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# Monetary union, asymmetric recession, and exit

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**Abstract**

We propose a model of the Eurozone and analyze an asymmetric recession in a vulnerable member state with high public debt, weak banks, and low growth. We compare macroeconomic adjustment under continued membership with two exit scenarios that introduce flexible exchange rates and autonomous monetary policy. An exit with stable investor expectations could significantly dampen the short-run impact. Stabilization is achieved by a targeted monetary expansion combined with depreciation. However, investor panic may lead to escalation, aggravate the recession and delay the recovery.

**KEYWORDS**

banks, currency union, exchange rate flexibility, fiscal consolidation, sovereign debt

**JEL CLASSIFICATION**

E42, E44, E60, F30, F36, F45, G15, G21

## 1 | INTRODUCTION

The global financial crisis revealed large imbalances in the Eurozone. The banking sector in several countries was highly leveraged and had a large share of non-performing loans. This impaired banks' ability to absorb shocks, requiring government support in many cases. With rising public debt, doubts emerged about fiscal stability, leading to higher risk premia. In addition, parts of the Eurozone periphery had gradually lost competitiveness in the pre-crisis boom and experienced stagnant growth thereafter. High public debt constrains the role of the fiscal budget

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in stabilizing the economy during a recession. Instead of providing fiscal relief, governments may be forced to pursue consolidation.

One prominent example of this trilemma of high public debt, weakened banks, and stagnant growth is Italy: First, public debt already accounted for 130% of GDP prior to the Covid-19 crisis. While it had remained stable at around 100% of GDP between the late 1990s and 2008, the financial crisis led to a surge in the debt ratio. Second, Italian banks suffered from non-performing loans. Their share increased from six to 16% between 2006 and 2013 (Schivardi et al., 2021) but has declined since then. Banks also hold large amounts of sovereign bonds, more than 11% of assets in 2017 by ECB data, which exposes them to sovereign risk. Third, the Italian economy suffered from sluggish growth. In 2017, real GDP per capita was virtually the same as in 2000.

The paper develops a model of the Eurozone trilemma and analyzes fundamental policy choices of a member state which experiences a local recession. First, we examine financial and fiscal shocks like an increase in non-performing loans or fiscal consolidation, which mirror key aspects of the financial and Eurozone debt crises. Second, we ask whether a vulnerable member state could benefit from removing the restrictions of the currency union and pursuing an autonomous monetary policy tailored to its own needs. Evidence by Terzi (2020) suggests that the lack of independent monetary policy explains 25% of the overly recessionary character of macroeconomic adjustment in the Eurozone periphery (2010–2015). We thus analyze a counterfactual exit from the monetary union when a severe local recession sets in. Thereby, the country switches from centralized to autonomous monetary policy with flexible exchange rates. Given the large uncertainty about how an exit might unfold, we consider different scenarios.

We propose a New Keynesian dynamic stochastic general equilibrium (DSGE) model with three regions: a Eurozone member state (Italy), the rest of the Eurozone, and the rest of the world. The regions are linked with trade and capital flows, and the key nominal rigidity is wage stickiness. A major contribution of the model is that it captures three reinforcing drivers of the Eurozone crisis. First of all, firms finance risky investments with bank loans. Bankruptcy shocks provide a micro-foundation of non-performing loans. Banks are also exposed to sovereign risk as they hold large amounts of sovereign bonds with fluctuating prices. Losses on bond holdings erode bank equity and impair the lending capacity. The model eventually includes fiscal consolidation rules in the spirit of the Maastricht criteria. The need to consolidate public debt may slow growth (e.g., due to increased tax distortions) and constrain fiscal interventions in a crisis.

We derive two sets of results: First using impulse response analysis, we explore the contagious effects between banks, governments, and the real economy and quantify the effects on economic performance. We also show how much autonomous monetary policy, targeted to national rather than union-wide aggregates, can contribute to the stabilization of the local economy, although at the cost of higher inflation variance.

Second, an exit from the monetary union may allow a vulnerable member state to reduce output losses from an asymmetric recession and to accelerate the recovery. The domestic monetary expansion implemented by an autonomous national central bank is roughly five times larger than in a ’remain scenario’. Together with the induced devaluation of the new domestic currency, this significantly lowers the output costs of the recession. In the presence of nominal wage rigidity, more inflation reduces real wages and dampens the short-run contraction. Depreciation offsets the effects of rising domestic prices on international competitiveness and thereby protects export performance.

However, the exit of a vulnerable member state likely involves severe short-run disruptions. For instance, investors are concerned about the solvency of banks and the sovereign and charge higher risk premia. We thus study an ’esclating scenario’ accompanied by a surge in borrowing

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costs of banks and the government upon the exit; these additional shocks are largely consistent with the movement on sovereign bond yields surrounding the haircut on privately owned Greek sovereign debt (Oct. 2010–Apr. 2012). This eliminates any short-term gains from a benign exit and reinforces the recession. Inflation driven by a larger devaluation stabilizes employment in the short run but at the cost of a much larger real wage decline. Our model indicates that an escalating exit leads to higher and longer-lasting income losses than a recession within the currency union.

The Eurozone literature is large and mostly relates to specific aspects of the crisis. Closest is the research by Gourinchas et al. (2016) and Chodorow-Reich et al. (2019), who use an open economy DSGE model to explain Greek economic adjustment during the crisis. Martin and Philippon (2017) develop a stylized two-country model to analyze the contrasting behavior of periphery and core countries. Unlike these papers, we include a full fledged banking sector with a balance sheet constraint which amplifies non-performing loan shocks and price risks of long-term sovereign bonds. This is key for the transmission of financial and fiscal shocks and for the emergence of vicious loops. Moreover, we consider exit scenarios, that is, moving from fixed to flexible exchange rates and from centralized to autonomous monetary policy. In studying currency pegs, Schmitt-Grohé and Uribe (2016) show how downward wage rigidity and free capital mobility cause over-borrowing in booms and unemployment during recessions, resembling key aspects of the Eurozone crisis.

The importance of expectations is one reason why we model shocks to risk premia in our 'escalating exit' scenario. The literature on public debt crises (e.g., Calvo, 1988; Cole & Kehoe, 2000; Ayres et al., 2018) emphasizes the role of investor expectations in models with multiple equilibria. Sudden shifts in investor confidence can alter risk premia quite dramatically and may even trigger a self-fulfilling debt crisis. Our analysis of an exit from the monetary union connects to Kriwoluzky et al. (2019). They focus on exit expectations during a sovereign debt crisis, which contribute to rising interest rates prior to an exit, thereby exacerbating the debt crisis.

Existing research mostly focuses on specific aspects of the Eurozone crisis. This paper highlights the reinforcing interactions of high public debt, weak banks, and deteriorating competitiveness (see Shambaugh, 2012). First, a systemic banking crisis entails severe costs. Laeven and Valencia (2012) estimate a 32% cumulative output loss. Furthermore, it typically leads to a massive increase in public debt and can rapidly transform into a sovereign debt crisis (e.g., Acharya et al., 2014). Second, a fiscal crisis undermines financial stability. European banks hold substantial parts of domestic sovereign bonds (e.g., Acharya & Steffen, 2015; Altavilla et al., 2016; Ongena et al., 2019). Given this exposure, a public debt crisis causes a contraction of private credit, if banks' bond holdings are large and they are highly leveraged (Gennaioli et al., 2014, Bofondi et al., 2018). Third, a lack of competitiveness is an obstacle to growth. This feeds back not only on the fiscal budget but also on banks because non-performing loans tend to rise as private defaults become more frequent. The empirical literature emphasizes the role of growth and unemployment (e.g., Louzis et al., 2012; Salas & Saurina, 2002). A large stock of non-performing loans weakens growth by constraining credit supply and investment and magnifies recessions (Quagliarello, 2007).

Our paper adds at least four novel extensions to existing research: (i) We explain the emergence of non-performing loans by bankruptcy shocks, which is a step towards a 'micro-foundation' of non-performing loans. (ii) We introduce an effect of sovereign bond prices on banks' balance sheets, which establishes a doom loop between banks and sovereigns. (iii) We introduce an equity channel of bank lending. Following Begenau (2020), we model dividend inertia that slows down equity accumulation. The erosion of bank equity restricts credit supply

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after large losses in a crisis. (iv) We model fiscal consolidation mimicking Maastricht rules. This captures the difficulty of highly indebted countries in providing fiscal stabilization when monetary policy is centralized. We claim that these extensions are central when analyzing an asymmetric recession in the Eurozone.

The remainder of the paper is organized as follows. Section 2 sets out the model, and Section 3 provides the quantitative analysis. Section 4 concludes.

## 2 | THE MODEL

We propose a monetary DSGE model with three regions, a domestic economy (Italy), the rest of the Eurozone (RoE), and the rest of the world (RoW). We refer to the Technical Appendix for a complete documentation (Keuschnigg, 2022).

### 2.1 | Firms

Firms produce output using capital and a bundle of specialized labor services. A capital structure choice between debt (bank loans) and equity rationalizes loan demand. A stylized bankruptcy process explains the origins of non-performing loans, which impose losses on banks. Output is subject to productivity shocks $Z_t$,

$$Y_t = Z_t K_{t-1}^{\alpha} L_t^{1-\alpha}, \quad L_t = \left[\int_0^1 L_{jt}^{(\sigma-1)/\sigma} dj\right]^{\sigma/(\sigma-1)}, \quad \sigma > 1. \tag{1}$$

Minimizing wage costs gives demand for specialized labor services $L_{jt} = \left(w_t^L / w_{jt}\right)^{\sigma} L_t$ with a wage index $w_t^L = \left[\int_0^1 w_{jt}^{1-\sigma} dj\right]^{1/(1-\sigma)}$. Total labor cost is $w_t^L L_t = \int_0^1 w_{jt} L_{jt} dj$.

Firms invest $\bar{I}_t$, consisting of of domestic and imported capital goods. Total investment cost is $\overline{P}_t \bar{I}_t + J_t$), where $\overline{P}_t$ is the price index and $J_t = \psi^k K_{t-1}\left(\bar{I}_t / K_{t-1} - \delta^k - s_t\right)^2/2$ are installation costs. Capital depreciates at a rate $\delta^k + s_t$ which capital losses due to bankruptcy at rate $s_t = (1-\rho^s)\left[\bar{s} + \sigma^s\left(\overline{Y} - Y_t\right)/\overline{Y}\right] + \rho^s s_{t-1} + \varepsilon_t^s$ are,

$$K_t = \bar{I}_t + \left(1 - \delta^k - s_t\right) K_{t-1}, \quad B_t^l = N_t^l + \left(1 - \delta^k - s_t\right) B_{t-1}^l, \tag{2}$$

Firms finance assets $K_t$ partly with bank loans $B_t^{\ell}$. New loans are $N_t^l$. Along with capital depreciation, firms repay $\delta^k B_{t-1}^l$ of their debt. A share $s_t$ of businesses faces bankruptcy and cannot repay. We postulate a stochastic process of bankruptcy rates $s_t$ which depends on the output gap. In case of bankruptcy, banks seize capital goods $s_t K_{t-1}$ and sell them at a discount to limit their losses on the *non-performing loans*.

The debt capacity of firms is constrained to a fraction $b^k$ of total assets,

$$B_t^l \leq b^k \cdot \overline{P}_t K_t. \tag{3}$$

Firms earn profits equal to revenue $P_t Y_t$ net of wages, installation cost $\overline{P}_t J_t$ and cost of debt $i_t^l B_{t-1}^l$ with $i_t^l$ denoting the loan rate. Profit is taxed at rate $\tau_t^k$. Investment spending $\overline{P}_t \bar{I}_t$ is financed with new debt $N_t^l$ and retained earnings. Dividends are

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$$\chi_t^k = \left(1 - \tau_t^k\right)\left(P_t Y_t - \overline{P}_t J_t - w_t^L L_t - i_t^l B_{t-1}^l\right) - \overline{P}_t \bar{I}_t + N_t^l - \delta^k B_{t-1}^l. \tag{4}$$

Owners require a return on equity $i_t^k = i_t + \theta_t^k$ ($i_t$ is the safe deposit rate and $\theta_t^k$ an equity premium). Firms choose employment, new debt and investment to maximize value, $V_t = \max_{\bar{I}_t, N_t^l, L_t} \chi_t^k + V_{t+1} / \left(1 + i_t^k\right)$. Given $i_t^k > i_t^l$, the debt constraint binds and, by (3), links loan demand to capital. Investment follows Tobin's Q-theory,

$$\bar{I}_t = \left[\delta^k + s_t + \frac{Q_t^k - \left(1 - b^k\right)}{\left(1 - \tau_t^k\right)\psi^k}\right] \cdot K_{t-1}, \quad Q_t^k \equiv \frac{\lambda_{t+1}^f}{\left(1 + i_t^k\right)\overline{P}_t}. \tag{5}$$

Net investment is positive if the marginal value of equity $Q_t^k$ exceeds the value of retained earnings, $1 - b^k$. The shadow price $\lambda_{t+1}^f$ measures the expected value of equity, equal to the present value of marginal future dividends.

## 2.2 | Households

Households derive utility from consuming a bundle of goods $\overline{C}_t$, holding real money balances $\overline{M}_t = M_t / \overline{P}_t$, and supplying specialized labor of type $N_{j,t}$ by member $j \in [0, 1]$,

$$u_t\left(\overline{C}_t, \left\{N_{j,t}\right\}, \overline{M}_t\right) = \frac{\left[\overline{C}_t - \Phi\left(\left\{N_{j,t}\right\}\right)\right]^{1-1/\sigma^c}}{1 - 1/\sigma^c} + m_t^{1/\sigma^m} \frac{\overline{M}_t^{1-1/\sigma^m}}{1 - 1/\sigma^m}. \tag{6}$$

Total effort cost of work is $\Phi_t \equiv \phi_t^{-1/\eta} \int_0^1 N_{jt}^{1+1/\eta} \overline{N} dj / (1 + 1/\eta)$, where $\eta$ is the Frisch elasticity of labor supply. Given family size $\overline{N}$, total labor supply of variety $j$ is $N_{jt}\overline{N}$.

To model trade flows, we consider goods that are differentiated by geographic origin. The same aggregator applies to consumption and investment. Composite consumption $\overline{C}_t = \left[\sum_j \left(s^j\right)^{1/\sigma^r} \left(C_t^{ij}\right)^{(\sigma^r - 1)/\sigma^r}\right]^{\sigma^r/(\sigma^r - 1)}$ is a basket of domestic goods $C_t^{ii}$ and imports from the rest of the Eurozone $C_t^{ie}$ and the rest of the world $C_t^{io}$ where the second index $j = \{i, e, o\}$ refers to the source country. The exchange rate $e_t^{ij}$ is defined as domestic currency per unit of foreign currency (e.g., one Euro is $e_t^{ij}$ of the domestic currency). Within the currency union, the exchange rate is fixed at $e_t^{ie} = 1$. Accordingly, prices of domestic and import goods are $P_t$, $P_t^{ie} = e_t^{ie} \cdot P_t^e$, and $P_t^{io} = e_t^{io} \cdot P_t^o$ (with $P_t^o = 1$ being the numeraire). Goods demand is $C_t^{ij} = s^j \left(\overline{P}_t / P_t^{ij}\right)^{\sigma^r} \overline{C}_t$, where $\overline{P}_t$ is the *consumer price index* and spending amounts to $\overline{P}_t \overline{C}_t = \sum_j P_t^{ij} C_t^{ij}$.

Households earn wages $w_{jt}$ for labor services $N_{j,t}$, pay income and consumption taxes at rates $\tau_t$ and $\tau_t^c$, and receive transfers $E_t$, seignorage $T_t^M$, and capital income $\chi_t^A$ from all sources other than residual savings $A_t$ (international bonds). The budget is

$$\begin{aligned} A_t = {} & (1 + i_{t-1}) A_{t-1} + \int_0^1 (1 - \tau_t) w_{jt} N_{jt} \overline{N} dj + E_t \\ & : + \chi_t^A + T_t^M - (M_t - M_{t-1}) - \left(1 + \tau_t^c\right) \overline{P}_t \overline{C}_t. \end{aligned} \tag{7}$$

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Households choose consumption $\overline{C}_t$, real money balances $\overline{M}_t$, and set a wage $w_t^*$ whenever a new wage setting opportunity emerges (see below). Maximizing life-time utility $V_t^h = \max_{\overline{C}_t,\overline{M}_t,w_t^*} u\left(\overline{C}_t, \{N_{j,t}\}, \overline{M}_t\right) + \beta_t V_{t+1}^h$ gives

$$u_{\overline{C},t} = \beta_t (1+r_t) \cdot u_{\overline{C},t+1}, \quad \frac{u_{\overline{M},t}}{u_{\overline{C},t}} = \frac{1}{1+\tau_t^c} \frac{i_t}{1+i_t}, \tag{8}$$

where $u_{\overline{C},t} \equiv du_t/d\overline{C}_t$ and $u_{\overline{M},t} \equiv du_t/d\overline{M}_t$ are marginal utilities. Using (7) relates demand for real money balances $\overline{M}_t = m_t \cdot \left[\frac{1+i_t}{i_t}\left(1+\tau_t^c\right)\left(\overline{C}_t - \Phi_t\right)^{1/\sigma^c}\right]^{\sigma^m}$ to consumption and leisure utility. Consumption growth is governed by the real interest rate,

$$1+r_t = \frac{1+i_t}{1+\pi_t}, \quad 1+\pi_t = \frac{\left(1+\tau_{t+1}^c\right)\overline{P}_{t+1}}{\left(1+\tau_t^c\right)\overline{P}_t}. \tag{9}$$

Individuals of type $j$ are organized in a 'union' and face demand $L_{j,t}$ for differentiated services as noted in (1). Unions exploit local market power. A real wage after taxes equal to the marginal rate of substitution $MRS_{j,t} = -u_{N_{j,t}}/u_{\overline{C},t}$ would compensate for work effort but unions charge a mark-up over $MRS_{j,t}$. In a steady state where old and new wages are the same, the real wage is

$$\frac{(1-\tau)\,w^*}{(1+\tau^c)\,\overline{P}} = \frac{\sigma}{\sigma-1} \cdot MRS. \tag{10}$$

In the short term, nominal wages are rigid. Following Calvo (1988) and Gali (2015), only a *fraction* $1-\omega$ of workers can set wages. The wage chosen in $t$ is $w_t^*$ and remains constant until a new wage setting opportunity arrives. It equates the current real wage with a present value of future valuations $MRS_{t,t+i}$ on the right-hand side of (10). Only a fraction $1-\omega$ of wages are re-optimized while the remaining part $\omega$ of contracts are stuck with previously set wages as reflected in $w_{t-1}^L$. The wage index changes only with delay,

$$\left(w_t^L\right)^{1-\sigma} = (1-\omega) \cdot \left(w_t^*\right)^{1-\sigma} + \omega \cdot \left(w_{t-1}^L\right)^{1-\sigma}. \tag{11}$$

## 2.3 | Government

The government invests in infrastructure, $K_t^G = G_t + (1-\delta^g)\,K_{t-1}^G$, which boosts productivity $Z_t$ in (1) by $Z_t = (1-\rho)\,\overline{Z}\left(1+\sigma^z\left(K_{t-1}^G - \overline{K}^G\right)/\overline{K}^G\right) + \rho Z_{t-1} + \varepsilon_t^Z$, along the lines of Barro (1990). Other spending consists of social transfers $E_t$. Revenue $T_t$ stems from taxing wages, profits and consumption at rates $\tau_t$, $\tau_t^k$ and $\tau_t^c$, respectively. The business tax base $T_t^k$ follows from (4). We also account for revenue losses $T_t^l$ from tax avoidance and evasion, fluctuating around a given GDP share of $\overline{t}^l$. The primary surplus is

$$\begin{aligned} S_t^G &= T_t - P_t G_t - E_t, \quad T_t = \tau_t \cdot w_t^L L_t + \tau_t^k \cdot T_t^k + \tau_t^c \cdot \overline{P}_t \overline{C}_t - T_t^l, \\ P_t G_t &= \overline{g} \cdot P_t Y_t - \xi^g \cdot S_t^G, \quad E_t = \overline{e} \cdot w_t^L L_t - \xi^e \cdot S_t^G. \end{aligned} \tag{12}$$

Fiscal policy targets a GDP share $\bar{g}$ of productive spending, and legislates social entitlements equal to a share $\bar{e}$ of wage earnings. When consolidation requires a surplus $S_t^G$, the government enacts spending cuts that contribute a share $\xi^g$ and $\xi^e$ of the surplus target. The remainder is financed by scaling up tax rates. Parameters $\xi^e$ and $\xi^g$ determine whether consolidation is tax or expenditure based. This connects to research on the effectiveness of tax- versus spending-based consolidation (e.g., Alesina et al., 2015).

Moreover, the government issues long-term bonds sold to domestic banks and households. Each period, a bond is repaid at face value with probability $\mu$ and continues with probability $1 - \mu$. Expected duration is $1/\mu$. The payout consists of a coupon $\bar{\imath}$ and a repayment at face value $\mu$. The bond price $Q_t$ satisfies

$$\left(1 + i_t^g\right) Q_t = \bar{\imath} + \mu + (1 - \mu) Q_{t+1}, \quad B_t^G = N_t^G + (1 - \mu) B_{t-1}^G. \tag{13}$$

Investors require a return $i_t^g = i_t + \theta_t^g$, including a sovereign risk-premium. A higher required return $i_t^g$ depresses bond prices $Q_t$ and the value of bond holdings. By this channel, fiscal problems lead to contagion of banks and private investors.

The value of newly issued bonds $Q_t N_t^G$ and the primary surplus $S_t^G$ must finance interest expenses and debt repayment,

$$Q_t N_t^G + S_t^G = \bar{\imath} B_{t-1}^G + \mu B_{t-1}^G, \quad S_t^G = \left[\bar{\imath} + \mu + (1 - \mu) Q_t\right] B_{t-1}^G - Q_t B_t^G. \tag{14}$$

The second equality follows from multiplying (13.ii) by the bond price and substituting the constraint for new bond issues $Q_t N_t^G$.

Stabilizing debt requires a consolidation policy. In the spirit of the Maastricht rules, we assume the government to target a long-run debt-to-GDP ratio $\bar{b}^g$, which it aims to approach with a given speed $\gamma^g$. Consolidation policy thus follows

$$Q_t B_t^G = \gamma^g Q_t B_{t-1}^G + \left(1 - \gamma^g\right) \bar{b}^g P_t Y_t, \quad 0 < \gamma^g < 1. \tag{15}$$

The value of debt converges to $QB^G = \bar{b}^g PY$ in a steady state, corresponding to the GDP ratio $\bar{b}^g$. Substituting the above consolidation rule into (14.ii) specifies a certain primary surplus $S_t^G$ that the government must achieve.[1] Depending on tax- versus spending-based consolidation, this target surplus determines spending in (12). Appendix A.1 documents a model variant that allows for temporary deviations as suggested by the Maastricht rules.

## 2.4 | Banks

We model two major sources of asset risk: non-performing loans (NPL) and sovereign bond holdings. Italian banks recorded one of the highest NPL ratios in Europe after the financial crisis. The latter evolves according to (2) and causes credit losses for banks.

Banks as major buyers of sovereign bonds are also exposed to large price fluctuations during a public debt crisis. We assume that banks purchase a share $\tilde{s}^b$ of newly issued bonds each period, giving flows and stocks of $N_t^g = \tilde{s}^b N_t^G$ and $B_t^g = \tilde{s}^b B_t^G$, respectively. Trading results in bond turnover, $B_t^g = N_t^g + (1 - \mu - \delta) B_{t-1}^g$. Each period, a fraction $\mu$ of sovereign bonds is paid back, and banks sell a fraction $\delta$ at the market price. This forces them to realize gains or losses. The

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book value of bonds in terms of acquisition costs is $V_t^g = \sum_i Q_{t-i} B_{t-i,t}^g$. Since bonds purchased at date $s < t$ are sold off at rate $\mu + \delta$, the book value of bond holdings changes by $V_t^g = Q_t N_t^g + (1 - \mu - \delta) V_{t-1}^g$.

At the end of $t$, assets consist of loans $B_t^l$ and bond holdings worth $V_t^g$, and are financed with equity $E_t^b$ and deposits $D_t$. The balance sheet is

$$E_t^b + D_t = B_t^l + V_t^g, \quad E_t^b \geq \kappa^B B_t^l + \kappa^G V_t^g. \tag{16}$$

Bank equity grows by $E_t^b = E_{t-1}^b + N_t^b - (\delta^k + s_t) B_{t-1}^l - (\delta + \mu) V_t^g$ where $N_t^b$ denotes retained earnings. Any reduction in assets due to repayment, depreciation, write-offs, or realized losses leads to a corresponding reduction in equity. The bank's capital structure is largely determined by minimum capital requirements as in (16.ii). Lending is thus a multiple of equity. Variations in bank equity driven, for instance, by credit losses or varying sovereign bond prices translate into fluctuations in credit supply.

Banks accumulate equity with retained earnings, equal to inflows minus outflows. Inflows consist of earnings on loans and bonds. Loans generate interest earnings $i_t^l B_{t-1}^l$. A part $\delta^k$ is repaid in full, while a share $s_t$ defaults and fails to repay. Banks recover a share $1 - \ell_t$ of these loans, giving revenues of $(1 - \ell_t) s_t B_{t-1}^l$. Bond holdings yield revenue $(\bar{\imath} + \mu) B_{t-1}^g$ from coupon plus repayment, and from selling a part $\delta B_{t-1}^g$ at a price $Q_t$ prior to maturity. Finally, sourcing new deposits adds $N_t^d$. Outflows are interest on deposits $i_{t-1}^d D_{t-1}$, new lending $N_t^l$, bond purchases $Q_t N_t^g$ and dividends $\chi_t$. Using the balance sheet identity and the flow constraint to replace $D_{t-1}$ and $N_t^l$ gives retained earnings

$$\begin{aligned} N_t^b = & \left(i_t^l + (1 - \ell_t) s_t + \delta^k - i_{t-1}^d\right) B_{t-1}^l + i_{t-1}^d E_{t-1}^b \\ & + \left(\bar{\imath} + \mu + \delta Q_t\right) B_{t-1}^g - i_{t-1}^d V_{t-1}^g - \chi_t^b. \end{aligned} \tag{17}$$

Banks which need to recapitalize quickly can, in principle, retain a larger part of their earnings by cutting dividends $\chi_t^b$. However, shareholders value steady dividends close to a benchmark $\overline{\chi}^b$. To capture dividend inertia, we follow Begenau (2020) and introduce convex dividend adjustment costs, $z\left(\chi_t^b\right) = \frac{1}{2}\psi^b \left(\chi_t^b - \overline{\chi}^b\right)^2$ such that shareholders receive a net dividend of $\chi_t^b - z\left(\chi_t^b\right) \overline{P}_t$ only. Thus, banks with substantial losses refrain from large dividend cuts and build up new equity only gradually. Together with capital requirements in (16), this tends to constrain credit supply of banks that recover from past losses.

The required return on equity is $i_t^b = i_t + \theta_t^b$, including a premium. To maximize value, $V_t^b = \max_{N_t^l, N_t^b} \chi_t^b - z\left(\chi_t^b\right) \overline{P}_t + V_{t+1}^b / \left(1 + i_t^b\right)$, managers choose new loans and retained earnings subject to capital requirements in (16). The Technical Appendix documents the detailed solution. Since equity is more expensive than deposits, $i_t^b > i_t^d$, the regulatory constraint binds. The optimal loan interest rate is an average of the cost of deposits and equity plus a premium $\ell_t s_t$ to account for credit risk,

$$i_t^l = \kappa^B \cdot \tilde{\imath}_t^b + \left(1 - \kappa^B\right) \cdot i_{t-1}^d + \ell_t s_t, \quad \tilde{\imath}_t^b \equiv \left(1 + i_t^b\right) \lambda_t^b / \lambda_{t+1}^b - 1. \tag{18}$$

The shadow price of equity $\lambda_t^b \equiv dV_t^b / dE_{t-1}^b$ reflects the present value of marginal equity created by an increase in retained earnings today (as in a '*Q*-theory of bank equity'). Given dividend adjustment costs, a shortage of equity leads to a high valuation $\lambda_t^b$ today relative to the future and thereby implies a high cost of equity $\tilde{\imath}_t^b$.

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## 2.5 | International equilibrium

The domestic economy (Italy) trades with the rest of the Eurozone and the rest of the world (RoW). Given our focus on Italy, we abstract from fiscal policy, banks, firms, and labor in the other two regions. Furthermore, Italy borrows internationally by issuing (net) foreign debt purchased exclusively by Eurozone investors.

Households are primarily invested in domestic assets, and only their residual savings (borrowing) in (7) are in foreign bonds issued (held) by Eurozone investors, $B_t^f = A_t$. Net foreign assets promise an interest rate $i_{t-1}$ and grow by the trade balance

$$B_t^f = (1 + i_{t-1}) B_{t-1}^f + TB_t, \quad TB_t = P_t E_t^x - P_t^{ie} \left( C_t^{ie} + I_t^{ie} \right) - P_t^{io} \left( C_t^{io} + I_t^{io} \right). \tag{19}$$

Exchange rates convert prices in foreign currency into domestic currency. As long as the home economy is part of the Eurozone, the internal exchange rate is fixed, $e_t^{ie} = 1$. Otherwise, it follows from a modified interest rate parity condition,

$$(1 + i_t) e_t^{ie} / e_{t+1}^{ie} = \left(1 + i_t^e\right) \theta_t^f. \tag{20}$$

Following Schmitt-Grohé and Uribe (2003), we assume that the risk-premium $\theta_t^f$ on Italian bonds increases in the foreign debt-to-GDP ratio $b_t^f$,

$$\theta_t^f = \left(1 - \rho^f\right) \left[1 + \gamma \left(e^{b_t^f - \overline{b}^f} - 1\right)\right] + \rho^f \theta_{t-1}^f + \varepsilon_t^f, \quad b_t^f \equiv B_t^f / (P_t Y_t). \tag{21}$$

In a steady state, interest and exchange rates are constant and equal to $i = i^e = 1/\beta$ to support stationary consumption. The country premium vanishes, $\theta^f = 1$, giving $b^f = \overline{b}^f$.

The rest of the Eurozone (indexed by $e$) is stylized. GDP fluctuates around potential output $\overline{Y}^e$ with an auto-regressive process

$$Y_t^e = \left(1 - \rho^{Y,e}\right) \overline{Y}^e + \rho^{Y,e} Y_{t-1}^e + \varepsilon_t^{Y,e}. \tag{22}$$

Given income $P_t^e Y_t^e$, households choose consumption and money demand. Preferences are similar to (6), except that labor supply is fixed. Current consumption $\overline{C}_t^e$ follows from intertemporal optimization and is spent on home goods and imports,

$$\overline{P}_t^e \overline{C}_t^e = P_t^e C_t^e + P_t^{ei} C_t^{ei} + P_t^{eo} C_t^{eo}, \tag{23}$$

where $P_t^{ei} = P_t^i / e_t^{ie}$ and $P_t^{eo} = P^o e_t^{eo}$ are Euro prices of imports from Italy and RoW. The trade balance $TB_t^e = P_t^e E_t^{x,e} - P_t^{ei} C_t^{ei} - P_t^{eo} C_t^{eo}$ and the current account are a mirror image of (19). Italy's net foreign debt corresponds to foreign assets of the Eurozone.

The Rest of the World (indexed by $o$) is modeled even simpler. The fixed endowment of the final good serves as the *numeraire*, $P^o = 1$. We thus abstract from monetary policy in RoW and exclude savings and capital flows. Consumers simply allocate their endowment to different goods. Demand for Italian and Eurozone exports are

$$C_t^{oi} = s^{oi} \cdot \left(e_t^{io} / P_t\right)^{\sigma_r}, \quad C_t^{oe} = s^{oe} \cdot \left(e_t^{eo} / P_t^e\right)^{\sigma_r}. \tag{24}$$

Without capital flows, trade is balanced in RoW, $TB_t^o = P^o E_t^{x,o} - P_t^{oe} C_t^{oe} - P_t^{oi} C_t^{oi} = 0$.

### 2.6 | Currency union and monetary policy

We distinguish (i) monetary policy in a currency union, and (ii) autonomous monetary policy in Italy and the remaining union. The exchange rate $e_t^{ie}$ is fixed in a currency union and flexible otherwise. Money demand follows Gali (2020). Money supply responds to output gaps and inflation, as in Ascari and Ropele (2013) and Sargent and Surico (2011).

In a *currency union*, monetary policy is centralized, and money supply must accommodate total demand for real balances, $M_t^{s,u} = \overline{P}_t\overline{M}_t + \overline{P}_t^e\overline{M}_t^e$. Common monetary policy is based on the state of the whole union and targets inflation and output gaps,

$$M_t^{s,u} = \left(1-\rho^m\right)\phi^{m,u}\overline{Y}^u \cdot \frac{\left(\overline{Y}^u/Y_t^u\right)^{\psi_y}}{\left(1+\pi_t^u\right)^{\psi_\pi}} + \rho^m M_{t-1}^{s,u} + \varepsilon_t^{m,u}. \tag{25}$$

Actual and potential outputs are $Y_t^u = Y_t + Y_t^e$ and $\overline{Y}^u = \overline{Y} + \overline{Y}^e$. Inflation is the growth rate of the average price level $\overline{P}_t^u = s^Y\overline{P}_t + \left(1-s^Y\right)\overline{P}_t^e$ where $s^Y$ is the nominal GDP weight $s^Y = PY/\left(PY + P^eY^e\right)$. Money supply deviates from a normal level $\phi^m\overline{Y}^u$ to dampen short-run fluctuations. It is scaled up if output is below trend, $Y_t^u < \overline{Y}^u$ and reduced if actual inflation exceeds the trend rate ($\pi_t^u > 0$). The smaller the home economy relative to the entire union, the weaker is the common policy response to local shocks.

In an *autonomous regime*, money markets are separate, $M_t^s = \overline{P}_t\overline{M}_t$ and $M_t^{s,e} = \overline{P}_t^e\overline{M}_t^e$. Monetary policy is decentralized and tailored to local conditions,

$$M_t^s = \left(1-\rho^m\right)\phi^m\overline{Y} \cdot \frac{\left(\overline{Y}/Y_t\right)^{\psi^{yi}}}{\left(1+\pi_t\right)^{\psi^{\pi i}}} + \rho^m M_{t-1}^s + \varepsilon_t^m. \tag{26}$$

A Eurozone exit is a regime change from common to separate monetary policy as well as from fixed to flexible exchange rates.

## 3 | QUANTITATIVE ANALYSIS

We calibrate the model and estimate selected parameters and shock processes to track past economic performance, focusing on Italy as part of the Eurozone. We use de-trended, quarterly data such that growth and inflation rates are zero in the steady state. Model solutions reflect deviations from long-run rates. Details on calibration and estimation including a shock decomposition are reported in Appendices A.2 and A.3.

### 3.1 | Impulse responses

Economists such as Shambaugh (2012) have argued that weak competitiveness and slow growth, high sovereign debt and banking sector risks are mutually reinforcing and destabilizing. This vulnerability could threaten the stability of the Eurozone and create exit pressure when a country is hit by strong asymmetric shocks and a sudden loss of market confidence. The following impulse

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response analysis illustrates transmission channels that could initiate a doom loop between the real sector, the government and banks.

### 3.1.1 | Non-performing loans shock

We explain non-performing loans (NPL) as a result of firm bankruptcy shocks. In a bankruptcy, firms loose their entire equity capital when debt is not fully repaid, and control of assets goes to banks. Since banks can sell the underlying assets only at a discount, the shock creates banking sector losses. When confronted with a larger NPL ratio, banks must raise the loan rate to account for higher credit risk, leading to higher borrowing costs for the real sector. In addition, increased credit losses shrink bank equity and, due to regulatory constraints, limit credit supply. As shown in Figure A3b, such bankruptcy shocks had meaningful effects on bank lending in Italy and explain a significant part of economic fluctuations observed during the estimation period (2000–2019). Their impact was particularly strong during and after the global financial crisis.

To highlight this reinforcing mechanism, we simulate a shock that unexpectedly raises the NPL ratio $s$ by 50%, up from 6% in stationary equilibrium to 9% annually, and vanishes thereafter. An auto-regressive coefficient of $\rho^s = .95$ implies a half-life of 13 quarters. The output sensitivity $\sigma^s = .031$ induces pro-cyclical behavior so that the subsequent contraction magnifies the NPL shock.

Figure 1 illustrates the short-run consequences. The black solid line gives the baseline response, the other two lines report sensitivity analyses. The first panel plots the shocked NPL ratio. Loan pricing reflects funding costs of banks plus a credit risk premium. As a direct effect, the NPL shock forces banks to raise the loan rate. However, the deposit rate significantly declines which reduces funding costs of banks and dampens the increase in the loan rate. The offset is almost complete in the base case. The other direct effect is a loss in bank equity, which restricts lending, investment and income.

A key driver of this result is dividend inertia. Banks cannot fully offset credit losses by retaining more earnings. Therefore, equity shrinks which forces banks to deleverage to maintain capital standards. Also, banks charge higher loan rates to cover credit losses as long as the loss rate is above average. Effects get weaker as the shock fades away. After about fifteen quarters, bank equity is lowest, about 4% below the stationary state. The loan volume, the capital stock and GDP are at their turning point, with GDP about 1.75% below trend. As the shock eventually disappears, recovery sets in, and the economy reverts back to the steady state.

Since bankruptcy tends to be low in booms and high in recessions, we have introduced a procyclical component of the NPL ratio in (2), which magnifies macroeconomic fluctuations. To illustrate the effects of procyclicality, we shut off the output sensitivity by setting $\sigma^s = 0$. The green dashed lines show how the impulse response reactions change relative to the base case. The output losses after a shock lead to a further increase in non-performing loans and thereby make them more persistent. When the output sensitivity is shut off, the NPL ratio declines faster as the first panel shows. In consequence, the erosion of bank equity is more limited. For this reason, the same NPL shock produces a more moderate credit crunch and smaller output losses.

Finally, the transmission to the banking sector should importantly depend on the loan recovery rate that results from frictions in liquidating capital goods after a bankruptcy. The red dotted lines in Figure 1 illustrate the impact of the NPL shock when the loss rate is 50% instead or 30% in the base case. Calibration with a higher loss rate shifts the path of loan interest rates to a permanently higher level, see the second panel. The key consequence of a higher loss rate is that

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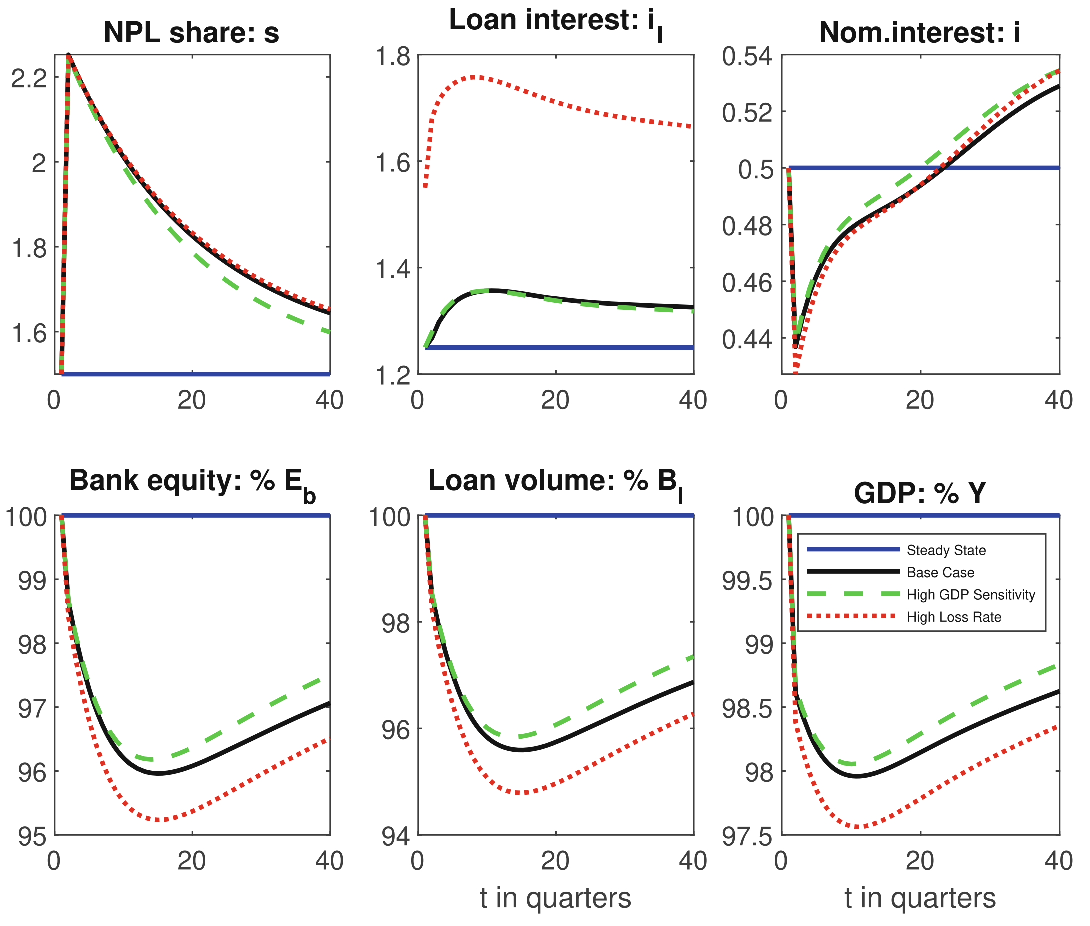


**FIGURE 1** A non-performing loan shock. [Colour figure can be viewed at wileyonlinelibrary.com]

the same shock produces larger credit losses, destroys more bank equity and magnifies the credit crunch and output losses.

### 3.1.2 | Sovereign risk premium shock

Highly indebted countries are more susceptible to a loss of investor confidence, which may cause a surge in required sovereign bond returns and borrowing costs. A higher required bond return not only tightens the fiscal budget, it also depresses the market value of outstanding bonds often held by banks, eventually causing a decrease in bank equity. Since accumulating new equity is a slow process, the shock forces banks to deleverage and restrict credit supply. Reduced economic activity negatively feeds back on the government. The shock decomposition in Figure A3a reveals that sovereign risk premium shocks contributed to rising Italian public debt, in particular, during the financial and Eurozone debt crisis. We highlight this mechanism by simulating a shock that raises the required sovereign bond return by 1% point quarterly (four points annually). Thereafter, investor confidence rebounds and the premium returns to normal levels.

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**Base case:** The black solid lines in Figure 2 illustrate the base case. In general, effects are quite small. Even though the debt-to-GDP ratio is large (130% of annual GDP pre-Covid), the low interest rate environment (0.75% per quarter, or 3% annually) limits the fiscal burden of debt. An isolated temporary shock thus involves a minor impact. Our model assumes long-term bonds with an average duration of 32 quarters and a fixed coupon rate. The first panel plots the required return on sovereign bonds. The immediate consequence of the confidence shock is a drop in the market value of about 10%, see panel 2. A large part of these bonds is held by local banks. Depending on trading behavior and bond turnover, banks experience substantial losses when selling off bonds at a lower market price. These losses impair the volume of bank equity by about 1.5% (panel 3). With a binding regulatory constraint, the lower equity leads to reduced lending, which lowers investment and GDP over several quarters. As the shock fades away, bond prices recover again and reverse the adjustment. The strong recovery even leads to a slight overshooting in loan volume. The maximum loss in output is about 1.2% points and already occurs in the second quarter. The recovery in employment after the initial drop shifts the recovery in GDP forward. Although consolidation policy allows for some temporary deficits, the government must raise tax rates and cut spending to prevent a larger deterioration of the fiscal surplus. The effect is rather small, though.

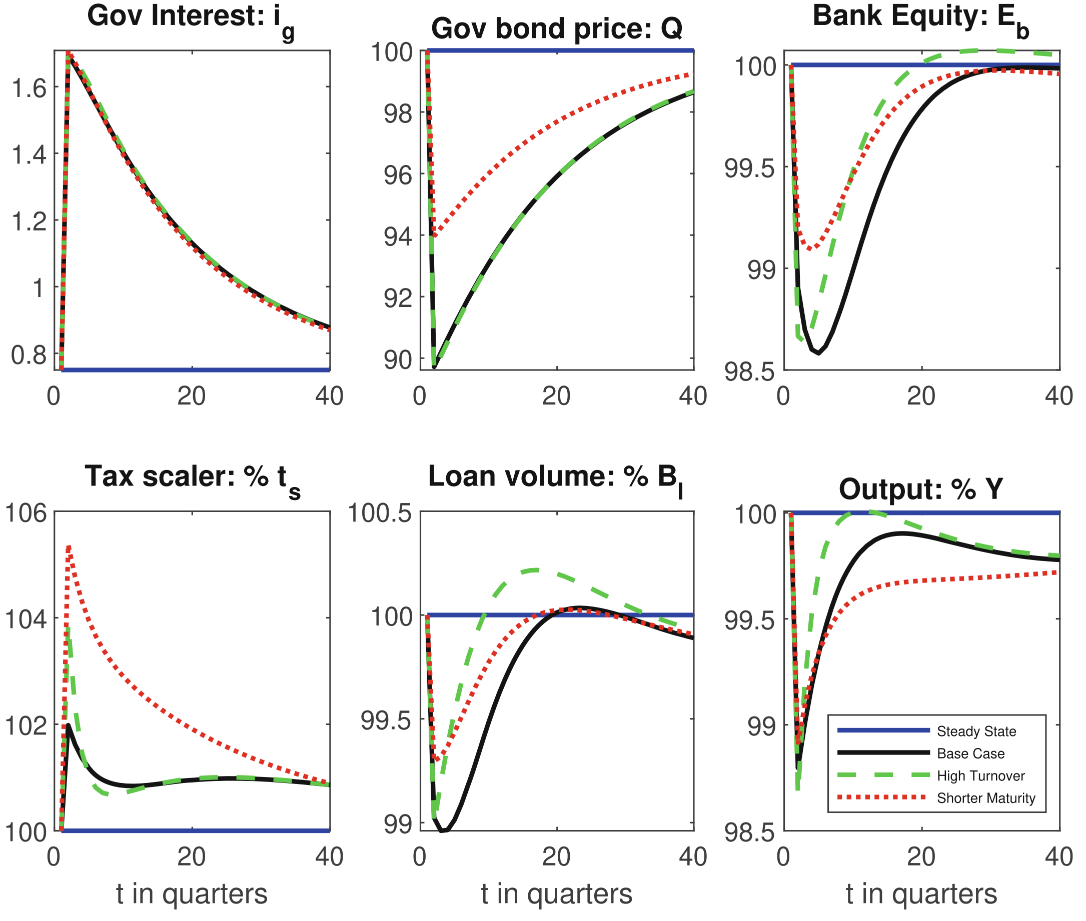


**FIGURE 2** A sovereign risk premium shock. [Colour figure can be viewed at wileyonlinelibrary.com]

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**Bond trading:** How a loss of investor confidence in sovereign bonds affects banks partly depends on the frequency of bond turnover. In the base case, banks sell off 20% of their bonds each quarter ($\delta = 0.2$) and replace them with new bonds. To check sensitivity, we increase the turnover rate to 40%. The green dashed lines highlight the consequences relative to the base case. Initially, the reduction in market valuation of bonds is largest. With more frequent trading, banks realize a larger part of losses in bond values in the first two quarters, which erodes equity. However, they also benefit earlier from the recovery of bond prices when trading more frequently. The reduction of bank equity due to losses on bond holdings is shifted forward in time. As a result, the credit crunch is worse in the first two quarters but disappears faster thereafter. This pattern transmits to the real economy and results in a sharper but shorter recession.

**Debt maturity:** How interest rate shocks affect the fiscal budget much depends on the maturity structure of debt. The parameter $\mu$ is the fraction of debt to be refinanced each period, and $1/\mu$ is bond duration. With one period bonds ($\mu \to 1$), the government must fully repay and refinance all debt. Changing interest rates would apply to the entire stock and may have quite dramatic budget effects. With long-term bonds, interest shocks change bond prices, while the coupon rate remains fixed. Changes in interest rates apply only to newly issued debt and affect the budget with much delay.

In the base case, bond duration is 32 quarters (8 years), so that 3% of debt is rolled over each quarter. We now reduce it to 10 quarters (2.5 years) so that 10% of the stock must be refinanced. Comparing the red dotted lines in Figure 2 to the black solid lines illustrates the reasoning above. The instantaneous drop in the bond price is much lower. The government must refinance a much larger share of debt with initially high interest rates which inflates the interest burden. Given consolidation rules, it must raise tax rates substantially and over a prolonged period of about 20 quarters, with unfavorable consequences for employment and investment. Banks dampen this negative effect since a weaker drop in bond prices inflicts smaller losses and thus restricts credit supply by less. On net, the tax increases lead to higher output losses over a longer period.

### 3.1.3 | Fiscal spending shock

The 'Maastricht-type' consolidation rule in (15), together with high public debt, restricts fiscal stabilization during a recession. To illustrate the mechanism, we consider an increase in public transfers. A temporary spending shock is not part of the structural deficit but raises public debt, which activates the consolidation rule. Specifically, we add 5% of GDP to social spending over a three-year period, accumulating to 15% of annual GDP.[2]

The consolidation rule kicks in after the first quarter, when the debt-to-GDP ratio starts deviating from the long-run target. For that reason, the total increase in public debt, about 13% of initial annual GDP, falls short of the cumulative spending increase. The consolidation rule requires a mix of tax hikes and spending cuts to bring the debt ratio back to its initial level. In the baseline scenario with $\gamma^g = 0.97$, the half-life of consolidation is about 23 quarters (6 years, roughly corresponding to Maastricht rules). In line with past experience, consolidation is mostly tax based.

**Base case:** The black solid lines in Figure 3 show the effects of the spending shock which lasts for 12 quarters. At the end of the deficit period, the face value of public debt is almost 10% higher, raising the debt-to-GDP ratio by 13 ($= 130 \times 0.1$) percentage points of initial GDP. Consolidation requires tax hikes and spending cuts right from the beginning, and ever more so as the debt ratio increasingly deviates from the long-run target. After 12 quarters, the spending shock

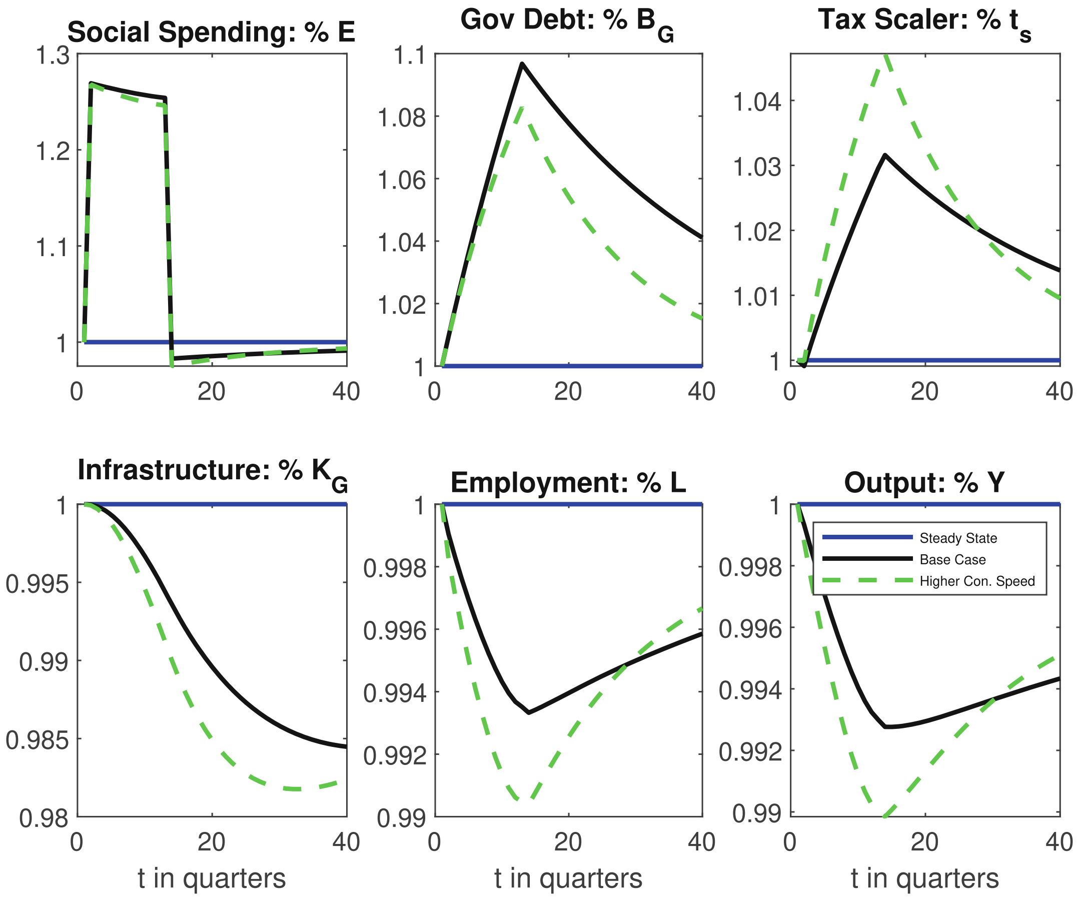


**FIGURE 3** A fiscal spending shock. [Colour figure can be viewed at wileyonlinelibrary.com]

ends. Debt is highest in quarter 13 and then falls due to consolidation. At the end of the shock period, consolidation needs are largest and *all* tax rates must be scaled up by a factor of 1.03. For instance, the wage tax rate rises from 30% to 31%. Higher taxes discourage economic activity. To a minor extent, the consolidation policy also cuts productive spending, which impairs factor productivity.

The impact on economic performance is quite moderate, however. Low interest rates imply a relatively small debt burden. When debt is largest, output is less than 1% below trend, reflecting lower employment and reduced capital formation. If interest rates were higher, consolidation needs and the required tax increases could be substantially larger.

**Higher consolidation speed:** Arguably, high-debt countries must be more ambitious in reducing debt and pursue more aggressive consolidation. One reason could be a deterioration in bond market access. We can approximate this argument by reducing the parameter $\gamma^g$ from 0.97 to 0.95. With this change, the half-life of debt reduction falls from 23 quarters (5.7 years) to 13.5 quarters (3.4 years). Comparing the green dashed lines with the base case illustrates how debt reduction is shifted forward. The policy rule responds to the growing gap between the debt ratio and its long-run target right from the start. The cumulative increase in the debt-to-GDP ratio is smaller. With more aggressive consolidation, the government must raise tax rates faster and by more. Spending similarly is reduced by more, leading to minor cuts in social spending and

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public services (infrastructure), see the first, third and fourth panels of Figure 3. The reduction in employment, capital formation and output is faster and deeper. However, recovery after the shock is faster as well, overtaking base case employment and GDP after about thirty quarters. More consolidation early on means that fiscal policy can relax earlier thereafter.

### 3.1.4 | Monetary stabilization

In a currency union, monetary policy is centralized and the internal exchange rate is fixed by sharing the same currency. Common monetary policy aims at smoothing output and inflation in the entire union. It is less effective in stabilizing output and inflation in specific member states. For illustration, we assume that both regions are subject to productivity shocks (corresponding to output shocks in the rest of the Eurozone) with a standard error of 1%. Figure 4 compares the domestic variance of output and inflation in two regimes. Within EMU, the home economy (Italy) experiences stronger output fluctuations, while inflation variance is low. Membership in the currency union comes with improved price stability but higher output fluctuations. Since the weight of Italy in union-wide output is about 18%, monetary stabilization is relatively weak. Indeed, economists argue (e.g., Colciago et al., 2008) that national policies should compensate for the loss of monetary autonomy by strengthening fiscal stabilizers and boost resilience with other reforms.

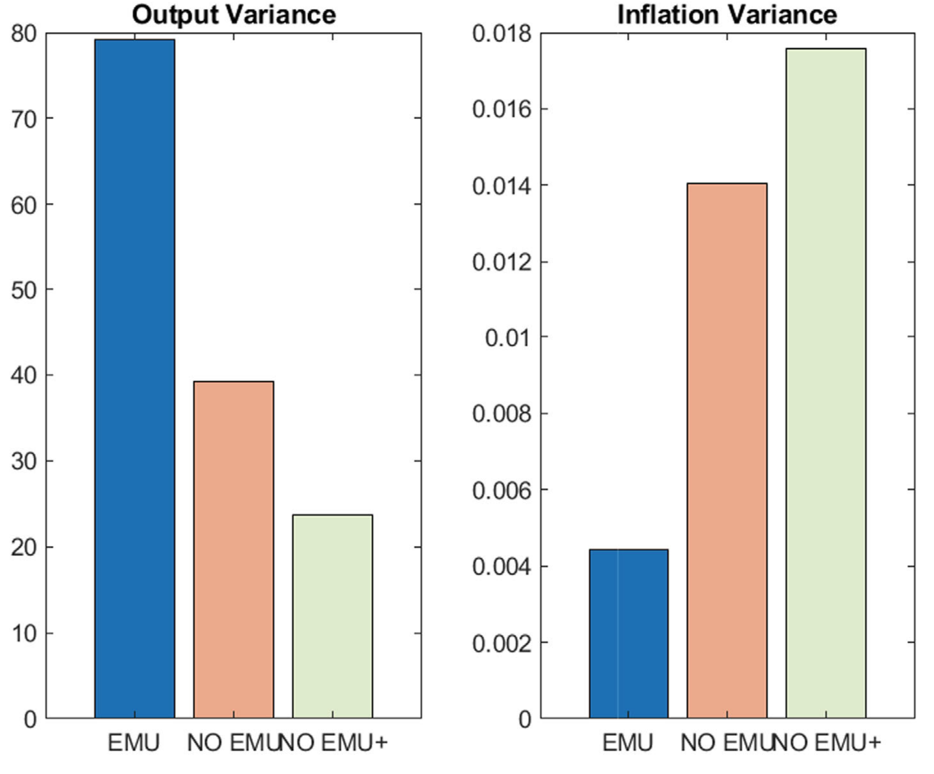


FIGURE 4 Monetary stabilization. [Colour figure can be viewed at wileyonlinelibrary.com]

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The scenario ‘No EMU’ considers autonomous monetary policy. With separate currencies, the internal exchange rate is flexible. We assume that both regions adopt exactly the same monetary policy rule, except that it is now conditional on output and inflation within each own region separately. Rather than being attributed a weight of only 18%, domestic output fluctuations now fully enter into the central bank’s objective function. The targeted reaction reduces local output variance by almost a half whereas inflation variance more than doubles. More stable output is at the expense of weaker price stability. Finally, the national central bank may pursue a more aggressive policy (‘No EMU+’). We double the sensitivity of local money supply with respect to output gaps. Output variance is further reduced at the cost of even higher inflation variance.

## 3.2 | Recession and exit

How can a vulnerable country cope with a severe asymmetric recession if the exchange rate cannot adjust and monetary policy cannot directly target local conditions? Whether intentional or forced, an exit from the currency union might become a possibility. A natural question is whether an exit could dampen the recession, and by how much.

We focus on three scenarios in response to an asymmetric recession in the home economy that results from adverse shocks: factor productivity falls by 3%, and the NPL ratio increases by 50%. These shocks are temporary and last for four quarters.

- Currency union: Monetary policy is centralized and the internal exchange rate is fixed. Apart from exogenous shocks, the emerging output gap endogenously magnifies the share of non-performing loans. The consolidation rule imposes tax increases and restricts (productive) fiscal spending, which aggravates the recession.
- Benign exit: The country experiences the same shocks, which instantaneously trigger an exit from the currency union. The exchange rate is flexible, and monetary policy is autonomously chosen. The exit is benign in the sense that it does not involve other shocks like shifts in investor expectations.
- Escalating exit: Unfavorable fundamentals (high public debt, vulnerable banks, weak growth) increase the likelihood that the exit triggers a general loss of confidence. To capture investor pessimism, we simultaneously raise the risk premium on government bonds and bank deposits relative to the safe reference asset (international bonds). All else equal, the deposit rate rises from 2% to 6% and the sovereign bond return from 3% to 7% annually. In addition, increased uncertainty about the future triggers a temporary shock to the discount rate. Households thus require a higher interest rate to supply funds. Technically, we reduce the subjective discount factor $\beta$ by 2 points (from 0.995 to 0.975). All shocks last four quarters.

The escalating scenario is reminiscent of the sudden stop emphasized by Martin and Philippon (2017) and, more broadly, shifts in investor expectations that feature prominently in models of public debt crises (e.g., Ayres et al., 2018) and bank runs (e.g., Diamond & Dybvig, 1983). We calibrate this shock to mirror the increased sovereign stress around the haircut on privately held Greek sovereign debt (2010–2012). Specifically, the shock to the sovereign risk premium ceteris paribus raises the required return on sovereign bonds from 3% to 7% annually, which is an increase of 133%. This increase mirrors quite closely the sovereign stress in the time period including the

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haircut on privately held Greek public debt. An exit of a major member state like Italy should trigger investor reactions that are at least as large. According to data of the Fed St. Louis, yields on long-term Greek sovereign bonds (10 years) rose from 10.8% in the third quarter of 2010 to at most 25.4% in the second quarter of 2012, when the Greek government concluded the exchange of bonds worth EUR 197bn. These shocks correspond to a relative increase in yields by 135%. We use the upper bound of these developments to calibrate our escalating scenario.

The parallel increase in risk premia on deposits is meant to capture the loss of confidence in times of crisis (e.g., reflecting a perceived lack of credibility of deposit insurance or the risk of redenomination). Hence, they may rapidly withdraw large amounts of deposits and trigger a sudden increase in the required return on remaining deposits. The Greek crisis, for instance, involved large-scale withdrawals of deposits from domestic banks. Data from the Bank of Greece report that, from January 2010 to December 2011, the volume of household deposits imploded by EUR 50bn or 25%. In 2015 when a left-wing party challenged austerity and bailout policies, deposits again fell by almost one quarter. The mirror image is an increase in deposit interest on remaining funds.

### 3.2.1 | Recession within the currency union

The dashed, black lines in Figures 5 and 6 refer to the impact of a deep asymmetric recession in Italy. The internal exchange rate is fixed, and monetary policy is conditional on the average economic performance in the entire union. Therefore, it cannot directly address the recession

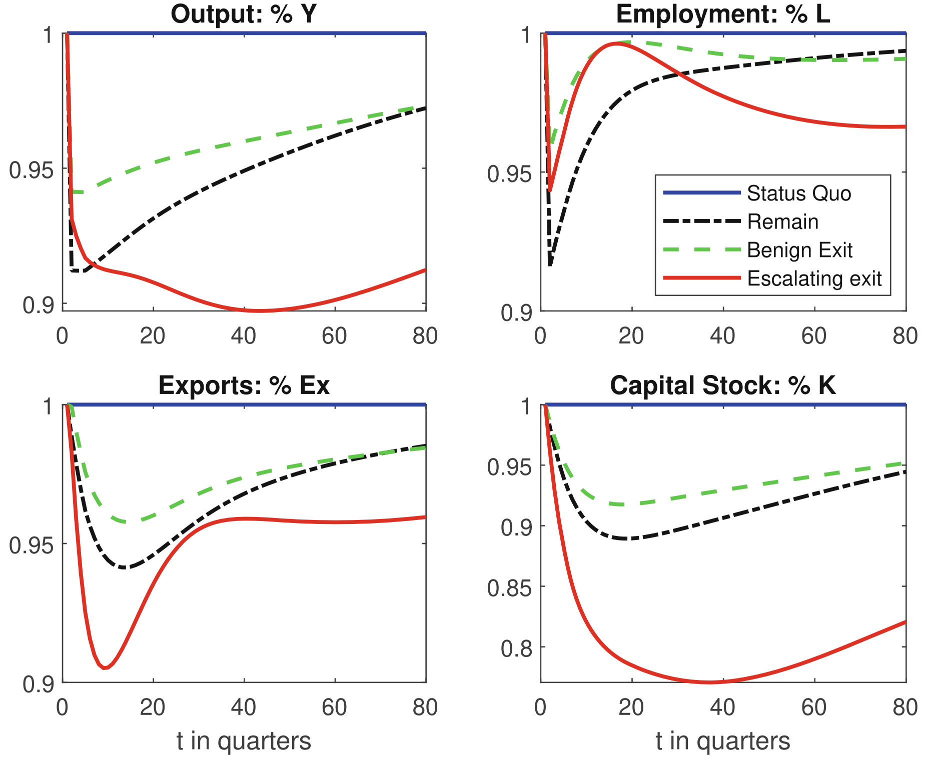


FIGURE 5 Recession and exit. [Colour figure can be viewed at wileyonlinelibrary.com]

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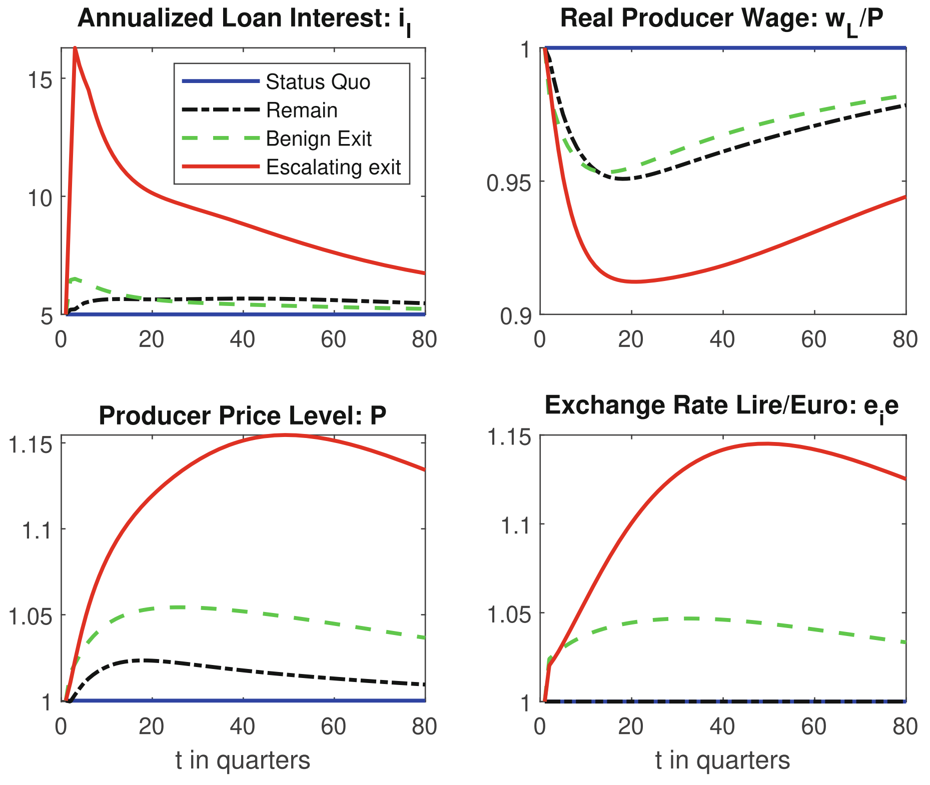


**FIGURE 6** Recession and exit. [Colour figure can be viewed at wileyonlinelibrary.com]

in one member state and responds only insofar as the recession affects union-wide output and inflation. Given large negative shocks to productivity and loan quality, the recession is bound to be very severe and involves an instantaneous output loss of about 9%. This loss persists over four quarters. After that, shocks start to fade out, and economic recovery sets in.

The recession feeds on several sources. The negative productivity shock reduces investment and labor demand. The effect on investment is reinforced by a rising NPL ratio, which is magnified by the large output gap. Banks raise the loan rate both because credit risk is higher and equity losses restrict their lending capacity. Despite a decline in the deposit rate due to the reduced demand of banks, the loan rate rises on net. Both lower productivity and higher costs of capital discourage firm investment. Roughly 20 quarters after the start of the crisis, the capital stock is almost 11% below the stationary value.

The productivity shock also reduces employment. Nominal wage stickiness prevents an immediate wage cut. Since the productivity loss causes higher producer prices, the real wage falls, which stabilizes employment. It falls by much less than the capital stock. However, given a fixed exchange rate with the most important trading partners, the rising producer prices weaken competitiveness and substantially erode exports.

By construction, centralized monetary policy cannot target the special situation in Italy and remains rather passive. Fiscal policy is constrained by a high level of debt and cannot run into a substantial deficit, thereby preventing automatic fiscal stabilization to a large degree. The consolidation rule even forces the government to tighten the fiscal stance to prevent a large further increase in public debt. Our model simulation thus emphasizes that a Eurozone member state

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with excessive public debt, weak competitiveness and a vulnerable banking sector is bound to experience more severe recessions than other member states if they were subject to the same shocks.

### 3.2.2 | Benign exit

This scenario is defined as an exit that occurs without any adverse investor reactions (green, dashed lines in Figures 5 and 6). We consider the same asymmetric shocks as before but now the internal exchange rate is flexible, and monetary policy is autonomous and can help cushion the recession. The national central bank is a mere replica of the common central bank, with the same sensitivity of money supply to output and inflation gaps. However, the weight of the national economy in the local monetary policy rule is now 100%, rather than 18% in the currency union. The expansion of domestic money supply in response to the recession is thus roughly five times larger than under continued membership in the monetary union.

The key difference is higher inflation since money supply rises much more. The increase in domestic producer prices is more than twice as large. The larger price increase is facilitated by a depreciation of the new currency of roughly 5% which prevents a loss in international competitiveness. With more inflation, nominal interest rates including the nominal loan rate now substantially increase, while real rates follow roughly the same pattern as in the remain scenario. The targeted monetary response and the exchange rate flexibility lead to a considerable stabilization relative to continued membership. The depreciation benefits the home economy by reducing imports and strengthening exports. Exports shrink significantly less than in the baseline scenario. The substantial increase in inflation shifts the reduction in real wages forward in time and thereby prevents some unemployment. A benign exit could significantly reduce output and employment losses in the early adjustment period, see Figure 5. In line with this, investment and exports are much stronger compared to the base case.

One might argue that national monetary policy could intervene much stronger to the emerging output gap in a large asymmetric recession and accept even more inflation compared to centralized policy making. Such a policy change could also devalue the real value of debt. Surely, short-run stabilization would be significantly enhanced, although at the cost of higher inflation. Since we do not want to mix the effects of an exit scenario with the effects of a change in monetary policy, we abstract from such possibility.

### 3.2.3 | Escalating exit

An exit from the monetary union likely triggers sudden shifts in investor expectations and may even cause a general loss of confidence, especially for a vulnerable country. We picture a sudden increase in risk premiums on sovereign bonds and bank deposits, reflecting growing concerns about the solvency of the government and local banks. These returns surge during the four-quarter recession before gradually reverting to normal levels.[3] We also capture household pessimism regarding future developments by a preference shock that implies higher discounting. This shock shifts forward future consumption, thereby dampens the immediate recession but delays the recovery thereafter. It also pushes up interest rates to keep up funding of the real economy. The red solid lines in Figures 5 and 6 illustrate the adjustment, and Table A3 reports detailed results.

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The 'sudden stop' characterized by exceptionally high interest rates magnifies the recession caused by the original shocks to productivity and loan quality. Banks pass the higher funding costs onto borrowers via higher loan rates. In addition, larger losses on loans and sovereign bonds further erode equity and constrain credit supply. Much higher costs of capital sharply restrict investment and erode the capital stock: Eight quarters after the onset of crisis, the capital stock is 17% lower, see Table A3.

Reacting to a much larger output gap, the central bank aggressively expands money supply and accepts substantially higher inflation. Domestic inflation initiates a reduction in real wages and real interest rates. Real rates decline sharply at the onset of crises and then quickly increase and remain at higher levels over a prolonged period, see Table A3. The real wage reduction leads to a more favorable response of employment early on. However, employment remains subdued over a long period thereafter, compared to the other scenarios. The large reduction of investment in the early crisis period and the slow recovery of productive capital thereafter leads to reduced capital intensity and a long-lasting impairment of labor market performance.

The sudden increase in inflation has two important consequences. First, higher prices erode export competitiveness. Even the larger devaluation of the currency does not fully compensate for the loss in international price competitiveness. Exports fall substantially. In addition, devaluation is partly contributing to domestic inflation via higher import prices. Second, the real value of outstanding sovereign debt falls because of both higher inflation and lower bond prices, which decrease by 18% after four quarters mainly due to a higher risk premium. Lower bond prices inflict large losses on banks and households.

The large public debt prevents a decisive fiscal intervention to fight the crisis. Although the consolidation rule does allow for temporary deficits and requires only a slow reduction of structural deficits, consolidation must start early on to keep the debt ratio from increasing too much. After all, the high indebtedness with insolvency concerns might in the first place be a key reason for the escalating scenario. Except for the first quarter, tax rates must even increase during the crisis, to a small extent, as Table A3 shows. Productive government spending is similarly held back by consolidation needs so that the stock of public infrastructure remains below trend over a long time period, with negative consequences for productivity and economic recovery after the crisis.

## 4 | CONCLUSION

In this paper, we have considered an economy that is part of a monetary union and is exposed to a 'trilemma' of high public debt, weak banks, and a lack of competitiveness. We have analyzed the macroeconomic adjustment to an asymmetric recession under continued membership in the monetary union, compared to an exit. Key results are: First, under continued membership in the monetary union, the recession is severe, given a lack of monetary autonomy and tight constraints on fiscal policy. Second, a 'benign exit' from the Eurozone with stable investor expectations could dampen the negative short-run output and employment losses. Stabilization is achieved by monetary expansion that reduces real wages in the short run and leads to an exchange rate depreciation. This helps restore international competitiveness. However, stable investor expectations after an exit might be unrealistic, given the vulnerable state of the economy and the large uncertainties associated with an exit. We have thus considered a third scenario of an 'escalating exit', in which a loss of investor confidence causes a surge in risk premiums upon exit. This magnifies private and public borrowing costs, further depressing investment and constraining fiscal policy. Unfavorable capital market reactions offset the advantages of monetary autonomy. Such an exit scenario makes the recession deeper than under continued membership and considerably delays the full recovery.

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## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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## ENDNOTES

[1] Combine (14.ii) and (15) to eliminate $Q_t B_t^G$ gives an equivalent representation of consolidation rule by specifying a primary surplus target, $S_t^G = \left[\bar{\imath} + \mu + (1-\mu) Q_t - \gamma^g Q_t\right] B_{t-1}^G - (1-\gamma^g)\,\bar{b}^g P_t Y_t$. The Maastricht rules indeed specify targets for the primary surplus.

[2] A recent example would be the Covid crisis which has greatly increased government spending to replace private incomes and has led to a discrete jump in sovereign debt.

[3] Figure A3a in the Appendix illustrates to which extent these shocks (based on estimated rather than counterfactual shocks) contributed to the rise in Italian public debt during the financial crisis.

[4] Acharya et al. (2007) report a mean loan recovery rate of 81% from a sample of non-financial US corporations over 1982–1999. Grunert and Weber (2009) find a 73% retrieval rate for German firms while Caselli et al. (2008) estimate a rate of only 48% for Italian SMEs.

[5] Specifically, we define $(1+i_t)\,e_t^e/e_{t+1}^e \equiv 1 + \tilde{\imath}_t$ to calculate the slope $d\tilde{\imath}_t/db_t^f = (1+i^e)\,\gamma$ where $e^{b^f - \bar{b}^f} = 1$ in a steady state. Replicating this response requires $d\tilde{\imath}_t/db_t^f = (1+i^e)\,\gamma = .0025/.2$. Noting $i^e = i = .0075$, we find the parameter $\gamma = .0124$.

[6] Colombier (2009) finds that an increase in spending on transport, water systems and education by 1% point raises the per capita growth rate of real GDP by 0.5 percentage points. The estimate of Bleaney et al. (2001) is lower at 0.3% points. In Section 2.3, the long-run productivity effect is $\hat{Z} = \sigma^z \hat{G}$, where $Z = \overline{Z}$ and $G = \delta^g K^G$. Assuming constant user cost and employment, technology $Y = ZK^\alpha L^{1-\alpha}$ implies $\hat{Y} = \hat{Z} + \alpha\hat{K}$ while $Y_K$ constant yields $\hat{Y}_K = \hat{Z} - (1-\alpha)\hat{K} = 0$. Combining, the long-run output effect is $\hat{Y} = \frac{1}{1-\alpha}\hat{Z} = \frac{\sigma^z}{1-\alpha}\hat{G}$. In levels (percentage points, $dY = Y \cdot \hat{Y}$), we obtain $\frac{dY}{dG} = \frac{\sigma^z}{1-\alpha}\frac{Y}{G}$. With $\alpha = .3$ and our estimate $\sigma^z = .03$, the output effect of productive spending is $\frac{.03}{.7}\frac{100}{15} = 0.29$ is at the lower end, but still in line with empirical estimates.

[7] Since the model requires stationary data, we detrend the data by output growth. We also remove seasonal trends in wages.

[8] The mode is the most frequently computed value. It does not coincide with the mean for non-normal (non-symmetric) distributions and not necessarily with the peak of the posterior distribution.

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## REFERENCES

Acharya, V. V., Bharath, S. T., & Srinivasan, A. (2007). Does industry-wide distress affect defaulted firms? Evidence from creditor recoveries. *Journal of Financial Economics*, *85*, 787–821.

Acharya, V. V., Drechsler, I., & Schnabl, P. (2014). A phyrric victory? Bank bailouts and sovereign credit risk. *Journal of Finance*, *69*, 2689–2739.

Acharya, V. V., & Steffen, S. (2015). The greatest carry trade ever? Understanding eurozone bank risks. *Journal of Financial Economics*, *115*, 215–236.

Adolfson, M., Laseen, S., Linde, J., & Villani, M. (2007). Bayesian estimation of an open economy DSGE model with incomplete pass-through. *Journal of International Economics*, *72*, 481–511.

Alesina, A., Favero, C., & Giavazzi, F. (2015). The output effect of fiscal consolidation plans. *Journal of International Economics*, *96*, 19–42.

Altavilla, C., Pagano, M., & Simonelli, S. (2016). Bank exposures and sovereign stress transmission. *Review of Finance*, *21*, 2103–2139.

Ascari, G., & Ropele, T. (2013). Disinflation effects in a medium-scale new Keynesian model: Money supply rule versus interest rate rule. *European Economic Review*, *61*, 77–100.

Ayres, J., Navarro, G., Nicolini, J. P., & Teles, P. (2018). Sovereign default: The role of expectations. *Journal of Economic Theory*, *175*, 803–812.

Barro, R. J. (1990). Government spending in a simple model of endogenous growth. *Journal of Political Economy*, *98*, S103–S125.

Begenau, J. (2020). Capital requirements, risk choice, and liquidity provision in a business-cycle model. *Journal of Financial Economics*, *136*, 17–34.

Bleaney, M., Gemmell, N., & Kneller, R. (2001). Testing the endogenous growth model: Public expenditure, taxation, and growth over the long run. *Canadian Journal of Economics*, *34*, 36–57.

Bofondi, M., Carpinelli, L., & Sette, E. (2018). Credit supply during a sovereign debt crisis. *Journal of the European Economic Association*, *16*, 696–729.

Calvo, G. A. (1988). Servicing the public debt: The role of expectations. *American Economic Review*, *78*, 647–661.

Caselli, S., Gatti, S., & Querci, F. (2008). The sensitivity of the loss given default rate to systematic risk: New empirical evidence on bank loans. *Journal of Financial Services Research*, *34*, 1–34.

Chetty, R., Guren, A., Manoli, D., & Weber, A. (2011). Are micro and macro labor supply elasticities consistent? A review of evidence on the intensive and extensive margins. *American Economic Review P&P*, *101*, 471–472.

Chodorow-Reich, G., Karabarbounis, L., & Kekre, R. (2019). The macroeconomics of the Greek recession. *CEPR DP*, *13762*, 1–67.

Colciago, A., Ropele, T., Muscatelli, V. A., & Tirelli, P. (2008). The role of fiscal policy in a monetary union: Are national automatic stabilizers effective? *Review of International Economics*, *16*(3), 591–610.

Cole, H. L., & Kehoe, T. J. (2000). Self-fulfilling debt crises. *Review of Economic Studies*, *67*, 91–116.

Colombier, C. (2009). Growth effects of fiscal policies: An application of robust modified m-estimator. *Applied Economics*, *41*, 899–912.

Diamond, D. W., & Dybvig, P. H. (1983). Bank runs, deposit insurance, and liquidity. *Journal of Political Economy*, *91*(3), 401–419.

Erceg, C. J., Henderson, D. W., & Levin, A. T. (2000). Optimal monetary policy with staggered wage and Price contracts. *Journal of Monetary Economics*, *46*, 281–313.

Gali, J. (2015). *Monetary policy, inflation, and the business cycle* (2nd ed.). Princeton University Press.

Gali, J. (2020). The effects of a money financed fiscal stimulus. *Journal of Monetary Economics*, *115*, 1–19.

Gennaioli, N., Martin, A., & Rossi, S. (2014). Sovereign default, domestic banks and financial institutions. *Journal of Finance*, *69*, 819–866.

Gerali, A., Neri, S., Sessa, L., & Signoretti, F. M. (2010). Credit and banking in a DSGE model of the euro area. *Journal of Money, Credit and Banking*, *42*, 107–141.

Gourinchas, P.-O., Philippon, T., & Vayanos, D. (2016). The analytics of the Greek crisis. *NBER Macroeconomics Annual*, *31*, 1–81.

Grunert, J., & Weber, A. (2009). Recovery rates of commercial lending: Empirical evidence from Germany. *Journal of Banking and Finance*, *33*, 505–513.

Ireland, P. N. (2009). On the welfare cost of inflation and the recent behavior of money demand. *American Economic Review*, *99*, 1040–1052.

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Keane, M., & Rogerson, R. (2012). Micro and macro labor supply elasticities: A reassessment of conventional wisdom. *Journal of Economic Literature*, *50*, 464–476.

Keuschnigg, C. (2022). A monetary model of the eurozone, technical appendix. https://www.alexandria.unisg.ch/266805

Kriwoluzky, A., Müller, G., & Wolf, M. (2019). Exit expectations and debt crises in currency unions. *Journal of International Economics*, *121*, 103253.

Laeven, L., & Valencia, F. (2012). Systemic banking crises database: An update. IMF WP No. 12/163.

Louzis, D. P., Vouldis, A. T., & Metaxas, V. L. (2012). Macroeconomic and Bank-specific determinants of non-performing loans in Greece: A comparative study of mortgage, business and consumer loan portfolios. *Journal of Banking and Finance*, *36*, 1012–1024.

Martin, P., & Philippon, T. (2017). Inspecting the mechanism: Leverage and the great recession in the eurozone. *American Economic Review*, *107*, 1904–1937.

Obstfeld, M., & Rogoff, K. (2000). *The six major puzzles in international macroeconomics: Is there a common cause?* In B. Bernanke & K. Rogoff (Eds.), *NBER macroeconomics annual 2000* (Vol. *15*, pp. 339–412). The University of Chicago Press.

Ongena, S., Popov, A., & Van Horen, N. (2019). The invisible hand of the government: Moral suasion during the European sovereign debt crisis. *American Economic Journal: Macroeconomics*, *11*, 346–379.

Quagliarello, M. (2007). Banks' riskiness over the business cycle: A panel analysis on Italian intermediaries. *Applied Financial Economics*, *17*, 119–138.

Salas, V., & Saurina, J. (2002). Credit risk in two institutional regimes: Spanish commercial and savings banks. *Journal of Financial Services Research*, *22*, 203–224.

Sargent, T. J., & Surico, P. (2011). Two illustrations of the quantity theory of money: Breakdowns and revivals. *American Economic Review*, *101*, 109–128.

Schivardi, F., Sette, E., & Tabellini, G. (2021). Credit misallocation during the European financial crisis. *Economic Journal*, *132*, 391–423.

Schmitt-Grohé, S., & Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, *61*, 163–185.

Schmitt-Grohé, S., & Uribe, M. (2005). Optimal fiscal and monetary policy in a medium-scale macroeconomic model. *NBER Macroeconomic Annual*, *20*, 383–425.

Schmitt-Grohé, S., & Uribe, M. (2016). Downward nominal wage rigidity, currency pegs, and involuntary unemployment. *Journal of Political Economy*, *124*, 1466–1514.

Shambaugh, J. C. (2012). The Euro's three crises, Brookings papers on economic activity, Spring 2012, 157–231.

Smets, F., & Wouters, R. (2003). An estimated dynamic stochastic general equilibrium model of the euro area. *Journal of the European Economic Association*, *1*, 1123–1175.

Smets, F., & Wouters, R. (2005). Comparing shocks and frictions in US and euro area business cycles: A Bayesian DSGE approach. *Journal of Applied Econometrics*, *20*, 161–183.

Terzi, A. (2020). Macroeconomic adjustment in the euro area. *European Economic Review*, *128*, 103516.

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# APPENDIX A

## A.1 Consolidation of structural deficits

Maastricht rules for fiscal consolidation specify targets for the structural surplus, $\tilde{S}_t^G$. Any temporary deviations go into debt and are to be consolidated in future periods. Allowing for transitory shocks, spending rules are thus modified to

$$P_tG_t = \bar{g} \cdot P_tY_t - \xi^g \cdot \tilde{S}_t^G + \varepsilon_t^G, \quad E_t = \bar{e} \cdot w_t^L L_t - \xi^e \cdot \tilde{S}_t^G + \varepsilon_t^E. \tag{A1}$$

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As in (15) and the footnote thereafter, we specify a structural surplus target $\tilde{S}_t^G$,

$$\tilde{S}_t^G = \left[\bar{i} + \mu + (1-\mu)Q_t - \gamma^g Q_t\right] B_{t-1}^G - \left(1-\gamma^g\right) \bar{b}^g P_t Y_t. \tag{A2}$$

Absent shocks, structural and actual surpluses are identical, $S_t^G = \tilde{S}_t^G$. Using (A2) in (14.ii) shows that consolidation policy is equivalent to (15) in this case. When $S_t^G$ and $\tilde{S}_t^G$ are different, the unconsolidated part $S_t^G - \tilde{S}_t^G$ is debt financed. Financing only structural spending $P_t\tilde{G}_t = \bar{g}P_tY_t - \xi^g\tilde{S}_t^G$ and $\tilde{E}_t = \bar{e}w_t^L L_t - \xi^e\tilde{S}_t^G$ requires tax revenue $T = \tilde{S}_t^G + P_t\tilde{G}_t + \tilde{E}_t = \bar{g}P_tY_t + \bar{e}w_t^L L_t + (1-\xi^g-\xi^e)\tilde{S}_t^G$. The part $(1-\xi^g-\xi^e)\tilde{S}_t^G$ of the structural surplus is tax financed and dictates a scaling of tax rates.

### A.2 Calibration

We use detrended quarterly data and normalize Italian GDP to 100. All macro data are thus in percent of GDP. We infer country size from Eurostat and Worldbank data. Italy produced 18% of Eurozone GDP which, in turn, accounted for 17% of world GDP.

Table A1 lists key parameters and data that are calibrated. Table A2 reports selected estimated parameters. By OECD data, Eurozone sovereign bonds paid an annual rate of roughly 4%, largely

**TABLE A1** Key parameters and data.

| | | |
|---|---|---|
| Quarterly interest rates | | |
| $i$ | 0.5% | Safe, benchmark interest rate |
| $i^g$ | 0.75% | Sovereign interest rate |
| $i^k, i^b$ | 2.5% | Required return on equity |
| $i^l$ | 1.25% | Loan interest rate |
| Households | | |
| $\eta$ | 0.4 | Frisch labor supply elasticity |
| $\sigma$ | 4.5 | Elasticity of labor substitution |
| $\sigma^c$ | 0.5 | Intertemporal elasticity of substitution |
| $\sigma^m$ | 0.035 | Interest elasticity of money demand |
| $\omega$ | 0.8 | Rate of wage adjustment |
| Firms and banks | | |
| $\alpha$ | 0.3 | Capital income share |
| $b^k$ | 0.6 | Debt/asset ratio firms |
| $\delta^k$ | 0.03 | Capital depreciation rate |
| $s$ | 0.015 | Non performing loans (NPL) ratio |
| $\ell$ | 0.3 | Loss share of NPL |
| $\kappa^B$ | 0.15 | Equity/asset ratio banks |
| Dynamics | | |
| $b^f$ | 0.88 | Net foreign debt/GDP ratio (quarterly) |
| $\gamma$ | 0.0124 | Interest sensitivity w.r.t. foreign debt |

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**TABLE A2** Prior and posterior distributions.

| Parameter | | Prior distribution | | | Posterior distribution | | |
|---|---|---|---|---|---|---|---|
| | | Density | Mean | Std. dev | 10% | Mean | 90% |
| Autocor. risk premia | $\rho^{th}$ | Beta | 0.95 | 0.01 | 0.9336 | 0.9471 | 0.9598 |
| Autocor. NPL shock | $\rho^{s}$ | Beta | 0.95 | 0.01 | 0.9330 | 0.9489 | 0.9609 |
| Autocor. revenue losses | $\rho^{T}$ | Beta | 0.95 | 0.01 | 0.9365 | 0.9513 | 0.9627 |
| Autocor. business cycle | $\rho$ | Beta | 0.95 | 0.01 | 0.9371 | 0.9481 | 0.9588 |
| Consolidation speed | $\gamma^{g}$ | Beta | 0.97 | 0.001 | 0.9608 | 0.9727 | 0.9828 |
| Sensitivity NPL rate | $\sigma^{s}$ | Inv.Gamma | 0.05 | 0.1 | 0.0172 | 0.0274 | 0.0507 |
| Sensitivity productivity | $\sigma^{z}$ | Inv.Gamma | 0.05 | 0.1 | 0.0179 | 0.0311 | 0.0492 |
| Armington trade elasticity | $\sigma^{r}$ | Normal | 5 | 1 | 4.7162 | 5.7600 | 6.8527 |
| Dividend adj. costs | $\psi^{b}$ | Normal | 0.25 | 0.01 | 0.2382 | 0.2517 | 0.2644 |
| Investment adj. costs | $\psi^{k}$ | Normal | 1 | 0.1 | 0.8433 | 0.9721 | 1.0959 |
| Consolidation share G | $\xi^{g}$ | Normal | 0.2 | 0.001 | 0.1873 | 0.2002 | 0.2128 |
| Consolidation share E | $\xi^{e}$ | Normal | 0.1 | 0.001 | 0.0863 | 0.0997 | 0.1126 |
| SD productivity shock IT | $\tilde{\sigma}^{z}$ | Inv.Gamma | 0.1 | 2 | 0.0107 | 0.0120 | 0.0135 |
| SD income shock EZ | $\tilde{\sigma}^{ye}$ | Inv.Gamma | 10 | 4 | 3.7093 | 4.0954 | 4.5652 |
| SD deposit shock | $\tilde{\sigma}^{d}$ | Inv.Gamma | 0.1 | 2 | 0.0087 | 0.0096 | 0.0108 |
| SD gov. interest shock | $\tilde{\sigma}^{g}$ | Inv.Gamma | 0.1 | 2 | 0.0087 | 0.0097 | 0.0109 |
| SD preference | $\tilde{\sigma}^{\beta}$ | Inv.Gamma | 0.1 | 2 | 0.0127 | 0.0145 | 0.0163 |
| SD NPL shock | $\tilde{\sigma}^{s}$ | Inv.Gamma | 0.1 | 2 | 0.0087 | 0.0097 | 0.0110 |

the same in all member states. The prototype safe asset are long-term US treasuries, which paid on average 2% per annum. We assume that all assets other than deposits yield the same risk-adjusted return of 3% annually, corresponding to 0.75% quarterly. Eurostat data yield a typical return on equity of 2.5% (10% p.a.). The interest rate on private credit is 1.25%, or 5% p.a. We calibrate the discount factor $\beta$ and the risk premia $\theta$ to support these interest rates and returns in stationary equilibrium.

Preferences are calibrated in line with prior research: We use a Frisch labor supply elasticity of 0.4 (Keane & Rogerson, 2012; Chetty et al., 2011). The intertemporal substitution elasticity is $\sigma^c = 0.5$, a typical value as in Smets and Wouters (2003, 2005), for example. The price sensitivity of trade flows depends on the Armington elasticity of substitution between goods of different country origin. Evidence in Adolfson et al. (2007) and Obstfeld and Rogoff (2000) gives $\sigma^r = 5$. Taking this as a pior, we estimate a value of 5.76 in Table A2. Finally, we follow Gali (2015, p. 177) and set the substitution elasticity for labor varieties to $\sigma = 4.5$ and the degree of wage stickiness to $\omega = 0.8$. This is broadly consistent with Schmitt-Grohé and Uribe (2005) who rely on wage stickiness between 0.64 and 0.87 and with Erceg et al. (2000) who use a value of 0.75.

In production, we set the capital share in value added to $\alpha = 0.3$, which is close to OECD data on the income share of capital. The depreciation rate is $\delta^k = 0.03$, or 12% annually. Demand for

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bank credit follows from firms' debt-to-asset ratio $b^k = 0.6$, which corresponds to Eurostat data for Eurozone non-financial firms.

Turning to the banking sector, the equity ratio of Italian banks has recently fluctuated around 15% of total assets ($\kappa^B = 0.15$) well above the minimum capital requirements of 8% for corporate credit. In the early 2000's, their non-performing loans (NPL) ratio amounted to 6.6%, substantially exceeding the 2.5% NPL ratio in the Eurozone. In the aftermath of the Eurozone crisis, this share reached a maximum of almost 18% in 2015, and declined considerably since then. We view these (large) deviations to be temporary in nature and calibrate a stationary ratio of 6% p.a., or a quarterly flow rate of 1.5%. The loss ratio on non-performing loans amounts to 30% ($\ell = 0.3$), reflecting estimates for total recovery rates between 50% and 85%.[4] The NPL ratio is sensitive to output fluctuations. We estimate a sensitivity of $\sigma^s = 0.027$, see Table A2.

Moreover, net foreign debt amounts to 22% of annual GDP, or 88% of quarterly GDP. An increase in net foreign indebtedness translates into a higher country premium and raises domestic interest rates. We normalize the country premium to zero in the steady state, so that $\theta^f = 1$ in (21). We then calibrate $\gamma$ such that an increase in the debt-to-GDP ratio by 20% points raises the interest rate by 25 basis points (1% point annually)[5] Turning to trade flows, Italy imported 23% of GDP and exported 21%, according to Eurostat data. Of all imports, 47% were sourced from the EA and 53% from RoW. On the export side, 47% of all exports went to the EA and 53% to RoW. Using export data from RoW to all individual EA countries (except Italy), we can determine EA's import share as 19% of GDP, of which 12% stemmed from Italy and 88% from RoW.

By OECD data, Italian public debt was 105% of annual GDP in 2006 and has grown since then to about 130% of GDP pre Covid, which is much higher than in the Eurozone excluding Italy. We take the pre-Covid level to be the stationary debt ratio equal to 520% of quarterly GDP, and set $\overline{b}^g = 5.2$. Banks (and other financial institutions) hold around 35% of public debt in Italy, giving $\tilde{s}^b = 0.35$. The parameter $\gamma^g$ determines the speed of fiscal consolidation. We estimate this value to be $\gamma^g = 0.97$, which implies a half-life of debt adjustment of 30 quarters, or about 7.5 years. We also estimate that 70% of consolidation rests on tax increases and 30% on spending cuts, of which one third reduce social spending ($\xi^e = 0.1$), and two thirds productive spending ($\xi^g = 0.2$).

Social spending absorbs 18.5% of GDP which is 30% of gross wage income ($\bar{e} = 0.295$). Public consumption in Italy amounts to 14.6% of GDP ($\overline{g} = .15$). Adding debt service gives a total expenditure share of 44.3% of GDP. Following Barro (1990), we allow for a positive productivity effect of productive public spending. Our estimate of $\sigma^z = 0.03$ in the Appendix is consistent with available estimates of the output effect.[6]

Turning to money demand, Gali (2020, p. 7) reports an average, quarterly income velocity of 2.7 in the Euro Area for 1999–2015. Accordingly, we set money balances to be $M^s = \overline{PM} = \phi^m \cdot Y$ with $\phi^m = 2.7$. Taking money demand as in (8), we compute a semi-elasticity of $\frac{d\overline{M}/\overline{M}}{di} = -\frac{\sigma^m}{(1+i)i}$. Following Gali (2020) and Ireland (2009), we take empirical estimates of the (quarterly) semi-elasticity of money demand to be $\epsilon^{md} = 7$ and accordingly calibrate $\sigma^m = (1+i)i \cdot \epsilon^{md}$. Monetary policy in (25), (26) allows for rule based stabilization. Ascari and Ropele (2013) have estimated the sensitivities of money supply to changes in the price level and the output gap and report values between 1 and 3 for $\psi_\pi$ and a range of 0 to 1 for $\psi_y$. We use $\psi y = 1$ and $\psi_\pi = 2$.

Transitional dynamics depend on adjustment costs and auto-regressive shock processes: First, we assume quadratic capital installation costs, and allow for dividend inertia in banking as

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in Begenau (2020). We estimate the cost parameters at $\psi^k = 0.97$ for capital adjustment and $\psi^b = 0.25$ for dividend inertia. Second, short-run dynamics depend on the persistence of shock processes. We set the priors of the auto-regressive coefficients of business cycle shocks ($\rho$-coefficients) equal to 0.95. Estimated values stay close to the prior (see Table A2). Shocks are thus slightly more persistent compared to the estimates of 0.85 and 0.95 by Smets and Wouters (2003) and Gerali et al. (2010).

### A.3 Estimation

The calibration with prior parameter values results in a steady state reflecting the conditions at the start of the monetary union in the early 2000s. Using Bayesian estimation procedures, we estimate several structural parameters. Specifically, we let the model determine the shock processes to replicate key time series from 2000 to 2019.[7] Specifically, we estimate shocks to total factor productivity $Z_t$, to the non-performing loan share $s_t$, risk premia on sovereign bonds $\theta_t^g$, and deposits $\theta_t^d$, as well as work preferences $\phi_t$. Furthermore, our estimation includes a shock process to the Eurozone GDP $Y_t^e$.

With six endogenous shocks, the model replicates without error six selected time series as part of stochastic equilibrium. Motivated by earlier discussion of past performance in Italy, we track the GDP share of public and private debt $B_t^G/(P_tY_t)$, $B_t^l/Y_t$, the non-performing loan share $s_t$, interest rates $i_t^d$ and $i_t^g$ on deposits and fiscal debt, as well as Eurozone output $Y_t^e$. The estimation provides us with values for twelve parameters, which determine fiscal spending behavior ($\gamma^g$, $\xi^g$, $\xi^e$), elasticities ($\sigma^z$, $\sigma^s$, $\sigma^r$), adjustment costs ($\psi^k$, $\psi^b$), as well as speeds of adjustment ($\rho^\theta$, $\rho^s$, $\rho^T$, $\rho$). Table A2 provides an overview of estimated shocks together with selected structural parameters and reports our prior assumptions together with the resulting posterior distributions.

Since standard deviations of shocks should be non-negative, we assume an inverse-gamma distribution (e.g., Gerali et al., 2010) with size-appropriate priors. Moreover, the persistence of the

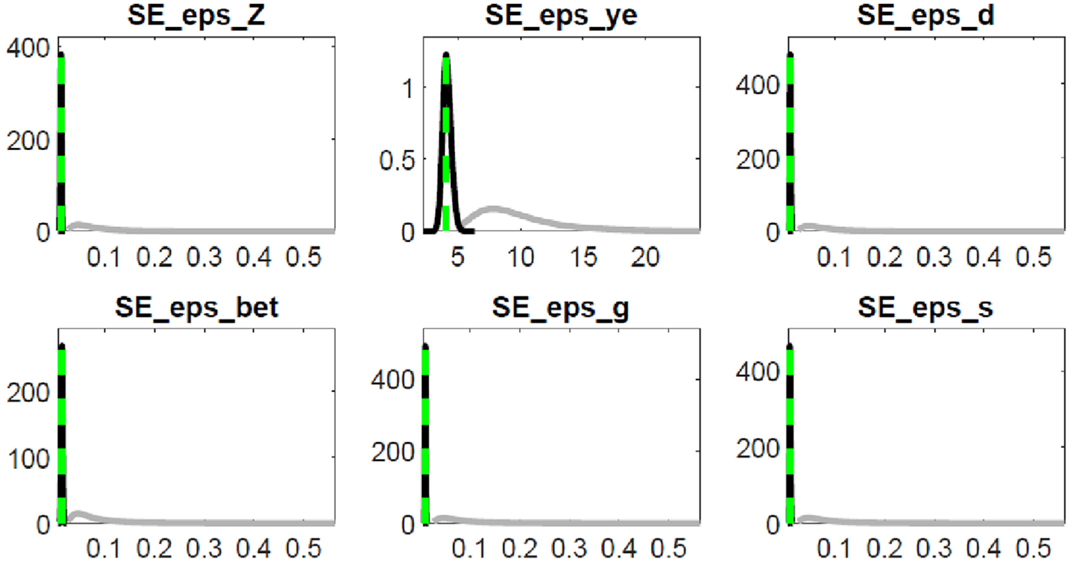


FIGURE A1 Prior and posterior distribution of shocks.

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AR(1) processes should fall within the 0–1 range. The parameters are thus assumed to be beta distributed with mean 0.95 and standard deviation 0.01.

Figure A1 plots prior and posterior distributions of estimated standard deviations. Moreover, Figure A2 shows prior (gray curves) and posterior distributions (black curves) of estimated parameters. The vertical dashed lines indicate the estimated posterior mode.[8] The smaller variance of the posterior indicates that the data appear to be informative of the persistence of shock processes.

The last three columns of Table A2 show the means and confidence intervals of the posterior distributions as obtained by the Metropolis Hastings algorithm. We used five chains, each

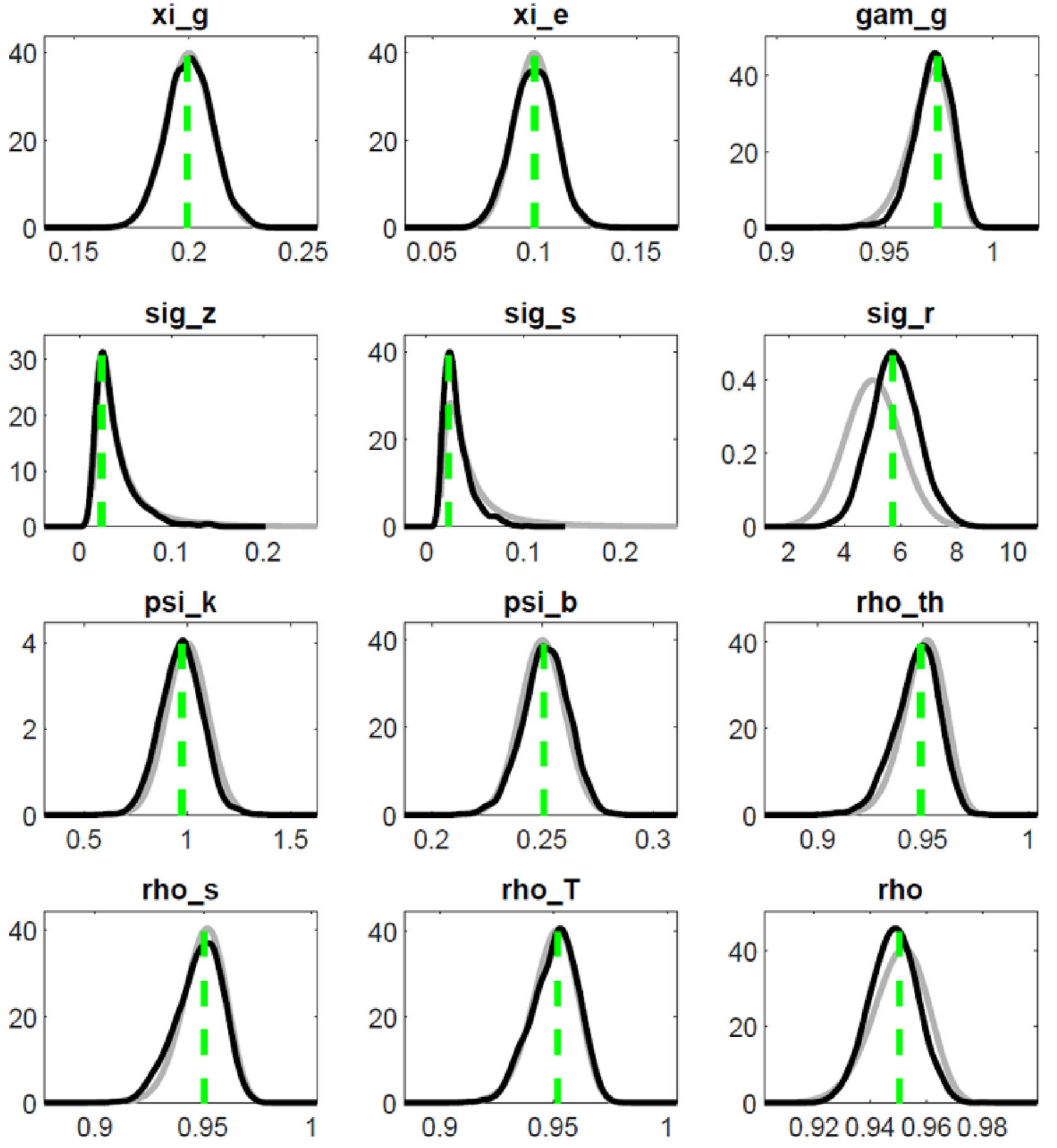


**FIGURE A2** Prior and posterior distribution of parameters.

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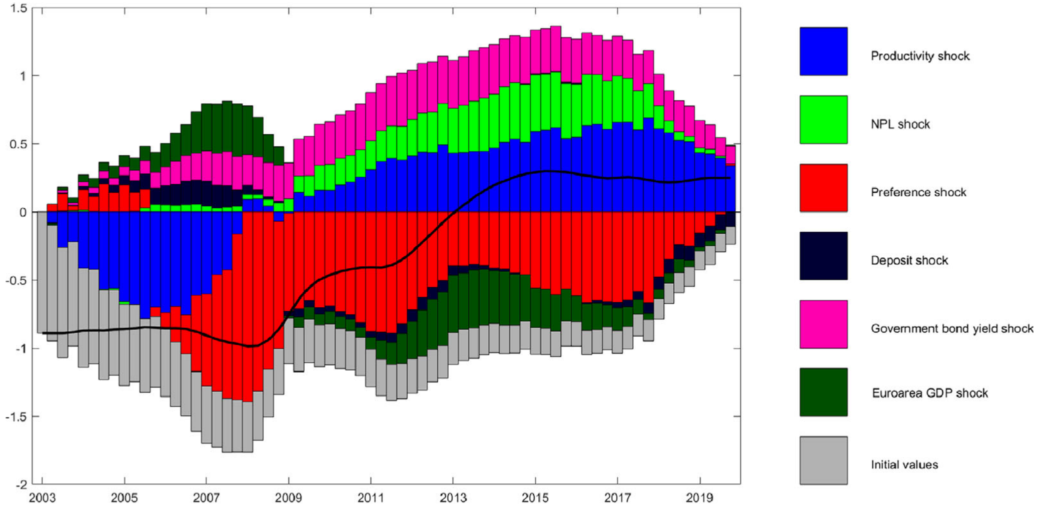
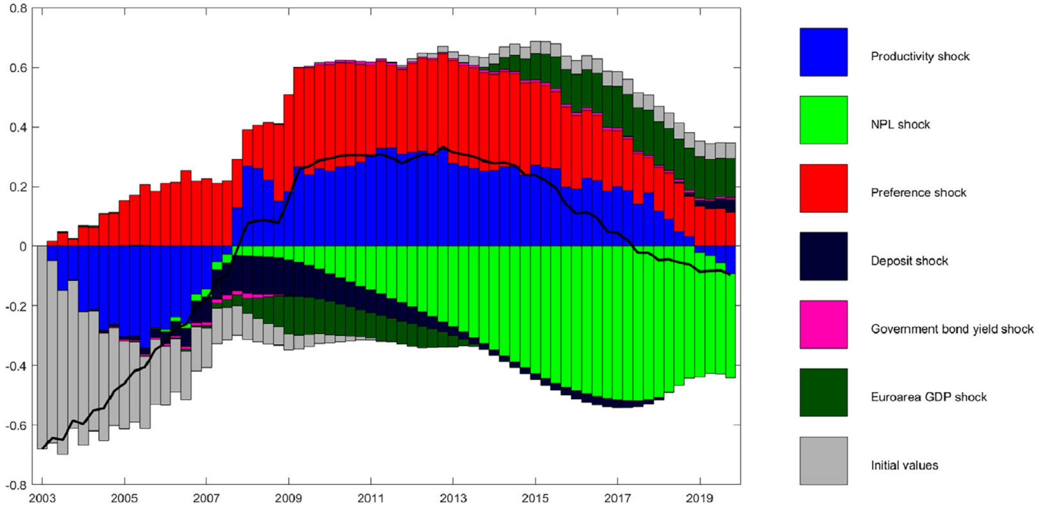
with 25,000 draws which ensures convergence of the sampling algorithm. Shock persistence is estimated to be quite high. Autocorrelation coefficients range from 0.94 (for the risk premia) to 0.97 for the consolidation speed. All other parameters are estimated to a value close to our prior assumptions.




(a) Public debt




(b) Private debt

FIGURE A3 Shock decompositions.

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### A.4 Shock decomposition and detailed results

Estimation endogenously determines six shock processes for tracking past performance in Italy. The shock decompositions in Figure A3a,b show how the estimated shocks have contributed to public and private debt trajectories. The same shocks play a key role in the exit scenarios. The shock decompositions are thus discussed in Section 3 of the main text. Table A3 offers detailed results on the escalating exit scenario.

**TABLE A3** Detailed results of escalating exit scenario.

| | | SS | Q1 | Q4 | Q8 | Q20 | Q40 |
|---|---|---|---|---|---|---|---|
| $\frac{QB^G}{PY}$ | Fiscal debt/GDP** | 5.2 | 4.53 | 4.56 | 4.6 | 4.86 | 5.2 |
| $Q$ | Sovereign bond price | 1 | 0.81 | 0.82 | 0.84 | 0.89 | 0.94 |
| $s$ | Ann. bad loan share | 6 | 9.05 | 9.19 | 8.78 | 7.92 | 7.25 |
| $Y$ | Real GDP | 0% | −7.11% | −8.48% | −8.24% | −7.38% | −6.92% |
| $Z$ | Factor productivity | 0% | −3% | −3% | −2.44% | −1.36% | −0.62% |
| $K$ | Capital stock | 0% | −3.82% | −11.66% | −16.51% | −18.47% | −16.04% |
| $L$ | Employment | 0% | −6% | −3.93% | −1.42% | −0.22% | −1.78% |
| $\overline{C}$ | Private consumption | 0% | 9.62% | 5.03% | 0.79% | −5.38% | −7.33% |
| $E^{x,e}$ | Exports to rest of EZ | 0% | 0.21% | −6.5% | −8.65% | −5.11% | −2.88% |
| $E^{x,o}$ | Exports to ROW | 0% | −0.24% | −6.07% | −7.9% | −4.81% | −2.86% |
| $K^G$ | Public capital stock | 0% | −0.27% | −1.12% | −2.13% | −4.24% | −6.25% |
| $w^L/P$ | Producer real wage | 0% | −1.18% | −4.74% | −6.92% | −7.18% | −5.24% |
| $MRS$ | Consumer real wage | 0% | −3.27% | −7.34% | −8.76% | −8.76% | −6.67% |
| $\tau$ | Income tax rate* | 30 | 29.75 | 30.3 | 30.28 | 30.63 | 30.83 |
| $P$ | Producer prices* | 100 | 100.92 | 104.31 | 107.05 | 109.83 | 110.09 |
| $\overline{P}$ | Consumer price index* | 100 | 100.9 | 103.92 | 106.52 | 109.5 | 109.89 |
| $i$ | Ann. domestic interest | 2 | 2.72 | 3.54 | 3.82 | 3.66 | 3.2 |
| $i^d$ | Ann. deposit interest | 2 | 6.72 | 7.54 | 7.03 | 5.34 | 3.76 |
| $i^g$ | Ann. gov. debt interest | 3 | 7.72 | 8.54 | 8.03 | 6.34 | 4.76 |
| $i^l$ | Ann. loan interest | 5 | 9.54 | 13.96 | 11.8 | 8.81 | 7.1 |
| $\pi$ | Ann. inflation rate | 0 | 5.69 | 3.02 | 1.75 | 0.43 | −0.17 |
| $r$ | Ann. real interest | 2 | −2.92 | 0.51 | 2.05 | 3.23 | 3.37 |
| $e^{ie}$ | Lire/€ exchange rate* | 100 | 102.46 | 103.6 | 105.24 | 108.58 | 109.56 |
| $e^{eo}$ | €/$ exchange rate* | 100 | 100.88 | 103.2 | 105.54 | 108.9 | 109.54 |
| $\frac{B^f}{PY}$ | Net for. debt/GDP** | −0.88 | −0.91 | −0.89 | −0.96 | −1.14 | −1.11 |

*Note*: SS refers to initial and final steady states. (*) × 100. (**) Quarterly GDP ratios.

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