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ABSTRACT

Money financing returns to policy debate as governments around the world adopted massive fiscal measures during the pandemic. Using a fully nonlinear New Keynesian model with endogenous policy regime switching, we show that a moderate inflation-driven switching probability to a debt-financing regime reduces money-financed spending multipliers. When interacted with high government debt, money-financed spending multipliers fall below one, similar to the size of debt-financed spending multipliers. This result holds at the zero lower bound, with long-term government debt, and under a wide range of key parameter values. Policy regime uncertainty, on the other hand, has little effect on debt-financed spending multipliers.

Keywords: government spending effects, fiscal multipliers, regime-switching policy, monetary and fiscal policy interaction, nonlinear New Keynesian models

JEL Classification: E32, E52, E62, E63, H30

1 INTRODUCTION

The economic crisis triggered by the COVID-19 pandemic has resulted in the most severe global recession since WWII. In response to the crisis, monetary policies in most advanced economies quickly reached the zero lower bound (ZLB), and fiscal policies swiftly moved with unprecedented support. On-budget fiscal measures totaled 10.2% of GDP globally and 25.5% of GDP for the U.S. (International Monetary Fund, 2021). Since many indebted economies suffered serious harm from the pandemic, a relevant policy question is: How can heavily indebted governments support economic growth or deal with the next recession?

One bold but old tool is money-financed fiscal measures (e.g., Buiter, 2014; Turner, 2015; Galí, 2020b; Turner, 2020; Yashiv, 2020). Implicitly, this policy has been used recently, such as with the Bank of England's partial funding of pandemic-related fiscal costs and the seemingly coordinated quantitative easing (QE) with fiscal expansions in the U.S. and the euro area.[1] English et al. (2017) and Galí (2020a) find that money-financed fiscal measures have bigger multipliers than traditional debt-financed ones. Also, Bernanke (2003, 2016) highlights the benefits of money financing in averting deflationary pressure. Despite the potential advantages, money financing risks higher inflation and may weaken central bank independence. Careful assessment of its effectiveness in boosting growth is warranted.

Using a fully non-linear New Keynesian (NK) model, we study how policy regime uncertainty between money- and debt-financing regimes matters for government spending effects, a factor largely overlooked in the research on money-financed spending effects. Money financing refers to government spending mainly financed by seigniorage and inflation taxes, with the monetary authority ignoring inflation (hereinafter the "money regime"). Debt financing refers to government spending mainly financed by debt and subsequent taxes, with the monetary authority following a Taylor rule to control inflation (hereinafter the "debt regime").

Different from existing work modeling regime switching as an exogenous process (e.g., Davig and Leeper, 2006b, 2011; Bianchi, 2013; Davig and Doh, 2014; Bianchi and Melosi, 2022), we assume endogenous policy regime switching for the monetary and fiscal policy mix. In the money regime,

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[1]The Federal Reserve System (2020) motivates QE with its statutory mandate to foster maximum employment and price stability, but the monetary action provides essential financing for large-scale fiscal measures. See Cukierman (2021) for a discussion on raising seigniorage in various QE operations.

inflation exceeding its target triggers expectations of switching to the debt regime.[2] In the debt regime, high government debt prompts expectations of switching to the money regime.

Endogenous regime switching, particularly the inflation-driven switching expectations, is motivated by observation and econometric evidence. The loosening of monetary policy during recessions is often characterized as temporary, with a state-contingent endpoint (e.g., Federal Reserve System, 2020). Although monetary policy remained accommodative 17 months after the COVID-19 outbreak, the Federal Reserve explicitly communicated to the public a price stability goal and the criterion—"sustained higher inflation"—to reverse the policy course (Powell, 2021). Despite rising one-year inflation expectations since mid-2020, five-year expectations appear anchored (see Figure 1), which implies that agents anticipate monetary policy to be active again. Laumer and Philipps (2022) find that on average the Federal Reserve Bank becomes more active when inflation rises after a government spending increase. Modeling regime switching as endogenous emphasizes that economic states shape agents' expectations about regime changes, which can affect government spending effects.

Consistent with English et al. (2017) and Galí (2020a), our simulations under the fixed regime assumption find that money financing generates much bigger spending multipliers than debt financing. When the initial debt-to-annual output ratio is 100% (the net U.S. federal debt ratio in 2021), the baseline calibration produces an impact spending multiplier of 1.13 in the money regime, compared to 0.59 in the debt regime. Two main channels drive this divergence: negative wealth effects through higher future taxes and intertemporal substitution effects through a lower real interest rate. Money financing increases inflation, which decreases the real interest rate, crowds in consumption, and produces spending multipliers exceeding one. Debt financing, instead, generates a higher real interest rate because of more government borrowing, which crowds out consumption. Also, debt financing leads agents to save for future higher taxes, discouraging consumption. Both factors produce spending multipliers below one in the fixed debt regime.

When policy regimes are uncertain, a moderate switching probability to the debt regime can substantially decrease money-financed spending multipliers, relative to those in the fixed money regime.

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[2]Davig and Leeper (2006a) also model endogenous monetary policy switching based on inflation. In their setup, monetary policy switches to a more active regime with probability one if inflation exceeds a threshold. In our setup, the switching probability is time-varying, depending on the periodic inflation deviation from the monetary authority's target.

Higher inflation from money-financing induces expectations of switching to the debt regime. These expectations revive the negative wealth effect from anticipating higher taxes in the debt regime. The expectations also suppress the expected and current inflation increases, resulting in a smaller debt devaluation effect and a bigger financing need to be filled by seigniorage revenues. Higher real money balances in the uncertain money regime make agents substitute away from consumption to accomdate more money holding. Combined with the negative wealth effect, consumption responds negatively to a government spending shock in the uncertain money regime, opposite to the positive consumption response in the fixed money regime. Consequently, spending multipliers are smaller in the uncertain money regime. With an initial debt-to-annual output ratio of 100%, the impact multiplier drops from 1.13 to 0.70, not much higher than the debt-financed spending impact multiplier near 0.6. Thus, policy uncertainty substantially shrinks the multiplier difference between the money and debt regimes when government debt is sufficiently high.

The two recent episodes of extraordinary fiscal measures—following the Global Financial Crisis and the COVID-19 pandemic—were associated with severe recessions that drove the economy to the ZLB. Our simulations suggest that government spending becomes more expansionary at the ZLB, as shown in Christiano et al. (2011) and Erceg and Lindé (2014). The ZLB is, however, more effective in raising spending multipliers in the debt regime than in the money regime, consistent with Galí (2020a). Accounting for both high debt and the ZLB, policy uncertainty still generates multipliers below one in the money regime.

To establish the quantitative robustness of our results, we conduct extensive simulations on alternative model specifications and parameter values. Particularly important is to consider long-term government debt, as debt maturity has shown to be important in inflation dynamics under passive monetary policy (e.g., Sims, 2013; Leeper et al., 2017; Chen et al., 2022; Cochrane, 2023). When the policy regime is uncertain, expectations of switching to the debt regime lowers the expected future bond price (because of a higher expected nominal interest rate), which decreases the current bond price and increases agents' holding of real money balances. Together with the negative wealth effect, consumption decreases as in the baseline model with short-term debt. Thus, the main result that policy regime uncertainty dampens money-financed spending multipliers holds with long-term debt.

Our study adds to the literature that investigates macro policy regime switching. For example,

Davig and Leeper (2007) and Chung et al. (2007) investigate equilibrium properties of policy regime switching or their implications on interpreting macroeconomic data. Bianchi and Melosi (2017) rely on agents' expectations for a fiscally-led policy regime to explain the lack of deflation spirals following the Global Financial Crisis. Similar to our paper examining money-financed spending effects, Tsuruga and Wake (2019) show that money-financed spending deepens a recession if there exists a lag between spending decisions and implementation. Punzo and Rossi (2021) find that money-financed spending has a stronger redistribution effect from savers to borrowers. The bigger macroeconomic fluctuations, however, result in a larger welfare loss than debt-financed spending.

Also related is the literature on government spending effects in regimes $\mathcal{F}$ (active monetary policy/passive fiscal policy) and $\mathcal{M}$ (active monetary policy/passive fiscal policy, à la Leeper, 1991). While regime $\mathcal{F}$ is similar to the money regime in the sense that rising inflation, instead of real fiscal backing, stabilizes government debt, they differ in the nominal interest rate dynamics.[3] Several papers that model fixed regimes find spending multipliers exceeding one in regime $\mathcal{F}$ (e.g., Kim, 2003; Leeper et al., 2017). The online appendix contains an analysis using a model with money that distinguishes between regimes $\mathcal{F}$ and $\mathcal{M}$ (similar to those in Ho, 2005; Mao and Yang, 2020). It finds that incorporating endogenous regime switching decreases spending multipliers below one in regime $\mathcal{F}$ and, hence, makes the spending multipliers much closer between regimes $\mathcal{F}$ and $\mathcal{M}$.

2 THE BASELINE MODEL

The baseline model is a standard NK model with money, in which government spending can be financed by money or debt (see, e.g., Galí, 2008). The most distinguishable feature is an endogenous regime-switching process such that agents form state-contingent expectations of switching between the money and debt regimes.[4]

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[3]In regime $\mathcal{F}$, the nominal interest rate remains a policy instrument to be determined by the monetary policy rule. In the money regime, the nominal interest rate is jointly determined by the government budget constraint and money demand.

[4]Our model economy abstracts from capital. Modeling capital requires adding one more endogenous state variable in solving the model, which is technically challenging given all the features in the baseline model. Mao et al. (2022) specifies an NK model with capital to study the fiscal implications of passive monetary policy but omits modeling the zero lower bound and real money balances. They find that the presence of capital enlarges the spending multiplier difference in the fixed versus uncertain regime $\mathcal{F}$.

2.1 The Private Sector

The representative agent chooses consumption (c_t), labor (n_t), nominal money holding (M_t), and one-period nominal government bonds (B_t) for each period t to maximize lifetime utility by solving

$$\max_{c_t, n_t, M_t, B_t} E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{c_t^{1-\sigma}}{1-\sigma} - \chi \frac{n_t^{1+\varphi}}{1+\varphi} + \delta \frac{(M_t/P_t)^{1-\eta}}{1-\eta} \right], \tag{2.1}$$

subject to

$$P_t c_t + Q_t B_t + M_t + P_t \frac{\Xi}{2} \left(\frac{M_t}{P_t} \right)^2 = B_{t-1} + M_{t-1} + (1-\tau_t) W_t n_t + P_t d_t + P_t z_t + P_t \xi_t, \tag{2.2}$$

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 combined with the Dixit-Stiglitz aggregator, β is the discount factor, θ indicates the elasticity of substitution among goods varieties, P_t is the unit price of composite consumption, R_t is the gross nominal interest rate, $Q_t = \frac{1}{R_t}$ is the nominal bond price, τ_t is a distorting income tax rate, W_t is the nominal wage rate, d_t is firms' real profit, and z_t is real government transfers. The term, $\frac{\Xi}{2} \left(\frac{M_t}{P_t} \right)^2$, is the money holding cost. Introducing a small but non-zero holding cost helps solution convergence and prevents real money balances from becoming infinite when the ZLB binds.[5] Together with the price adjustment cost explained below, the money holding cost, contained in ξ_t, is rebated to the agent so it does not affect the agent's wealth.

The production sector consists of a continuum of monopolistically competitive firms. Each firm i chooses price, $P_t(i)$, and labor, $n_t(i)$, to maximize the present value of future nominal profits, discounted by the agent's (firm owner's) stochastic discount 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

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

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[5] This is quantitatively similar to imposing an upper bound for the real money balance, as in Aruoba et al. (2017) and Galí (2020a).

and demand for each intermediate good i

$$y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\theta} y_t,$$ (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, π is the steady-state gross inflation rate, and a is constant total factor productivity. The discount factor between time $t+s$ and t, $\beta^s \frac{\lambda_{t+s}}{\lambda_t}$, follows from the agent's Euler equation and $\lambda_t = c_t^{-\sigma}$ is the marginal utility of consumption. Price adjustments are subject to a quadratic adjustment cost, $\frac{\psi}{2}(\frac{P_t}{\pi P_{t-1}} - 1)^2 y_t$, where $\psi > 0$ governs nominal price rigidity. In aggregation, the price adjustment cost is rebated back to the agent, which is also included in ξ_t in equation (2.2).[6]

To solve firm i's the optimality condition, rewrite equation (2.3) in real terms:

$$\max_{n_t(i),P_t(i)} E_t \sum_{s=0}^{\infty} \beta^{t+s} \frac{\lambda_{t+s}}{\lambda_t} \left[\left(\frac{P_{t+s}(i)}{P_{t+s}}\right)^{1-\theta} y_{t+s} - w_{t+s}n_{t+s}(i) - \frac{\psi}{2}\left(\frac{P_{t+s}(i)}{\pi P_{t+s-1}(i)} - 1\right)^2 y_{t+s}\right].$$ (2.6)

Solving this optimization problem and imposing the symmetric equilibrium conditions yield the NK Phillips curve

$$(1-\theta) + \theta mc_t - \psi\left(\frac{\pi_t}{\pi} - 1\right)\frac{\pi_t}{\pi} + \psi\beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\frac{y_{t+1}}{y_t}\frac{\pi_{t+1}}{\pi}\left(\frac{\pi_{t+1}}{\pi} - 1\right)\right] = 0,$$ (2.7)

where $\pi_t \equiv \frac{P_t}{P_{t-1}}$ and $mc_t \equiv \frac{w_t}{a}$ is the real marginal cost.

The aggregate resource constraint is

$$c_t + g_t = y_t,$$ (2.8)

where g_t is government consumption.

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[6]When inflation changes are large, rebating the price adjustment cost back to agents makes the results under the two ways of modeling nominal rigidities, à la Rotemberg (1982) and Calvo (1983), closer to each other, a shown in Eggertsson and Singh (2019) and Miao and Ngo (2019). This is relevant for our analysis in the money regime, which tends to generate a big inflation increase.

2.2 THE PUBLIC SECTOR

The public sector consists of the fiscal authority (the government) and the monetary authority. The government budget constraint is

$$g_t + \frac{b_{t-1}}{\pi_t} + z_t = \tau_t w_t n_t + \frac{b_t}{R_t} + \frac{M_t - M_{t-1}}{P_t}, \tag{2.9}$$

where $b_t \equiv \frac{B_t}{P_t}$ is real government debt. Define real money balances as $l_t \equiv \frac{M_t}{P_t}$. Then, $\frac{M_t - M_{t-1}}{P_t} = l_t - \frac{l_{t-1}}{\pi_t}$ is seigniorage in period t. We set $z_t = z \ \forall \ t$ for simplicity. Government consumption follows the AR(1) process

$$\ln \frac{g_t}{g} = \rho^g \ln \frac{g_{t-1}}{g} + \varepsilon_t^g, \tag{2.10}$$

where g is steady-state government consumption. Other fiscal rules and monetary policy depend on the policy regime.

2.2.1 THE MONEY REGIME

In the money regime, nominal debt at t grows at the steady-state inflation rate,

$$B_t = \pi B_{t-1}, \tag{2.11}$$

which can be written as

$$b_t = \frac{b_{t-1}}{\pi_t/\pi}. \tag{2.12}$$

As debt is stabilized through inflation with money financing, fiscal adjustments are not needed. We thus keep the tax rate at the steady state, $\tau_t = \tau$, consistent with the money regime in Galí (2020a).

Given the debt rule and other fiscal variables, seigniorage and inflation taxes adjust to finance a spending increase, so that the government budget constraint, equation (2.9), is satisfied. In this sense, the spending is financed by money. The nominal interest rate is determined by the money demand function

$$\frac{\delta l_t^{-\eta}}{\lambda_t} - \Xi l_t = \frac{R_t - 1}{R_t}. \tag{2.13}$$

In this formulation, the monetary authority gives up control of the nominal interest rate. Also from equation (2.12), it can be seen that inflation exceeding the steady-state level reduces the real value of debt inherited from last period.

The debt rule in the money regime, equation (2.11), differs slightly from Galí (2020a), which keeps the real debt value unchanged in the money regime ($b_t = b_{t-1}$), or equivalently $B_t = \pi_t B_{t-1}$. Galí's rule assumes that the government can observe the price level contemporaneously. In practice, the government may be able to coordinate with the monetary authority within the quarter to target a real debt value. Equation (2.12) makes it clear that our rule has inflation reduce the real government debt burden, as captured by $\frac{b_{t-1}}{\pi_t}$ in equation (2.11).

2.2.2 THE DEBT REGIME

In the debt regime, the monetary policy instrument is the nominal interest rate, and monetary policy follows the simple Taylor rule

$$R_t = R \left(\frac{\pi_t}{\pi} \right)^{\alpha_\pi}, \tag{2.14}$$

where $\alpha_\pi > 1$ and π is the inflation target set by the monetary authority.

The income tax rate depends on the deviation of public debt from the steady-state level:

$$\tau_t = \tau + \gamma_b(b_{t-1} - b), \tag{2.15}$$

where $\gamma_b > 0$ and its magnitude is sufficiently large to preclude government debt from becoming explosive. Both English et al. (2017) and Galí (2020a) assume that lump-sum taxes adjust to balance the budget or in response to debt deviation. Adopting distorting taxes allows us to better account for the macroeconomic costs of fiscal adjustments in the debt regime.

2.3 POLICY REGIME UNCERTAINTY

We follow Davig et al. (2010) and assume that the policy regime is captured by a two-state Markov chain with time-varying and endogenous transition probabilities. Define

$$p_{i,t} \equiv \Pr \left[s_t^{\mathcal{P}} = i | s_{t-1}^{\mathcal{P}} = i \right], \qquad i \in \{\mathbf{M}, \mathbf{D}\}, \tag{2.16}$$

where $s_t^{\mathcal{P}}$ indicates the state of the realized policy regime—either the money (**M**) or debt (**D**) regime. Let $p_{\mathbf{M},t}$ ($p_{\mathbf{D},t}$) denote the probability that the money (debt) regime at $t-1$ remains in the same regime at t. The transition matrix between the money and debt regimes is then summarized as

$$\mathbf{P}_t^{\mathcal{P}} \equiv \begin{bmatrix} p_{\mathbf{M},t} & 1-p_{\mathbf{M},t} \\ 1-p_{\mathbf{D},t} & p_{\mathbf{D},t} \end{bmatrix}. \tag{2.17}$$

In the money regime, we assume that once inflation reaches the target, π (also the steady-state inflation level), the probability of switching to the debt regime in period t is an increasing function of the inflation rate in period $t-1$. The transition probability follows the logistic function

$$p_{\mathbf{M},t} = \begin{cases} 1 - \dfrac{\exp\left(\iota_1^{\mathbf{M}}+\iota_2^{\mathbf{M}}(\pi_{t-1}-\pi)\right)}{1+\exp\left(\iota_1^{\mathbf{M}}+\iota_2^{\mathbf{M}}(\pi_{t-1}-\pi)\right)} & \text{if} \quad \pi_{t-1} \geqslant \pi; \\[2ex] 1 & \text{otherwise.} \end{cases} \tag{2.18}$$

In the debt regime, we assume that the probability of switching to the money regime in period t is an increasing function of the debt-to-annual steady-state output ratio ($s_{t-1}^b \equiv \frac{b_{t-1}}{4y}$) in period $t-1$. The transition probability follows a similar logistic function

$$p_{\mathbf{D},t} = \begin{cases} 1 - \dfrac{\exp\left(\iota_1^{\mathbf{D}}+\iota_2^{\mathbf{D}}(s_{t-1}^b-s^{b*})\right)}{1+\exp\left(\iota_1^{\mathbf{D}}+\iota_2^{\mathbf{D}}(s_{t-1}^b-s^{b*})\right)} & \text{if} \quad s_{t-1}^b \geqslant s^{b*}; \\[2ex] 1 & \text{otherwise.} \end{cases} \tag{2.19}$$

For both logistic switching functions, ι_2's govern the degree of state-dependence of the endogenous switching probabilities. When the inflation rate or the debt ratio is at the threshold value, the endogenous switching component disappears. We rely on existing estimates of exogenous switching probabilities in the literature to pin down ι_1's (see Section 3 for details).

3 MODEL SOLUTION AND CALIBRATION

The equilibrium system consists of first order conditions, budget and resource constraints, and fiscal and monetary policies (see Appendix A). The model is solved by Euler equation iteration, following Coleman (1991) and Davig (2004) (see Appendix B). This delivers a fully nonlinear

solution under rational expectations with endogenous regime switching. It also allows us to explore how initial states (such as debt levels) can affect government spending effects.[7] Table 1 summarizes the baseline calibration. We evaluate the solution accuracy in Appendix C.

The model is calibrated quarterly. Since the model extends Galí (2020a), we adopt his calibration for most structural parameters. The quarterly discount factor, $\beta = 0.995$, implies a 2% annualized real interest rate. The Rotemberg quadratic cost parameter is set to $\psi = 95$, equivalent to an average price rigidity of one year. The inverse of interest semi-elasticity of money demand, η, is set to $\frac{1}{7}$, and the inverse money velocity, $\frac{l}{y}$, is set to $\frac{1}{3}$. The elasticity of substitution between different intermediate goods is set to $\theta = 9$, consistent with a steady-state 12.5% price markup. For the utility parameters, we follow Smets and Wouters' (2007) estimate to set $\sigma = 1.38$ and $\varphi = 1.83$. The inflation target is set to the steady-state inflation, $\pi = 1.005$, an annual target of 2%. For real money balances, Ξ and δ are jointly determined by equation (2.13) in the steady state and at the ZLB when real money balances reach the upper bound, assumed to be 20 percent above the steady-state real money balance, to minimize the quantitative effects of money balance adjustment costs.

For fiscal values in the steady state, we follow Drautzburg and Uhlig (2015) to calibrate with U.S. federal government data. The debt-to-annual output ratio $(\frac{b}{4y})$ is 60%, the government purchase-to-output ratio $(\frac{g}{y})$ is 0.15, and the labor income tax rate is (τ) is 0.28. Given the calibrated fiscal values, transfers (z) clear the government budget constraint. In the debt regime, we assume $\gamma_b = 0.05$ for a gradual adjustment of the tax rate in response to rising debt. Monetary policy in the debt regime follows the simple Taylor rule, with $\alpha_\pi = 1.5$. We calibrate $\sigma_g = 0.0096$ and $\rho_g = 0.8$, based on Shen and Yang (2018).

For the regime switching process in the money regime, we rely on the estimates in Bianchi and Ilut (2017) to calibrate the switching probability when inflation is at its threshold value. The baseline value of $\iota_1^{\mathbf{M}} = -3.18$ matches their estimated mean probability of staying in regime $\mathcal{F}$, 0.96. While regime $\mathcal{F}$ is not equivalent to the money regime, they both represent a passive monetary policy stance. To pin down $\iota_2^{\mathbf{M}}$, which governs the slope of the logistic function, we assume that the switching probability almost reaches 1 when inflation is about 10%—the core CPI inflation

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[7]Barthélemy and Marx (2017) develop a perturbation method to solve endogenous regime switching models, whereas we use a global method and include a more comprehensive policy block to study government spending effects.

level in 1979 when Chairman Volcker adopted a dramatically tighter monetary policy. This implies $\iota_2^{\mathbf{M}} = 400$. The solid line in Figure 2 plots the relationship between the switching probability $(1 - p_{\mathbf{M,t}})$ and the net annualized inflation rate under the baseline calibration. When the annualized inflation rate is 4% in the money regime, agents place a probability of 0.24 of switching to the debt regime next period.

The logistic function in the debt regime is determined in a similar way. The baseline value of $\iota_1^{\mathbf{D}} = -4.60$ matches Bianchi and Ilut's (2017) mean probability of staying in the conventional regime $\mathcal{M}$, 0.99. We set $\iota_2^{\mathbf{D}} = 2.5$ and $s^{b*} = 0.8$ so that the probability of switching from the debt regime to the money regime is 0.02 when the debt ratio is 100%, roughly matching the simulated fiscal limits for the U.S. federal government in Bi et al. (2022), which is based on the federal government's ability to pay. Figure 3 shows that the implied switching probabilities are relatively low for a debt ratio below 1.5, consistent with the rarity of switching to the money regime in advanced economies.[8]

4 MAIN ANALYSIS

Our focus is on how policy regime uncertainty affects government spending effects. We first simulate under the fixed regime assumption to see if our model produces bigger spending multipliers with money financing than with debt financing, as in English et al. (2017) and Galí (2020a). Since the recent episode of big government spending increases occurred against the backdrop of high government debt and at the ZLB, we also consider these two states jontly with policy regime uncertainty.

4.1 FIXED POLICY REGIMES

To simulate under fixed policy regimes, we set $p_{\mathbf{M},t} = p_{\mathbf{D},t} = 1 \; \forall \; t$ in equations (2.18) and (2.19). Figure 4 plots the impulse responses to a government spending increase of 1% of steady-state output. The figure plots the differences between the paths with and without a spending shock.

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[8]When the economy is in the money regime, simulations also require specification of $p_{\mathbf{D,t}}$. For computational simplicity, we assume $p_{\mathbf{D,t}} = 1 \; \forall \; t$. This implies that households believe that the debt regime will continue indefinitely after switching from money to debt financing. Alternative simulations that assume $p_{\mathbf{D}} = 0.95$ and $p_{\mathbf{D}} = 0.9$ produce spending multipliers very close to those under $p_{\mathbf{D}} = 1$. Hence, we only present the results under $p_{\mathbf{D}} = 1$. Likewise, when the economy is in the debt regime, we assume $p_{\mathbf{M,t}} = 1 \; \forall \; t$.

The initial state is the steady state, which has a debt ratio equal to 60% of annual output.

Consistent with English et al. (2017) and Galí (2020a), we find that a government spending increase is more expansionary and generates higher inflation in the money regime than in the debt regime. The two main channels driving the different responses are the wealth effects and the intertemporal substitution effect. On the wealth effect, debt-financed government spending triggers expectations that the government may raise future taxes to provide fiscal backing for government debt. The negative wealth effect induces agents to save more, further reducing consumption. In the money regime, this negative wealth effect does not operate.[9]

On the intertemporal substitution effect, the monetary authority raises the nominal interest rate more than the inflation increase ($\alpha_\pi > 1$) in the debt regime, which drives up the real interest rate, crowding out consumption. In the money regime, the monetary authority gives up controlling inflation. Much higher inflation expectations, combined with the lower nominal interest rate, decrease the real interest rate, helps reverse the crowding-out effect of government spending in the conventional debt regime.

Higher inflation in the money regime has important fiscal implications. Seigniorage revenues as a share of output ($\frac{M_t - M_{t-1}}{P_t y_t}$) only increase slightly despite more money creation. Rising inflation reduces the real value of the existing debt stock, as well as debt servicing costs ($\frac{b_{t-1}}{\pi_t}$). Together with more tax revenues from the output expansion (a bigger tax base), the financing need to be filled by seigniorage is much lower than the size of the government spending increase.

Although higher inflation reduces the government debt burden, the flip side is that agents' real bond income falls in the money regime, as shown in the bottom middle plot of Figure 4. The inflation tax (the real income reduction resulting from higher inflation) generates a negative income effect that offsets some of the positive consumption responses in the money regime. While not analyzed here, this negative income effect is likely to be smaller if part of government debt is held abroad, further increasing the spending multipliers in the money regime.

Rows (1) and (2) of Table 2 summarize the cumulative multipliers in present value in the two fixed regimes. In addition to an initial debt ratio of 60%, we also simulate under a much higher debt ratio of 100% (the 2021 net U.S. federal debt-to-GDP ratio, Congressional Budget Office, 2022).

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[9]In the money regime, the *nominal* wealth effect still exists as agents expect higher inflation (or inflation taxes). This effect, however, is dominated by the intertemporal substitution effect from the decreased real interest rate.

The output multipliers (or spending multipliers) are computed as

$$\frac{\sum_{j=0}^{k} \left(\prod_{i=0}^{j} r_{t+i}^{-1} \right) \Delta y_{t+j}}{\sum_{j=0}^{k} \left(\prod_{i=0}^{j} r_{t+i}^{-1} \right) \Delta g_{t+j}}, \tag{4.1}$$

where Δy and Δg are level changes relative to the path without a government spending increase and $r_t \equiv \frac{R_t}{E_t(\pi_{t+1})}$ is the gross real interest rate. When $j = 0$, $\prod_{i=0}^{j} r_{t+i}^{-1} \equiv 1$. When computing consumption multipliers, Δy is replaced by Δc. The impact, one-year, and five-year multipliers are computed by setting $k = 0$, 4, and 20, respectively.

Under an initial debt ratio at the steady-state level ($\frac{b_0}{4y_0} = 0.6$), the impact output multiplier is 1.25 in the money regime, versus 0.59 in the debt regime, and the differences remain large for longer horizons: 0.87 versus 0.52 five years after the initial spending increase. The impact consumption multiplier is 0.25 in the money regime, versus -0.41 in the debt regime.[10]

The much bigger output and consumption multipliers in the money regime, relative to those in the debt regime, are qualitatively the same as the difference between regimes $\mathcal{F}$ and $\mathcal{M}$; see, e.g., Kim (2003); Dupor and Li (2015); Leeper et al. (2017); Dupor et al. (2019), as well as our analysis in the online appendix. The similarity of government spending effects in the money regime and regime $\mathcal{F}$ is due to the common properties of the two regimes, including passive monetary policy (the monetary authority not controlling inflation), high inflation, and inflation taxes as an important financing source of a government spending increase.[11]

Comparing rows (1) and (2) of Table 2 shows that a higher initial debt ratio has a negative effect on the output and consumption multipliers in the money regime. When the initial debt ratio becomes 100%, the impact output (consumption) multiplier decreases to 1.13 (0.13) in the money regime, from 1.25 (0.25) with an initial debt ratio of 60%. As explained in Leeper et al. (2017), a bigger debt stock provides a larger base for inflation taxes, reducing the financing needs from seigniorage revenues, and hence, inflation does not increase as much. As inflation increases less, it reduces the magnitude of the real interest rate decline. Comparing the responses of the ex-ante

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[10]The goods market clearing condition, equation (2.8), means that an output multiplier exceeding one is associated with a positive consumption multiplier and vice versa, because a consumption multiplier equals an output multiplier minus one.

[11]In the money regime, seigniorage is also important. In regime $\mathcal{F}$, however, seigniorage is often overlooked as most models abstract from money. When money is explicitly modeled in regime $\mathcal{F}$ (like the model in the online appendix), seigniorage adjusts passively to satisfy money demand with a given nominal interest rate set by the monetary policy rule.

real interest rate for the fixed money regime (the dashed lines) in Figures 4 and 5, we see that the ex-ante real interest rate with an initial debt ratio of 100% only decreases by about 70 basis points on impact, while it declines by about 100 basis points with an initial debt ratio of 60%. A smaller real interest rate decline weakens intertemporal substitution effect, crowding in less consumption in the money regime with higher initial government debt.

In the debt regime, however, the initial debt level has almost no influence on spending multipliers, as shown in Table 2. Conditional on the same fiscal adjustment rule, the present value of fiscal adjustments is about the same for a given debt-financed government spending increase. Although an initial higher debt level calls for a bigger fiscal adjustment in the near term, an initial lower debt level postpones most of the adjustment to later periods. Hence, the initial debt level has little influence on the multipliers in the debt regime.[12]

4.2 Uncertain Policy Regimes

Our analysis under policy regime uncertainty focuses on the expectation effects from regime switching; throughout the simulation horizon, regimes do not switch ex post. Row (3) of Table 2 presents the multipliers under policy regime uncertainty. To investigate the interaction of high debt and policy uncertainty, we set the initial debt ratio to be 100% (the net federal debt level in 2020) for the baseline analysis. Figure 5 compares the impulse responses of money-financed government spending under policy regime uncertainty (solid lines) to those under the fixed regime (dashed lines).

4.2.1 The Money Regime

In the money regime, policy uncertainty substantially lowers output, labor, inflation, and the real wage in the short run, relative to those under the fixed money regime. Moreover, it reverses the positive consumption response in the fixed money regime, leading to less expansionary government spending.

With an initial debt ratio of 100%, the annual inflation rate is about 4%, higher than the steady-state 2% to maintain debt sustainability. The 4% inflation corresponds to modest uncertainty about

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[12]If, however, a government spending increase with an initial high debt level induces the government to adopt a more aggressive adjustment rule, government spending has lower multipliers in the debt regime with higher initial debt, as shown in Bi et al. (2016).

switching to the debt regime, as shown in Figure 2. Government spending shocks put upward pressure on inflation further, increasing the switching probability by 12% (as shown in the bottom left plot of Figure 5). Through the expectation of a possible regime switch, the negative wealth effect in the debt regime is revived because of potential higher tax rates in the future. The negative wealth effect induces agents to cut consumption for accommodating more savings.

As agents expect the monetary authority to switch to the debt regime, in which inflation is actively controlled, it lowers the magnitude of expected inflation increases in the short run. The policy regime uncertainty, while modest, helps anchor agents' inflation expectations, producing a smaller inflation increase. A smaller inflation increase reduces the debt devaluation effect in the money regime. This means that more seigniorage is required to support the financing needs than in the fixed money regime. As a result, the real money balance increases in the uncertain money regime, and the nominal interest rate must fall to clear the money market. The decreased nominal interest rate keeps the real interest rate from rising in the uncertain money regime, resulting in a lower real interest rate than that in the fixed money regime after the initial period. Despite a lower real interest rate, the increased holding of real money balances makes agents substitute away from consumption. Together with the negative wealth effect, government spending crowds out consumption in the uncertain money regime.

With the negative consumption response, output increases less in the uncertain money regime than in the fixed money regime. Row (3) of Table 2 shows that, with an initial debt ratio of 100%, the impact output multiplier declines from 1.13 in the fixed money regime to 0.70. Also, the impact and one-year consumption multipliers turn negative in the uncertain money regime, qualitatively the same as in the debt regime. Over a longer horizon, the multiplier differences become smaller. The five-year (20Q) cumulative output multiplier is 0.80 in the fixed money regime, compared to 0.77 in the uncertain money regime (see Row (3) of Table 2). This is due to a more negative response in the nominal interest rate in the uncertain money regime, which keeps the ex-ante real interest rate lower than in the fixed money regime after the initial period. In other words, a more negative response in the ex-ante real interest rate helps offset the negative wealth effect somewhat in decreasing consumption in the uncertain money regime. Hence, the longer-run output multiplier in the uncertain money regime increases slightly, shrinking the difference in the uncertain and fixed money regime.

The baseline simulation shows that a moderate degree of policy regime uncertainty combined with high government debt has a nontrivial effect in decreasing spending multipliers in the money regime. Regime uncertainty makes the Ricardian effect of government spending in the debt regime spill into the money regime, generating similar multipliers as observed in the debt regime.

4.2.2 THE DEBT REGIME

Figure 6 compares the impulse responses in the debt regime with an initial debt ratio of 100% under policy regime uncertainty (solid lines) to those in the fixed debt regime (dashed lines). In the uncertain debt regime, expecting the switch to the money regime diminishes the negative wealth effect. This should enhance the expansionary effect of government spending. On the other hand, expecting more money issuance drives up expected inflation and, hence, current inflation, prompting the monetary authority to raise the nominal interest rate more. This aggravates the crowding-out effect of government spending in the debt regime. Also, higher nominal and real interest rates in the uncertain debt regime increase the debt servicing costs and debt burden. Under the fiscal adjustment rule, equation (2.15), the income tax rate rises more with policy regime uncertainty than without, further reducing output.

Overall, the expectations that government debt can be monetized lower the spending multipliers, but only marginally. The three columns of row (3) under the debt regime in Table 2 show that the impact and one-year (4Q) multipliers are only a bit smaller in the uncertain debt regime than those in the fixed debt regime in row (2).

The above analysis shows that policy regime uncertainty shrinks the multiplier differences between money and debt regimes considerably and should be accounted for when analyzing government spending effects in the money regime. The online appendix shows that policy regime uncertainty plays a similar role in regime $\mathcal{F}$ to reduce spending multipliers but not so much in regime $\mathcal{M}$.

4.3 WELFARE ANALYSIS

In addition to multipliers, we compare welfare under fixed and uncertain money regimes, following the method in Schmitt-Grohé and Uribe (2004). Superscripts Df, Mf, and Mu denote variables under the fixed debt, fixed money, and uncertain money regimes. Let the fixed debt

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regime with an initial debt ratio of 100% be the reference regime in the welfare calculation for a government spending increase of 1% of steady-state output. Welfare in period 0 is computed as

$$\mathcal{W}_0^{Df} = E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(c_t^{Df})^{1-\sigma}}{1-\sigma} - \chi \frac{(n_t^{Df})^{1+\varphi}}{1+\varphi} + \delta \frac{(l_t^{Df})^{1-\eta}}{1-\eta} \right], \tag{4.2}$$

where $\mathcal{W}_0^{Df}$ is the welfare in the fixed debt regime conditional on the state of the economy in period 0. The welfare gain is computed as the fraction of consumption (χ^{Mf} and χ^{Mu}) that agents have to give up to equate the welfare in the fixed debt regime to that in the fixed or uncertain money regime. Specifically,

$$\mathcal{W}_0^{Df} = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\left[(1-\chi^{Mf})c_t^{Mf}\right]^{1-\sigma}}{1-\sigma} - \chi \frac{(n_t^{Mf})^{1+\varphi}}{1+\varphi} + \delta \frac{(l_t^{Mf})^{1-\eta}}{1-\eta} \right\} \tag{4.3}$$

$$\mathcal{W}_0^{Df} = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\left[(1-\chi^{Mu})c_t^{Mu}\right]^{1-\sigma}}{1-\sigma} - \chi \frac{(n_t^{Mu})^{1+\varphi}}{1+\varphi} + \delta \frac{(l_t^{Mu})^{1-\eta}}{1-\eta} \right\}. \tag{4.4}$$

Aggregate welfare can be written recursively,

$$\mathcal{W}_t^x = u_t^x + \beta E_t \mathcal{W}_{t+1}^x, \qquad x \in \{Df, Mf, Mu\} \tag{4.5}$$

where $u_t^x = \frac{(c_t^x)^{1-\sigma}}{1-\sigma} - \chi \frac{(n_t^x)^{1+\varphi}}{1+\varphi} + \delta \frac{(l_t^x)^{1-\eta}}{1-\eta}$. When solving for the welfare gain, we include equation (4.5) as an equilibrium condition.

Relative to the fixed debt regime, both the fixed and uncertain money regimes increase welfare. The computation finds the welfare gain in the fixed money regime is $\chi^{Mf} = 0.25\%$, while it is only $\chi^{Mu} = 0.02\%$ in the uncertain money regime. This suggests that ignoring regime uncertainty exaggerates the welfare gain from a money-financed spending increase, relative to a debt-financed spending increase.

4.4 GOVERNMENT SPENDING EFFECTS AT THE ZLB

The literature has generally established that government spending is more expansionary at the ZLB. Following Richter and Throckmorton (2015), we abstract from the cause of the ZLB and

assume that the economy switches exogenously between the non-ZLB and ZLB states.[13] In the non-ZLB state, the economy is the same as described in Section 2.1. In the ZLB state, the monetary authority pegs the gross nominal interest rate at one, independent of policy regimes.

Let $\mathbf{N}$ denote the non-ZLB state and $\mathbf{Z}$ denote the ZLB state. We assume the nominal interest rate follows a Markov chain with constant transition probabilities $p_j = \Pr[s_t^{\mathcal{R}} = j | s_{t-1}^{\mathcal{R}} = j]$, where $s_t^{\mathcal{R}}$ indicates the realized state of the nominal interest rate and $j \in \{\mathbf{Z}, \mathbf{N}\}$. Let $p_{\mathbf{N}}$ ($p_{\mathbf{Z}}$) be the probability that the non-ZLB (ZLB) state at $t-1$ stays the same state in period t. The transition matrix between the non-ZLB and ZLB states is specified as

$$\mathbf{P}^{\mathcal{R}} = \begin{bmatrix} p_{\mathbf{Z}} & 1 - p_{\mathbf{Z}} \\ 1 - p_{\mathbf{N}} & p_{\mathbf{N}} \end{bmatrix}. \tag{4.6}$$

Together with the two policy regimes, there are four states: $i \times j$, $i \in \{\mathbf{M}, \mathbf{D}\}$ and $j \in \{\mathbf{Z}, \mathbf{N}\}$. Recall that $\mathbf{P}_t^{\mathcal{P}}$ denotes the transition probability between the money and debt regimes (see equation (2.17)). The joint transition matrix among the four states is given by

$$\mathbf{P}_t = \mathbf{P}_t^{\mathcal{P}} \otimes \mathbf{P}^{\mathcal{R}}, \tag{4.7}$$

where $\otimes$ is the Kronecker product.

We simulate government spending effects at the ZLB using the calibrations $p_{\mathbf{Z}} = 0.5$, $p_{\mathbf{N}} = 0.9975$, at an initial debt ratio of 100%. Historically, the duration of the non-ZLB state is much longer than that of the ZLB state, so we assume that agents place a very small switching probability to the ZLB state when they are in the non-ZLB state. The other calibrations, including $\mathbf{P}_t^{\mathcal{P}}$, are the same as those in Table 1.

Figures 7 and 8 plot the government spending effects at the ZLB under fixed and uncertain regime assumptions and in the debt and money regime. For comparison easiness, we repeat the fixed regime scenario in the non-ZLB state, as those simulated in Section 4.1. Table 3 summarizes the spending multipliers at the ZLB, and compare them to those in the non-ZLB state.

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[13]Another modeling strategy is to have some structural shocks deliver a severe recession, which constrains the economy at the ZLB. For example, Christiano et al. (2011) and Erceg and Lindé (2014) use discount factor shocks to generate the ZLB. This strategy adds one more state variable and increases the technical complexity of solving the model fully nonlinearly with the ZLB and policy regime uncertainty.

4.4.1 THE ZLB IN FIXED POLICY REGIMES

The dashed lines in Figure 7 are the responses in the fixed debt regime in the ZLB state. Relative to the responses in the non-ZLB state (the solid lines in Figure 7), the ZLB increases spending multipliers noticeably in the fixed debt regime. Similar to money financing, the ZLB lowers the real interest rate as government spending increases inflation when the net nominal interest rate is constrained at zero. The negative real interest rate encourages consumption, raising the spending multiplier. In the fixed debt regime, the impact output multiplier rises from 0.59 in the non-ZLB state to 0.94 at the ZLB when the initial debt ratio is 100% (see the three columns of rows (1) and (2) in Table 3). These results are qualitatively the same as those in Christiano et al. (2011) and Erceg and Lindé (2014) for government spending effects at the ZLB that is driven by a structural shock.

In the fixed money regime, however, the ZLB also increases output in the short run but by a much smaller magnitude (comparing the dashed and solid lines in Figure 8). The impact output multiplier increases from 1.13 in the non-ZLB state to 1.23 at the ZLB under an initial debt ratio of 100%. Since the ex-ante real interest rate in the fixed money regime in the non-ZLB state already responds negatively to the spending shock, the additional decline in the real interest rate at the ZLB is small. Therefore, the additional contribution of the ZLB in increasing the output multiplier is small, consistent with Galí (2020a).

4.4.2 THE ZLB IN UNCERTAIN POLICY REGIMES

The dotted-dashed lines in Figures 7 and 8 plot the responses in the uncertain debt and money regimes at the ZLB state, respectively. In the uncertain debt regime, the ZLB has similar effects in increasing spending multipliers as in the fixed debt regime (see the three columns under the debt regime of rows (3) and (4) in Table 3). As policy regime uncertainty matters little for debt-financed spending multipliers, spending multipliers in the uncertain debt regime at the ZLB are very close to those in the fixed debt regime at the ZLB.[14]

Unlike the debt regime, policy regime uncertainty reduces short-run spending multipliers in

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[14]In Figure 7, the debt-to-steady state output ratio falls below the debt threshold in equation (2.19) at $t = 6$, which implies that the probability of staying in the debt regime is 1. Thus, the impulse responses are the same under the uncertain and fixed debt regimes starting from $t = 6$.

the money regime at the ZLB, relative to those in the fixed money regime. The impact spending multiplier falls from 1.23 in the fixed money regime to 0.79 in the uncertain money regime at the ZLB. As in the non-ZLB state, the expectations of switching to the debt regime generates a negative wealth effect. Regime uncertainty also makes the ex-ante real interest rate decrease by less, which weakens the intertemporal substitution effect of the ZLB in increasing spending multipliers.

In summary, three messages emerge from the ZLB simulations. First, the ZLB amplifies the expansionary government spending effects in both money and debt regimes whether there exists policy regime uncertainty or not, but the ZLB is more powerful in boosting spending multipliers in the debt regime. Second, policy regime uncertainty is negligible in the debt regime (as in the non-ZLB state) but remains important in the money regime at the ZLB in decreasing spending multipliers. Third, policy regime uncertainty at the ZLB shrinks the difference between the money- and debt-financed spending multipliers, as in the non-ZLB state. The money-financed spending multipliers remains below one in the uncertain money regime in the ZLB state.

5 SENSITIVITY ANALYSIS

Our baseline model without regime switching is a standard NK model. While the calibration values are largely standard, they are not systematically estimated from data. To see if our key message—a modest degree of policy regime uncertainty substantially reduces money-financed government spending multipliers—is robust, we perform extensive sensitivity simulations on government debt maturity, an alternative regime switching function, and wide ranges of values for four parameters. As our focus is money-financed spending effects, simulations in the sensitivity analysis are only conducted for the money regime with an initial debt ratio of 100%.

The online appendix contains two more sensitivity simulations: one under the exogenous regime switching assumption, which is more widely used in the literature (e.g., Davig and Leeper, 2006b; Bianchi, 2013), and the other for a much bigger government spending shock than the one assumed in the baseline simulations.

5.1 Longer Debt Maturity

Our baseline model features one-period government bonds. Since the debt maturity structure plays an essential role in the fiscal theory of the price level (e.g., Sims, 2013; Chen et al., 2022), related to our discussion on money-financing, we simulate money-financed spending effects under a long-term debt specification.

Following Woodford (2001), we assume that agents have access to a portfolio of government bonds, B_t, which sells at a price of Q_t at t and pays $(1 - \kappa)^t$ dollars $t + 1$ periods later for each $t \geq 0$. The average bond maturity is $[1 - \beta(1 - \kappa)]^{-1}$ quarters. The setting of one-period bonds in the baseline model is nested by $\kappa = 1$. The agent's and the government's budget constraints are revised as

$$P_t c_t + Q_t \left[B_t - (1 - \kappa)B_{t-1} \right] + M_t + P_t \frac{\Xi}{2} \left(\frac{M_t}{P_t} \right)^2 = B_{t-1} + (1 - \tau_t)W_t n_t + P_t d_t + P_t z_t + P_t \xi_t \quad (5.1)$$

and

$$Q_t \left[b_t - \frac{(1 - \kappa)b_{t-1}}{\pi_t} \right] + \tau_t w_t n_t + l_t - \frac{l_{t-1}}{\pi_t} = \frac{b_{t-1}}{\pi_t} + g_t + z_t. \quad (5.2)$$

We set $\kappa = 0.05$, so the average debt maturity of 20 quarters roughly matches the average maturity of total U.S. outstanding Treasury marketable debt at the end of 2020—about 65 months (Office of Debt Management, 2021).

Figure 9 plots government spending effects under the fixed and uncertain money regimes with an initial debt ratio of 100%. When debt maturity is longer, the impact and one-year output multipliers are 1.17 and 1.03 in the fixed money regime, versus 0.74 and 0.83 in the uncertain money regime. Our main result that a small policy regime uncertainty substantially decreases spending multiplier holds for the long-term debt specification. With long-term debt, policy regime uncertainty still induces agents to expect higher future tax rates, as in the baseline model with short-term debt. The negative wealth effect remains the main cause that decreases consumption and generates a smaller output increase in the uncertain money regime with long-term debt.

Different from short-term debt, the expected future bond price matters for government spending effects in the case of long-term debt. As shown from the following optimality condition of bond

holding, the expected future bond price, $E_t Q_{t+1}$, matters for the current bond price,[15]

$$Q_t = E_t \left[\beta \frac{\lambda_{t+1}}{\lambda_t} \frac{1 + Q_{t+1}(1-\kappa)}{\pi_{t+1}} \right]. \tag{5.3}$$

In economics, the possible switch to the debt regime increases the expected nominal interest rate, which decreases the future bond price. Expecting a lower resale value of government bond reduces the current bond demand and, hence, a decline in the current bond price, as shown in Figure 9.

In general, the long-term debt specification should produce a smaller inflation increase in the money regime or regime $\mathcal{F}$ than the short-term debt specification. Our simulation, however, shows that the magnitude of the inflation increase is similar between the long-term and short-term debt specifications under policy regime uncertainty. As debt issuance is constrained by the debt rule, a lower current bond price implies larger financing needs for a given government spending increase, relative to the scenario with short-term debt. As shown in Figures 5 and 9 (the solid lines), seigniorage as a share of output and real money balances increase more with long-term debt in the uncertain money regime. More money issuance offsets the effect of a longer debt maturity in dampening inflation increase, and thus produces similar inflation responses between long-term and short-term debt scenarios.

5.2 A Smaller Degree of Policy Uncertainty

Our baseline calibration has a modest degree of regime uncertainty with an initial debt of 100%. We also simulate under an alternative parameterization—a flatter logistic function ($\iota_2^{\mathbf{M}'} = 200$)— the dashed line in Figure 2. At an annualized inflation rate of 10%, agents place a probability of 0.65 for switching to the debt regime next period under the flatter logistic function, compared to almost one against the the baseline logistic function. Figure 10 compares the impulse responses of money-financed spending with an initial debt ratio of 100% under the two parameterizations of the logistic function, equation (2.18).

When agents expect that switching to debt financing becomes less likely, it reduces the magnitude of the increase in the expected tax rate, as shown in Figure 2. This mitigates agents' saving

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[15]When $\kappa = 1$ (the short-term debt specification in the baseline), $Q_t = E_t \left(\beta \frac{\lambda_{t+1}}{\lambda_t} \frac{1}{\pi_{t+1}} \right)$ so the expected bond price does not matter for the current bond price.

motive from expecting higher future taxes, leading to a smaller consumption decline under a flatter logistic function. Row (3) of Table 4 shows that a flatter logistic function produces bigger multipliers. With an initial debt ratio of 100%, the impact multiplier increases from 0.70 under the baseline logistic function to 0.76 under the flatter function.

Between the two logistic functions, a flatter function should generate more inflationary government spending in the money regime, as agents place a smaller probability of switching to the debt regime. As explained, more inflation is associated with a bigger debt devaluation effect. Since government debt falls more with a flatter logistic function, real money balances do not increase as much. As a result, the nominal interest rate falls less, and the real interest rate decreases less, which generates a smaller intertemporal substitution effect to support consumption. This explains why the output multipliers only increase slightly when the degree of regime uncertainty is much smaller, as shown by the flatter logistic function simulated here.

5.3 DIFFERENT PARAMETER VALUES

Figures 11-14 plot the impact output multipliers in the fixed and uncertain money regime under various degrees of price rigidities, government spending persistence, Frisch labor elasticity, and the steady-state income tax rate.

5.3.1 PRICE RIGIDITY

Figure 11 plots the impact spending multiplier for $\psi = 22 - 300$, corresponding to the Calvo price updating frequency between 0.55 and 0.85. In the uncertain money regime, a higher degree of price rigidity increases the output multiplier, more so than in the fixed money regime.

As emphasized in the literature (e.g., Monacelli and Perotti, 2008; Woodford, 2011), when the price stickiness increases, the price over marginal cost falls more after a government spending shock. The fall in the markup induces an increase in labor demand that generates expansionary government spending effects. A higher degree of price rigidity, however, makes current and expected inflation increase less. In the fixed money regime, a small increase in inflation leads to a smaller decline in the real interest rate, weakening the intertemporal substitution effect channel. Overall, the output multiplier increases moderately with the degree of price stickiness in the fixed money regime. When the policy regime is uncertain, a small increase in inflation induced by high price

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stickiness mitigates the increase in the switching probability to the debt regime. Since the negative wealth effect is weaker, output multipliers increase more with a higher degree of price stickiness.

Our simulations indicate that even with a very high degree of price rigidity at $\psi = 300$ (equivalent to an average price rigidity of 1.7 years), the impact output multiplier increases to 0.88, below 1.11 in the fixed money regime.

5.3.2 PERSISTENCE OF GOVERNMENT SPENDING SHOCKS

Figure 12 plots the impact output multipliers for $\rho_g = 0.5 - 0.9$. The persistence of government spending shocks has opposite effects on the impact multipliers in the fixed and uncertain money regime.

Conditional on a given size of government spending shocks, higher persistence means that the size of the total spending increase is bigger. In a fixed money regime, the larger the overall spending package is, the higher the inflation is, because more money financing is needed. This reinforces the intertemporal substitution effect channel, producing bigger spending multipliers. When the money regime is uncertain, more persistent government spending increases expected inflation and current inflation, implying a higher probability of switching to the debt regime. The high switching probability mitigates the decrease in the real interest rate and reinforces the increase in expected tax rates, producing lower spending multipliers as government spending persistence increases.

5.3.3 FRISCH LABOR ELASTICITY

Figure 13 plots the impact output multipliers for $\varphi = 0.2 - 5$. A higher φ means a smaller Frisch labor elasticity and is associated with smaller spending multipliers in both fixed and uncertain money regime.

A government spending increase adds aggregate demand and induces firms to demand more labor, generating higher real wages. A smaller Frisch labor elasticity implies that agents are less willing increase labor supply in response to higher wages, dampening the expansionary effects of government spending. Policy regime uncertainty does not interact with the parameter value of the Frisch labor elasticity. The multipliers in fixed and uncertain money regimes both fall as φ increases, leaving the differences in multipliers stable.

5.3.4 The steady-state Tax Rate

Figure 14 plots the impact output multipliers for $\tau = 0 - 0.5$ In the fixed money regime, a higher steady-state income tax rate results in less inflation to finance government spending. This weakens the intertemporal substitution effect and lowers spending multipliers, similar to Leeper et al's (2017) conclusion that eliminating steady-state taxes increase the possibility of bigger multipliers in regime $\mathcal{F}$. On the other hand, when the money regime is uncertain, the role of the steady-state tax rate in reducing the spending multipliers is less obvious. A smaller inflation increase associated with a higher steady-state tax rate also means that agents place a smaller probability on switching to the debt regime. The opposite influences from the two channels on government spending effects largely offset each other, leaving a slight decline in the spending multipliers as the steady-state tax rate increases.

6   Conclusion

Policy regime uncertainty affects government spending effects in the context of monetary and fiscal policy interaction. The literature generally finds that money-financed government spending has much bigger spending multipliers than debt-financed spending. This conclusion is based on a fixed policy regime assumption. In reality, upon observing high inflation, agents are likely to form expectations that the monetary authority would return to its normal role in maintaining price stability. We find that with a moderate level of policy regime uncertainty, the expectations of regime switching substantially diminish money-financed spending multipliers, particularly when the government is highly indebted, as is the U.S. federal government currently. Our results are robust at the ZLB and under a slew of sensitivity simulations on long-term debt, alternative parameterization of the regime switching function, and wide ranges of key parameter values.

From a policy perspective, when policy regimes are uncertain, money-financed government spending is not much more expansionary than conventional debt-financed spending. The conclusion is particularly relevant for highly-indebted governments. Although constrained monetary policy and high debt burden make money-financed fiscal support appealing, policymakers, especially those with weak central banks, should be highly cautious in adopting such a policy to avoid the risks of

damaging central bank's credibility and runaway inflation.

Appendices

A Equilibrium System

$$\lambda_t = c_t^{-\sigma} \tag{A.1}$$

$$\chi n_t^{\varphi} = \lambda_t(1 - \tau_t)w_t \tag{A.2}$$

$$\lambda_t = \beta R_t E_t \frac{\lambda_{t+1}}{\pi_{t+1}} \tag{A.3}$$

$$\frac{\delta l_t^{-\eta}}{\lambda_t} - \Xi l_t = \frac{R_t - 1}{R_t} \tag{A.4}$$

$$(1 - \theta) + \theta mc_t - \psi\left(\frac{\pi_t}{\pi} - 1\right)\frac{\pi_t}{\pi} + \beta\psi E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\frac{y_{t+1}}{y_t}\frac{\pi_{t+1}}{\pi}\left(\frac{\pi_{t+1}}{\pi} - 1\right)\right] = 0 \tag{A.5}$$

$$mc_t = \frac{w_t}{a} \tag{A.6}$$

$$y_t = an_t \tag{A.7}$$

$$c_t + g_t = y_t \tag{A.8}$$

$$g_t + \frac{b_{t-1}}{\pi_t} + z_t = \tau_t w_t n_t + \frac{b_t}{R_t} + l_t - \frac{l_{t-1}}{\pi_t} \tag{A.9}$$

$$\ln\frac{g_t}{g} = \rho^g \ln\frac{g_{t-1}}{g} + \varepsilon_t^g \tag{A.10}$$

The debt regime:

$$\tau_t = \tau + \gamma_b(b_{t-1} - b) \tag{A.11}$$

$$R_t = R(\pi_t/\pi)^{\alpha_\pi} \tag{A.12}$$

The money regime:

$$\tau_t = \tau \tag{A.13}$$

$$b_t = \frac{b_{t-1}}{\pi_t/\pi} \tag{A.14}$$

The ZLB state (for both the money and debt regime):

$$R_t = 1 \tag{A.15}$$

Transition matrices:

$$\mathbf{P}_t^{\mathcal{P}} = \begin{bmatrix} p_{\mathbf{M},t} & 1 - p_{\mathbf{M},t} \\ 1 - p_{\mathbf{D},t} & p_{\mathbf{D},t} \end{bmatrix} ; \qquad \mathbf{P}^{\mathcal{R}} = \begin{bmatrix} p_{\mathbf{Z}} & 1 - p_{\mathbf{Z}} \\ 1 - p_{\mathbf{N}} & p_{\mathbf{N}}. \end{bmatrix} \tag{A.16}$$

B COMPUTATIONAL ALGORITHM

The model is solved with Euler equation iteration as described in Coleman (1991), which finds the fixed point of the Euler equations directly. Specifically, it makes initial guesses for future policy functions and iterates backwards to solve for the policy functions. In this paper, the method is implemented in `Fortran 90` and paralleled with `OpenMP`.

When solving the model, the minimum set of state variables is $\mathcal{S}_t = \{b_{t-1}, g_t, l_{t-1}, s_t^{\mathcal{P}}, s_t^{\mathcal{R}}\}$. Define the decision rules for labor as $n_t = f^n(\mathcal{S}_t)$, inflation as $\pi_t = f^\pi(\mathcal{S}_t)$, and real money balances as $l_t = f^l(\mathcal{S}_t)$. The decision rules are solved as follows.

1. Define the grid points by discretizing the state space. Make initial guesses for f_0^n, f_0^π, and f_0^l over the state space.

2. At each grid point, solve the nonlinear model and obtain the updated rules, f_i^n, f_i^π, and f_i^l using the given rules f_{i-1}^n, f_{i-1}^π, and f_{i-1}^l. Specifically,

    (a) Derive y_t, c_t, and λ_t in terms of f_{i-1}^n from equations (A.1), (A.7), and (A.8).

    (b) Given $s_t^{\mathcal{P}}$, derive τ_t using equations (A.11) or (A.13). Then, compute w_t and mc_t, using equations (A.2) and (A.6), respectively.

    (c) Depending on the combination of the policy regime and whether the economy is at the ZLB or not, derive the the nominal interest rate, R_t, and real government debt, b_t. The four cases are described as follows.

- $s_t^{\mathcal{R}} = \mathbf{Z}$ and $s_t^{\mathcal{P}} = \mathbf{M}$: Set R_t using equation (A.15), and b_t is given by equations (A.14).

- $s_t^{\mathcal{R}} = \mathbf{Z}$ and $s_t^{\mathcal{P}} = \mathbf{D}$: Set R_t using equation (A.15), and derive b_t from equation (A.9).

- $s_t^{\mathcal{R}} = \mathbf{N}$ and $s_t^{\mathcal{P}} = \mathbf{M}$: b_t is given by equation (A.14), and derive R_t using equation (A.9).

- $s_t^{\mathcal{R}} = \mathbf{N}$ and $s_t^{\mathcal{P}} = \mathbf{D}$: R_t is given by equation (A.12), and derive b_t from equation (A.9).

(d) Use linear interpolation to obtain $f_{i-1}^n(\mathcal{S}_{t+1})$, $f_{i-1}^\pi(\mathcal{S}_{t+1})$, and $f_{i-1}^l(\mathcal{S}_{t+1})$, where the state vector is $\mathcal{S}_{t+1} = \{b_t, g_{t+1}, l_t, s_{t+1}^{\mathcal{P}}, s_{t+1}^{\mathcal{R}}\}$. Then, follow the above steps to solve y_{t+1} and λ_{t+1}.

(e) Update the decision rules, f_i^n, f_i^π, and f_i^l, using equations (A.3), (A.4) and (A.5), where the expectations of policy regimes are evaluated given the transition probability from period t to $t+1$, $P_{t+1}^{\mathcal{P}}$ and $P^{\mathcal{R}}$ from equation (A.16).

3. Check convergence of the decision rules. If $|f_i^n - f_{i-1}^n|$, $|f_i^\pi - f_{i-1}^\pi|$ or $|f_i^l - f_{i-1}^l|$ is above the desired tolerance (set to $1e-6$), go back to step 2. Otherwise, f_i^n, f_i^π, and f_i^l are the decision rules.

C Solution Accuracy Evaluation

This section assesses solution accuracy of our nonlinear solution method. Since the main concern is the accuracy at the ZLB, we use the model described in Section 4.4, which covers the ZLB in the money and debt regime, as described in equation (4.7). We follow the methodology in Judd (1992) and Aruoba et al. (2006) for computing the Euler equation error, based on equation (A.3). We also compute the errors for the NK Phillips Curve, equation (A.5), analogously.

Specifically, we adopt the error definitions described in Appendix B.4 of Cuba-Borda (2014) and simulate the model for 100,000 periods from its stochastic steady state. The unconditional distribution is formed by counting the number of realization in evenly spaced intervals.

Figure 15 plots the error distributions for the Euler equation and the NK Phillips Curve in base

10 logarithms. Table C reports the maximum, minimum, and the mean of errors. The average approximation error is about 10^{-6} for the Euler equation and 10^{-4} for the NK Phillips Curve. The magnitudes of these errors are relatively small, compared to other NK models with the ZLB (e.g., those in Cuba-Borda, 2014; Plante et al., 2014).

parameters		values
β	discount factor	0.995
σ	inverse of intertemporal elasticity	1.38
φ	inverse of Frisch labor elasticity	1.83
η	inverse of interest semi-elasticity of money demand	$\frac{1}{7}$
θ	elasticity of substitution of intermediate goods	9
ψ	The Rotemberg quadratic cost parameter	95
a	steady-state total factor productivity	1
γ_b	tax response to debt in the debt regime	0.05
α_π	interest rate response to inflation in the debt regime	1.5
π	inflation and inflation target	1.005
τ	income tax rate	0.28
$\frac{b}{4y}$	debt to annual output ratio	0.6
$\frac{g}{y}$	government spending to GDP ratio	0.15
$\frac{l}{y}$	inverse of money velocity	$\frac{1}{3}$
ρ_g	persistence in government spending process	0.8
σ_g	standard deviation of government spending shock	0.0096
$\iota_1^{\mathbf{M}}$	switching parameter in the money regime	-3.18
$\iota_2^{\mathbf{M}}$	switching parameter in the money regime	400
$\iota_1^{\mathbf{D}}$	switching parameter in the debt regime	-4.60
$\iota_2^{\mathbf{D}}$	switching parameter in the debt regime	2.50
s^{b*}	debt threshold triggering regime switching in the debt regime	0.8

Table 1: **Baseline calibration and steady-state values**

Policy Regime	Money Regime			Debt Regime		
	impact	4Q	20Q	impact	4Q	20Q
	output multiplier: $\frac{PV(\Delta y)}{PV(\Delta g)}$					
(1) *Fixed regime*: $\frac{b_0}{4y_0} = 0.6$	1.25	1.09	0.87	0.59	0.58	0.52
(2) *Fixed regime*: $\frac{b_0}{4y_0} = 1.0$	1.13	1.00	0.80	0.59	0.58	0.51
(3) *Uncertain regime*: $\frac{b_0}{4y_0} = 1.0$	0.70	0.73	0.77	0.56	0.53	0.26
	consumption multiplier: $\frac{PV(\Delta c)}{PV(\Delta g)}$					
(1) *Fixed regime*: $\frac{b_0}{4y_0} = 0.6$	0.25	0.09	-0.13	-0.41	-0.42	-0.48
(2) *Fixed regime*: $\frac{b_0}{4y_0} = 1.0$	0.13	0.00	-0.20	-0.41	-0.42	-0.49
(3) *Uncertain regime*: $\frac{b_0}{4y_0} = 1.0$	-0.30	-0.27	-0.23	-0.44	-0.47	-0.74

Table 2: **Cumulative spending multipliers: fixed versus uncertain policy regimes.** Multipliers are calculated based on equation (4.1).

Policy Regime	Money Regime			Debt Regime		
	impact	4Q	20Q	impact	4Q	20Q
	fixed policy regime					
(1) *Non-ZLB*	1.13	1.00	0.80	0.59	0.58	0.51
(2) *ZLB*	1.23	1.01	0.66	0.94	0.95	1.01
	uncertain policy regime					
(3) *Non-ZLB*	0.70	0.73	0.77	0.56	0.53	0.26
(4) *ZLB*	0.79	0.79	0.84	0.91	0.90	0.94

Table 3: **Cumulative spending multipliers: the role of the ZLB.** At the ZLB, $p_{\mathbf{Z}} = 0.5$ and $p_{\mathbf{N}} = 0.9975$ in equation (4.6). The initial debt ratio is 100% . Multipliers are calculated based on equation (4.1).

	impact	4Q	20Q
	output multiplier		
(1) *Baseline regime switching function*	0.70	0.73	0.77
(2) *Flatter regime switching function*	0.76	0.79	0.82

Table 4: **Sensitivity analysis: regime switching probability.** The baseline and steeper regime switching functions are the solid and dashed lines in Figure 2, respectively. The initial debt ratio is 100%. Multipliers are calculated based on equation (4.1).

	Euler equation	NK Phillips Curve
Mean error	-6.47	-4.15
Minimum error	-7.42	-6.38
Maximum error	-6.00	-2.31

Table 5: **Summary of errors**.
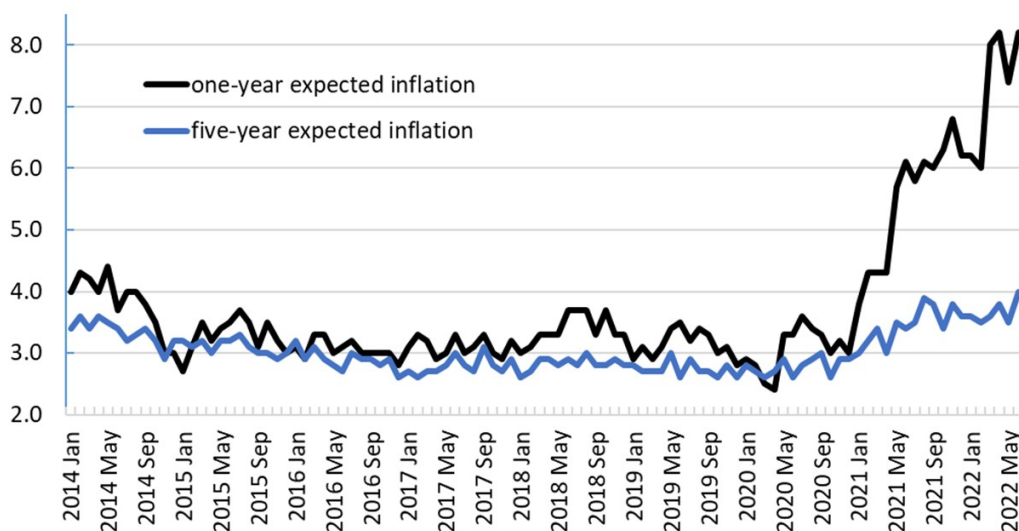
Figure 1: **Expected inflation.** The means of expected changes in prices during the next year and next five years from January 2014 to June 2022: Tables 32 and 33 of the Survey of Consumers, University of Michigan (2022).
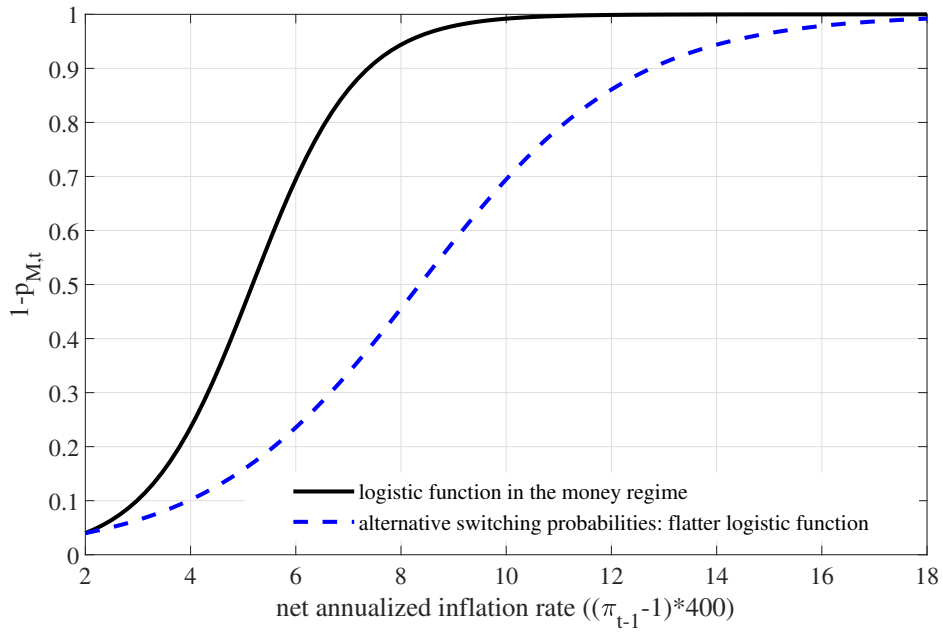
Figure 2: **Endogenous regime switching probabilities in the money regime.** See equation (2.18).
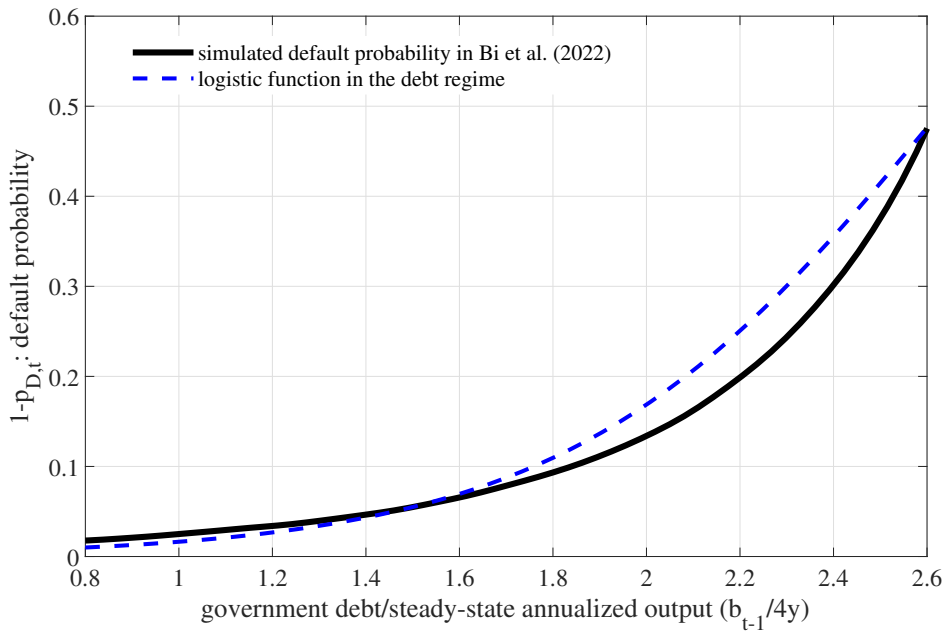
Figure 3: **Endogenous regime switching probabilities in the debt regime.** See equation (2.19). The dashed line is the default probability implied by the fiscal limit distribution for a given debt ratio, simulated in Bi et al. (2022).
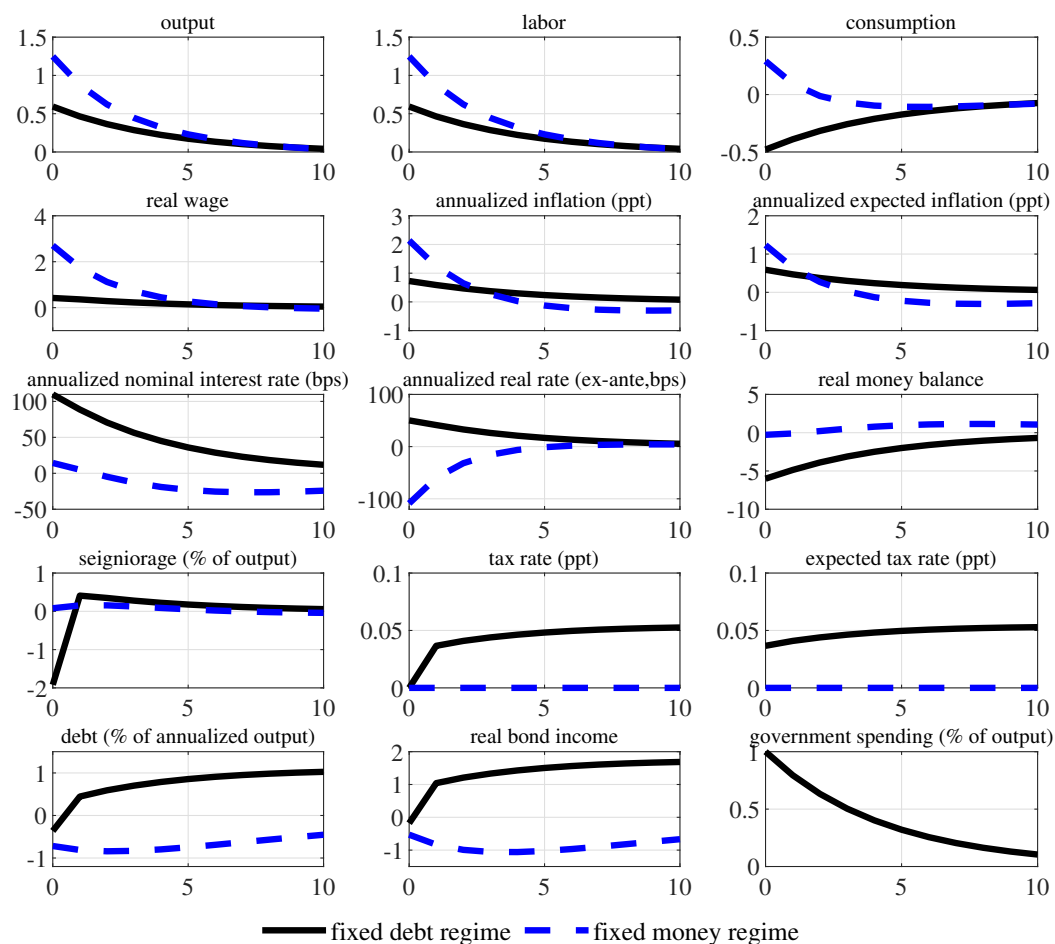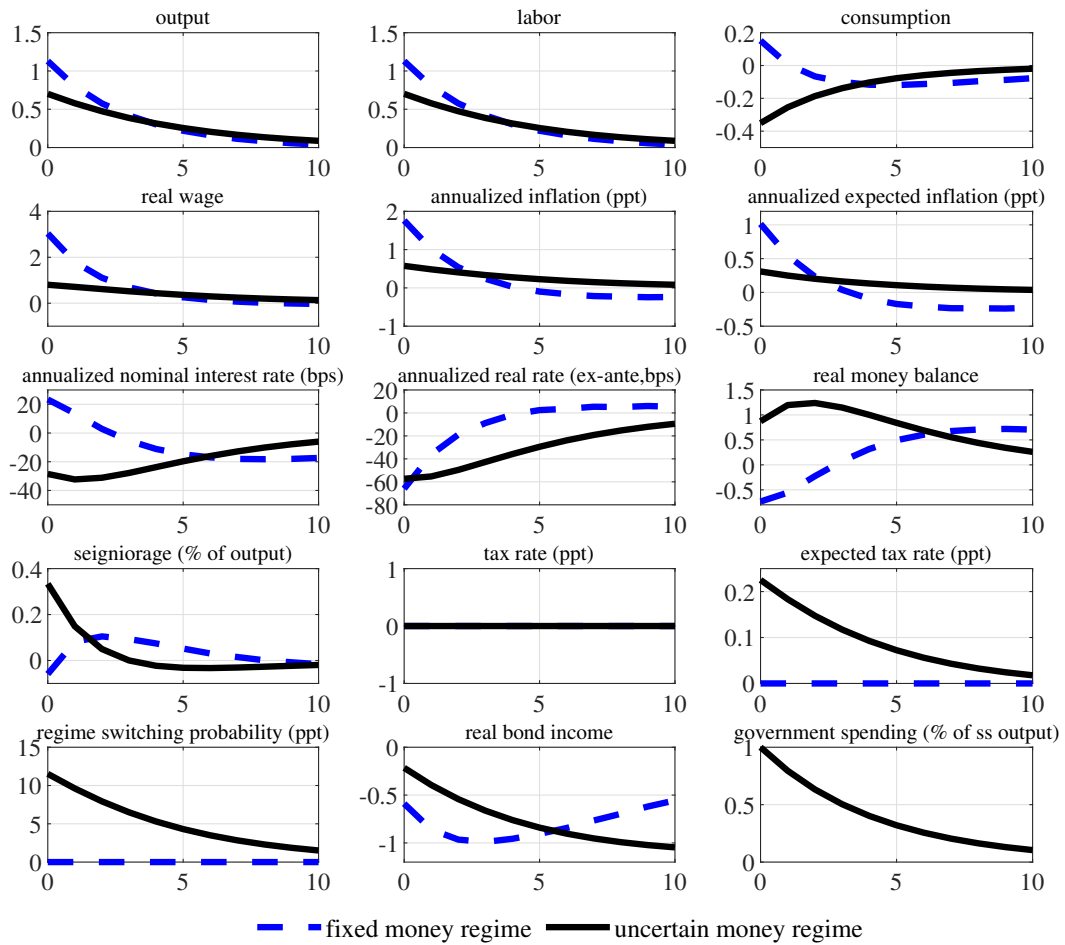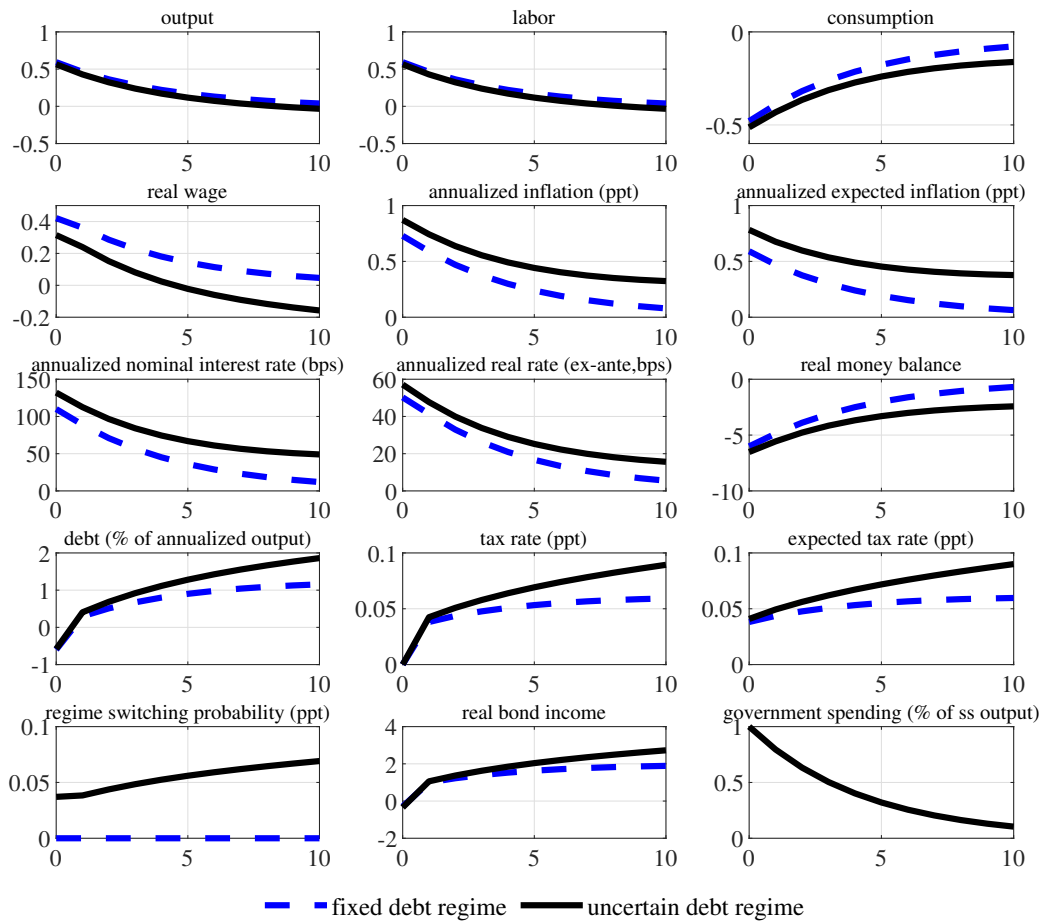
Figure 4: **Impulse responses of a government spending increase: fixed policy regimes.** The initial debt ratio is 60% of annual output. The impulse responses are the differences between the paths with and without a government spending shock. For variables without parentheses, the differences are presented as percentage deviation from their steady-state values. Those with parentheses are plotted as level differences; "bps" is basis points, "ppt" is percentage points, and "ss" is steady-state.

Figure 5: **Impulse responses of a government spending increase in the money regime: fixed versus uncertain policy regimes.** The initial debt ratio is 100% of annual output. See Figure 4 for axis units.
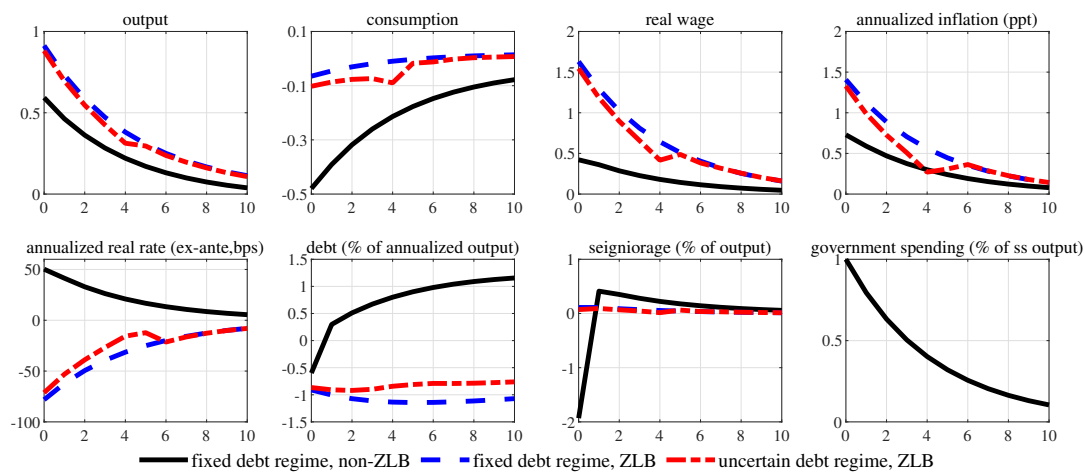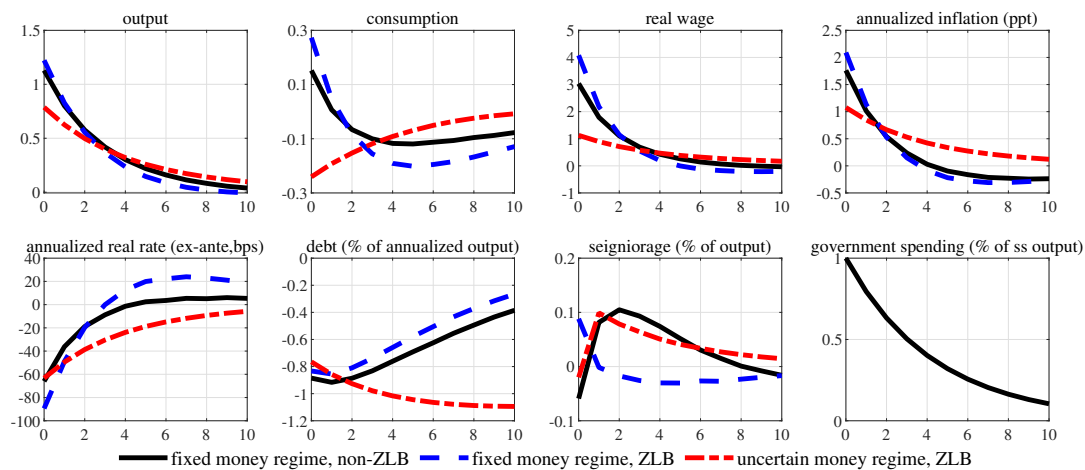
Figure 6: **Impulse responses of a government spending increase in the money regime: fixed versus uncertain policy regimes.** The initial debt ratio is 100% of annual output. See Figure 4 for axis units.

Figure 7: **The role of the ZLB: fixed vs. uncertain debt regimes.** The initial debt ratio is 100% of annual output. See Figure 4 for axis units.

Figure 8: **The role of the ZLB: fixed vs. uncertain money regimes.** The initial debt ratio is 100% of annual output. See Figure 4 for axis units.
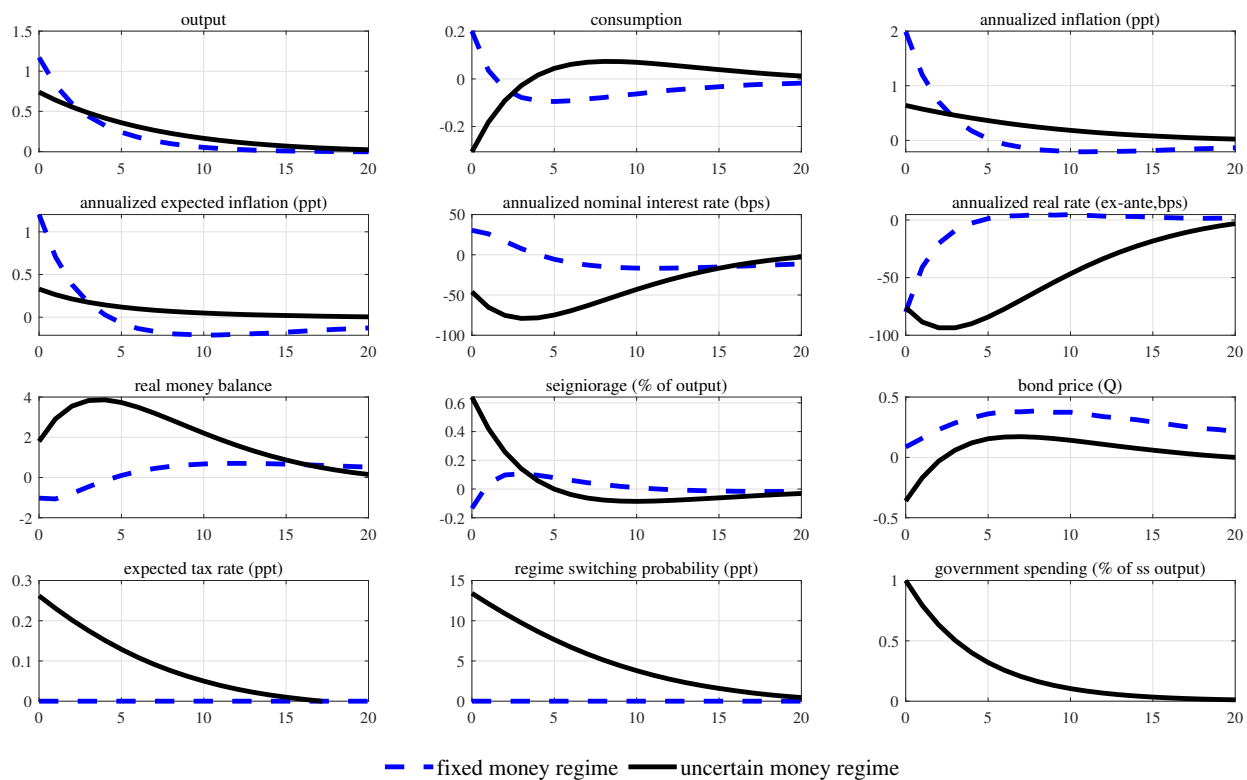
Figure 9: **Sensitivity analysis: long-term debt.** The initial debt ratio is 100% of annual output. See Figure 4 for axis units.
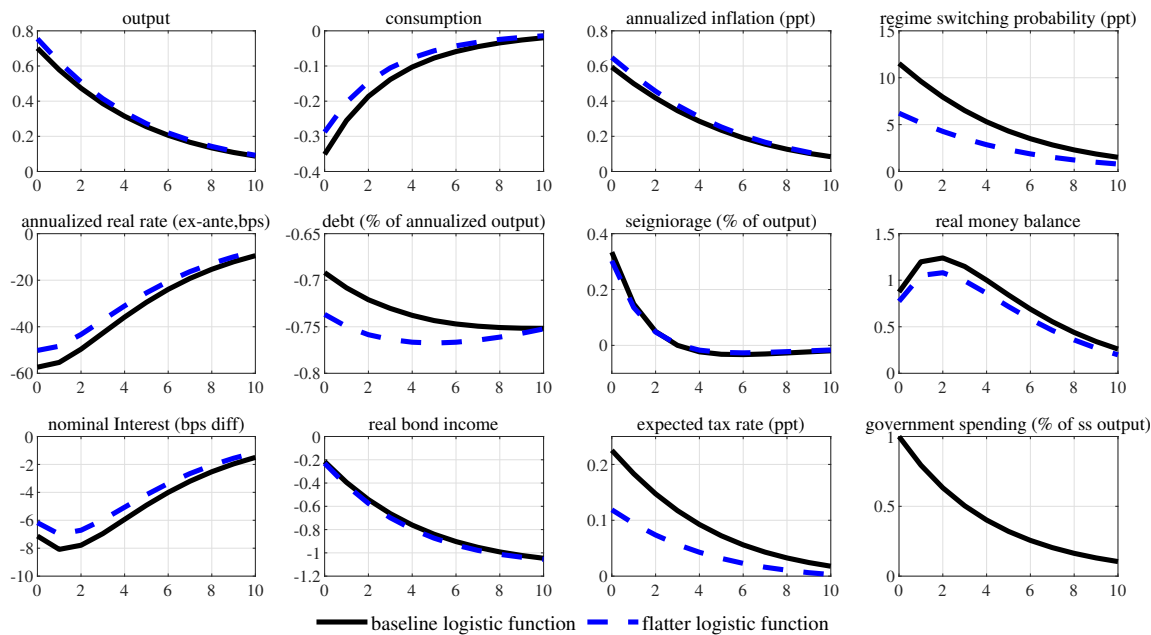
Figure 10: **Sensitivity analysis: regime switching probability.** The two impulse responses of money-financed government spending under two parameterization of the logistic function, equation (2.18). The initial debt ratio is 100% of annual output. See Figure 4 for axis units.
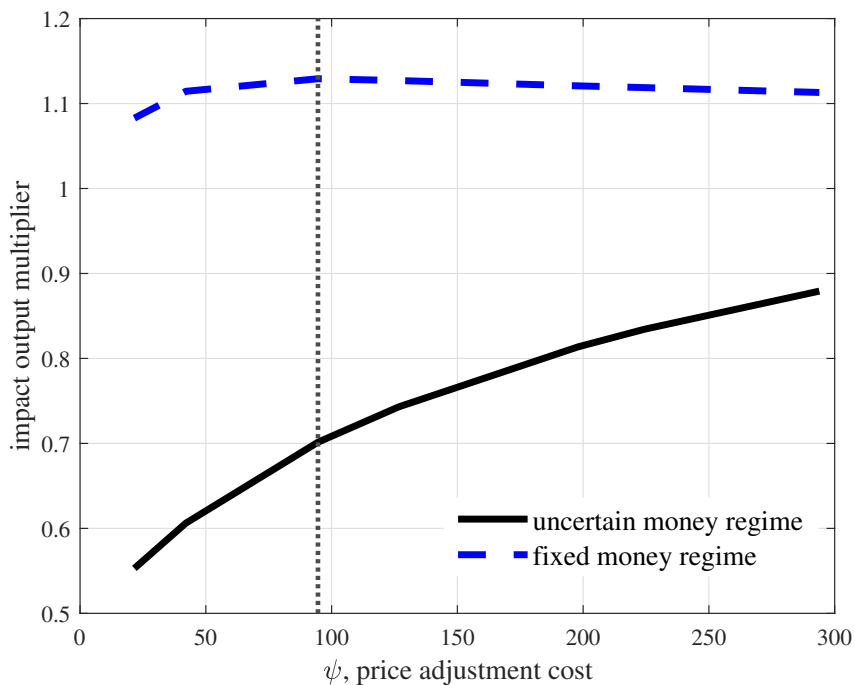

Figure 11: **Sensitivity analysis: price rigidity.** The initial debt ratio is 100% of annual output. The vertical dotted line indicates the baseline value of ψ.
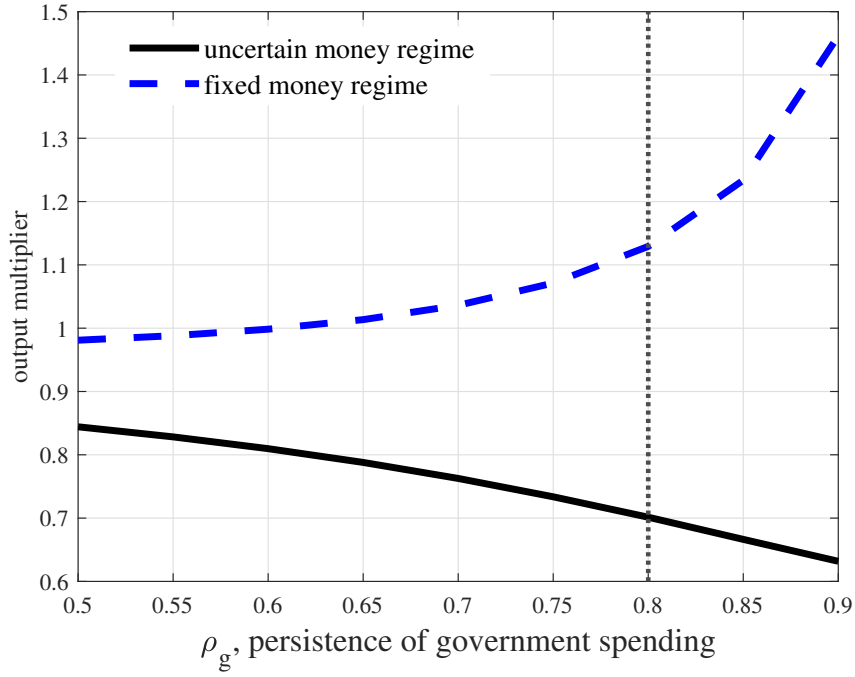
Figure 12: **Sensitivity analysis: persistence of government spending shocks.** The initial debt ratio is 100% of annual output. The vertical dotted line indicates the baseline value of ρ_g.
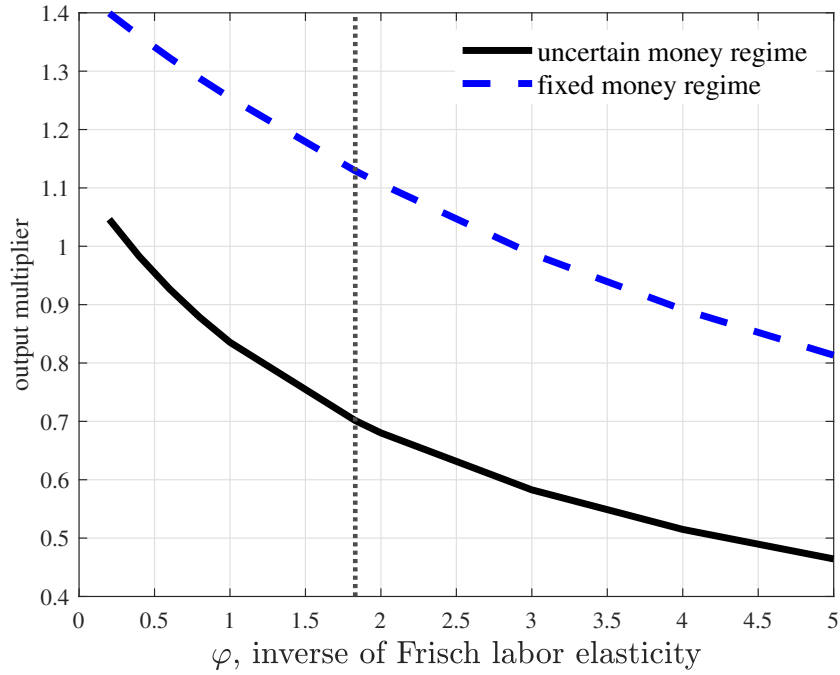

Figure 13: **Sensitivity analysis: the inverse of Frisch labor elasticity.** The initial debt ratio is 100% of annual output. The vertical dotted line indicates the baseline value of φ.
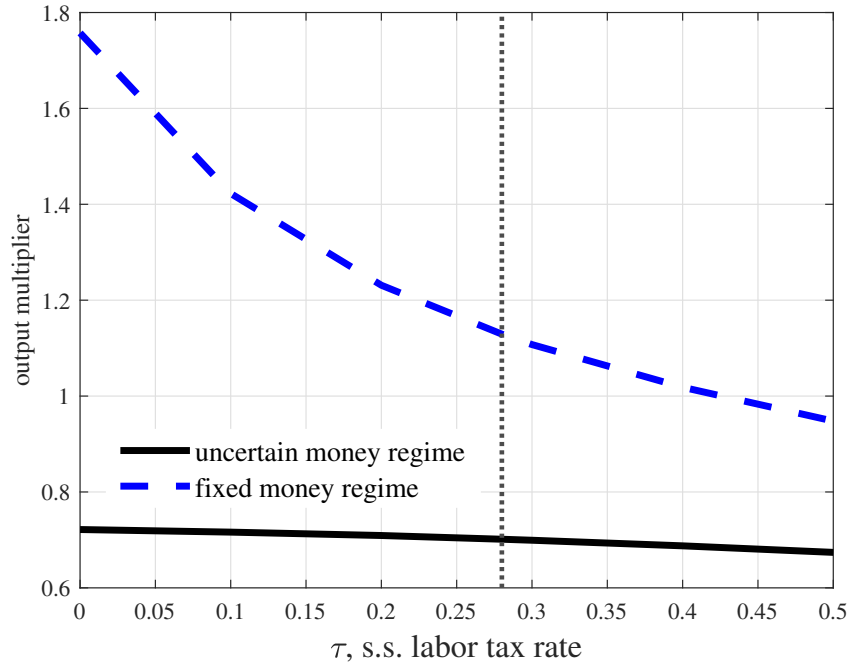
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Figure 14: **Sensitivity analysis: the steady-state tax rate.** The initial debt ratio is 100% of annual output. The vertical dotted line indicates the baseline value of τ.
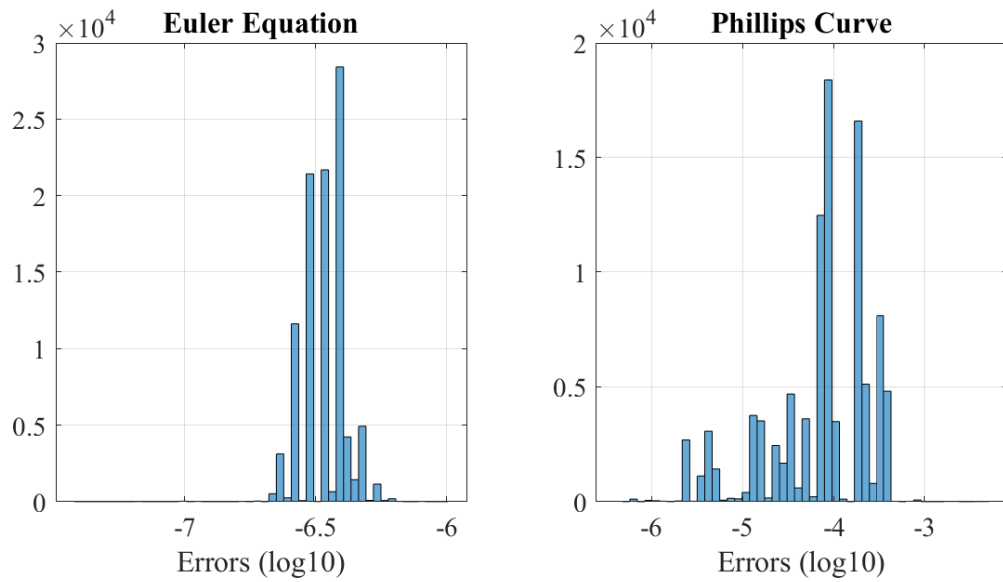

Figure 15: **Distributions of the errors in absolute values in base 10 logarithms.**

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