# Can Passive Monetary Policy Decrease the Debt Burden?*

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Abstract

When a government is highly indebted, and the timing of switching to the conventional regime $\mathcal{M}$ (passive fiscal/active monetary policies) is uncertain, a spending increase in regime $\mathcal{F}$ (active fiscal/passive monetary policies) increases government debt accumulation. Such regime uncertainty dampens inflation and the debt revaluation effect through a higher price level in regime $\mathcal{F}$. Also, as regime uncertainty generates a smaller real interest rate decline, debt servicing costs fall less, and tax revenues increase less than in the fixed regime $\mathcal{F}$. All these factors contribute to reversing the debt decline for a spending increase in the *fixed* regime $\mathcal{F}$. The result holds under adverse supply shocks and potentially higher capital taxes, relevant in the post-COVID U.S. economy.

Keywords: passive monetary policy, government spending effects, endogenous regime-switching policy, monetary and fiscal policy interaction, nonlinear DSGE

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# 1 Introduction

The COVID-19 pandemic prompted governments worldwide to adopt unprecedented fiscal measures to support the economies. These measures have added strain to already high levels of government debt, accumulated since the global financial crisis (Figure 1). Meanwhile, central banks were accommodative by lowering policy rates (Gopinath, 2020), conducting quantitative easing, and providing liquidity (English et al., 2021; Tsatsaronis et al., 2022). Conventional wisdom suggests that expansionary fiscal measures without sufficient future fiscal adjustments should increase the debt burden and worsen sustainability. Several recent studies, however, argue that government spending in conjunction with monetary accommodation does not harm debt sustainability and may even reduce debt levels (English et al., 2017; Galí, 2020; Elenev et al., 2021; Hofmann et al., 2021; Billi and Walsh, 2022). Bianchi et al. (2022) also find that a positive unfunded transfer shock (as part of the 2021 American Rescue Plan Act) reduces the government debt burden. In light of substantial debt increases during the pandemic in most economies, we ask whether government spending under monetary accommodation with uncertain duration can increase debt accumulation, opposite to the recent findings in the literature.

The theoretical result that government spending reduces the debt burden under monetary accommodation is mainly driven by rising inflation and output. Mixed evidence, however, exists on whether government spending drives up inflation or reduces debt under monetary accommodation or in a low-interest rate environment. Miyamoto et al. (2018) find that expected inflation rises following a spending shock in the post-1995 sample when the nominal interest is near the zero lower bound in Japan. Also, Jacobson et al. (2019) find a negative primary surplus shock generates higher inflation but does not increase government debt significantly from 1933 to 1940, a period of unbacked fiscal expansion. On the other hand, Dupor and Li (2015) find that inflation does not increase after a spending increase from 1959 to 1979—a period deemed passive monetary policy in the U.S. Canova and Pappa (2011) estimate the effects of big government spending increases when the nominal interest rate is restricted from reacting. They find that the government debt-to-GDP ratio falls for the U.S. but not for the euro area and the U.K.

The lack of empirical consensus suggests that other mechanisms influencing inflation and debt dynamics with monetary accommodation may be important. The aforementioned theoretical analyses assume permanent or highly persistent monetary accommodation. However, central banks' historically active role in maintaining price stability could induce agents to expect that monetary accommodation was only temporary. Before the interest rate lift-off in March 2022, rising inflation in the U.S. prompted expectations that future monetary policy would be tightened. As inflation began to rise in mid-2020, more and more consumers expected rising interest rates in the coming years, as shown in Figure 2.

In this paper, we model the combination of monetary accommodation and fiscal expansion with a passive monetary/active fiscal policy regime, "regime $\mathcal{F}$," (á la Leeper, 1991; Leeper et al., 2017, in regime terminology). Regime $\mathcal{F}$ does not persist indefinitely. The policy regime may switch to an active monetary/passive fiscal policy mix, "regime $\mathcal{M}$." As surging inflation constrains central banks' ability to keep interest rates low, we assume that the switching probability from regime $\mathcal{F}$ to $\mathcal{M}$ increases with inflation. We show that endogenous regime uncertainty (as in Mao et al., 2022), combined with high government debt, can increase the government debt burden, contrary to the debt dynamics in a fixed regime $\mathcal{F}$.

In the fixed regime $\mathcal{F}$, government spending generates high inflation and produces a debt revaluation effect on existing nominal government liabilities (e.g., Leeper, 2011; Berkovich et al., 2021; Neely, 2022). Since monetary policy does not actively control inflation, high inflation combined with a low-interest rate decreases the real interest rate and, therefore, the debt servicing costs. Also, the decreased real interest rate amplifies the expansionary effect of government spending, leading to higher tax revenues and a smaller financing need. All these factors help contain debt growth or even reduce the debt-to-GDP ratio, supporting the benevolent debt implications under the passive monetary policy.

When agents expect that future policies can switch to regime $\mathcal{M}$, current and expected inflation does not increase as much as in the fixed regime $\mathcal{F}$. Consequently, the magnitude of the real interest rate decline is not as big, the negative debt revaluation effect is smaller, and debt servicing costs decrease less than in the fixed regime $\mathcal{F}$. As a smaller real interest rate decline dampens the crowding-in effect of spending, tax revenues do not increase as much, driving up the borrowing needs for a given spending increase. Overall, expansionary fiscal measures increase the government debt burden in regime $\mathcal{F}$, qualitatively the same as the typical debt dynamics in regime $\mathcal{M}$.

Our theoretical finding that passive monetary policy increases the debt burden is purely driven by expectations of switching to regime $\mathcal{M}$. This expectation effect is relevant empirically. Estimations of average regime switching probabilities in the post-war U.S. history find that policy regimes are not permanent, and the average switching probability is higher for regime $\mathcal{F}$; see Davig and Leeper (2006), Bianchi (2013), Davig and Doh (2014), and Chang et al. (2021). Ozlale (2003) and Chen et al. (2022) estimate policy rules together with objective functions. They find the dominance of active monetary policy and passive fiscal policy in the postwar U.S. data; policies that temporarily deviate from controlling inflation and stabilizing debt are expected to return to the dominant regime $\mathcal{M}$.

To see if our finding holds in the post-pandemic U.S. economy, we then simulate under a variety of scenarios, including 1) negative supply shocks to capture global supply chain disruption and increased energy prices due to the pandemic and the Russia-Ukraine war, 2) higher future capital taxes to reflect the expiration of the lower income tax rate on high-income earners, and 3) productive government spending as embedded in the Infrastructure Investment and Jobs Act of 2021. The simulations show that government debt increases further with negative supply shocks, mainly because agents expect bigger fiscal adjustment once switching to regime $\mathcal{M}$. Also, adding capital and capital taxes make government debt increase more because expecting higher capital taxes lowers current investment and tax revenues, increasing the budget gap and borrowing. Lastly, productive government spending makes government debt increase less, mainly because more expansionary spending effects increase tax revenues.

Our paper relates to studies on the expectation effects of the monetary and fiscal policy mix. Sargent (1983) ascribes the ending of hyperinflation in Austria, Germany, Hungary, and Poland to a drastic switch to the policy mix with central bank independence and fiscal discipline. Temin and Wigmore (1990) and Eggertsson (2008) suggest that the expectation of switching from the Hoover regime (constrained by the small-government and balanced-budget dogmas) to the unconventional Roosevelt regime is crucial in the recovery from the Great Depression. Jacobson et al. (2019) emphasize the importance of President Roosevelt's commitment to not reverting to the fiscal orthodox for a sustained period. Bianchi and Ilut (2017) argue that expectations of fiscal backing are important in lowering inflation after Volcker's tightened monetary policy in the 1980s. Bianchi and Melosi (2017) contribute the lack of deflation during the Great Recession to the uncertainty about how the rising federal debt would be stabilized. Finally, Mao et al. (2022) study how policy regime uncertainty affects government spending multipliers in the money and debt regimes. The focus here is the fiscal implications of regime uncertainty in regime $\mathcal{F}$.[1]

Another relevant line of research is the macroeconomic strategies for coping with the pandemic's economic consequences and aftermath. Because agents probably did not expect a quick return to the regime $\mathcal{M}$, Bianchi et al. (2020) argue that an emergency budget amid passive monetary policy can reflate the economy without endangering debt sustainability. Upon persistent high inflation since mid-2021, Bianchi and Melosi (2022) advocate that controlling inflation in the post-pandemic era requires the fiscal authority to be passive again to ensure debt sustainability. Cochrane (2022b) warns against the risk of a debt crisis as expectations of unbacked fiscal expansions may not persist. Our simulations align with Cochrane's (2022b) message: the significant increase in government spending observed during the pandemic under passive monetary policy raises concerns about government debt.

## 2 The Baseline Model

We augment a standard New Keynesian (NK) model with an endogenous regime switching process. Economic agents in regime $\mathcal{F}$ form inflation-contingent expectations about switching to regime $\mathcal{M}$, following Mao et al.'s (2022) specification for switching from the money regime to the debt regime. In Section 5, we extend the model to include capital and capital taxes.

[1] In regime $\mathcal{M}$, government spending is financed by debt. Therefore, in our modeling, regime $\mathcal{M}$ is the same as the debt regime in Mao et al. (2022). However, regime $\mathcal{F}$ differs from the money regime, to be explained in Section 2.3.

## 2.1 Agents

The representative agent maximizes the lifetime utility by choosing consumption ($c_t$), labor ($n_t$), and nominal government bonds ($B_t$) each period $t$ to solve the following optimization problem:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{c_t^{1-\sigma}}{1-\sigma} - \chi \frac{n_t^{1+\varphi}}{1+\varphi} \right), \tag{2.1}$$

subject to the budget constraint

$$c_t + \frac{B_t}{R_t P_t} = \frac{B_{t-1}}{P_t} + (1-\tau_{l,t}) w_t n_t + \Upsilon_t + z_t + \xi_t, \tag{2.2}$$

where $c_t \equiv \left[ \int_0^1 c_t(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}$ is a basket of goods aggregated by the Dixit-Stiglitz aggregator, $P_t$ is the price of the composite good, $R_t$ is the nominal interest rate, $w_t$ is the real wage rate, and $\tau_{l,t}$ is the labor tax rate. Besides bond payments from the government and the after-tax labor income, the agent receives dividends from owning the firms ($\Upsilon_t$), transfers from the government ($z_t$), and the rebate of nominal price adjustment costs ($\xi_t$) to be explained later in the firms' optimization problem.

## 2.2 Firms

The production sector consists of a continuum of monotonically competitive firms. Each firm $i$ chooses price ($P_t(i)$) and labor ($n_t(i)$) each period to maximize the present value of the future profits, discounted by the agent's stochastic discounting factor:

$$\max_{n_t(i), P_t(i)} E_t \sum_{s=0}^{\infty} \beta^s \frac{\lambda_{t+s}}{\lambda_t} \left[ P_{t+s}(i) y_{t+s}(i) - W_{t+s} n_{t+s}(i) - \frac{\psi}{2} \left( \frac{P_{t+s}(i)}{\pi P_{t+s-1}(i)} - 1 \right)^2 y_{t+s} P_{t+s} \right], \tag{2.3}$$

subject to linear technology for each intermediate good $i$,

$$y_t(i) = A n_t(i), \tag{2.4}$$

and the demand for each intermediate good $i$,

$$y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\theta} y_t, \tag{2.5}$$

where $y_t \equiv \left[\int_0^1 y_t(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}$ is the final good, $\pi$ is the inflation target set by the monetary authority—also the steady-state inflation rate—and $A$ is the common total factor productivity (TFP). The discount factor between time $t+s$ and $t$ follows from the agent's Euler equation, $\beta^s \frac{\lambda_{t+s}}{\lambda_t}$, where $\lambda_t$ is the marginal utility of consumption. Price adjustments are subject to a quadratic adjustment cost, $\xi_t \equiv \frac{\psi}{2}(\frac{\pi_t}{\pi} - 1)^2 y_t$, which is rebated back to the agent, as shown in equation (2.2).

Solving the firms' optimization problem and imposing the symmetric equilibrium conditions yield the standard Phillips curve:

$$\psi\left(\frac{\pi_t}{\pi} - 1\right)\frac{\pi_t}{\pi} = (1-\theta) + \theta mc_t + \psi E_t\left[\beta \frac{\lambda_{t+1}}{\lambda_t} \frac{y_{t+1}}{y_t} \frac{\pi_{t+1}}{\pi}\left(\frac{\pi_{t+1}}{\pi} - 1\right)\right], \tag{2.6}$$

where $\pi_t \equiv \frac{P_t}{P_{t-1}}$ is the gross inflation rate and $mc_t \equiv \frac{w_t}{A}$ it the real marginal cost.

### 2.3 Monetary and Fiscal Authorities

Each period the government collects a proportional labor tax and issues nominal bonds to finance its goods purchases ($g_t$) and transfers to agents, subject to the flow government budget constraint,

$$\frac{B_t}{R_t P_t} + \tau_{t,l} w_t n_t = \frac{B_{t-1}}{P_t} + g_t + z_t. \tag{2.7}$$

where the government purchases follow the exogenous AR(1) process

$$\log \frac{g_t}{g} = \rho_g \log \frac{g_{t-1}}{g} + \varepsilon_t^g, \tag{2.8}$$

with the innovation $\varepsilon_t^g \sim i.i.d.N\left(0, \sigma_g^2\right)$ and steady-state government goods purchase $g$. We assume that $z_t = z$ for simplicity.

Iterating (2.7) forward and imposing the transversality condition for government debt,

$$E_t \lim_{i\to\infty} \beta^i \lambda_{t+i} b_{t+i}, \tag{2.9}$$

yields the intertemporal government constraint,

$$\frac{B_{t-1}}{P_t} = \frac{b_{t-1}}{\pi_t} = \sum_{i=0}^{\infty} \beta^i E_t \left[ \frac{\lambda_{t+i}}{\lambda_t} \left( \tau_{t+i,l} w_{t+i} n_{t+i} - g_{t+i} - z \right) \right], \tag{2.10}$$

where $b_{t+i} \equiv \frac{B_{t+i}}{P_{t+i}}$ is real debt value in units of goods at time $t+i$.

The public sector consists of a fiscal authority and a monetary authority. We follow Leeper (1991) to define the two policy regimes by different fiscal adjustment responses to government debt and the interest rate responses to inflation. In regime $\mathcal{M}$, the monetary authority actively controls inflation and the fiscal authority raises taxes to stabilize debt. In regime $\mathcal{F}$, neither the monetary authority controls inflation, nor the fiscal authority stabilizes debt.

The regime dependent monetary policy and labor tax rules are

$$R_t = \max\left\{1, R \cdot \left(\frac{\pi_t}{\pi}\right)^{\alpha^{\mathfrak{s}}}\right\} \tag{2.11}$$

and

$$\tau_{l,t} = \tau_l + \gamma_l^{\mathfrak{s}} (b_{t-1} - b), \tag{2.12}$$

where $\mathfrak{s} \in \{\mathcal{F}, \mathcal{M}\}$, $b_t \equiv \frac{B_t}{P_t}$ is real government debt, $b$ and $R$ are the steady-state real debt and nominal interest rate, $\alpha^{\mathcal{M}} > 1 > \alpha^{\mathcal{F}}$, and $\gamma^{\mathcal{M}} > \gamma^{\mathcal{F}} \geq 0$. Our calibration setting $\alpha^{\mathcal{F}} = 0$ means that the policy rate does not react to inflation, and the price level must adjust to pin down the real debt value at $t$, given other fiscal values in the government budget constraint, as shown by equation (2.10).

Regime $\mathcal{F}$ is similar to the money regime (e.g., Galí, 2020; Mao et al., 2022) in the sense that they both have passive monetary policy, that is, the monetary authority does not control inflation. Nonetheless, they differ in how the policy rate is determined. In regime $\mathcal{F}$, the policy rate is solely determined by the interest rate rule, like equation (2.11) in our model. In the money regime, the nominal interest rate and the real money balance are jointly determined by the money demand function and the unified government budget constraint between monetary and fiscal authorities. The money regime makes the role of seigniorage revenues in the unified government budget explicit.[2]

We assume the switching probability to regime $\mathcal{M}$ increases with inflation. The lift-off of the federal funds rate in March 2022 shows that the persistent high inflation is a major consideration in the Federal Open Market Committee's decision to switch to active monetary policy (Board of Governors, 2022). Specifically, the probability of switching from regime $\mathcal{F}$ to $\mathcal{M}$ ($p_{\mathcal{F},t}$) follows

$$p_{\mathcal{F},t} = 1 - \frac{\exp\left[\iota_1 + \iota_2(\pi_{t-1} - \pi)\right]}{1 + \exp\left[\iota_1 + \iota_2(\pi_{t-1} - \pi)\right]}. \tag{2.13}$$

In reality, agents are uncertain about not only how soon the monetary policy turns active but also how active monetary policy would be. Our switching function directly models the first uncertainty, but it can be broadly interpreted as providing a probabilistic view of the activeness of future monetary policy. A larger $\alpha^{\mathcal{M}}$ is equivalent to the calibrated baseline value with a higher switching probability. Section 6.1 explores different parameterizations for equation (2.13).

We assume the probability of staying in regime $\mathcal{M}$ is 1 for computational easiness. This does not mean the policy regime cannot switch once it is in regime $\mathcal{M}$. It only means that ex-ante agents do not expect the regime to switch once settling in regime $\mathcal{M}$. Our results do not depend on this assumption. An alternative simulation assuming the persistence in regime $\mathcal{M}$ to be 0.992, the estimated regime persistence in Bianchi and Melosi (2017), yields very similar results to those presented in this paper.

Finally, the aggregate resource constraint is

$$c_t + g_t = y_t. \tag{2.14}$$

[2]The modeling of regime $\mathcal{F}$ can also incorporate the money stock, as in the model in the online appendix of Mao et al. (2022). In that case, seigniorage adjusts passively to satisfy the money demand function with given inflation and the policy rate is determined by the interest rate rule. The adjustment in the monetary stock in regime $\mathcal{F}$ is initiated by the price level or inflation changes.

## 3 Model Solution and Calibration

The model is calibrated quarterly to the U.S. economy. We adopt common structural parameter values for calibrating standard NK models; see Table 1 for parameter values and sources. For steady-state fiscal values, we rely on federal government data from 1980 to 2021. The debt-to-annual output ratio is 0.7, based on the average ratio of total federal debt (Office of Management and Budget, 2022). The tax rate is set to $\tau_l = 0.22$, the average labor tax rate based on Jones' (2002) method for the federal government. The government spending-to-output ratio is set to $\frac{g}{y} = 0.11$.[3] These values give a steady-state transfer-to-output ratio of $\frac{z}{y} = 0.05$ to satisfy the government budget constraint in the steady state.

For policy regime parameters, we set $\alpha^{\mathcal{F}} = 0$ and $\gamma^{\mathcal{F}} = 0$, consistent with Leeper's (1991) definitions for passive monetary and active fiscal policies. Also, we set $\alpha^{\mathcal{M}} = 1.6$ and $\gamma^{\mathcal{M}} = 0.07$, taken from Bianchi and Melosi (2017), for active monetary and passive fiscal policies. For consistency, the regime-switching probability function parameters, equation (2.13), are calibrated based on Bianchi and Melosi (2017). They estimate that the mean probability of staying in regime $\mathcal{F}$ is 0.99 using the post-war U.S. data; hence, we set $\iota_1 = -4.5951$ such that the switching probability is 0.99 in the steady state. For the slope parameter, we set $\iota_2 = 400$, implying that the switching probability is 1 when the net annual inflation rate is 12%. Chairman Volcker announced tightening measures in October 1979 when the CPI inflation rose to about 12% in 1979Q3 (U.S. Bureau of Labor Statistics, 2022). The baseline parameterization of the regime-switching function is plotted in Figure 3 (the solid line).

The interest rate increase in March 2022, followed by the annualized CPI inflation of 7.9% in February, corresponds to a switching probability of about 0.8 under our baseline calibration. However, since we can not directly estimate the endogenous regime switching probabilities, we conduct simulation under an alternative steeper regime switching function (the dashed line in Figure 3).

With regime switching, linear solutions are not sufficient. We solve the model by Euler equation

[3] Federal government spending is computed as the sum of current expenditures, gross government investment, and capital transfer payments minus transfers to persons and interest payments (NIPA Table 3.2 lines 24, 45, 46, 28, and 33, Bureau of Economic Analysis, 2022).

iteration, following Coleman (1991) and Davig (2004), to obtain a fully nonlinear solution under rational expectations. Appendix A summarizes the equilibrium system, and Appendix B describes the solution method.

# 4 Fiscal Implications of Government Spending in Regime $\mathcal{F}$

We simulate the responses to a government spending shock, equal to 1% of steady-state output in regime $\mathcal{F}$ with an initial government debt-to-annual output ratio (or "the debt ratio") of 120%, roughly the 2021 gross federal debt ratio of 123%. In addition to regime uncertainty and government indebtedness, we explore other factors relevant to the post-COVID U.S. economy, including supply disruption and productive government spending. Our analysis focuses on the expectation effects of regime switching. The policy regime does not switch ex-post through out the simulation horizon.

## 4.1 Policy Regime Uncertainty

Figure 4 plots the impulse responses to the government spending shock under the fixed versus uncertain regime $\mathcal{F}$. When agents believe that the current policy regime is permanent (the fixed regime $\mathcal{F}$), the standard results that government spending lowers both the debt level and debt ratio hold. Under this circumstance, government spending decreases the debt burden in regime $\mathcal{F}$, as found in English et al. (2017), Galí (2020), Elenev et al. (2021), and Bianchi et al. (2022).

In the fixed regime $\mathcal{F}$, a substantial inflation increase lowers both the ex-ante and ex-post real interest rate, as the monetary authority does not control inflation. The decrease in the ex-ante real interest rate crowds in consumption in the short run. Higher goods demand from both public, and private sectors increases labor, producing more expansionary government spending effects than typical spending in regime $\mathcal{M}$ with the well-known crowding-out effect.

Despite a constant labor tax rate in regime $\mathcal{F}$, tax revenues as a share of output rise by 0.6 percentage points. Also, the decrease in the ex-post real interest rate reduces government interest payments: the interest payments-to-output ratio declines by about one percentage point. More tax revenues and lower debt servicing costs reduce government financing needs. Furthermore, high inflation decreases the real value of the existing nominal debt stock. Consequently, the government debt burden falls, opposite to the common and intuitive finding that deficit-financed spending increases debt accumulation in the conventional regime $\mathcal{M}$ (see, e.g., Coenen et al., 2012; Traum and Yang, 2015).

In the uncertain regime $\mathcal{F}$, an initial debt ratio of 120% corresponds to an annual inflation rate of 5.2%. The government spending shock puts upward pressure on inflation, driving up the switching probability further by about 5 percentage points. This level of uncertainty, while modest, has nontrivial fiscal consequences, similar to its important role in affecting spending multipliers in the money regime (Mao et al., 2022).[4]

As agents believe that future monetary policy can become active in maintaining price stability, expected inflation and current inflation are much lower relative to those in the fixed regime $\mathcal{F}$. Moreover, as agents believe that future fiscal policy can resume its normal role in stabilizing debt, agents increase saving to smooth possible future consumption loss from potential higher taxes, further offsetting the inflationary pressure in regime $\mathcal{F}$. Both factors result in a noticeable difference in inflation and real interest rate dynamics from those under the fixed regime assumption. Although the economy is in regime $\mathcal{F}$, the consumption response to a spending increase now turns negative because of a smaller reduction in the real interest rate (weakening the intertemporal substitution effect) and potentially higher future taxes (reviving the negative wealth effect).

With a much smaller decline in the real interest rate, interest payments only fall slightly in the uncertain regime $\mathcal{F}$. Moreover, the negative consumption response makes output expand less, and so do the tax base and revenues. A smaller interest payment reduction, a smaller tax revenue increase, and a smaller debt revaluation effect all contribute to higher debt accumulation in the uncertain regime $\mathcal{F}$. Because of higher output, the debt ratio decreases initially but increases above the level without the spending shock one year after in the uncertain regime $\mathcal{F}$.

The very different debt dynamics between the fixed and uncertain regime $\mathcal{F}$ can also be examined from the fiscal financing aspect. A spending shock in the fixed regime $\mathcal{F}$ is financed by inflation and higher tax revenues resulting from expansionary government spending, but not by the new issuance of government debt. Under the uncertain regime $\mathcal{F}$, a spending shock is financed by inflation, higher tax revenues, as well as some debt issuance—the main financing instrument in

[4] An analytical derivation based on a simplified, linearized NK model, which shows the importance of policy regime uncertainty in government spending effects in regime $\mathcal{F}$, is available upon request.

regime $\mathcal{M}$. An increasing resemblance in the financing methods through regime uncertainty helps explain similar debt dynamics between the uncertain regime $\mathcal{F}$ and regime $\mathcal{M}$.

Technically, incorporating policy regime uncertainty narrows the government spending effects between regimes $\mathcal{F}$ and $\mathcal{M}$. As shown in Figure 4, the magnitude of the inflation increase shrinks substantially in regime $\mathcal{F}$. Cochrane (2022a) proposes using "partially-repaid long-term debt" to dampen an unrealistic price-level jump in response to a deficit shock. His thought experiment is similar to our government spending shock in regime $\mathcal{F}$, in which the fiscal theory of the price level holds. Although the two modeling strategies are different, they produce a similar effect in making the economic dynamics in regime $\mathcal{F}$ less extreme, mitigating its theoretical controversy. Also, our findings are in line with Liu et al.'s (2009) suggestion for the importance of regime-switching expectations on agents' economic behaviors. In our context, regime uncertainty can have nontrivial effects on equilibrium dynamics for government spending effects under the passive monetary policy.

From a policy perspective, regime uncertainty helps anchor inflation expectations in regime $\mathcal{F}$ when sizable fiscal measures are needed to support households and firms in an economic crisis, like the COVID-19 pandemic. This implies that the government can adjust fiscal policies under the passive monetary policy without concerns about a rapid inflation surge for an extensive period.[5] Government spending in regime $\mathcal{F}$ nonetheless can increase the government debt burden. Returning to regime $\mathcal{M}$ is necessary to address both the legacy of inflation and high debt from regime $\mathcal{F}$, as advocated by Rogoff (2022).

### 4.2 The Role of Initial Government Debt

This section examines how the initial government debt burden matters for debt dynamics following a spending increase in regime $\mathcal{F}$. Figure 5 contrasts the simulation with an initial debt ratio of 70% (the steady-state value) to the baseline with a debt ratio of 120%.

When the initial debt ratio is 70%, a government spending increase in regime $\mathcal{F}$ decreases the debt burden, as in the fixed regime $\mathcal{F}$ (dashed lines in Figure 5). A lower initial debt ratio in regime $\mathcal{F}$ is associated with a lower inflation *level* in equilibrium. Under the fiscal theory of the price level, price adjustment is crucial to ensure debt sustainability when neither current nor future

[5] Eusepi and Preston (2012) make a similar point in a learning environment: anchoring monetary policy expectations on inflation and fiscal policy expectations on debt enlarge the set policies consistent with stability.

primary balance reacts to high debt (see Cochrane, 2023, for a survey). At the steady-state debt ratio of 70%, the corresponding annualized inflation rate is 2%, versus 5.2% under a debt ratio of 120%. The bottom right plot in Figure 5 shows that the spending shock increases the switching probability by less than one percentage point with the initial debt ratio of 70%, compared to a 5-percentage-point increase with an initial debt ratio of 120%. A higher switching probability in turn, brings a stronger spillover effect from regime $\mathcal{M}$, contributing to a bigger real debt burden, as analyzed in Section 4.1. Our simulations imply that an economy with a higher initial debt burden in regime $\mathcal{F}$ generates a higher inflation *level* and less expansionary government spending. Similar to our results, Jo and Zubairy (2022) also find that government spending is less expansionary in a high-inflation environment than in a low-inflation environment. Our theoretical channel is through initial indebtedness burden in regime $\mathcal{F}$, while theirs is through downward nominal wage rigidity in recessions.

Aside from regime switching probabilities, another factor contributing to decreased debt with an initial debt ratio of 70% is the marginal inflation change. Similar to Mao et al. (2022), a smaller initial debt ratio is equivalent to a smaller inflation tax base; inflation must increase more to finance a given spending increase (as pointed out in Leeper et al., 2017, for analysis under different steady-state debt ratios). A bigger decrease in the ex-ante real interest rate under a smaller initial debt ratio contributes to a more expansionary spending increase and more tax revenues, which helps reduce borrowing needs.

Our simulation results under different initial debt ratios illustrate that regime uncertainty alone may not reverse the negative debt response to a government increase in regime $\mathcal{F}$; the initial state of government debt is important as well. As most governments are highly indebted in the post-COVID era, expansionary fiscal measures under the passive monetary policy are less likely to decrease government debt, as found in the fixed regime $\mathcal{F}$.

### 4.3 Interaction with Supply Shocks

Inflation is important for regime $\mathcal{F}$ debt dynamics. Since supply chain disruption contributed to inflation surges during the pandemic, we consider a scenario that a government spending shock coincides with negative supply shocks.

We modify the baseline model by adding a TFP shock to equation (2.4), and assume TFP follows an AR(1) process

$$\log \frac{A_t}{A} = \rho_a \log \frac{A_{t-1}}{A} + \varepsilon_t^a, \quad \varepsilon_t^a \sim i.i.d.N(0, \sigma_a^2), \tag{4.1}$$

where $A = 1$ in the steady-state TFP. We use TFP shocks to capture the generic supply-side disruption and adopt the estimation values in Smets and Wouters (2007) to set $\rho_a = 0.95$ and $\sigma_a = 0.0045$.

Figure 6 presents the responses of output and inflation to the adverse TFP shocks alone by plotting the differences between the paths with and without the shocks under the initial debt ratio 120%. A sequence of negative TFP shocks is injected from $t = 1$ to 4. The size of the TFP shocks is gauged such that the output declines by 6.8% in the trough. The shocks increase inflation by 2.2% at $t = 4$, which delivers a high inflation level at 7.4% under an initial debt ratio of 120%, roughly the U.S. CPI inflation level in January of 2022. As expected, TFP shocks have inflation and output moving in opposite directions.

Figure 7 compares the government spending effects in the economy under the negative TFP shocks (solid lines) to the baseline economy without the TFP shocks (dashed lines). In both scenarios, government spending increases by 1% of steady-state output at $t = 4$. Compared with the scenario without the negative TFP shocks, government spending becomes less expansionary, and the economy accumulates more debt. Since agents know that the negative TFP shocks are persistent ($\rho_a = 0.95$), output and tax revenues are expected to be lower than the scenario without the TFP shocks.

Potential higher government debt induces expectations of more significant fiscal adjustments once switching to regime $\mathcal{M}$, as shown by higher expected labor tax rates in Figure 7. Anticipating bigger fiscal adjustments in the scenario with negative TFP shocks makes agents cut more consumption to save for potentially higher future taxes. A weaker private demand makes government spending in the uncertain regime $\mathcal{F}$ less expansionary than the scenario without the TFP shocks. A smaller output increase produces a smaller increase in tax revenues and, hence, more debt accumulation in regime $\mathcal{F}$.

Although the economy with the TFP shocks has much higher expected inflation than the scenario without the TFP shocks, the current inflation responses are similar between the two scenarios. This is because the marginal cost—also crucial in driving current inflation dynamics (see equation (A.2) in Appendix A)—is lower with the TFP shocks. The negative supply shocks decrease labor productivity and the marginal cost of production. The opposite influences from expected inflation and marginal cost largely offset each other, leaving inflation and the ex-post real interest rate roughly the same as the scenario without the supply shocks. As a result, interest payments as a share of output are similar for the two scenarios as inflation, and the ex-post real interest rate responses are almost the same.

# 5 An Extended Model with Capital

As the federal debt approaches a historical high (the level at the end of World War II), the Biden administration proposed to increase taxes in the budget for the fiscal year 2023. Particularly relevant for our analysis is the tax rate increase for the top income earners and on capital gains, both raising taxes on capital income. Also, the current law embedded in the Tax Cuts and Jobs Act sets an expiration date for the top individual tax rate to return to 39.6% in 2026, suggesting potential higher income taxes. In this section, we extend the baseline model by adding capital. This allows us to examine how capital and capital taxes, as a fiscal adjustment instruments, affect government spending effects. Also, we study whether productive government spending can decrease the debt burden in regime $\mathcal{F}$.

In the extended model, the representative agent now also chooses investment ($i_t$) and capital ($k_t$), subject to the revised budget constraint

$$c_t + i_t + \frac{b_t}{R_t} = \frac{b_{t-1}}{\pi_t} + (1-\tau_{l,t})w_t n_t + (1-\tau_{k,t})r_t^k k_{t-1} + \Upsilon_t + z_t + \xi_t, \tag{5.1}$$

and the law of motion for capital

$$k_t = (1-\delta)k_{t-1} + i_t - \frac{\kappa}{2}\Big(\frac{i_t}{k_{t-1}} - \delta\Big)^2 k_{t-1}, \tag{5.2}$$

where $\tau_{k,t}$ is the capital tax rate, $r_t^k$ is the rental price of capital, $\delta$ is the depreciation rate, and $\kappa$ is the capital adjustment cost parameter, assumed to be rebated to the household and included in $\xi_t$.

Each firm $i$ now produces intermediate goods with the modified production function

$$y_t(i) = A_t k_{t-1}(i)^{\eta} n_t(i)^{1-\eta}, \qquad 0 < \eta < 1. \tag{5.3}$$

The capital tax rate responds to debt, similar to the labor tax rate rule (2.12),

$$\tau_{k,t} = \tau_k + \gamma_k^{\mathfrak{s}}(b_{t-1} - b), \tag{5.4}$$

where $\mathfrak{s} \in \{\mathcal{F}, \mathcal{M}\}$ and $\gamma_k^{\mathcal{M}} > \gamma_k^{\mathcal{F}}$.

The aggregate resource constraint, equation (2.14), is modified as

$$y_t = c_t + g_t + i_t. \tag{5.5}$$

Appendix A lists the additional equilibrium conditions associated with capital and investment. The calibration adopts common values to set $\delta = 0.025$ (an annual depreciation rate of 10%) and $\kappa = 1.7$ (Gourio, 2012). We set $\tau_k = 0.2$, the average capital tax rate from 1980 to 2021, calculated based on Jones' method described in Section 3. The fiscal adjustment parameters are set to $\gamma_k^{\mathcal{M}} = \gamma_l^{\mathcal{M}} = 0.07$ and $\gamma_k^{\mathcal{F}} = 0$.

### 5.1 Capital and Capital Tax Adjustments

Figure 8 compares the spending responses in the uncertain regime $\mathcal{F}$ under three scenarios. The first two are conditional on an initial debt ratio of 120%: the model without capital (the baseline model, solid lines) and the model with capital (the extended model, dashed lines). The third scenario is conditional on an initial debt ratio of 70% (dotted lines) under the extended model.

Conditional on an initial debt ratio of 120%, government spending is less expansionary and generates more debt in the model with capital than without. The impact spending multiplier drops substantially, from 0.62 without capital to 0.23 with capital.[6] Potential higher capital taxes reduce the expected return on investment and impose a long-lasting negative effect on capital formation. This offsets some positive government spending effects on output. The simulations here show that capital and capital taxes amplify the role of regime uncertainty in decreasing the spending multipliers. Since changes in tax revenues are closely related to the output response, it means that capital and capital taxes should be quantitatively important in the debt response. Figure 8 shows that the extended model with capital generates more debt accumulation for a given spending increase. The debt ratio in three years increases by almost one percentage point versus a 0.6-percentage-point increase in the model without capital. Because of the reduced private demand increase, inflationary pressure is smaller in the model with capital. This leads to a smaller decrease in the real interest rate, and hence, interest payments decrease by less.

Next, we examine the scenario with an initial debt ratio of 70% (dotted lines in Figure 8). We see that debt declines to a spending increase in the extended model, qualitatively the same as in the model without capital. Another conspicuous difference is that investment responds positively on impact with 70% initial debt. Since the probability of switching to regime $\mathcal{M}$ is trivial, the channel from expecting higher capital taxes analyzed with an initial debt ratio of 120% is largely muted. Therefore, it does not matter whether there is capital or a capital tax adjustment. This result shows that initial debt remains an essential factor in reversing the debt dynamics in the uncertain regime $\mathcal{F}$ in the model with capital.

### 5.2 Productive Government Spending

Our baseline model assumes that government spending is unproductive. The $1.2 trillion package in the Infrastructure Investment and Jobs Act passed in 2021 includes numerous infrastructure and transportation programs. These types of spending are supposed to enhance private productivity. We further modify the extended model to have government spending enhance TFP, supported by the empirical evidence in Bachmann and Sims (2012), D'Alessandro et al. (2019), and Jørgensen

[6] Using a model without capital, Mao et al. (2022) shows that regime uncertainty decreases the impact spending multiplier from about 1.1 to 0.7 in the money regime.

and Ravn (2022).[7] Equation (5.3) is modified as

$$y_t(i) = \left[A_t\left(\frac{g_t}{g}\right)^{\eta_g}\right]k_{t-1}(i)^{\eta}n_t(i)^{1-\eta}, \tag{5.6}$$

where $\eta_g$ is the output elasticity with respect to government spending. The literature tends to model productive government spending through public capital. Without public capital, we rely on targeting reasonable model-implied impact multipliers to calibrate $\eta_g$. When $\eta_g = 0.05$ and 0.10, the impact multipliers are 0.70 and 1.17, embedded in the range of government investment short-run multipliers, $[0.16, 1.12]$ in Ramey (2020). They are also higher than Ilzetzki et al.'s (2013) estimate of the impact multiplier for high-income countries, 0.39.

Figure 9 presents the simulation results with an initial debt ratio of 120%. Relative to $\eta_g = 0$ (solid lines, same as the dashed lines in Figure 8), more productive government spending produces a smaller debt increase, although the differences are small. When government spending is productive ($\eta_g = 0.05, 0.10$), it generates more expansionary output and tax revenues. The debt ratio decreases for the first year because of a stronger output effect, but it eventually rises above the pre-spending level as the output effect wanes.

Opposite to the negative supply shocks analyzed earlier, a higher $\eta_g$ acts like a positive supply shock, which expands output and eases inflation. With $\eta_g = 0.10$, the positive supply side effect is the strongest, leading to a smaller inflation increase, relative to $\eta_g = 0.05$ and $\eta_g = 0$. Expected inflation, on the other hand, decreases for all three $\eta_g$'s. Expectations of switching to regime $\mathcal{M}$ exert downward pressure on expected inflation. As inflation is the lowest with $\eta_g = 0.10$, the smallest probability of switching to regime $\mathcal{M}$ makes expected inflation fall the least for $\eta_g = 0.10$.

# 6 Sensitivity Analysis

We conduct two alternative simulations for a robustness check: a steeper regime switching function and risky government debt.

[7] A more common approach is to assume that government spending (investment) adds to productive public capital, which elevates the productivity of labor and private capital, similar to the effect of higher TFP (see, e.g., Barro, 1990; Baxter and King, 1993; Glomm and Ravikumar, 1997; Leeper et al., 2010). Given our fully nonlinear solution method, modeling public capital requires adding one more state variable, which substantially increases computational complexity.

### 6.1 A Steeper Regime Switching Function

The baseline logistic function implies the switching probability to regime $\mathcal{M}$ is one once the last-period inflation rate is 12%. Based on the interest rate increase in March 2022—triggered by an inflation rate of 7.9% in February 2022, we consider a steeper function (dashed line in Figure 3) with $\iota_1 = -5.8061$ and $\iota_2 = 800$ in equation (2.13). A bigger $\iota_2$ increases the steepness, and $\iota_1$ is adjusted such that the steeper function is similar to the baseline function when inflation is relatively low (0$\sim$ 3%). The steeper function has a switching probability of 1 when the annualized inflation rate is 7.4%.

Figure 10 compares the impulse responses under the two regime switching functions using the baseline model without capital. The comparison shows that government debt increases more, and the spending is less expansionary under the steeper switching function. When inflation is 5.2% (associated with an initial debt ratio of 120%), the steeper function has a switching probability close to 0.60, compared to 0.17 under the baseline function. A higher switching probability decreases the magnitude of the inflation increase because agents expect that monetary policy is more likely to turn active. As lower inflation generates a smaller tax increase and a smaller interest payment reduction, the government must borrow more, accumulating more debt.

Despite a substantial increase in the steepness of the logistic function, the difference in the switching probability change is small—only about two percentage points (the bottom right plot in Figure 10). This is due to a small difference in inflation between the two simulations. Overall, the simulation results for both the macro and fiscal variables show that the marginal effect of a steeper switching function is relatively small. Our conclusion that a government spending increase in the uncertain regime $\mathcal{F}$ increases debt burden remains when the degree of regime uncertainty increases substantially.

### 6.2 Sovereign Default Risk

Our analysis has treated government debt as a risk-free asset, consistent with very low costs for issuing U.S. Treasury bills or bonds. However, since risk premia affect the interest rate and are relevant for investment decisions, we consider risky government debt in the extended model with capital.

To incorporate default risk, we follow Corsetti et al. (2013) and assume that the ex-ante default probability ($p_t^d$) has a Beta distribution,

$$p_t = F_{beta}\left(\frac{b_t}{\bar{b}^{max}}; \alpha_b, \beta_b\right), \tag{6.1}$$

where $\bar{b}^{max}$ denotes the upper end of the support for the debt-to-output ratio. As in Corsetti et al. (2013), we set $\alpha_b = 3.70$, $\beta_b = 0.54$, and $\bar{b}^{max} = 2.56$. In Corsetti et al. (2013), the parameters are chosen to match the empirical relationship between the gross debt ratios and the sovereign risk premium (measured by credit default swap spreads) for 20 industrialized economies. Figure 11 replicates this relationship between the default probability and the debt-to-annual output ratio. The relationship is similar to the fiscal limit distribution simulated for the U.S. federal government in Bi et al. (2022): the default probabilities for federal debt below 150% is trivial.[8]

With default risk, the price of the government debt becomes

$$q_t^b = \beta E_t\Big(\frac{\lambda_{t+1}}{\lambda_t}\frac{1-\Delta}{\pi_{t+1}}\Big), \tag{6.2}$$

where $\Delta$ is the haircut if the government defaults. We calibrate $\Delta = 0.25$. A large variation in the haircut rate exists in the data and literature. For example, Bi et al. (2022) assume a haircut rate of 0.07, and Corsetti et al. (2013) assume 0.5. Our calibrated value of 0.25 falls in between this wide range.

Figure 12 compares the results with and without risk premia. The comparison shows that incorporating the risk premium observed for industrialized economies does not alter our main message that regime uncertainty increases the debt burden in regime $\mathcal{F}$. With risk premia, the government now pays more interest on debt, enlarging its borrowing needs. Meanwhile, higher debt implies higher expected labor and capital tax adjustments under regime uncertainty, which induces agents to save more by cutting consumption and investment. Our simulation is conducted under an initial debt ratio of 120%, corresponding to a minimal default probability based on Figure 11.

[8] Corsetti et al. (2013) point out that assuming a default probability function, like equation (6.1), is equivalent to having a fiscal limit as in Bi (2012). Depending on the assumption of future transfer trajectories, the default probabilities for a federal debt of around 150% fall between 0.05 and 0.12 in Bi et al. (2022).

The debt accumulation is 0.4% higher than the baseline case of risk-free debt three years after the spending shock. It remains the case that government spending in the uncertain regime $\mathcal{F}$ increases the debt burden.

# 7 Concluding Remarks

Passive monetary policy is often implemented in a severe recession to accommodate significant spending needs by keeping borrowing costs low. Under the fixed regime assumption, standard NK models generate a favorable outcome: a spending increase reduces the debt burden and improves debt sustainability under the passive monetary policy. When the policy regime is expected to switch, we show that government spending in regime $\mathcal{F}$ increases debt accumulation for a highly indebted government, just like a typical spending increase in regime $\mathcal{M}$. In addition, a spending increase, coinciding with negative supply shocks or expected higher future capital taxes, can further drive up debt accumulation in the uncertain regime $\mathcal{F}$. On the other hand, productive spending decreases the magnitude of the debt increase from the spending shock in the uncertain regime $\mathcal{F}$.

Our finding that government spending unbacked by future primary surpluses can increase the real debt burden raises concerns about injecting a considerable amount of fiscal support to the economy in regime $\mathcal{F}$, as advocated by the International Monetary Fund (2020) during the pandemic. Despite the initial debt revaluation effect from high inflation in regime $\mathcal{F}$, government debt remains high, as observed for most countries. Our simulations show that sovereign default risk premia are negligible for the U.S. federal government. This, however, may not be true for other countries, and sizable expansionary fiscal measures can bring debt sustainability risk. Large fiscal adjustments or returning regime $\mathcal{M}$ are unavoidable to rebuild fiscal space.

| Parameters | Values | Source or Target |
|---|---|---|
| **Structural parameters** | | |
| discounting factor ($\beta$) | 0.992 | annualized real interest rate 3% |
| risk aversion ($\sigma$) | 1.38 | Smets and Wouters (2007) |
| inverse of Frisch elasticity ($\varphi$) | 1.83 | Smets and Wouters (2007) |
| elasticity of substitution of intermediate goods ($\theta$) | 7.66 | 15% price markup, Basu and Fernald (1995); Adam and Billi (2006) |
| steady-state TFP ($A$) | 1 | normalization |
| price adjustment cost ($\psi$) | 78 | 1-year price rigidity; Smets and Wouters (2007) |
| **Policy-related parameters** | | |
| steady-state and targeted inflation ($\pi$) | 1.005 | annualized inflation of 2% |
| steady-state debt to GDP ratio ($\frac{b}{4y}$) | 0.7 | average federal debt-to-annual GDP, 2008-20 |
| steady-state government spending to GDP ratio ($\frac{g}{y}$) | 0.11 | average government consumption and investment-to-GDP, 2008-20 |
| steady-state income tax rate ($\tau^l$) | 0.22 | average federal income tax rate, 2008-2020 |
| switching function parameter ($\iota_1$) | $-4.5951$ | probability staying in regime $\mathcal{F}$, 0.99, Bianchi and Melosi (2017) |
| switching function parameter ($\iota_2$) | 400 | probability of switching to regime $\mathcal{M}$ is 1 with 12% inflation |
| interest rate response to inflation in regime $\mathcal{F}$ ($\alpha^{\mathcal{F}}$) | 0 | Leeper (1991) |
| labor/capital tax response to debt in regime $\mathcal{F}$ ($\gamma^{\mathcal{F}}$) | 0 | Leeper (1991) |
| interest rate response to inflation in regime $\mathcal{M}$ ($\alpha^{\mathcal{M}}$) | 1.6 | Bianchi and Melosi (2017) |
| labor tax rate response to debt in regime $\mathcal{M}$ ($\gamma_l^{\mathcal{M}}$) | 0.07 | Bianchi and Melosi (2017) |
| **Exogenous process** | | |
| persistence of government purchase ($\rho_g$) | 0.8 | Shen and Yang (2018) |
| standard deviation of government purchase ($\sigma_g$) | 0.0096 | Shen and Yang (2018) |

Table 1: **Baseline parameterization.**

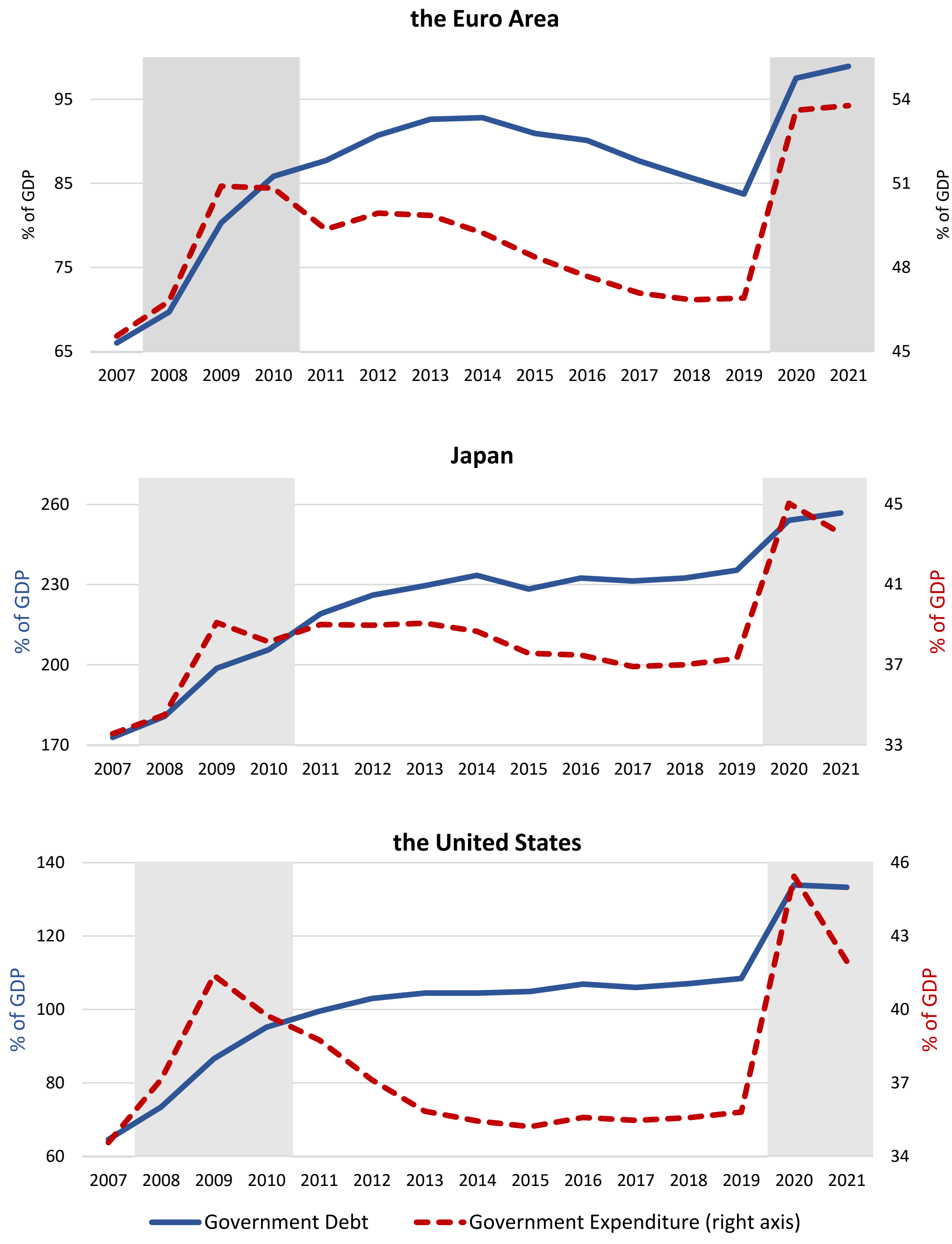


Figure 1: **Government debt and expenditure.** Government debt is general government gross debt, and government expenditure is total expenditure consisting of total expense and the net acquisition of nonfinancial assets (International Monetary Fund, 2021).

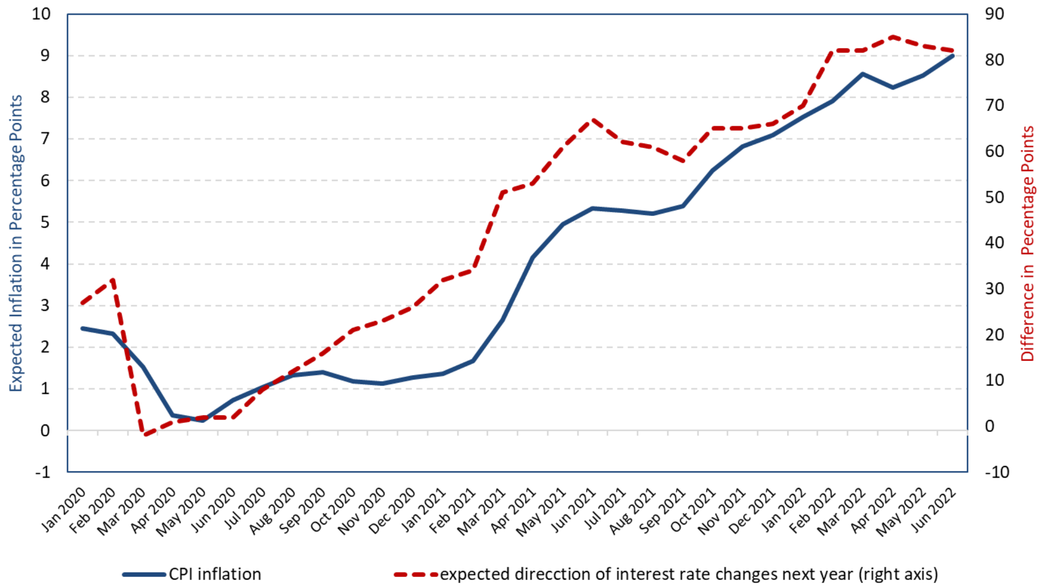


Figure 2: **Expected inflation vs. expected direction of interest rate changes.** Expected inflation is the mean expected annualized inflation rate for next year. The expected direction of interest rate changes is computed as the percentage of consumers who expected interest rates to go up next year minus the percentage of consumers who expected interest rates to go down next year; a positive number means more consumers expecting interest rates to up (Tables 31 and 32 in Surveys of Consumers University of Michigan, 2022).

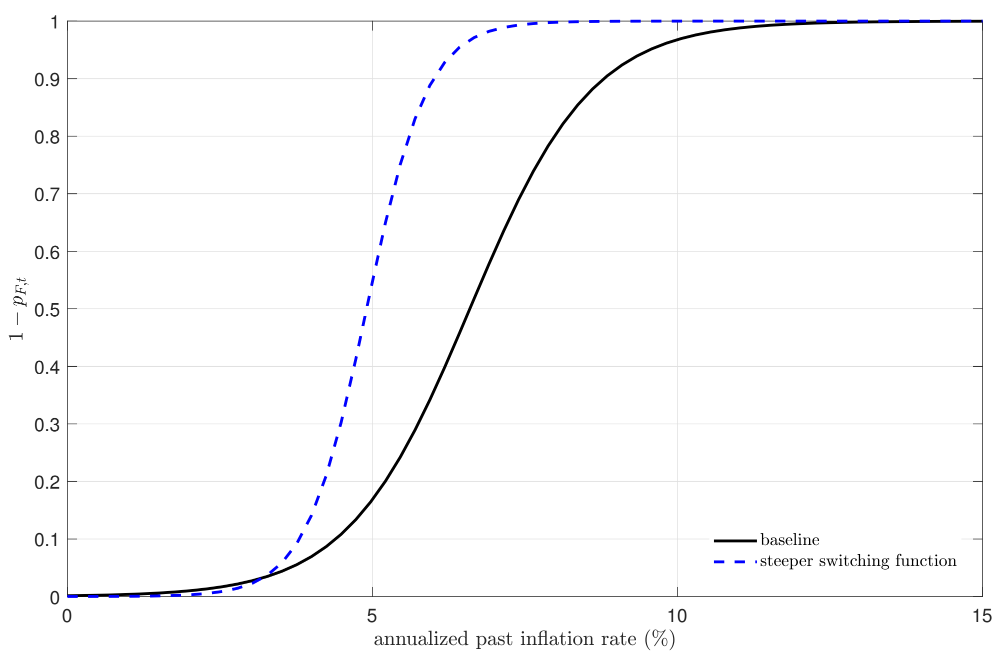


Figure 3: **Regime switching probability functions to regime $\mathcal{M}$.** The baseline function has $\iota_1 = -4.5951$ and $\iota_2 = 400$. The steeper switching function has $\iota_1 = -5.8061$ and $\iota_2 = 800$ in equation (2.13).

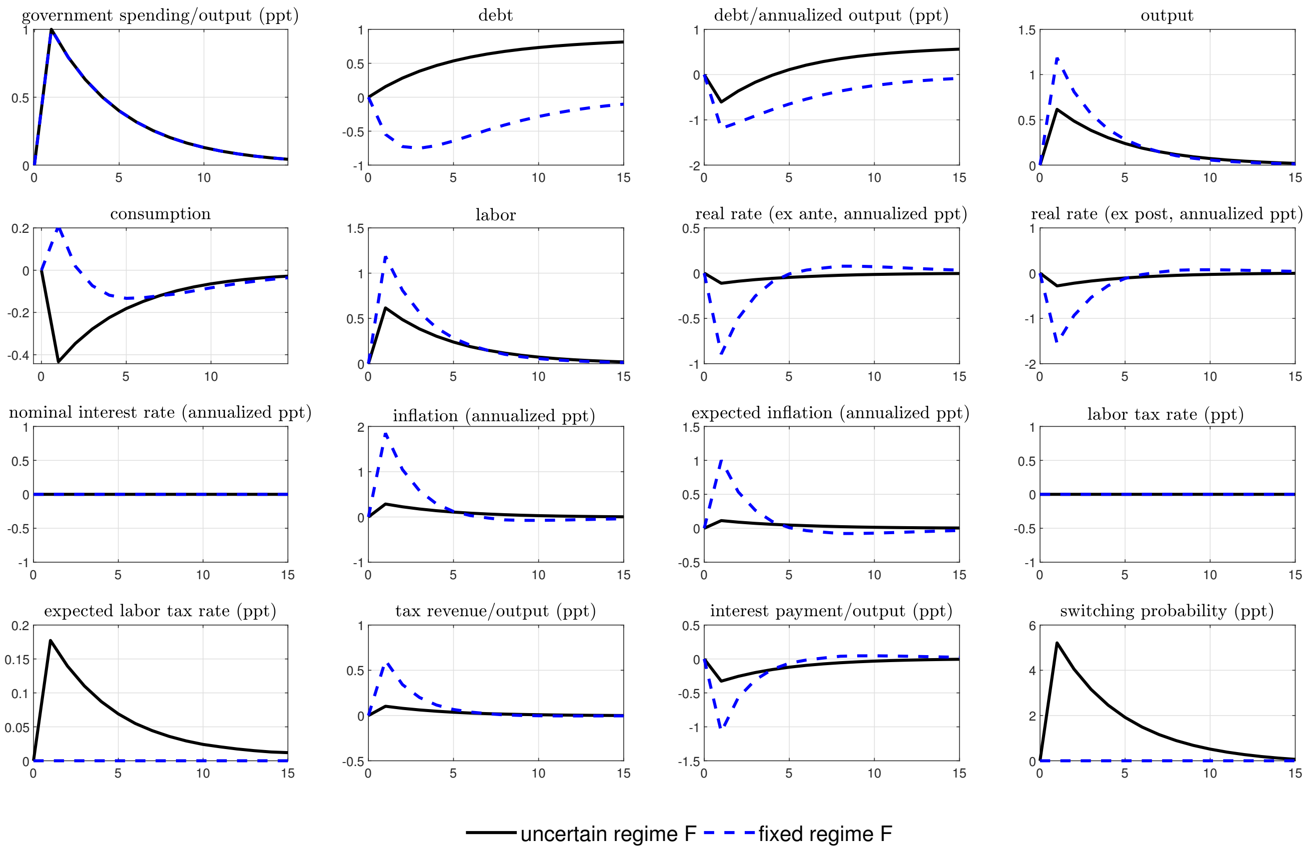


Figure 4: **Responses to a government spending shock in regime $\mathcal{F}$: the baseline simulations.** The responses are the differences between the paths with the shock and those without. The initial government debt-to-annual output is 120%. The y-axes are in percent deviation from the steady state unless otherwise specified in the parentheses, and "ppt" standards for percentage points. The x-axes are in quarters.

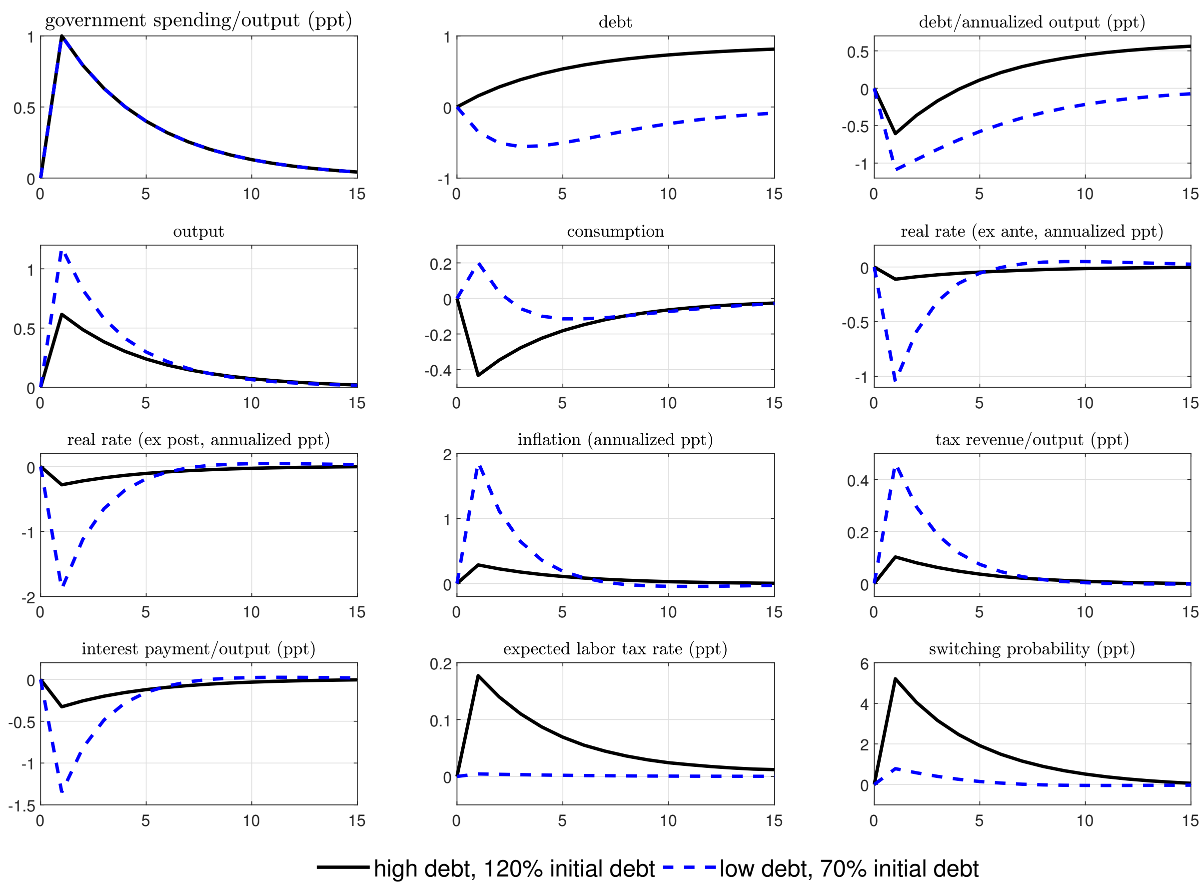


Figure 5: **Responses to a government spending shock: the role of initial government debt levels in the uncertain regime $\mathcal{F}$.** The initial government debt-to-annual output is 120%. See Figure 4 for axis units.

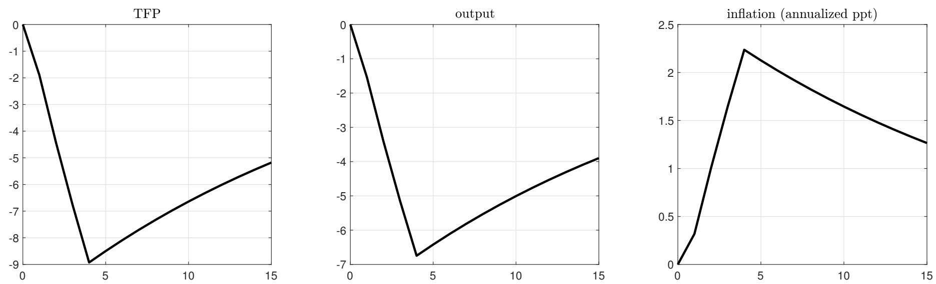


Figure 6: **Responses to negative supply (TFP) shocks.** The initial government debt-to-annual output is 120%. The responses are deviations from the paths with and without the TFP shocks. TFP and output are scaled by the steady-state values, and inflation is annualized in percentage points (ppt).

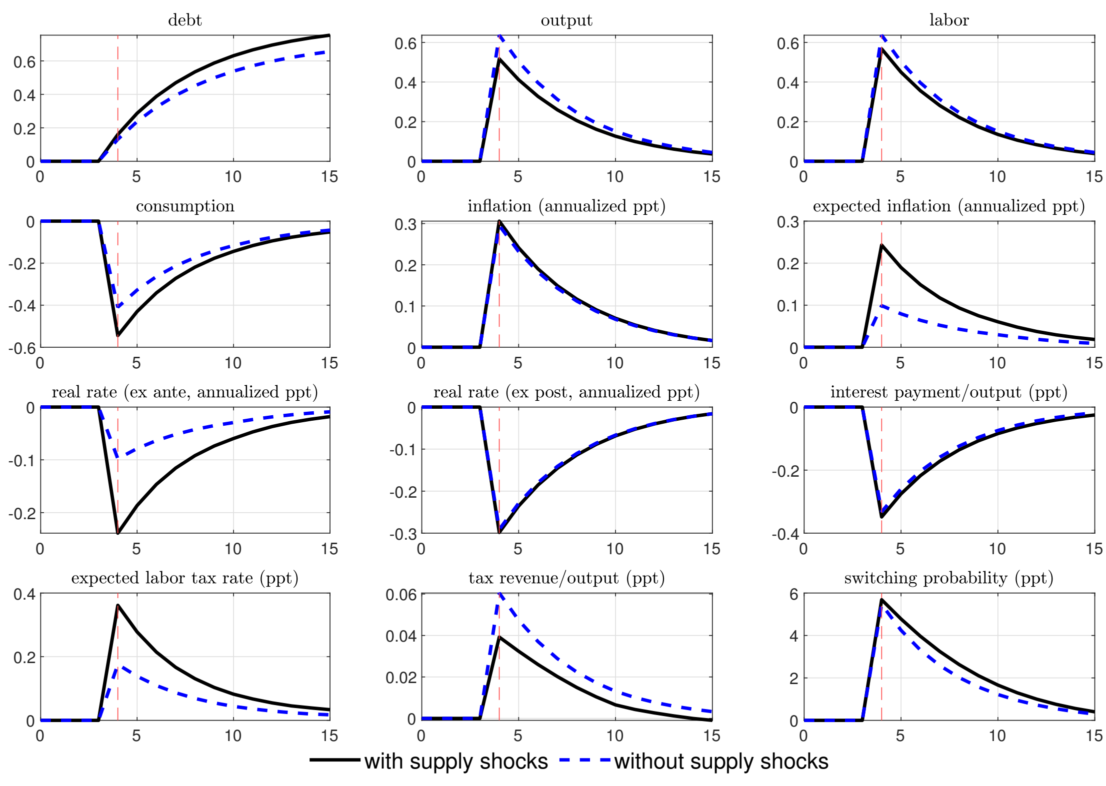


Figure 7: **Responses to a government spending shock: the role of negative supply (TFP) shocks.** The responses are plotted in terms of the differences between the paths with and without a government spending shock (equal to 1% of output injected at $t = 4$ as indicated by the vertical dashed lines) and scaled by the steady-state value of a variable, unless specified in parentheses. The simulation with the TFP shocks is subject to negative TFP shocks as those shocks injected from $t = 1$ to 4 in Figure 6. The initial government debt-to-annual output is 120%. See Figure 4 for axis units.

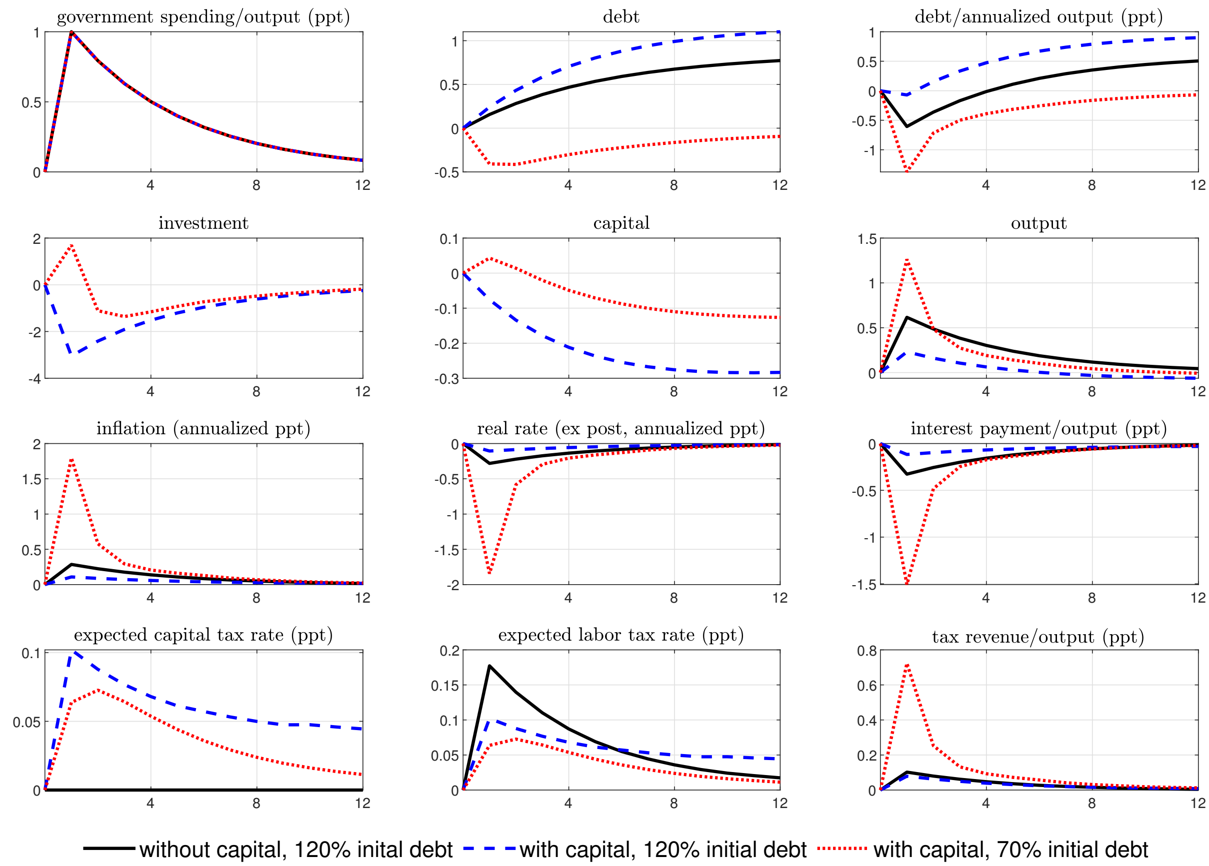


Figure 8: **Responses to a government spending shock: the role of capital in the uncertain regime $\mathcal{F}$.** The initial government debt-to-annual output is 120%. See Figure 4 for axis units.

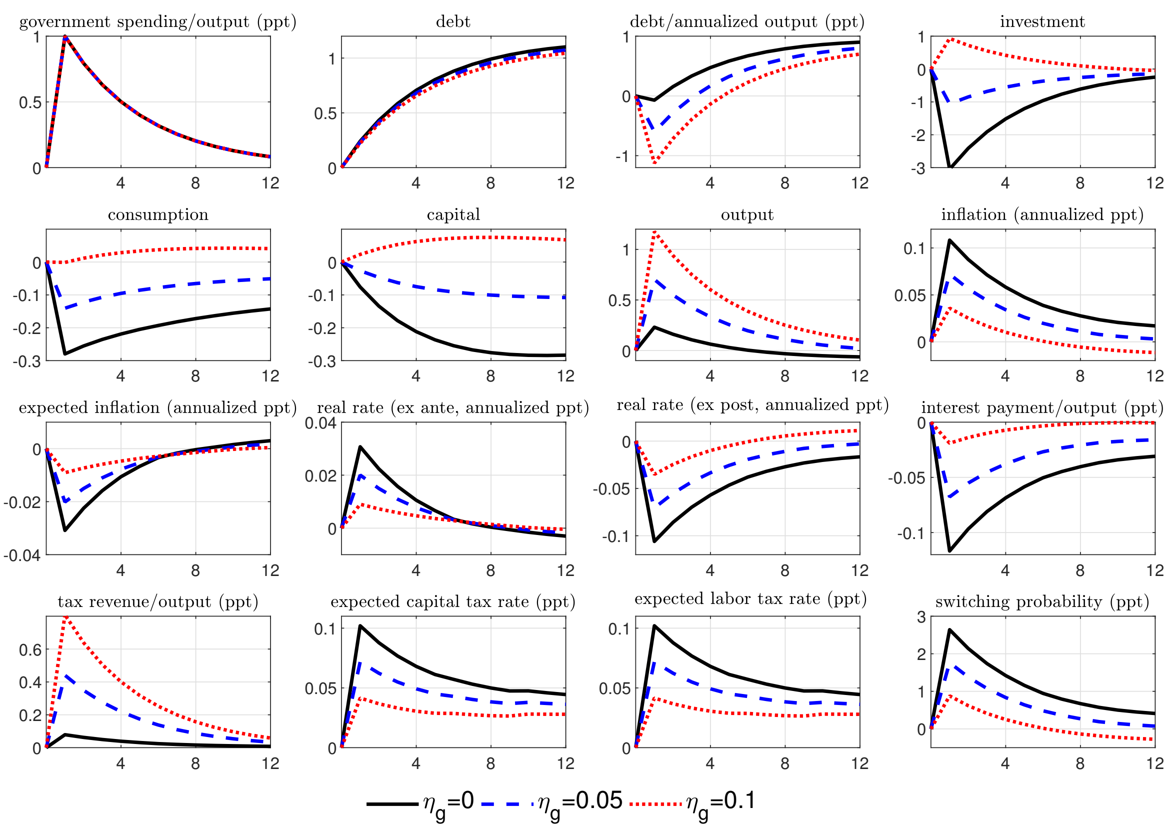


Figure 9: **Responses to a government spending shock: productive government spending.** The initial government debt-to-annual output is 120%. See Figure 4 for axis units.

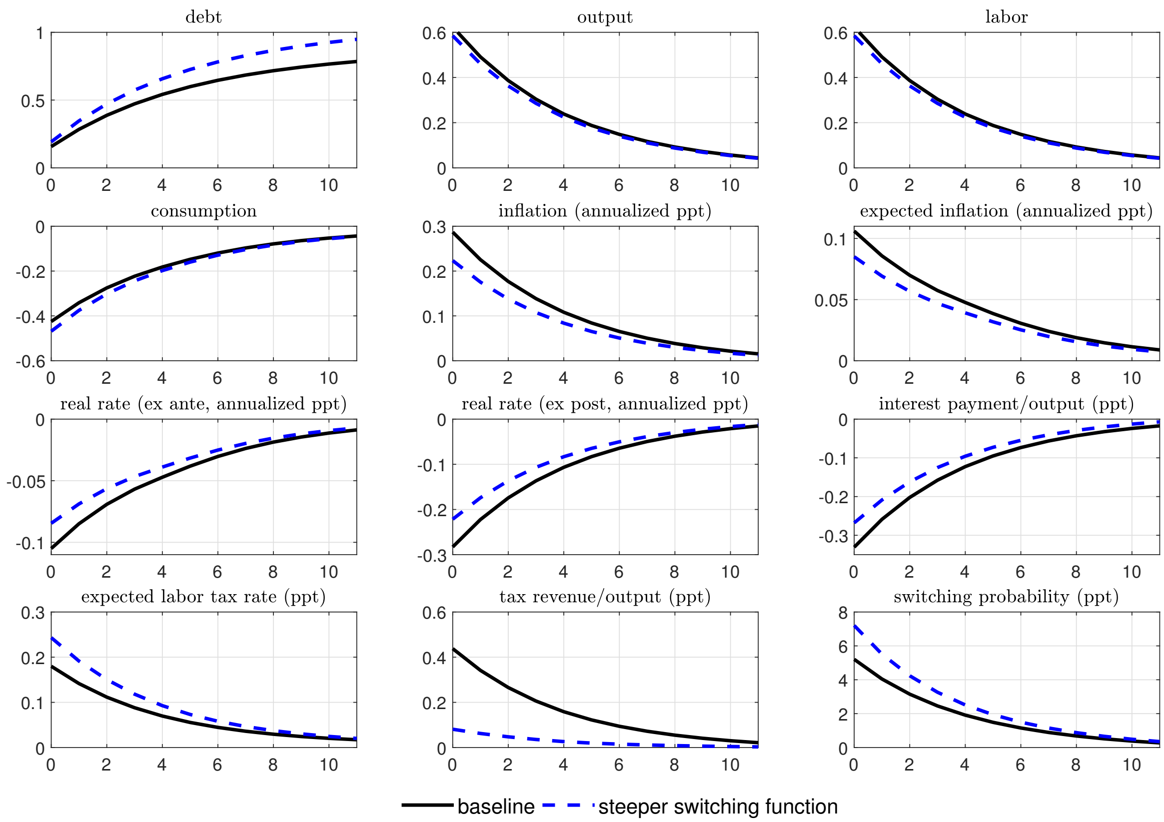


Figure 10: **Sensitivity analysis: a steeper regime switching function.** The simulations are based on the baseline model without capital. The steeper function sets $\iota_1 = -5.8061$ and $\iota_2 = 800$, compared to the baseline switching function with $\iota_1 = -4.5951$ and $\iota_2 = 400$. The initial government debt-to-annual output is 120%. See Figure 4 for axis units.

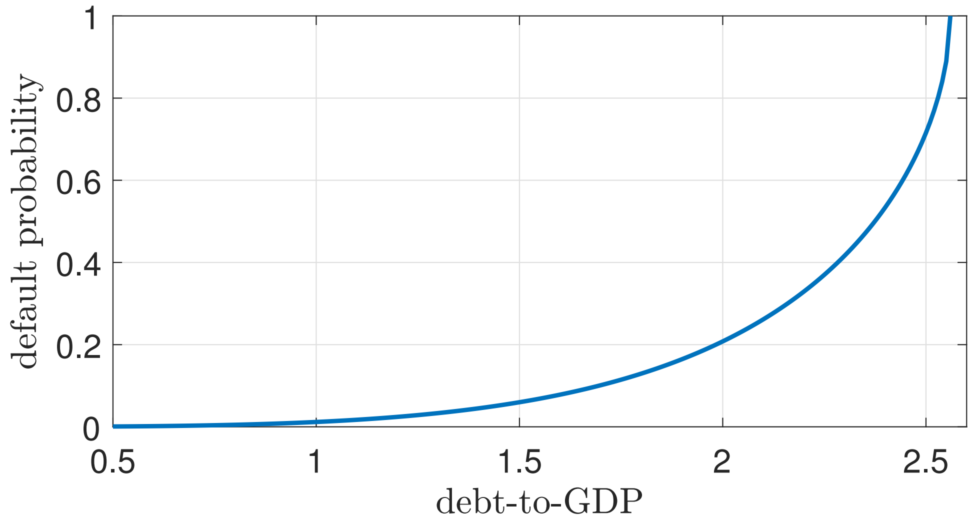


Figure 11: **Simulated sovereign default risk.** The relationship between the debt ratio-to-annual output ratio and risk premium in Corsetti et al. (2013).

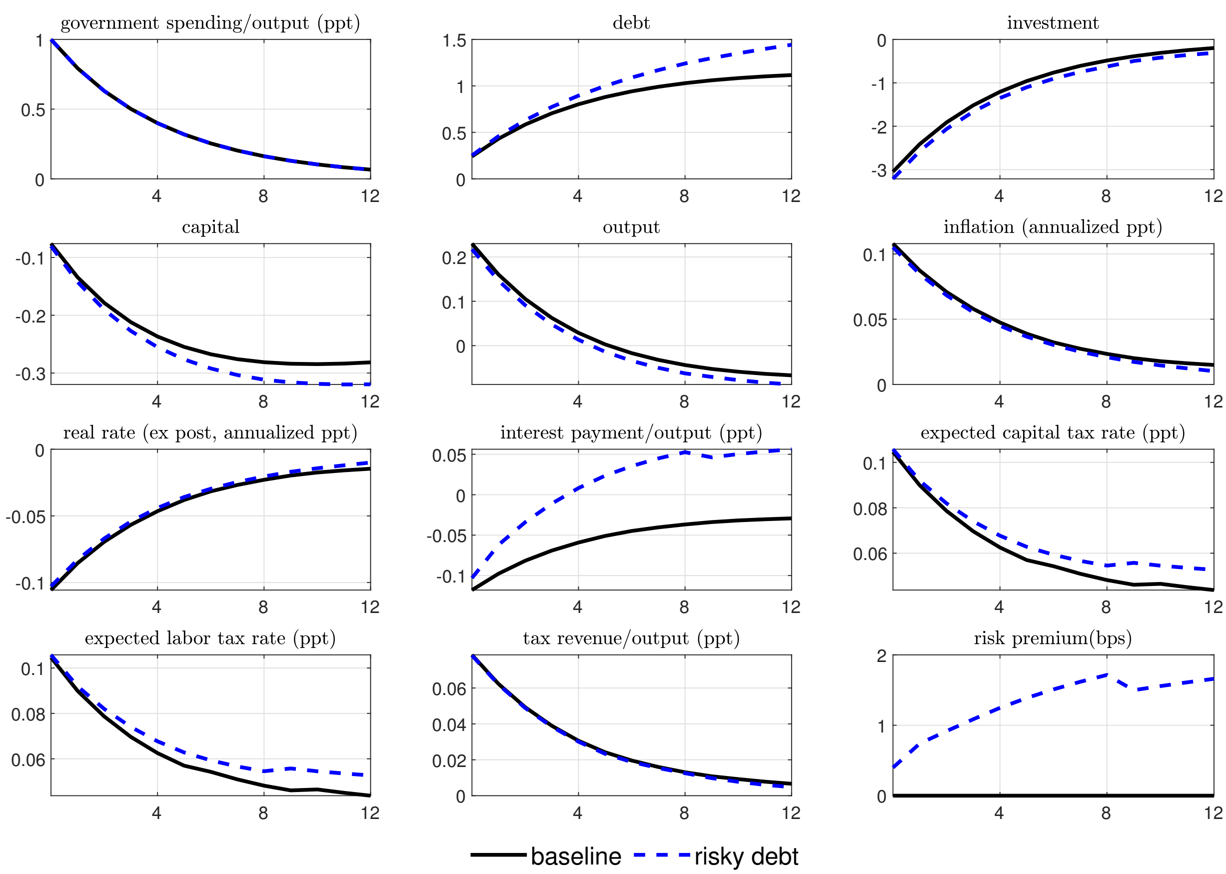


Figure 12: **Sensitivity analysis: risky debt.** The baseline has risk-free government debt. The initial government debt-to-annual output is 120%. See Figure 4 for axis units.

# Appendices

## A The Equilibrium System

The following equations characterize the equilibrium system for the baseline economy without capital, including optimality conditions for the representative agent and firms, government budget constraint, monetary and fiscal policy rules, the aggregate resource constraint, and the exogenous government spending process.

$$\frac{1}{R_t} = \beta E_t\Big(\frac{\lambda_{t+1}}{\lambda_t}\frac{1}{\pi_{t+1}}\Big) \tag{A.1}$$

$$\psi\left(\frac{\pi_t}{\pi} - 1\right)\frac{\pi_t}{\pi} = (1-\theta) + \theta mc_t + \psi\beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\frac{y_{t+1}}{y_t}\frac{\pi_{t+1}}{\pi}\left(\frac{\pi_{t+1}}{\pi} - 1\right)\right] \tag{A.2}$$

$$\lambda_t = c_t^{-\sigma} \tag{A.3}$$

$$(1-\tau_{l,t})w_t\lambda_t = \chi n_t^{\varphi} \tag{A.4}$$

$$mc_t = w_t \tag{A.5}$$

$$y_t = A_t n_t \tag{A.6}$$

$$y_t = c_t + g_t \tag{A.7}$$

$$\frac{B_t}{R_t P_t} + \tau_{t,l}w_t n_t = \frac{B_{t-1}}{P_t} + g_t + z_t \tag{A.8}$$

$$R_t = \max\left\{1, R\cdot\left(\frac{\pi_t}{\pi}\right)^{\alpha(\mathfrak{s}_t)}\right\} \quad \alpha(\mathfrak{s}_t) \in \{\alpha^M, \alpha^F\} \tag{A.9}$$

$$\tau_{l,t} = \tau + \gamma_l(\mathfrak{s}_t)(b_{t-1} - b) \quad \gamma(\mathfrak{s}_t) \in \{\gamma^M, \gamma^F\} \tag{A.10}$$

$$\log\frac{g_t}{g} = \rho_g \log\frac{g_{t-1}}{g} + \varepsilon_t^g \tag{A.11}$$

$$p_{F,t} = 1 - \frac{\exp\Big(\iota_1 + \iota_2(\pi_{t-1} - \pi)\Big)}{1 + \exp\Big(\iota_1 + \iota_2(\pi_{t-1} - \pi)\Big)}, \quad p_{M,t} = 1 \tag{A.12}$$

In the extended model with capital, adding investment and capital decision yields the following two additional optimality conditions, including Tobin's $q$ and the Euler equation for capital

$$q_t = \left[1 - \kappa\left(\frac{i_t}{k_{t-1}} - \delta\right)\right]^{-1}, \tag{A.13}$$

$$q_t = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \left\{ (1 - \tau_{k,t+1})\, r_{t+1}^k + q_{t+1} \left[ (1-\delta) - \frac{\kappa}{2}\left( \frac{i_t}{k_{t-1}} - \delta \right)^2 + \kappa \left( \frac{i_t}{k_{t-1}} - \delta \right)\left( \frac{i_t}{k_{t-1}} \right) \right] \right\}. \tag{A.14}$$

Also, the marginal cost in the Phillips Curve is

$$mc_t = \left( \frac{1}{1-\alpha} \right)^{1-\alpha} \left( \frac{1}{\alpha} \right)^{\alpha} \left( r_t^k \right)^{\alpha} \left( w_t \right)^{1-\alpha} = \frac{1}{1-\alpha} \frac{w_t n_t}{y_t} \times \frac{1}{\alpha} \frac{r_t^k k_{t-1}}{y_t}. \tag{A.15}$$

# B Computational algorithm

The solution to the model is a function that maps the set of states $\mathcal{S}_t = \{b_{t-1}, g_t, s_t\}$ to the set of endogenous variables, where $s_t$ is the indicator for the regime. When the baseline model is augmented with TFP shocks and capital, $A_t$ and $k_{t-1}$ are additional states. The model is solved using the Euler equation iteration described in Coleman (1991). The solution method discretizes the state space and finds the fixed point of the Euler equations directly. This paper discretizes the state space with Tauchen's (1986) method and solves the policy functions of $\{\lambda_t(\mathcal{S}_t), \pi_t(\mathcal{S}_t)\}$ with the following steps.

1. Guess the forms of policy functions $\lambda_t^{(0)}(\mathcal{S}_t)$ and $\pi_t^{(0)}(\mathcal{S}_t)$.

2. For each state, plug the initial guesses to the system of equations (A.3) to (A.10) to calculate $\{c_t, n_t, w_t, mc_t, b_t\}$.

3. With $b_t$ from last step, evaluate the expectations on the right hand side of equations (A.1) and (A.2) by calculating next period's policy values with the guessed policy function forms: $\lambda_t^{(0)}(\mathcal{S}_{t+1})$ and $\pi_t^{(0)}(\mathcal{S}_{t+1})$. When evaluating the expectations, the regime switching probability is summarized by equation (A.12).

4. Solve for the updated policy function $\lambda^{(1)}$ and $\pi^{(1)}$.

5. Check convergence. If $\max\{\|\lambda^{(0)} - \lambda^{(1)}\|, \|\pi^{(0)} - \pi^{(1)}\|\} < 1d-6$, then $\{\lambda^{(1)}, \pi^{(1)}\}$ is the final solution, else update $\lambda^{(0)}, \pi^{(0)}$ with $\lambda^{(1)}, \pi^{(1)}$ and repeat step 2-4 until it converges.

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