L_{1,t} + W_{2,t} L_{2,t}) \\ + P_t^{EA} \tau_t^{EA,C}(C_{1,t} + C_{2,t}) = (1 + \rho P_t^{B,EA}) B_{t-1}^{EA} + P_t^{EA} Z_t, \end{aligned} \tag{7}$$

where $P_t^{B,EA}$ is the price of Eurobonds and P_t^{EA} is the EA price index. The EA fiscal authority follows the fiscal rules below:

$$\hat{z}_{EA,t} = \rho^Z \hat{z}_{EA,t-1} - (1 - \rho^Z)\gamma^Z \hat{s}_{b,t-1}^{EA} - (1 - \rho^Z)\phi^Y \hat{y}_{t-1}^{EA} + u_{EA,t}^Z \tag{8}$$

$$\hat{\tau}_{EA,t}^J = \rho^J \hat{\tau}_{EA,t-1}^J + (1 - \rho^J)\gamma^J \hat{s}_{b,t-1}^{EA}, \tag{9}$$

where $J \in \{C, L, K\}$ and $\hat{s}_{b,t}^{EA}$ is the debt-to-GDP ratio at EA level, $\hat{y}_t = \frac{1}{2}\hat{y}_{1,t} + \frac{1}{2}\hat{y}_{2,t}$ is the EA output, $u_{EA,t}^Z = \rho_Z u_{EA,t-1}^Z + \epsilon_{EA,t}^Z$, and $\epsilon_{EA,t}^Z \sim N(0, \sigma_Z^{EA\,2})$.

2.5 Market Clearing

Aggregate consumption is $C_t = \int_0^1 C_t(j)dj = (1 - \mu)C_t^S + \mu C_t^N$. Market clearing in the final-good markets implies $Q_t^C = C_t$. The home country's aggregate resource constraint is $Y_t = C_t^H + C_t^{H*} + I_t + G_t + \psi(v_t)\bar{K}_{t-1}$.

2.6 Monetary Authority

The monetary authority follows a Taylor rule in which the EA interest rate R_t responds to its lagged value, the EA CPI inflation rate π_t and the EA output. Hatted variables denote percentage deviations from the steady state

$$\hat{R}_t = \max \left\{ -\ln R^*, \rho_r \hat{R}_{t-1} + (1-\rho_r) \left[\phi_\pi \hat{\pi}_t^{EA} + \phi_y \hat{y}_t^{EA} \right] \right\}, \tag{10}$$

where $\hat{\pi}_t^{EA} = \frac{1}{2}\hat{\pi}_{1,t} + \frac{1}{2}\hat{\pi}_{2,t}$ and $\hat{y}_t^{EA} = \frac{1}{2}\hat{y}_{1,t} + \frac{1}{2}\hat{y}_{2,t}$.[3]

2.7 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 introduced following Faccini and Melosi (2020) and Bianchi et al. (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 (dummy 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 60 quarters in every period. When the constraint is never expected to become binding, these anticipated shocks are set to zero.

2.8 Fiscal Discipline and Emergency Budget

We study two fiscal-monetary setups. 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. This implies values of the parameters $\gamma_i^G, \gamma_i^Z, \gamma_i^J > 0$ for the national fiscal rules and $\gamma^G, \gamma^Z, \gamma^J > 0$ for the euro area fiscal rules that are consistent with Ricardian fiscal policy. At the same time, the EA monetary authority follows the Taylor principle and $\phi_\pi > 1$.

Under *Emergency Budget* scenario, the EA fiscal authority does not commit to any fiscal provision to stabilize debt in response to an exceptionally large shock, which is instead worn away by inflation. Under this second fiscal-monetary policy mix, the parameters that control the reaction of fiscal variables to fiscal imbalances ($\gamma^G, \gamma^Z, \gamma^J$) are set to zero. From a technical point of view, the parameters only need to be lower than $1/\beta - 1$, but to simplify the illustration of the results, we choose this more extreme version of active fiscal policy. At the same time, the monetary authority agrees to accommodate the increase

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

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	0.33	Leeper et al. (2017)
Frictions and technology			
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	Price markup	0.163	Leeper et al. (2013)
η_w	Wage markup	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.

in inflation necessary to stabilize the emergency budget. In terms of parameter values, this requires setting the response to inflation generated by the emergency budget to a value less than 1 ($\phi_\pi < 1$).Notice that under the Emergency Budget scenario, national fiscal authorities are still committed to stabilize their fiscal imbalances pursuing Ricardian policies. Therefore, the central bank can keep targeting low and stable inflation with a response larger than one-to-one ($\phi_\pi < 1$).

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, 6.6 in Italy, Germany, and the EA respectively.

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	20.9%	EC, DG Taxation and Customs Union, 2018
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^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	20.8%	EC, DG Taxation and Customs Union, 2018
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	0.16	Coenen et al. (2013)
ρ_r	Interest rate smoothing	0.88	Coenen et al. (2013)
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.

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 20.9%, 22.8%, and 20.8%.[4] 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). The interest rate response to EA inflation and output are set to 1.89 and 0.16 respectively, while the interest rate smoothing parameter is set to 0.88.

Finally, the parameters that control the risk premium shock process 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.[5] 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 setup in place when a recessionary shock hits the currency union affects the depth and the length of the recession. In particular, we study how the economy responds to the recessionary shock under two fiscal setups. 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. 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.

[4] 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.

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

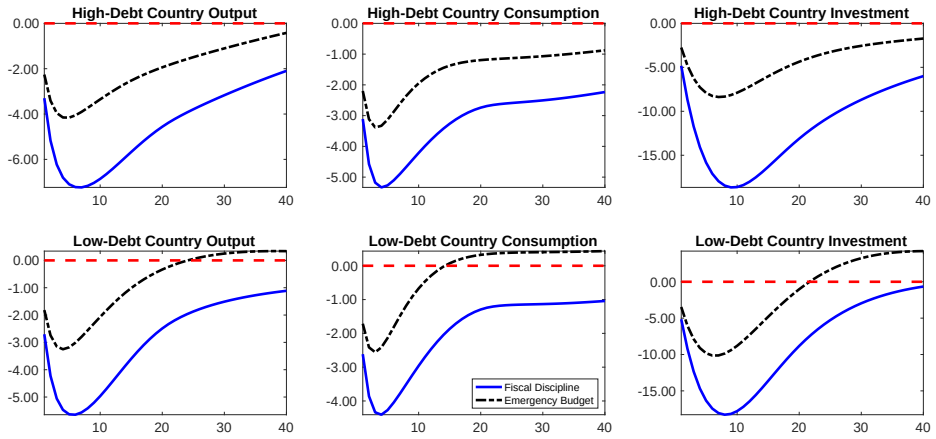


Figure 2 – Output dynamics for the high-debt and the low-debt country under *Fiscal Discipline* or the *Emergency Budget*. GDP is real output expressed in percentage log deviations from its steady state. The periods on the x-axis are quarters.

Modelling the Recession We initialize the model economy at its steady-state equilibrium, except for national debt. This is 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 the households.[6] We will study the dynamic responses to a one standard deviation risk premium shock that hits both countries contemporaneously.

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 subcomponents 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 is what causes the recession to hit the high-debt country even more severely. Nonetheless, the presence of distortionary taxation as well as the trade linkages between the two countries contribute to trigger a deep recession also

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

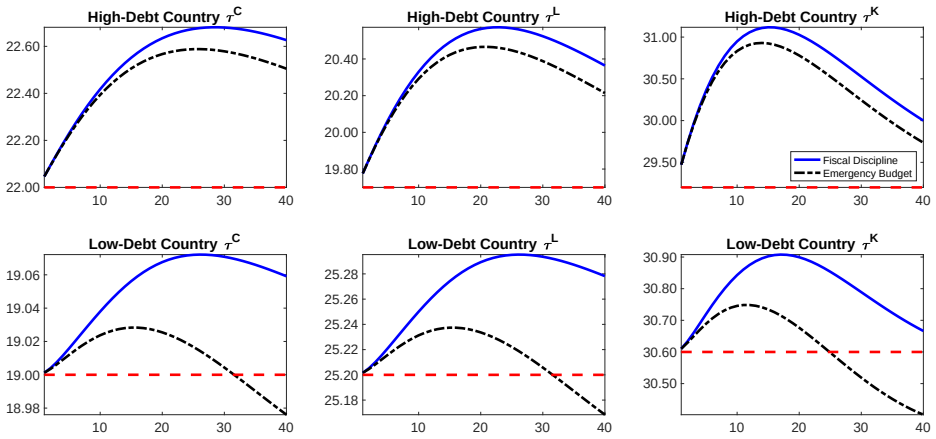


Figure 3 – Fiscal instruments for the high-debt and the low-debt country under *Fiscal Discipline* or the *Emergency Budget*. Tax rates are in percentage points. The periods on the x-axis are quarters.

in the low-debt country. The required fiscal adjustment in both countries is particularly strong as the nominal interest rate hits the zero lower bound and the monetary response is constrained. 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, debt-to-GDP rises both at the national and at the EA level. Under fiscal discipline inflation increases very mildly and 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. Finally, 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 steady state in less than ten years, it will take fifteen years and a deeper recession for the high-debt country to fully adjust its debt.

Eurobonds and Emergency Budget Rules The possibility of issuing Eurobonds does not 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 as national fiscal authorities, 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

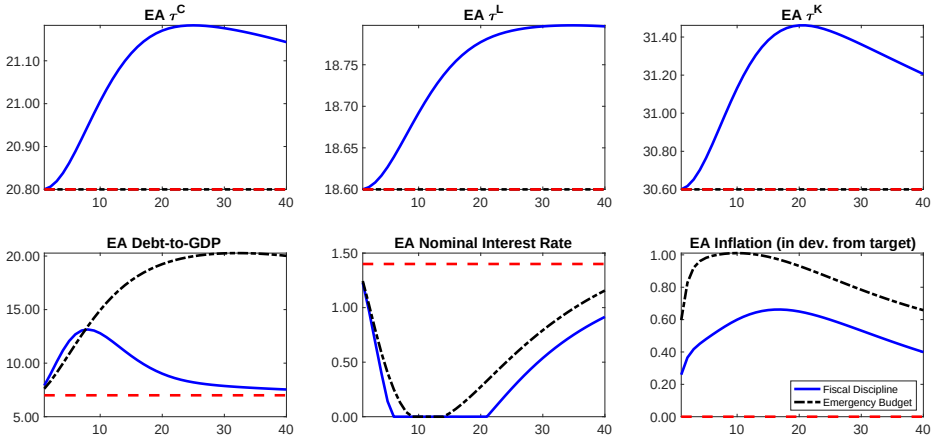


Figure 4 – Macroeconomic dynamics for the EA under *Fiscal Discipline* or the *Emergency Budget*. EA transfers are expressed as percentage of EA GDP. Tax rates are in percentage points. Inflation and the interest rate are expressed in percentage of annualized rates. EA debt-to-GDP ratio is the nominal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

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 debt would be only a matter of labels.

What makes a substantial difference in addressing the recession is the possibility opened up by Eurobonds issuance 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 repay the Eurobonds originated by an exceptionally large recession. This means that the new EA debt created to address the recession is not backed by future tax revenues or lower transfers. This implies setting the parameters γ^J and γ^Z of the EA fiscal rules 8 and 9 to zero. At the same time, the central bank allows inflation to rise persistently, as shown in Figure 4.

The EA 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 lower contraction is accounted for by a smaller drop 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.

While the EA fiscal authority adopts an emergency budget, the national fiscal author-

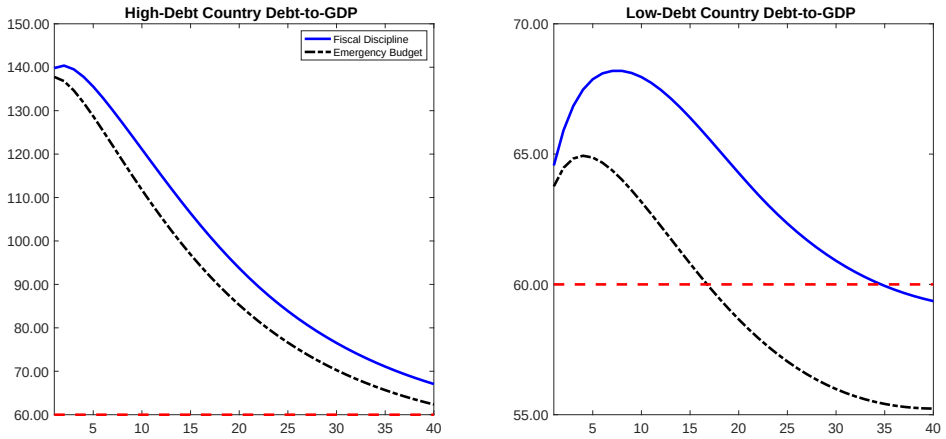


Figure 5 – Macroeconomic dynamics for the high-debt and the low-debt country under *Fiscal Discipline* or the *Emergency Budget*. National debt-to-GDP ratios are national nominal debts at the end of the quarter divided by the annualized national GDP in the quarter. The periods on the x-axis are quarters.

ities 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.

Eurobonds and Lack of Coordination There is a third, unpleasant scenario that may prevail in place of the fiscal discipline or the EA emergency budget. In this scenario, the EA fiscal authority does not commit to stabilize Eurobonds by raising future taxes or cutting transfers. At the same time, the central bank is adamant about keeping inflation under control, thus not giving up the Taylor principle. This lack of coordination between the EA fiscal authority and the EA central bank has dire consequences on the EA economy as described in detail in Bianchi and Melosi (2019). Under this scenario, EA debt-to-GDP would grow substantially and the central bank would lose control over inflation. The lack of coordination would push the economy into a spiral of heightened instability and economic stagnation.

What is more, in a currency union the possibility that one single country refuses to implement the necessary fiscal adjustments can trigger similar dynamics. This scenario is shown in Figure 6. Specifically, 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

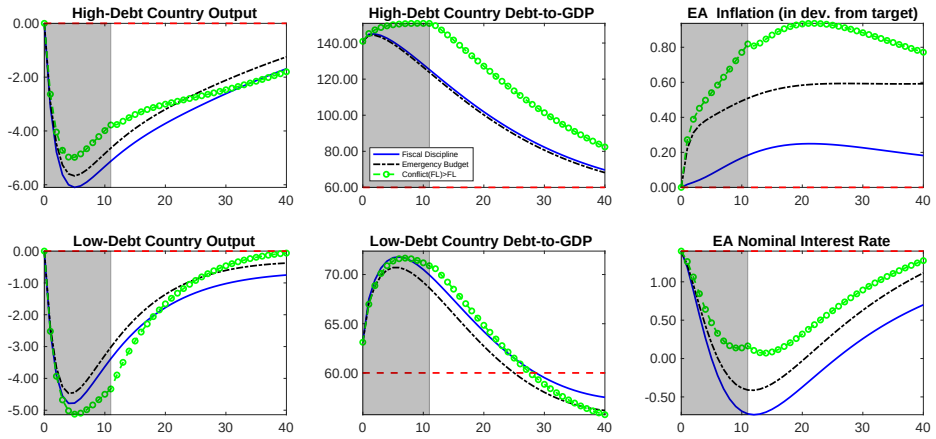


Figure 6 – EA inflation, EA nominal interest rate, high-debt country and low-debt country output and debt dynamics under *Fiscal Discipline*, the *Emergency Budget*, and *Conflict* with fiscally-led resolution between the high-debt country fiscal authority and the EA monetary authority. GDP is real output 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. Inflation and the interest rate are 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.

high-debt country. If this country is important enough for the existence of the currency union (Italy, France), markets might start expecting that eventually the central bank will have to allow inflation to increase to avoid a plain default that would likely trigger panic on financial markets with the possibility of the end of the currency union. Under these circumstances, inflationary pressure might arise. The central bank can increase rates to control inflation, but this would determine an economic slowdown with further increase in debt accumulation and inflationary pressure. Thus, the economy could enter a vicious spiral of stagnation and debt accumulation that would affect both the low- and high- debt country.

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.

5 A New Monetary and Fiscal Framework

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 following fiscal discipline irrespective of the causes behind the large fiscal imbalances. Alternatively, they can reform the monetary and fiscal framework of the EA in 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 needs of their economy.

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 national governments 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 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. The low interest rate environment critically limits the central bank's ability to stabilize the economy in recession. We also show that 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 the gloomiest one as 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 large recessions that pushes the policy rate to the zero lower bound, these authorities agree on the size of an emergency budget that will be financed by issuing Eurobonds. The central bank agrees on not responding to inflationary pressuring resulting from the need to stabilize the stock of Eurobonds. In doing so, the policymakers operate a controlled reflation of the EA economy. This strategy leads to 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 will make ZLB episodes less frequent, restoring monetary policy as a leading economic stabilization tool.

References

Albonico, A., Cales, L., Cardani, R., Croitorov, O., Ferroni, F., Giovannini, M., Hohberger, S., Pataracchia, B., Pericoli, F., Raciborski, R., and Rat (2019). The Global Multi-Country Model (GM): an Estimated DSGE Model for the Euro Area Countries. Working Papers 2019-102, Joint Research Centre, European Commission (Ispra site).

Bartsch, E., Benassy-Quere, A., Corsetti, G., and Debrun, X. (2020). It's All in the Mix: How Monetary and Fiscal Policies Can Work or Fail Together. *CEPR*.

Bassetto, M. (2002). A Game-Theoretic View of the Fiscal Theory of the Price Level. *Econometrica*, 70(6):2167–2195.

Beetsma, R. M. and Jensen, H. (2005). Monetary and Fiscal Policy Interactions in a Micro-founded Model of a Monetary Union. *Journal of International Economics*, 67(2):320–352.

Bergin, P. R. (2000). Fiscal Solvency and Price Level Determination in a Monetary Union. *Journal of Monetary Economics*, 45(1):37–53.

Bianchi, F., Faccini, R., and Melosi, L. (2020). Monetary and Fiscal Policies in Times of Large Debt: Unity is Strength. *NBER Working Paper*, (27112).

Bianchi, F. and Melosi, L. (2019). The Dire Effects of the Lack of Monetary and Fiscal Coordination. *Journal of Monetary Economics*, 104(C):1–22.

Billi, R. and Walsh, C. (2021). Seemingly Irresponsible but Welfare Improving Fiscal Policy at the Lower Bound. *Working Paper*.

Christiano, L. J., Eichenbaum, M., and Evans, C. L. (2005). Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. *Journal of Political Economy*, 113(1):1–45.

Cochrane, J. H. (1999). A Frictionless View of U.S. Inflation. In *NBER Macroeconomics Annual 1998, volume 13*, NBER Chapters, pages 323–421. National Bureau of Economic Research, Inc.

Cochrane, J. H. (2001). Long-Term Debt and Optimal Policy in the Fiscal Theory of the Price Level. *Econometrica*, 69(1):69–116.

Coenen, G., Straub, R., and Trabandt, M. (2013). Gauging the Effects of Fiscal Stimulus Packages in the Euro Area. *Journal of Economic Dynamics and Control*, 37(2):367–386. Fiscal Policy in the Aftermath of the Financial Crisis.

Faccini, R. and Melosi, L. (2020). Bad Jobs and Low Inflation. *CEPR Working Paper*, (13628).

Farhi, E. and Werning, I. (2017). Fiscal Unions. *American Economic Review*, 107(12):3788–3834.

Ferrero, A. (2009). Fiscal and Monetary Rules for a Currency Union. *Journal of International Economics*, 77(1):1–10.

Fisher, J. D. (2015). On the Structural Interpretation of the Smets–Wouters "Risk Premium" Shock. *Journal of Money, Credit and Banking*, 47(2-3):511–516.

Gali, J. and Monacelli, T. (2008). Optimal Monetary and Fiscal Policy in a Currency Union. *Journal of International Economics*, 76(1):116–132.

Jarocinski, M. and Mackowiak, B. (2018). Monetary-fiscal Interactions and the Euro Area's Malaise. *Journal of International Economics*, 112(C):251–266.

Leeper, E. (1991). Equilibria under 'Active' and 'Passive' Monetary and Fiscal Policies. *Journal of Monetary Economics*, 27(1):129–147.

Leeper, E. M., Traum, N., and Walker, T. B. (2017). Clearing up the fiscal multiplier morass. *American Economic Review*, 107(8):2409–54.

Nakamura, E. and Steinsson, J. (2014). Fiscal Stimulus in a Monetary Union: Evidence from US Regions. *American Economic Review*, 104(3):753–792.

Reis, R. (2016). QE in the Future: the Central Bank's Balance Sheet in a Financial Crisis. Discussion Papers 1620, Centre for Macroeconomics (CFM).

Sargent, T. J. and Wallace, N. (1981). Some Unpleasant Monetarist Arithmetic. *Quarterly Review*, 5(Fall).

Schmitt-Grohe, S. and Uribe, M. (2000). Price Level Determinacy and Monetary Policy under a Balanced-budget Requirement. *Journal of Monetary Economics*, 45(1):211–246.

Sims, C. (1994). A Simple Model for Study of the Determination of the Price Level and the Interaction of Monetary and Fiscal Policy. *Economic Theory*, 4(3):381–99.

Smets, F. and Wouters, R. (2007). Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach. *American Economic Review*, 97(3):586–606.

Woodford, M. (1994). Monetary Policy and Price Level Determinacy in a Cash-in-Advance Economy. *Economic Theory*, 4(3):345–80.

Woodford, M. (1995). Price-level Determinacy Without Control of a Monetary Aggregate. *Carnegie-Rochester Conference Series on Public Policy*, 43(1):1–46.

Woodford, M. (2001). Fiscal Requirements for Price Stability. *NBER Working Paper*, (8072).

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

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

- 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

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

- 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

$$\begin{aligned}\hat{q}_{1,t} =& E_t\hat{\lambda}_{1,t+1} - \hat{\lambda}_{1,t} + \beta e^{-\gamma}(1-\tau_1^K-\tau_{eu}^K)r_1^k E_t\hat{r}_{t+1}^K \\ &- \beta e^{-\gamma}\tau_1^K r^k E_t\hat{\tau}_{1,t+1}^K - \beta e^{-\gamma}\tau_{eu}^K r_1^k E_t\hat{\tau}_{eu,t+1}^K + \beta e^{-\gamma}(1-\delta)E_t\hat{q}_{1,t+1}\end{aligned} \tag{8}$$

- Household's FOC for investment

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

- Effective capital

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

- Law of motion for capital

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

- Euler equation of household

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

- Risk sharing condition

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

- Budget constraint of non savers

$$\begin{aligned}&\tau_1^C C_1^N\hat{\tau}_{1,t} + \tau_{EA}^C C_1^N\hat{\tau}_{EA,t} + (1+\tau_1^C+\tau_{EA}^C)C_1^N\hat{c}_{1,t}^N = (1-\tau_1^L-\tau_{EA}^L)w_1L_1(\hat{w}_{1,t}+\hat{L}_{1,t}) \\ &- \tau_1^L w_1L_1\hat{\tau}_{1,t}^L - \tau_{EA}^L w_1L_1\hat{\tau}_{EA,t}^L + Z_1\hat{z}_{1,t} + Z_{EA}(\hat{z}_{1,t}^{EA} - \hat{p}_{1,t}^{EA})\end{aligned} \tag{14}$$

- Household's aggregate consumption

$$C_1\hat{c}_{1,t} = C_1^S(1-\mu)\hat{c}_{1,t}^S + C_1^N\mu\hat{c}_{1,t}^N \tag{15}$$

- Aggregate resource constraint

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

- 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

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

- 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

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

- 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

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

- Fiscal rule for taxes

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

- EA fiscal rule for Z

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

- EA fiscal rule for taxes

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

- Monetary policy rule

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

- EA inflation

$$\hat{\pi}_t = \frac{1}{2}\hat{\pi}_{1,t} + \frac{1}{2}\hat{\pi}_{2,t} \tag{27}$$

- EA output

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

- Final consumption good technology

$$\hat{c}_{1,t} = (1-\nu_C)\hat{c}_t^H + \nu_C \hat{c}_t^F \tag{29}$$

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

- Consumption price index

$$(1-\nu_C)\hat{p}_t^H + \nu_C \hat{p}_t^F = 0 \tag{31}$$

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

- 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

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

$$\hat{\pi}_{2,t} = \hat{\pi}_{2,t}^C + \hat{p}_t^{F*} - \hat{p}_{t-1}^{F*} \tag{36}$$

- Combining LCP and foreign import inflation link to relative price

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

$$\hat{\pi}_{2,t} = \hat{\pi}_t^C + \hat{p}_t^F - \hat{p}_{t-1}^F \tag{38}$$

- 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

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

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

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

- Price definitions

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

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

$$rer_t - rer_{t-1} = \hat{\pi}_{2,t}^C - \hat{\pi}_{1,t}^C \tag{46}$$

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

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

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.

C Lack of Policy Coordination

The lack of policy coordination between the EA monetary authority and the high-debt country fiscal authority is modelled by solving a Markov-switching model as in Bianchi and Melosi (2019). 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 analyzed in the main text. 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. 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 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 3 reports the parameters under fiscal discipline, emergency budget, and conflict.

The transition matrix Q between the four regimes is the following:

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

Transition probabilities are calibrated as follows: $p^{MM} = 0.9995$, $p^{FF} = 0.9995$, $p^{CC} = 0.9$. The conflict is assumed to last 10 quarters.