



# **Government expenditure shocks and inflation: A new fiscal policy rule with monetary and fiscal interactions**

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# Government expenditure shocks and inflation: A new fiscal policy rule with monetary and fiscal interactions

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## Abstract

This paper introduces a new fiscal policy rule and examines how government expenditure shocks affect price stability with monetary and fiscal interactions. It finds that recent global inflation trends align with the principles of the fiscal theory of price level. Comparing this proposed rule to the LL rule from [Leeper and Leith \(2016\)](#), the new rule is more effective in reducing the impact of government shocks on inflation and the real economy. It also enhances debt stabilization without sacrificing price stability. Under active fiscal policy, the new rule outperforms the LL rule in both price stability and debt stabilization. Both rules significantly reduce volatility in these areas under active monetary policy. The proposed rule also enhances social welfare, especially under active fiscal policy. When bonds are long term, the proposed rule outperforms the baseline model with one-period bonds in attenuating the effects of government expenditure shocks on business cycle fluctuations.

*JEL Classification:* E3, E4, E5, E6, H6

*Keywords:* Monetary and fiscal interactions, the fiscal theory of the price level, government expenditure, inflation, welfare

## 1 Introduction

Inflation has risen worldwide, whereas U.S. inflation hit 40-year high of 8.5% (annualized) in March 2022. U.S. inflation, however, had been below 2% for most of the time since 2009. It was only from the second quarter of 2021, U.S. inflation started rising remarkably. Over the last two decades, the global economy has experienced a number of challenges, for instance, the 2007-08 financial crisis, the Great Recession, the European sovereign debt crisis, and the Covid-19 pandemic. To address these challenges, monetary authorities implemented unconventional policies, including quantitative easing, credit easing, and government debt management, to achieve their inflation targets and other macroeconomic goals. On the fiscal side, to aid economic recovery, fiscal authorities implemented fiscal stimulus packages through transfers and spending ([Leeper and Leith,](#)

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2016). Unconventional monetary policy and large fiscal stimulus packages can significantly impact inflation, as can the interaction between monetary and fiscal policy.

This paper proposes a new fiscal policy rule and exams its effectiveness in attenuating the effects of rising government expenditure on price stability through the interaction between monetary and fiscal policy. The proposed fiscal policy rule states that, in addition to government debt as discussed in [Leeper and Leith \(2016\)](#), the fiscal authority also adjusts the primary surplus in response to changes in government expenditure. The recent trends in the data suggest that inflation tends to move closely in line with government expenditure. As shown in [Figure 1](#), the government expenditure-to-output ratio has been stable over the period of interest, except for the spikes observed during the global financial crisis and the Covid-19 pandemic, with inflation following the same pattern and starting to increase after the sudden increases in government expenditure. In addition, [Figure 2](#) shows that inflation has been relatively stable except when government debt increased dramatically during the global financial crisis and the Covid-19 pandemic.

The standard fiscal rule in the literature, such as the one described in [Leeper and Leith \(2016\)](#) aligns with the fiscal theory of price level (FTPL), which argues that when there is a change in government debt issuance, the price level must be adjusted accordingly, so that the real value of nominal debt is equal to the present value of real primary surplus. If the government does not soak up the additional debt through taxes, namely not running a surplus in the future, the price of debt will decrease and the expected price level will increase (Cochrane, 2022). This seems to have been the case during the Covid-19 pandemic, when both short-term and long-term debt increased markedly and the primary surplus did not increase and, in fact, fell sharply,<sup>1</sup> while inflation increased significantly (see [Figure 1](#) and [Figure 2](#)).

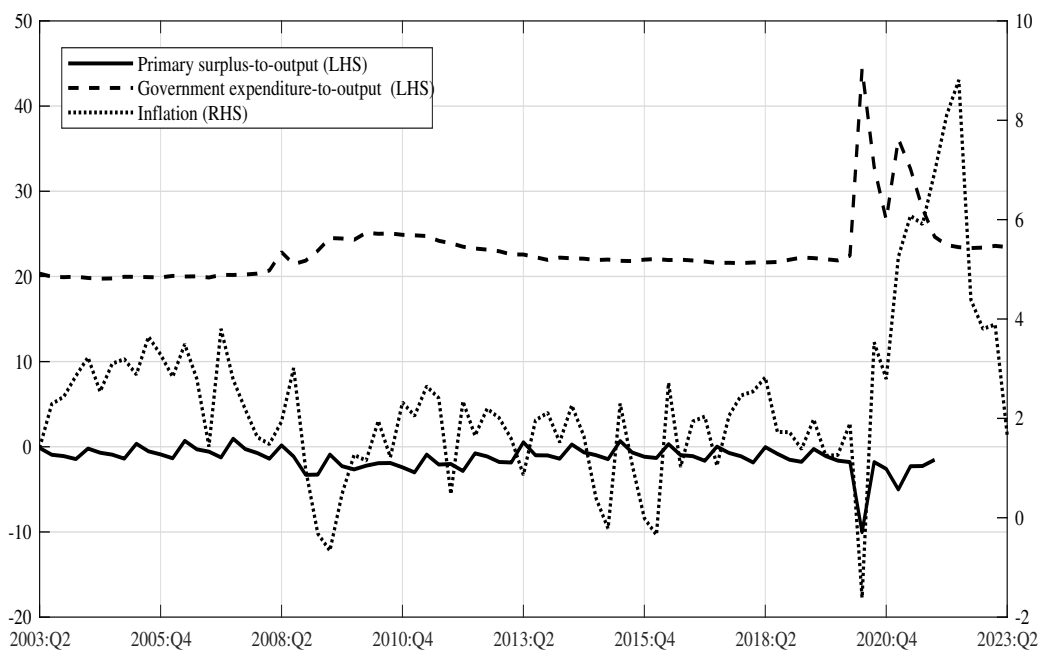


Figure 1: Inflation, primary surplus, and government expenditure.

<sup>1</sup>Indeed, the U.S. had been running deficits over the period.

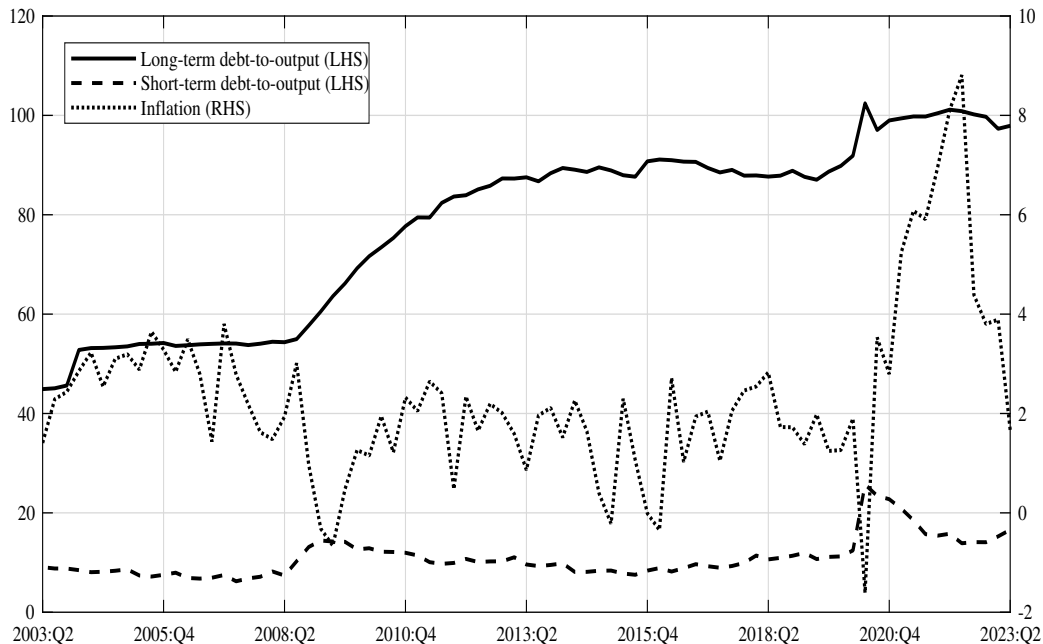


Figure 2: Inflation and growth rates of short-term debt and long-term debt.

This paper is related to two main streams of the literature. The first one is related to the interaction between monetary and fiscal policy. Under Regime M, monetary policy is responsible for price stability, while fiscal policy is responsible for debt stabilization. In the literature, this is also referred to as active monetary policy and passive fiscal policy. Under Regime F, monetary policy maintains the value of real debt, while fiscal policy controls inflation.<sup>2</sup> The latter is also referred to as the FTPL in the literature (see, e.g., [Cochrane, 2011, 2014](#); [Sims, 2013](#)). Recently, while the concept of optimal fiscal policy has drawn increasing attention in the literature, a general consensus on it is yet to emerge (see, e.g., [Adam, 2011](#); [Leeper et al., 2021](#)). This paper contributes to the literature on the interplay between monetary and fiscal policy by specifically examining the impact of expansionary fiscal policy on inflation via its interaction with monetary policy. Simultaneously, the paper aims to enhance the understanding of the optimal fiscal policy, by conducting an analysis within the framework of a Canonical New Keynesian model.

The second stream of the related literature is the theoretical literature on fiscal policy rules, with a specific focusing on welfare, debt stabilization, and macroeconomic stability. As pointed out by [IMF \(2018\)](#), there are few studies in the theoretical literature that address both debt stabilization and macroeconomic stability simultaneously.<sup>3</sup> This paper evaluates the ability of the proposed fiscal policy rule to ensure both debt stabilization and macroeconomic stability simultaneously. Fiscal policy rules in the spirit of FTPL can potentially avoid high levels of debt and consequent self-fulfilling debt crises. For instance, [Leeper \(1991\)](#) proposes that the fiscal authority adjusts lump-sum taxes in response to real government debt from the previous period. Other authors suggest that the fiscal authority adjusts the primary surplus in response to

<sup>2</sup>Studies include, but are not limited to, [Sargent and Wallace \(1981\)](#); [Leeper \(1991\)](#); [Sims \(1994\)](#); [Cochrane \(2001\)](#); [Leeper and Walker \(2012\)](#); [Leeper and Leith \(2016\)](#).

<sup>3</sup>One exception is [Cuadra et al. \(2013\)](#).

the real government debt for current period (see, e.g., [Lorenzoni, Guido and Werning, Iván , 2019](#); [Leeper and Leith, 2016](#)). The present study assumes that, in addition to government debt, the fiscal authority also adjusts the primary surplus in response to changes in government expenditure.

Prior to the comparative analysis between the proposed rule and the LL rule, the present study conducts a preliminary examination to ascertain whether the interactions between monetary and fiscal policy exert any influence on business cycle fluctuations subsequent to an expansionary fiscal policy shock. We find that the dynamics of the model with the proposed fiscal rule following an expansionary fiscal policy successfully mimic that observed in the data, while the model with Regime F provides a more coherent explanation for that observed in the data. These findings strongly indicate that the recent upward trend in global inflation aligns with the principles of the FTPL.

This paper also examines a more general portfolio of government bonds. The intuition of including a more general portfolio of government bonds is that the majority of the U.S. government debt is long-term in nature. [Figure 2](#) shows that long-term debt grew rapidly from 2008 to 2010 and again in 2020, with the same occurring with short-term debt. The long-term debt-to-output ratio reached 100% in 2020, whereas the short-term debt-to-output ratio only reached 20% that year. When fiscal policy is active (Regime F), long-term bonds provide a new channel for the interaction between monetary and fiscal policy, wherein increases in government expenditure reduce the value of government debt due to rising inflation and decreasing long-term bond prices ([Leeper and Leith, 2016](#)). Long-term bonds not only contribute to the stabilization of government debt but also attenuate the direct impact of government expenditure shocks on taxes and the primary surplus, thereby partially offsetting the increases in surplus. Moreover, it is worth noting that government debt stabilization is achieved without compromising price stability.

This paper assesses the proposed fiscal policy rule by comparing it with the LL rule. Firstly, we compare the effects of the two fiscal policy rules on business cycle fluctuations following an expansionary fiscal policy shock. This comparative analysis is used to evaluate the efficacy of the proposed fiscal policy rule for debt stabilization and macroeconomic stability. In addition to these two key criteria for the adoption of a fiscal policy rule ([IMF, 2018](#)), the study also focuses on price stability, subsequently analyzing the balance between maintaining price stability and achieving debt stabilization via an efficient policy frontier (EPF) analysis. Lastly, it explores the welfare implications of the proposed fiscal policy rule, aligning with the theoretical literature on fiscal policy rules, where welfare is a key objective for adopting such rules (see, e.g., [Aguar and Amador, 2014](#)).

The comparative analysis conducted between the proposed rule and the LL rule offers insights into the value of augmenting government expenditure in the proposed rule. Under Regime M, both fiscal rules are effective in reducing the inflation caused by fiscal expansion, while the proposed rule is more effective than the LL rule in attenuating the effects of the shock on macroeconomic stability. Another benefit of augmenting government expenditure in the proposed rule is the enhancement of debt stabilization, which, in turn, helps the monetary authority achieve price stability at a faster pace. Under Regime F, the benefits of augmenting government expenditure in the proposed fiscal rule become more significant, with a notable smaller increase in inflation and a quicker turn to the steady state following fiscal expansion. Moreover, the efficacy of the

proposed fiscal rule in achieving debt stabilization is significantly improved. However, this enhancement requires the fiscal authority to increase taxes to fund higher government expenditure, leading to a higher anticipated future primary surplus.

The EPF analysis results suggest that, under Regime M, both the proposed rule and the LL rule demonstrate a clear tradeoff between price stability and debt stabilization as the authority adjusts the relative weights on inflation and the surplus-debt gap. In contrast to the LL rule, under the proposed rule, the authority encounters a relatively balanced tradeoff between achieving both price stability and debt stabilization when adjusting its preference between these two policy objectives. The EPFs for Regime F differ significantly from those for Regime M. The condition that confines the LL rule to Regime F results in an EPF that does not allow for tradeoffs between price stability and debt stabilization. However, with the proposed rule, there is a significant tradeoff between price stability and debt stabilization. In addition, with the LL rule, the authority faces a much high volatility for both inflation and the surplus-debt gap. Lastly, in terms of achieving price stability and debt stabilization, Regime M outperforms Regime F for both the proposed rule and the LL rule, wherein the magnitudes of volatility are significantly smaller under Regime M, thus indicating greater efficiency in managing both policy objectives.

The welfare implications of a government expenditure shock are influenced by monetary and fiscal interaction and the maturity structure of the government debt. The present study finds that, in general, compared to the LL rule, the proposed fiscal rule improves social welfare, an improvement that becomes more significant under Regime F. The results show that the welfare implications under Regime M remain largely unaffected by the maturity structure of government debt, indicating its minimal impact on overall welfare outcomes. Under Regime F, however, long-term bonds significantly attenuate the expansionary effect of a government spending shock, resulting a significant decline in welfare.

The rest of the paper is organised as follows. Section 2 outlines the model; Section 3 presents the calibration of the model; Section 4 presents the main results of the study; Section 5 provides a complementary comparative analysis between the proposed fiscal rule and the LL rule; Section 6 concludes.

## 2 The model

We augment the Canonical dynamic stochastic general equilibrium (DSGE) New Keynesian model with a more general portfolio of government bonds, as in [Woodford \(2001\)](#). This portfolio structure includes the one-period bond case, which serves as the baseline model of this study. Consumption consists of both private and government consumption. We assume that the monetary authority follows a strict inflation-targeting rule such that the monetary authority is solely responsible for price stability. In this way, we assign the responsibility for managing debt and macroeconomic stability exclusively to the fiscal authority. We design the fiscal policy rule so that, in addition to government bonds as outlined in [Leeper and Leith \(2016\)](#), the primary surplus also responds to deviations in government expenditure from its steady state. The remaining components of the model are the same as in the Canonical New Keynesian model with Calvo-type sticky

prices.<sup>4</sup>

## 2.1 Households

There is a continuum of households in the model economy. The representative household chooses real consumption ( $c_t$ ), real money balances ( $M_t/P_t$ ), and labor supply ( $N_t$ ) to maximize the discounted expected utility:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{\eta}{\eta-1} \log \left( (\gamma_c) (c_t - j c_{t-1})^{\frac{\eta-1}{\eta}} + (1-\gamma_c) (g_t^c)^{\frac{\eta-1}{\eta}} \right) + \frac{1}{1-\chi} \left( \frac{M_t}{P_t} \right)^{1-\chi} - \frac{\varsigma}{1+\frac{1}{\varsigma}} (N_t)^{1+\frac{1}{\varsigma}} \right], \quad (1)$$

subject to the following budget constraint:

$$(1 + \tau_t) c_t + \frac{Q_t B_t}{P_t} + \frac{M_t - M_{t-1}}{P_t} = \frac{W_t N_t}{P_t} + \frac{(1 + \theta Q_t) B_{t-1}}{P_t} + \frac{Z_t}{P_t} + \frac{\Psi_t}{P_t}, \quad (2)$$

where  $\beta \in (0, 1)$  is the discount factor,  $\chi > 0$  is the inverse of elasticity of real money demand, and  $\varsigma > 0$  is the inverse of the Frisch elasticity of labor.  $j$  is the external habit formation in consumption;  $P_t$  is the price level;  $W_t$  is the nominal wage rate; and  $\Psi_t$  represents the nominal profits or dividends received from the intermediate-good firms.

Following [Sims and Wolff \(2018\)](#), we assume that consumption is a composite of private and government consumption ( $g_t^c$ ), where  $\gamma_c \in [0, 1]$  is the share of private consumption.  $\eta > 0$  is the elasticity of substitution between private and government consumption. Private and government consumption are substitutes when  $\eta > 1$  and complements when  $\eta < 1$ . [Sims and Wolff \(2018\)](#) report that the estimated  $\eta$  is less than 1, implying that private and government consumption are complements. [Woodford \(2001\)](#) also includes government consumption in the utility function, but in a more simplified way, assuming that private and government consumption are perfect substitutes (i.e.,  $\eta = \infty$ ). We opt the approach from [Sims and Wolff \(2018\)](#), as their medium-scale New Keynesian DSGE model estimated with U.S. data nests the baseline model in this study.

One important feature of our model is that, following [Woodford \(2001\)](#), we augment the Canonical New Keynesian model with a more general portfolio of government bonds. That is, bonds issued in period  $t$ ,  $B_t$ , pays  $\theta^\kappa$  dollars  $\kappa + 1$  periods later, with a decay factor of  $0 \leq \theta \leq \beta^{-1}$  controlling the duration of such a bond, which is  $(1 - \beta\theta)^{-1}$ . When  $\theta = 0$ , the model has a one-period bond in the model, which serves as our baseline case. When  $\theta = 0.985$ , the model has a 10-year bond, assuming  $\beta = 0.99$ . This feature enables the examination of the influence of debt maturity on the effects of our proposed fiscal policy rule.  $Q_t$  is the price of the bond issued in period  $t$ . The arbitrage condition is such that the following holds:

$$i_t = \mathbb{E}_t \left( \frac{1 + \theta Q_{t+1}}{Q_t} \right) - 1, \quad (3)$$

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<sup>4</sup>This section discusses the household sector and the government sector in detail. As the remaining components of the model are the same as those in the Canonical New Keynesian model, we exclude those details from the paper. However, we provide the system of model equations in [Appendix A](#).

where  $i_t$  is the nominal interest rate. With a one-period bond,  $i_t$  effectively becomes the treasury-bill rate and the price of such a bond then equals the inverse of the gross nominal interest rate.

The representative household receives nominal transfers ( $Z_t$ ) from the government, which captures significant increases in such government transfers during the financial crisis and the Covid-19 pandemic. Increases in government transfers provide household additional income, whereas increases in government consumption provide households with direct utility. The government imposes taxes on consumption, where  $\tau_t$  is the tax rate.

Denoting  $\lambda_t$  as the Lagrange multiplier for the representative household's budget constraint (2) obtains the following optimization conditions for households:

$$c_t : (1 + \tau_t) \lambda_t = \frac{(\gamma_c) (c_t - jc_{t-1})^{-1/\eta}}{(\gamma_c) (c_t - jc_{t-1})^{\frac{\eta-1}{\eta}} + (1 - \gamma_c) (g_t^c)^{\frac{\eta-1}{\eta}}}, \quad (4)$$

$$B_t : \frac{\lambda_t Q_t}{P_t} = \beta \mathbb{E}_t \frac{\lambda_{t+1} (1 + \theta Q_{t+1})}{P_{t+1}}, \quad (5)$$

$$\frac{M_t}{P_t} : \left( \frac{M_t}{P_t} \right)^{-\chi} = \lambda_t - \beta \mathbb{E}_t \frac{\lambda_{t+1} P_t}{P_{t+1}}, \quad (6)$$

$$N_t : \varsigma (N_t)^{\frac{1}{\varsigma}} = \frac{\lambda_t W_t}{P_t}. \quad (7)$$

Equation 4 describes the household's optimal decision on consumption, while Equation 5 is the household's optimal demand for government bonds. In the baseline model with one-period bond ( $\theta = 0$ ), Equation 5 boils down to a standard asset pricing equation for government bonds, which implies that  $1/(1 + i_t) = E_t Q_{t+1}$ . Equation 6 is the standard money demand equation, whereas Equation 7 is the household's optimal labour supply condition.

## 2.2 Government

The government sector comprises a monetary authority conducting the monetary policy and a fiscal authority conducting the fiscal policy. We assume that the monetary authority follows a Taylor-type interest rate rule:

$$1 + i_t = \alpha_i (1 + i_{t-1}) + (1 - \alpha_i) [(1 + i) + \alpha_\pi (\pi_t - \pi)], \quad (8)$$

where  $\alpha_\pi \geq 0$  captures the extent to which the monetary authority adjusts the interest rate in response to deviations in inflation from its steady state,<sup>5</sup> and  $\alpha_i \in (0, 1)$  is the smoothness of the interest rate.

We propose the following fiscal policy rule:

$$s_t = s + \gamma_{b,p} (b_{t-1} - b) + \gamma_g (g_{t-1} - g). \quad (9)$$

That is, the fiscal authority adjusts the primary surplus in response to changes in real government debt ( $b_t$ ) and expenditure ( $g_t$ ), with the real primary surplus is defined as:  $s_t = \tau_t c_t - g_t$ .  $\gamma_{b,p}, \gamma_g \in [0, 1]$  measure

<sup>5</sup>A variable without the time subscript  $t$  stands for its steady state.  $1 + \pi_t = P_t/P_{t-1}$ .

the extent to which the primary surplus reacts to changes in government debt and expenditure<sup>6</sup> from their steady states, respectively.

Following the same notion of [Leeper and Leith \(2016\)](#), the bounded solution implies that both inflation and government debt following an autoregressive process:

$$\mathbb{E}_t(\pi_{t+1} - \pi) = [\alpha_i + \beta\alpha_\pi(1 - \alpha_i)](\pi_t - \pi), \quad (10)$$

$$\mathbb{E}_t(b_{t+1} - b) = \left(\frac{1}{\beta} - \gamma_{b,p}\right)(b_t - b) - \gamma_g(g_t - g) - \mathbb{E}_t\left(m_{t+1} - \frac{m_t}{1 + \pi_{t+1}}\right). \quad (11)$$

The dynamics of inflation are driven by parameters in the monetary policy rule,  $\alpha_\pi$  and  $\alpha_i$ , and the discount factor  $\beta$ , whereas the dynamics of government debt are driven by parameters in the fiscal policy rule,  $\gamma_{b,p}$ ,  $\gamma_g$ , and the discount factor  $\beta$ .<sup>7</sup> Here, it is important to point out that there is a negative relationship between the dynamics of government debt and government expenditure. This implies that if government expenditure increases, government debt will decline under the proposed fiscal rule. Consequently, the government will need to raise future taxes to finance the increased government expenditure, assuming all other factors remain constant.

The proposed fiscal policy rule is based on the fiscal rule from [Leeper and Leith \(2016\)](#),<sup>8</sup>

$$s_t = s + \gamma_{b,b}(b_{t-1} - b). \quad (12)$$

Both the proposed fiscal rule (9) and the fiscal rule (12) from [Leeper and Leith \(2016\)](#) have the notion of what [Cochrane \(2001\)](#) refers to as the “equilibrium valuation equation”:

$$b_{t-1} = E_t \sum_{j=0}^{\infty} \beta^j s_{t+j}. \quad (13)$$

That is, the market value of the outstanding government debt is equal to the expected present value of future primary surplus. As noted by [Leeper and Leith \(2016\)](#), the valuation equation, derived by combining private agents’ optimal conditions with market clearing conditions, does not impose any restrictions on the two policy instruments in the model: the primary surplus and the interest rate.

We augment the LL rule with government expenditure because increases in government expenditure will ultimately be financed by primary surplus. In addition, as discussed in the introduction of this paper, the aftermath of the global financial crisis and the Covid-19 pandemic saw inflation starting to climb up following increases in both government expenditure and government debt. This suggests that, in addition to government debt, the fiscal authority should also adjust the primary surplus in response to changes in government expenditure.

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<sup>6</sup>Real government expenditure is the sum of transfers and government consumption,  $g_t = g_t^c + z_t$ . We assume that transfers are a fraction of government expenditure,  $z_t = \nu g_t$ , with the balance corresponding to government consumption  $g_t^c = (1 - \nu) g_t$ , where  $\nu \in [0, 1]$ .

<sup>7</sup>Conditions for Regime M and Regime F are discussed in [subsection 4.1](#).

<sup>8</sup>In [Leeper and Leith \(2016\)](#), the real primary surplus is defined as the differences between tax revenue and government transfers, whereas government expenditure is assumed to be zero.

The government's flow budget identity is as the following:

$$\frac{Q_t B_t}{P_t} = \frac{(1 + \theta Q_t) B_{t-1}}{P_t} - \left( \frac{M_t - M_{t-1}}{P_t} \right) - s_t, \quad (14)$$

while government expenditure (to output ratio) follows an AR(1) process:

$$\log \left( \frac{g_t}{y_t} \right) = (1 - \rho_g) \log \left( \frac{g}{y} \right) + \rho_g \log \left( \frac{g_{t-1}}{y_{t-1}} \right) + \xi_t^g, \quad \xi_t^g \sim N(0, \sigma_g^2), \quad (15)$$

where  $\rho_g \in (0, 1)$  is the AR(1) persistence parameter.  $\xi_t^g$  is a government expenditure-to-output shock, which is normally distributed with zero mean and constant standard deviation  $\sigma_g$ .

### 3 Calibration

This section presents the calibration of the baseline model with one-period bond. The model is calibrated on a quarterly basis using U.S. data from the sample period 2006Q1 – 2021:Q4. [Table 1](#) presents the parameter values and [Table 2](#) presents the calibrated steady-state ratios of the key variables to output.

As shown in [Table 1](#), the representative household's discount factor is set at  $\beta = 0.99$  such that the annualized return on one-period government bond is 4%. The habit formation parameter,  $j$ , is set at 0.5, which is in line with the average of the estimated habit formation parameter values for the U.S. (see. e.g., [Christiano et al., 2005](#); [Havranek et al., 2017](#)). Following [Sims and Wolff \(2018\)](#), the share of private consumption,  $\gamma_c$ , and the elasticity of substitution between private consumption and government consumption,  $\eta$ , in the utility function are set at 0.7 and 0.3748, respectively. As explained in [section 2](#), [Sims and Wolff \(2018\)](#) estimate a medium-scale New Keynesian DSGE model with U.S. data, obtaining an estimated  $\eta$  of less than 1, thus, implying that private and government consumption are complements. The inverse of the elasticity of real money demand,  $\chi$ , is set at 7 as in [Falagiarda \(2014\)](#). The elasticity of demand for intermediate goods,  $\epsilon$ , is set at 10, as in [Kurmman and Otrok \(2013\)](#). We assume that the inverse of Frisch elasticity of labor supply,  $\varsigma$ , is equal to 1 (see. e.g., [Christiano et al., 2005](#); [Sims and Wu, 2020](#)). The capital depreciation rate,  $\delta$ , is set at 0.025% per quarter, as in [Smets and Wouters \(2007\)](#), while the Calvo probability,  $\omega$ , is set at 0.65 (see, e.g., [Galí, 2015](#)). The persistence parameter of technology shocks,  $\rho_a$ , is equal to 0.9, whereas the persistence parameter of government expenditure-to-output shocks,  $\rho_g$ , is equal to 0.85. In the monetary policy rule, we assume  $\alpha_i = 0.65$  and  $\alpha_\pi = 1.5$ , as commonly used in the literature (see, e.g., [Taylor, 1993](#)).

The model is calibrated such that the steady-state ratios of the following key variables to output match those observed in the data. As reported in [Table 2](#), the steady-state ratio of government debt to output is calibrated at 91%, with 11% corresponding to short-term debt and 80% to long-term debt, as observed in the data. We calibrate both ratios of government transfers to output and government consumption to output at 15%, which is consistent with the data. This implies a steady-state ratio of government expenditure (sum of transfers and consumption) to output of 30%. It also implies that the share of transfers in government expenditure,  $\nu$ , is equal to 0.5. Based on the steady-state ratios calibrated above and the parameter values given in [Table 1](#), we obtain the following steady-state ratios. The steady-state ratio of private consumption

to output is equal to 85%, which is slightly higher than the 69%, observed in the data.<sup>9</sup> We obtain a positive but close-to-zero steady state primary surplus to output. The steady-state ratio of taxes to output is 31%, slightly higher than the 28% observed in the data.<sup>10</sup>

Table 1: Parameter values.

Parameter	Description	Value
$\beta$	Household discount factor	0.99
$j$	Habit formation	0.5
$\gamma_c$	Share of private consumption	0.7
$\eta$	Elasticity of substitution between private and government consumption	0.3748
$\chi$	Inverse of the elasticity of money demand	7
$\epsilon$	Elasticity of demand for intermediate goods	10
$\varsigma$	Inverse of Frisch elasticity of labor supply	1
$\delta$	Capital depreciation rate	0.025
$\omega$	Calvo probability	0.65
$\rho_a$	Persistence of technology shock	0.9
$\rho_g$	Persistence of government expenditure-to-output shock	0.85
$\alpha_i$	Degree of interest rate smoothing	0.65
$\alpha_\pi$	Monetary policy response to inflation	1.5
$\nu$	Share of transfers in government expenditure	0.5

Table 2: Steady state ratios.

Variable	Description	Value
$b/y$	Government debt to output	0.91
$z/y$	Government transfers to output	0.15
$g^c/y$	Government consumption to output	0.15
$g/y$	Government expenditure to output	0.30
$c/y$	Private consumption to output	0.85
$s/y$	Fiscal surplus to output	0.0092
$\tau c/y$	Taxes to output	0.3091

## 4 Main results

To evaluate the proposed fiscal rule's effectiveness in managing price stability and debt stabilization, in coordination with the monetary policy rule, we assume the government minimizes the following loss function:

$$L = \eta_\pi \sigma_{\pi_t}^2 + \eta_y \sigma_{y_t - y}^2 + \eta_s \sigma_{s_t - b}^2, \quad (16)$$

where  $\sigma_{\pi_t}^2$  is the variance of inflation,  $\sigma_{y_t - y}^2$  is the variance of output gap and  $\sigma_{s_t - b}^2$  is the variance of the gap between the primary surplus and the steady-state level of government debt (hereafter surplus-debt gap).  $\eta_\pi$ ,  $\eta_y$  and  $\eta_s$ , are the relative-weights of the variances of the three variables in the loss function, respectively.

<sup>9</sup>As our model does not consider investment, a slightly higher private consumption-to-output ratio is reasonable.

<sup>10</sup>We use federal government current receipts as a proxy for total tax revenue.

We assign a relatively higher weight on price stability ( $\sigma_{\pi_t}^2$ ) and set  $\eta_\pi = 0.6$ . Weights on macroeconomic stability ( $\sigma_{y_t-y}^2$ ) and debt stabilization ( $\sigma_{s_t-b}^2$ ) are set at  $\eta_y = 0.3$  and  $\eta_s = 0.1$ , respectively.<sup>11</sup>

The loss function proposed emphasizes two fundamental tasks that macroeconomic policies strive to achieve, namely determining the price level and stabilizing debt (Leeper and Leith, 2016). We include  $\sigma_{y_t-y}^2$  in the loss function to account for macroeconomic stability in the government's objective function. However, the focus in this study is on price stability and debt stabilization. The loss function proposed is partially based on Carnot (2014)'s rule-of-thumb for a balanced debt and macroeconomic stability. Carnot (2014) uses a single indicator, fiscal effort, to measure of the tradeoff between debt and macroeconomic stability of fiscal policy. Fiscal effort is defined as a simple weighted sum of the output gap and the difference between the current period surplus and the long-run equilibrium level of government debt.

In this section, we start our analyses with the baseline model with a one-period bond and examine the effects of a positive government expenditure shock on inflation and other main macroeconomic variables. We then focus on the role played by a long-term bond in the model developed here, comparing the dynamics of the baseline model with a one-period bond and the model with a long-term bond. Throughout these analyses, we investigate how the interaction between monetary and fiscal policies affects the dynamics of the models. The positive government expenditure shock mimics the increases in government expenditure seen during the Great Recession and the Covid-19 pandemic.

#### 4.1 Baseline model: Regime M vs. Regime F

Following Leeper (1991), Leeper and Walker (2012) and Leeper and Leith (2016), we look at two different scenarios of monetary and fiscal interaction, namely Regime M and Regime F. Under Regime M, the monetary authority controls inflation, while the fiscal authority is responsible for stabilizing government debt. Leeper (1991) defines Regime M as active monetary policy and passive fiscal policy. Regime M requires the following conditions to be satisfied simultaneously, namely,  $\alpha_i + (1 - \alpha_i)\alpha_\pi\beta > 1$ , and  $(1/\beta - \gamma_{b,p}) < 1$ . The condition of  $\alpha_i + (1 - \alpha_i)\alpha_\pi\beta > 1$  implies that the monetary authority adjusts the interest rate by more than one-to-one in response to changes in inflation. The condition of  $(1/\beta - \gamma_{b,p}) < 1$  implies that the fiscal authority adjusts the future primary surplus in response to changes in government debt with the magnitude of  $\gamma_{b,p}$ , which is greater than the return on government debt,  $1/\beta - 1$ . In other words, if government debt increases, the fiscal authority ensures that the future primary surplus will increase enough to cover debt service costs and retire a portion of debt.

Under Regime F, monetary policy becomes passive, weakly adjusting interest rates in response to changes in inflation,  $\alpha_i + (1 - \alpha_i)\alpha_\pi\beta < 1$ , whereas fiscal policy becomes active in the sense that the fiscal authority is responsible for controlling inflation and pays no attention to debt stabilization,  $(1/\beta - \gamma_{b,p}) > 1$ . In this case, the future surplus is not even sufficient to cover debt service costs.<sup>12</sup>

We obtain the optimal parameter values for the proposed fiscal rule by minimizing the loss function (16),

<sup>11</sup>The relative sizes of weights do not affect the quality of the results.

<sup>12</sup>We follow Leeper (1991) to derive conditions for Regime M and Regime F. As pointed out by Leeper (1991), there is no unique equilibrium or bounded solution when both monetary and fiscal policies are either active or passive. Therefore, only these two scenarios are considered in the present study: Regime M and Regime F.

subject to the constraints given by the model and the calibrated parameter values reported in [Table 1](#). For Regime M parameter  $\alpha_\pi = 1.5$ , implying a more aggressive response to changes in inflation. The resulting optimal parameter values are  $\gamma_{b,p}^* = 0.0259$  and  $\gamma_g^* = 0.7897$ , respectively. For Regime F, we set  $\alpha_\pi = 1$  and  $\gamma_{b,p} = 0.01$  so that conditions for Regime F are satisfied and then obtain the optimal parameter value  $\gamma_g^* = 1$ . We set  $\alpha_\pi = 1$ , implying a relatively weak response to changes in inflation. This is in contrast to the literature (see, e.g., [Leeper, 1991](#); [Leeper and Walker, 2012](#); [Leeper and Leith, 2016](#)), where authors opt for a pegged interest rate rule, setting  $\alpha_\pi = 0$  for Regime F. Our argument here is that, even though monetary policy is passive, it is unrealistic to assume that the monetary authority is implementing a policy rule completely independent of inflation.

[Figure 3](#) shows the impulse response functions (IRFs) of inflation and other key macroeconomic variables following a 1% unexpected positive government expenditure-to-output shock.<sup>13</sup> The results show that increases in government expenditure result in an increase in inflation under both regimes. It shows that increases in government expenditure, such as the American Rescue Plan Act (ARPA), not only increase output and private consumption as planned, but also inflation. In other words, the positive effects of such fiscal stimulus packages come with a cost, in terms of higher inflation.

The fiscal stimulus packages implemented by the government in response the Great Recession and Covid-19 pandemic were initially financed by issuing more government debt. This is reflected as what observed in the data (see [Figure 2](#)), which is also consistent with the initial increase in government debt shown in [Figure 3](#). It is worth noting that the initial increases in debt-to-output ratios under both regimes are approximately the same and, thereafter, the debt-to-output ratio declines at a faster pace due to a relatively lower bond price and higher tax revenues under Regime F. Regime M requires future taxes and surplus to increase in order to stabilize government debt. However, under Regime F, the fiscal authority does not commit itself to debt stabilization and increases in government expenditure require a larger initial jump in inflation to reduce the real value of government debt ([Leeper and Leith, 2016](#), p.2332). This is reflected in [Figure 3](#): while the initial jump in inflation is doubled, increases in future taxes and the primary surplus under Regime F are more or less the same as under Regime M.

To combat the rising inflation, the monetary authority increases interest rates. Compared to Regime M, under Regime F interest rates need to increase more due to a relatively smaller policy reaction parameter value  $\alpha_\pi$  and much higher inflation. Increases in government expenditure increase the marginal utility of consumption, which reinforces the increased interest rates. Higher inflation and interest rates make current consumption more attractive and households have less incentive to hold money.

In summary, the dynamics of the model with the proposed fiscal rule following an expansionary fiscal policy successfully mimic what we observed in the data. These findings strongly indicate that the recent upward trend in global inflation aligns with the principles of the FTPL – monetary policy gets its power from fiscal backing, with future taxes and primary surpluses increasing while inflation declines ([Leeper and Leith, 2016](#); [Cochrane, 2023](#)). Additionally, the model with Regime F provides a more coherent explanation for what we observed in the data (see [Figure 1](#) and [Figure 2](#)).

<sup>13</sup>In [section 4](#), we following the convention and report the IRFs of government debt, taxes, and surplus in terms of ratio to output.

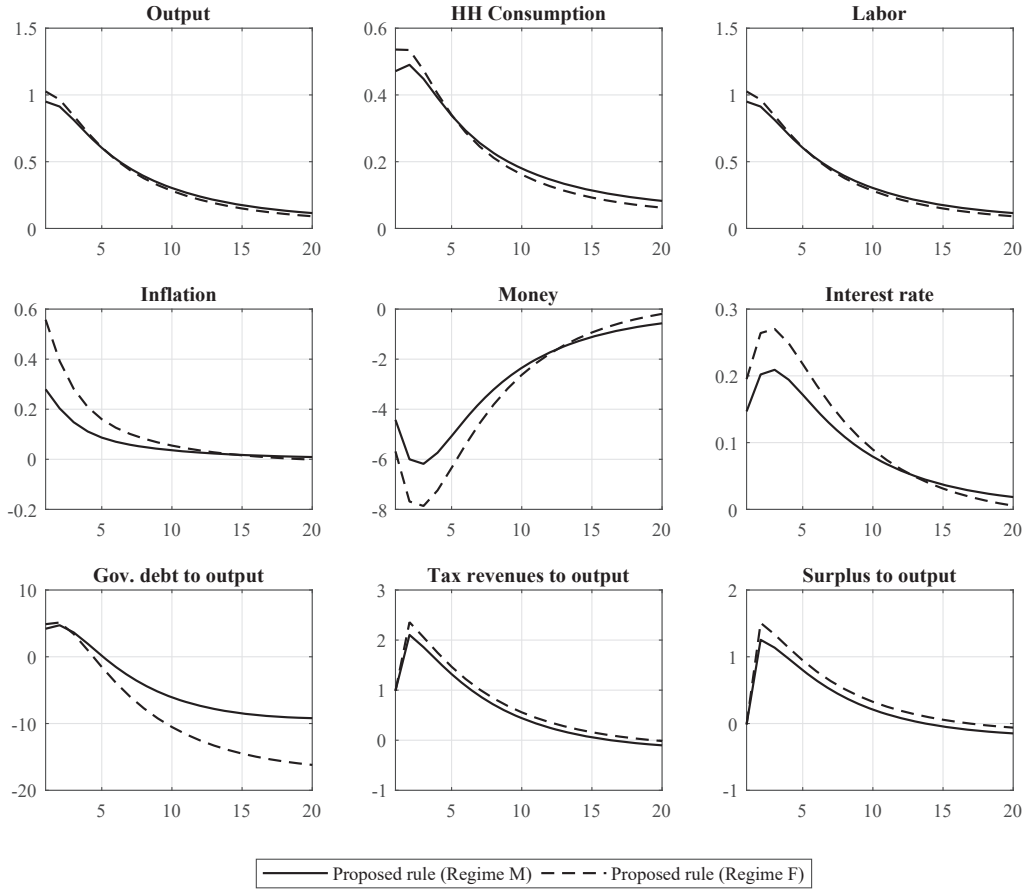


Figure 3: IRFs of the main variables (in percentage deviation from steady state) following a 1% positive government expenditure-to-output shock. Solid line: Regime M ( $\alpha_\pi = 1.5$ ,  $\gamma_{b,p}^* = 0.0259$  and  $\gamma_g^* = 0.7897$ ); Dashed line: Regime F ( $\alpha_\pi = 1$ ,  $\gamma_{b,p} = 0.01$  and  $\gamma_g^* = 1$ ); \* indicates that the parameter value is obtained optimally, by minimizing the loss function (16).

## 4.2 One-period bond vs. long-term bond

This section focuses on the role of the maturity structure of government debt and examines how inflation and other key macroeconomic variables respond to a positive government expenditure shock when bonds are long-term, as opposed to being one-period bonds in the baseline model. Here we solely focus on Regime F since debt maturity is irrelevant for inflation under Regime M (Leeper and Leith, 2016). In Figure 4, one-period bonds have the maturity of one quarter (solid line), whereas long-term bonds have the maturity of 10-year (dashed line).

When fiscal policy is active, long-term bonds provide a new channel for the interaction between monetary and fiscal policy: increases in government expenditure reduce the value of government debt due to the rising inflation and the decreases in the long-term bond price (Leeper and Leith, 2016). While the model with one-period bonds suggests that, following a positive government expenditure shock, the government has to issue more government debt and, at the same time, it has to raise more taxes to finance increases in government

expenditure than the case with long-term bonds.

When bonds are long term, government debt is stabilized, seeing not only a slight decline in the debt-to-output ratio following the shock, but also a relatively flat IRF of the debt-to-output ratio. At the same time, it attenuates the direct effect of the government expenditure shock on taxes and the primary surplus. As the proposed fiscal rule states, the primary surplus must increase if either government debt or government expenditure increases. With one-period bonds, both government debt and expenditure increase following the shock, resulting in increases in both taxes and surpluses. With long-term bonds, however, government debt declines following the shock. This, in turn, partially offsets the increases in surpluses. Hence, we observe a significant gap between the IRFs of surpluses and taxes in the model with one-period bonds compared to those with long-term bonds. It is worth noting that government debt stabilization is achieved without compromising price stability. That is, as shown in the figure, the initial jump in inflation in the model with long-term bonds is more or less the same as that in the model with one-period bonds. In fact, with long-term bonds, inflation starts declining faster 6 quarters following the shock.

The dynamics of the real money balance tend to mirror the impact of long-term bonds on inflation and interest rates. For instance, with long-term bonds, the initial increase in inflation is higher, leading to a more significant decline in the real money balance. As inflation associated with long-term bonds eventually falls below that of one-period bonds, real money balances with long-term bonds begin converging to its steady state more rapidly than that with one-period bonds. [Figure 4](#) shows the same pattern when comparing the scenarios with one-period bonds to those with long-term bonds for real money balances and interest rates.

## 5 The proposed fiscal rule vs. the LL rule: A comparison

This section compares our proposed fiscal rule [\(9\)](#) with the LL rule [\(12\)](#). This comparative analysis offers insights into the value of augmenting government expenditure in the proposed rule. We first compare how inflation and other macroeconomic aggregates respond to the shock under these two fiscal policy rules. We then look at the tradeoff between price stability and debt stabilization. Lastly, we compare the welfare implications of the two fiscal policy rules. Analyses are based on the simulation with a positive government expenditure shock.<sup>14</sup>

### 5.1 Regime M vs. Regime F

The results show that the proposed rule is more promising in attenuating the effects of government expenditure shocks on business cycle fluctuations. [Figure 5](#) shows that, under Regime M, both fiscal rules are able to bring down the inflation caused by fiscal expansion, while the proposed rule is more effective than the LL rule in terms of attenuating the effects of the shock on the real economy. With the proposed rule, we observe smaller increases in output, consumption, and labour supply following the shock, while the decline

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<sup>14</sup>For the sake of simplicity, this section focuses on the baseline model with one-period bonds only. Optimal parameter values for the LL rule are obtained in the same way as for our proposed rule (see [subsection 4.1](#)). For comparison purposes, we set  $\gamma_{b,p} = 0.01$  for Regime F for the proposed rule, which is the same as the optimal  $\gamma_{b,b}^*$  obtained for the LL rule. The optimal  $\gamma_g^* = 1$  is then obtained. For Regime M, the optimal  $\gamma_{b,b}^* = 0.1296$  for the LL rule.

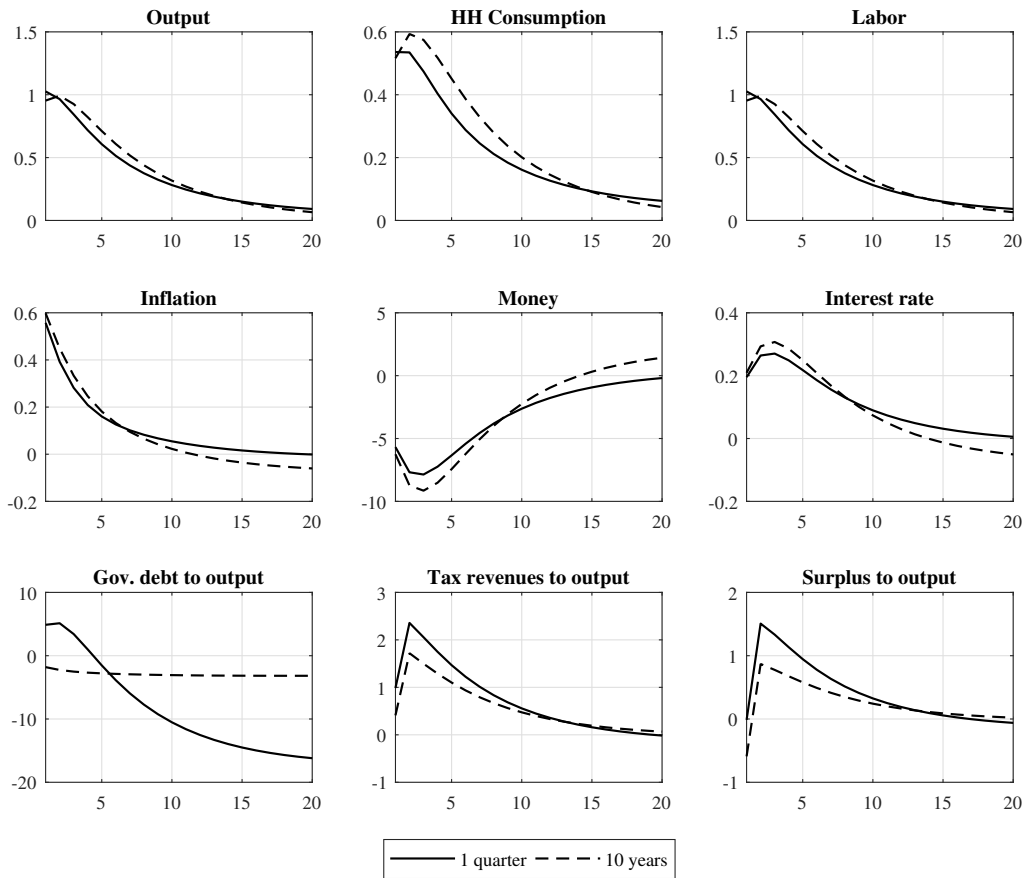


Figure 4: One-period bond vs. long-term bond (Regime F): IRFs of the main variables (in percentage deviation from steady state) following a 1% positive government expenditure-to-output shock. Solid line: One-quarter bond; Dashed line: 10-year bond.  $\alpha_\pi = 1$ ,  $\gamma_{b,p} = 0.01$  and  $\gamma_g^* = 1$ . \* indicates that the parameter value is obtained optimally, by minimizing the loss function (16).

in money is less pronounced. Another benefit of augmenting government expenditure in the proposed rule is the significant enhancement of debt stabilization.<sup>15</sup> This, in turn, helps the monetary authority to achieve price stability at a faster pace, seeing with inflation converging back to steady state faster. This advantage, however, comes with costs: the fiscal authority has to raise more taxes to finance the increases in government expenditure.

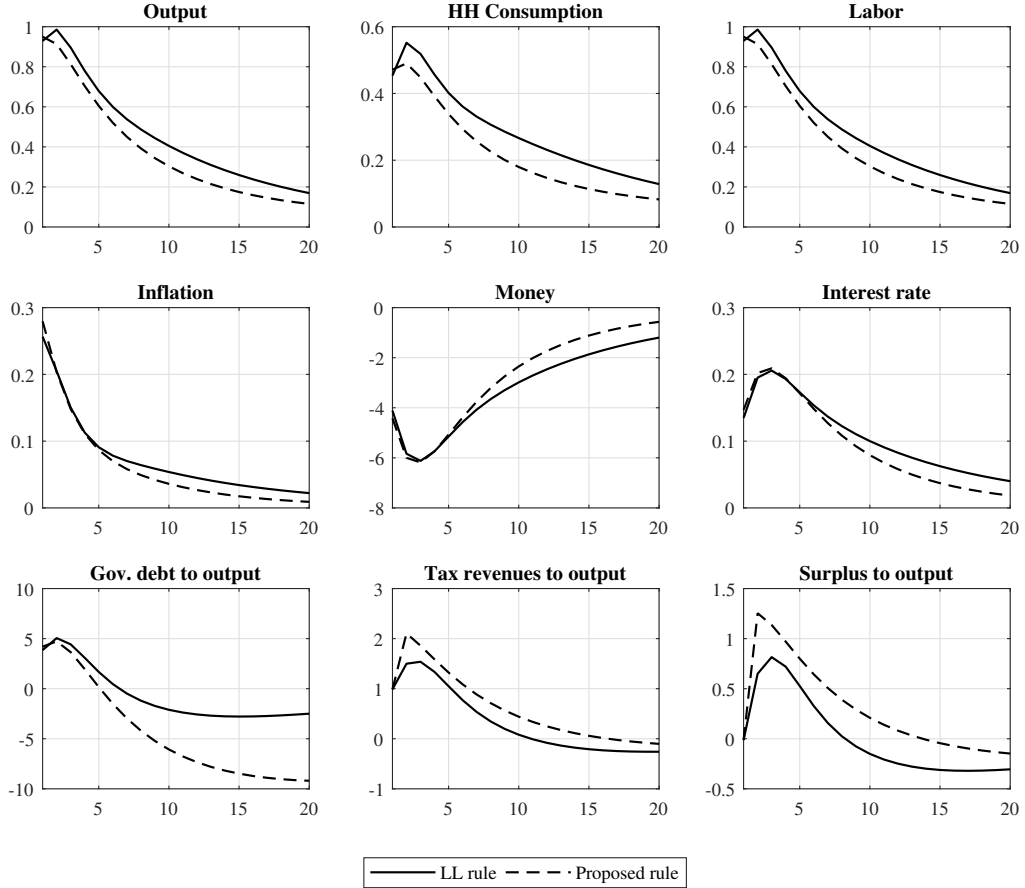


Figure 5: Proposed rule vs. LL rule (Regime M): IRFs of the main variables (in percentage deviation from steady state) following a 1% positive government expenditure-to-output shock. Solid line: LL surplus rule ( $\alpha_\pi = 1.5$ ,  $\gamma_{b,b}^* = 0.1296$ ); Dashed line: proposed rule ( $\alpha_\pi = 1.5$ ,  $\gamma_{b,p}^* = 0.0259$  and  $\gamma_g^* = 0.7897$ ); \* indicates that the parameter value is obtained optimally, by minimizing the loss function (16).

Under Regime F (Figure 6), the proposed fiscal rule requires less increase in government debt when government expenditure increases and government debt is also stabilized at a much faster pace. Similar to Regime M, this benefit comes with costs and these costs are higher under Regime F. While the magnitude of the policy reaction to the increases in government debt is the same ( $\gamma_{b,b} = \gamma_{b,p} = 0.01$ ) for both the proposed rule and the LL rule, the optimal policy parameter  $\gamma_g^* = 1$ , which is higher than that under Regime M (0.7897), implying that, under Regime F, the fiscal authority needs to respond more robustly to increases in government expenditure. Consequently, compared to the LL rule, costs associated with attaining price stability and debt stabilization are higher: requiring a more significant increase in taxes to finance the

<sup>15</sup>It is worth pointing out that this enhancement is achieved even with a relatively small value of the policy reaction parameter to government debt: the optimal policy parameter in the proposed fiscal rule  $\gamma_{b,p}^* = 0.0259$ , whereas in the LL rule  $\gamma_{b,b}^* = 0.1296$ .

expanded government expenditure, thus implying a larger future primary surplus. Lastly, the decline in the real money balances is substantially less pronounced.

In line with previous findings, we highlight the benefits of augmenting government expenditure in the proposed fiscal rule are consistent with the discussions on government debt dynamics (11) in subsection 2.2. A negative relationship between the dynamics of government debt and government expenditure helps to stabilize government debt at a faster pace compared to the LL rule. This, in turn, enhances the effectiveness of the proposed fiscal rule in mitigating inflation and achieving price stability.

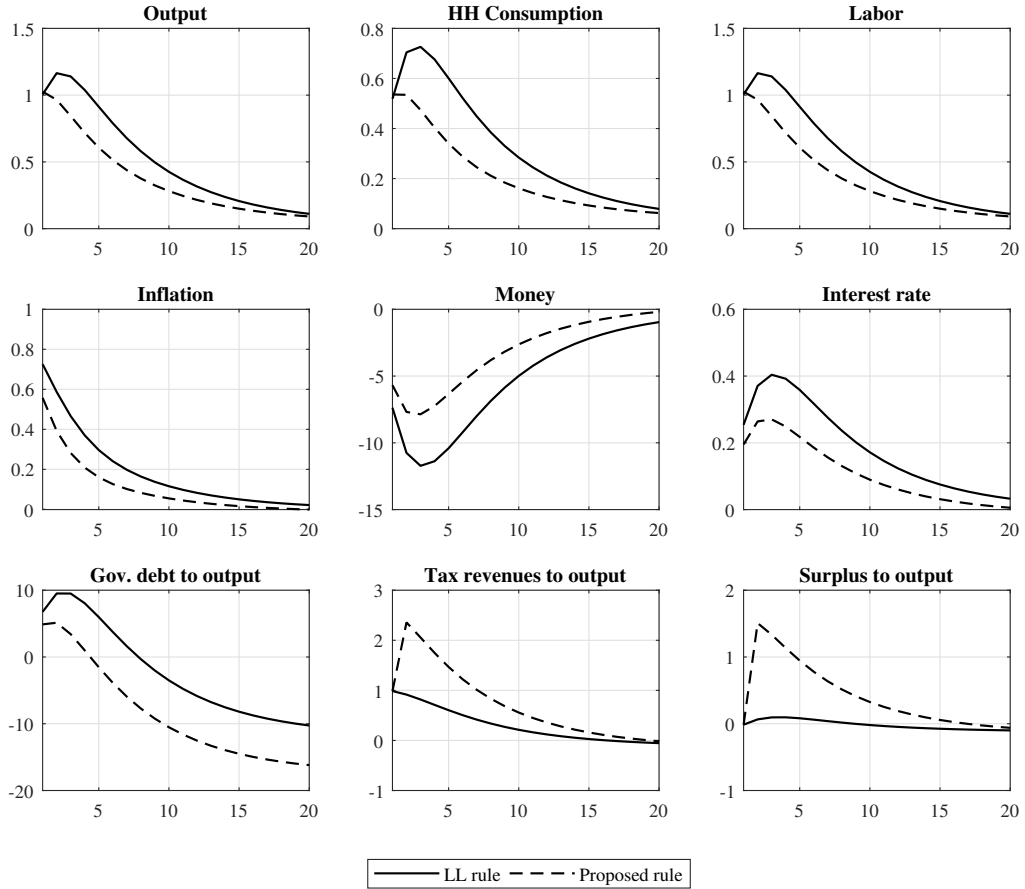


Figure 6: Proposed rule vs. LL rule (Regime F): IRFs of the main variables (in percentage deviation from steady state) following a 1% positive government expenditure-to-output shock. Solid line: LL surplus rule ( $\alpha_\pi = 1$ ,  $\gamma_{b,b}^* = 0.01$ ); Dashed line: proposed surplus rule ( $\alpha_\pi = 1$ ,  $\gamma_{b,p} = 0.01$  and  $\gamma_g^* = 1$ ). \* indicates that the parameter value is obtained optimally, by minimizing the loss function (16).

## 5.2 Price stability vs. debt stabilization

This section assesses the proposed fiscal policy rule by examining the tradeoff between price stability and debt stabilization through EPF analysis, comparing the outcomes of the proposed fiscal rule with the LL rule using two-dimensional EPFs. Specifically, we fix the relative weight parameter of output gap,  $\eta_y$ , in the loss function (16) to its calibrated baseline value of 0.3, and allow the other two relative weights to vary inversely within the range of  $[0, 1]$ . That is, the sum of the relative weights on the volatility of inflation and

the surplus-debt gap equals 1,  $\eta_\pi + \eta_s = 1$ . Moving from left to right in [Figure 7](#) and [Figure 8](#), the weight on the volatility of inflation is increasing from 0 to 1, while the weight on the volatility of the surplus-debt gap decreases from 1 to 0. The EPFs presented in both figures show the locus of the volatility of inflation and the volatility of the surplus-debt gap calculated at each set of optimal policy coefficients ( $\gamma_{b,p}^*$ ,  $\gamma_g^*$ , and  $\gamma_{b,b}^*$ ) that yield the lowest loss function value, given different combinations of  $\eta_\pi$  and  $\eta_s$ .

[Figure 7](#) presents the results for Regime M. The EPFs under both the proposed rule and the LL rule show a clear tradeoff between price stability and debt stabilization, as the authority adjusts the relative weights on inflation and the surplus-debt gap. For instance, when the authority increases the relative weight on inflation, the volatility of inflation decreases at the cost of the increased volatility of surplus-debt gap. Under the LL rule, when  $\eta_\pi$  increases from 0 to approximately 0.5, the volatility of inflation decreases at a faster pace, with relatively lower costs in terms of the increased volatility of the surplus-debt gap. The outcome reverses if  $\eta_\pi > 0.5$ : the authority will gain very little by reducing the volatility of inflation while incurring a high cost (a much higher volatility of the surplus-debt gap). This is, however, not the case for the proposed rule. In contrast to the LL rule, the EPF under the proposed rule exhibits a comparatively linear pattern. This implies that the authority encounters a relatively balanced tradeoff between achieving price stability and debt stabilization when adjusting its preference between these two policy objectives.

The EPFs for Regime F differ significantly from those for Regime M. In [Figure 8](#), the black dot represents the EPF for the LL rule. This is because, in order to satisfy the conditions for Regime F, we set  $\gamma_{b,b} = 0.01$  implying that, with the LL rule, this policy parameter does not change when the relative weights on inflation and the surplus-debt gap change. Therefore, the volatility of inflation and the volatility of the surplus-debt gap obtained from minimizing the loss function remain constant. It is also worth noting that the location of the LL rule's EPF implies that, compared to the proposed rule, the authority faces much higher levels of volatility for both inflation and the surplus-debt gap. For the proposed rule, we observe a significant tradeoff between price stability and debt stabilization. In order to reduce the volatility of inflation, the authority has to face higher volatility of surplus-debt gap. Similar to Regime M, the EPF for the proposed rule is also relatively linear. Lastly, in terms of achieving price stability and debt stabilization, Regime M outperforms Regime F for both the proposed rule and the LL rule. The volatility magnitudes are significantly smaller under Regime M, indicating greater efficiency in managing both policy objectives.

### 5.3 Welfare

The expansionary fiscal policy boosts private consumption, consequently contributing to an improvement in welfare. Conversely, the impact of expansionary fiscal policy on labour supply reduces welfare, as households increase their labour supply after the shock. Additionally, the role of real money balance in welfare is noteworthy. An increase in government expenditure initially raises government debt, which reduces households' real money holdings and welfare.

This section examines the welfare implications of the proposed fiscal rule and compares it with those of the LL rule. We first compute the welfare under both rules and then compute the welfare gain or loss in the consumption-equivalent measure under the two different rules. The social welfare is defined as the following:

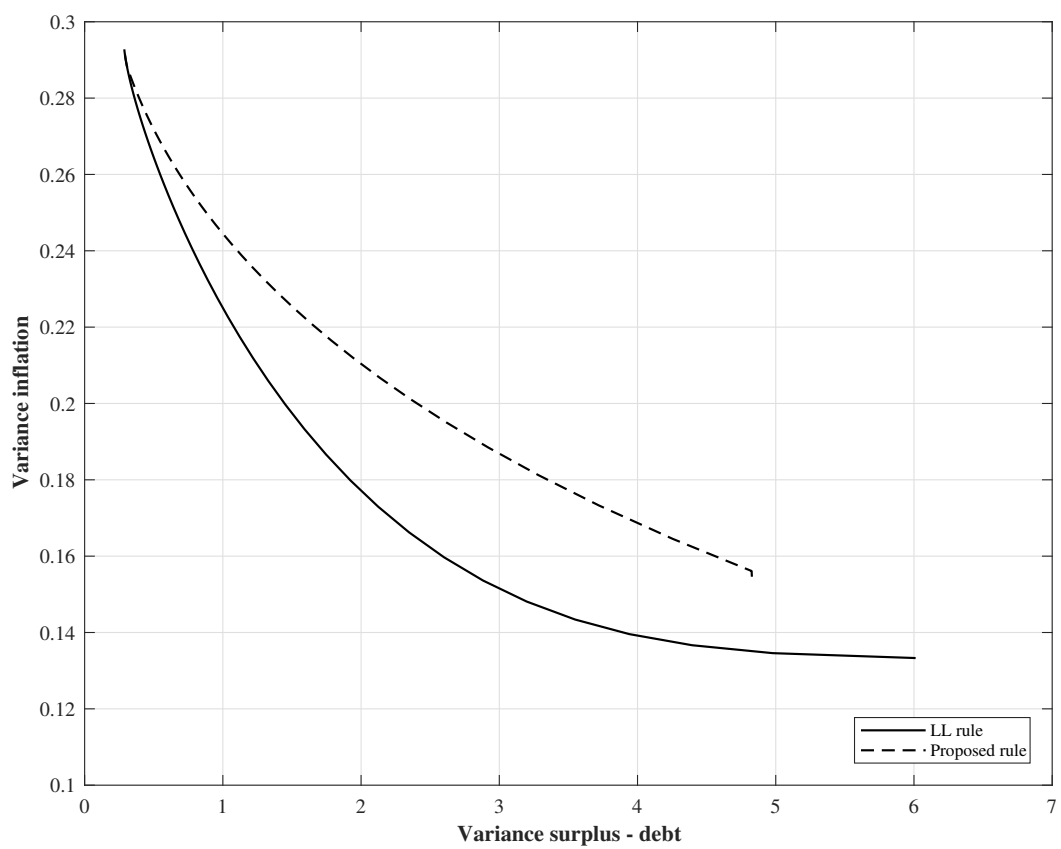


Figure 7: Efficient policy frontier (Regime M): following a 1% positive government expenditure-to-output shock. Solid line: LL rule; Dashed line: proposed rule. Variances are in %.

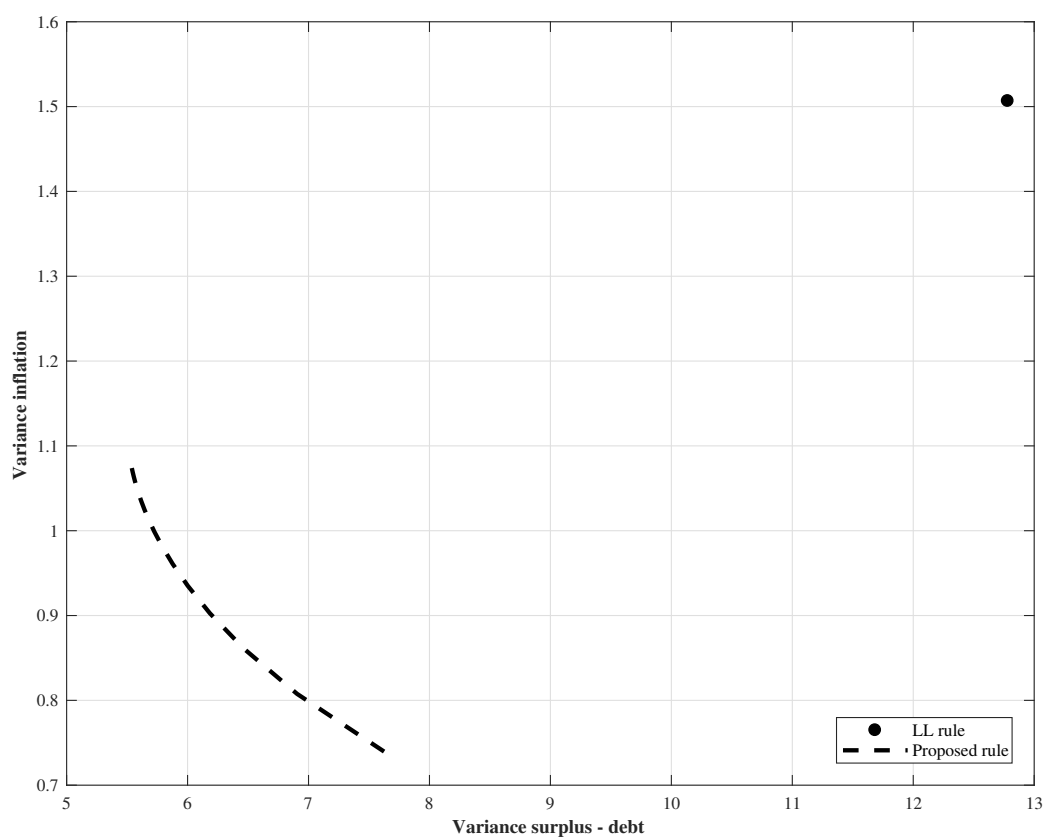


Figure 8: Efficient policy frontier (Regime F): following a 1% positive government expenditure-to-output shock. Solid line: LL rule; Dashed line: proposed rule. Variances are in %.

$$W_{i,t} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{\eta}{\eta-1} \log \left( \gamma_c (c_{i,t} - j c_{i,t-1})^{\frac{\eta-1}{\eta}} + (1 - \gamma_c) (g_{i,t}^c)^{\frac{\eta-1}{\eta}} \right) + \frac{1}{1-\chi} \left( \frac{M_{i,t}}{P_t} \right)^{1-\chi} - \frac{\varsigma}{1+\frac{1}{\varsigma}} (N_{i,t})^{1+\frac{1}{\varsigma}} \right], \quad (17)$$

where  $i = \{p, l\}$  represents the proposed rule (p) or the LL rule (l). The welfare gain or loss in the consumption-equivalent measure is defined as the following:

$$CE_t = \exp [(1 - \beta)(W_{p,t}^* - W_{l,t}^*)] - 1, \quad (18)$$

where  $W_{p,t}^*$  represents the welfare under the optimal proposed rule and  $W_{l,t}^*$  is the welfare under the optimal LL rule, respectively. A positive value of  $CE_t$  indicates a welfare gain in the consumption-equivalent measure when implementing the proposed rule compared to the LL rule, and vice versa.

Table 3 presents the welfare gain or loss in the consumption equivalent measure when implementing the proposed fiscal rule compared to the LL rule, following a 1% positive government expenditure-to-output shock.<sup>16</sup> We find that, in general, compared to the LL rule, the proposed fiscal rule enhances social welfare. This improvement becomes more significant under Regime F. For instance, in the baseline model with one-period bonds, the welfare gain of implementing the proposed rule is 0.43% in consumption equivalent terms. Under Regime M, the welfare gain is only 0.0365%.

Another main finding here is that the welfare gain declines when long-term bonds are considered in the model as opposed to one-period bonds. For instance, under Regime F, the welfare gain declines from 0.43% for the model with one-period bonds to 0.24% for the model with 10-year bonds. As highlighted earlier, the maturity structure of the government debt is irrelevant for inflation under Regime M. Nevertheless, we present findings for Regime M considering both one-period and long-term bonds. The results consistently affirm that, under Regime M, the welfare implications remain largely unaffected by the maturity structure of government debt, indicating its minimal impact on overall welfare outcomes.

Table 3: Welfare analysis.

	Regime M		Regime F	
Debt maturity	1 quarter	10 years	1 quarter	10 years
Welfare gain/loss (%)	0.0365	-0.0052	0.4321	0.2402

## 6 Conclusions

This paper shows that it is beneficial to augment government expenditure in a standard fiscal policy rule such as the one in [Leeper and Leith \(2016\)](#). The proposed rule is more effective than the LL rule in terms of attenuating the effects of fiscal expansion on inflation and business cycle fluctuations. Another benefit of augmenting government expenditure in the proposed rule is the enhancement of debt stabilization without compromising price stability. Compared to the LL rule, the proposed fiscal rule enhances social welfare,

<sup>16</sup>We compute welfare based on the second-order approximation solution provided by Dynare (see [Adjemian et al., 2011](#)).

especially under Regime F. Our findings are consistent with those in [Leeper et al. \(2017\)](#), namely that the expansionary effects of government spending shocks are larger under Regime F compared to Regime M. This implies higher welfare gain in general under Regime F.

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## A Appendix: Model equations

Considering  $b_t = B_t/P_t$ ,  $m_t = M_t/P_t$ ,  $w_t = W_t/P_t$ ,  $1 + \pi_t = P_t/P_{t-1}$ ,  $\psi_t = \Psi_t/P_t$ ,  $y_t = Y_t/P_t$ , and  $z_t = Z_t/P_t$ , the stationary model equations are the following.

**Households:**

$$(1 + \tau_t) c_t + Q_t b_t + m_t - \frac{m_{t-1}}{1 + \pi_t} = w_t N_t + \frac{(1 + \theta Q_{t-1}) b_{t-1}}{1 + \pi_t} + z_t + \psi_t, \quad (\text{A.1})$$

$$(1 + \tau_t) \lambda_t = \frac{(\gamma_c) (c_t - j c_{t-1})^{-1/\eta}}{(\gamma_c) (c_t - j c_{t-1})^{\frac{\eta-1}{\eta}} + (1 - \gamma_c) (g_t^c)^{\frac{\eta-1}{\eta}}}, \quad (\text{A.2})$$

$$\varsigma (N_t)^{\frac{1}{\varsigma}} = \lambda_t w_t, \quad (\text{A.3})$$

$$(m_t)^{-\chi} = \lambda_t - \beta \mathbb{E}_t \frac{\lambda_{t+1}}{1 + \pi_{t+1}}, \quad (\text{A.4})$$

$$\lambda_t Q_t = \beta \mathbb{E}_t \frac{\lambda_{t+1} (1 + \theta Q_{t+1})}{1 + \pi_{t+1}}, \quad (\text{A.5})$$

$$i_t = \mathbb{E}_t \frac{1 + \theta Q_{t+1}}{Q_t} - 1, \quad (\text{A.6})$$

**Government:**

$$g_t = \tau c_t + Q_t b_t - \frac{(1 + \theta Q_t) b_{t-1}}{1 + \pi_t} + m_t - \frac{m_{t-1}}{1 + \pi_t}, \quad (\text{A.7})$$

$$\log \left( \frac{g_t}{y_t} \right) = (1 - \rho_g) \log \left( \frac{g}{y} \right) + \rho_g \log \left( \frac{g_{t-1}}{y_{t-1}} \right) + \xi_t^g. \quad (\text{A.8})$$

$$1 + i_t = \alpha_i (1 + i_{t-1}) + (1 - \alpha_i) [(1 + i) + \alpha_\pi (\pi_t - \pi)], \quad (\text{A.9})$$

$$s_t = s + \gamma_{b,p} (b_{t-1} - b) + \gamma_g (g_{t-1} - g) \quad (\text{A.10})$$

$$s_t = \tau_t c_t - g_t, \quad (\text{A.11})$$

$$g_t = g_t^c + z_t, \quad (\text{A.12})$$

$$g_t^c = l g_t, \quad (\text{A.13})$$

**Real sector:**

$$m c_t = w_t / A_t, \quad (\text{A.14})$$

$$Y_t = A_t N_t / \nu_t, \quad (\text{A.15})$$

$$\nu_t = (1 - \omega) (1 + \pi_t^i)^{-\epsilon} (1 + \pi_t)^\epsilon + \omega (1 + \pi_t)^\epsilon \nu_{t-1}, \quad (\text{A.16})$$

$$(1 + \pi_t)^{1-\epsilon} = (1 - \omega) (1 + \pi_t^i)^{1-\epsilon} + \omega, \quad (\text{A.17})$$

$$1 + \pi_t^i = \frac{\epsilon}{\epsilon - 1} \frac{x_{1,t}}{x_{2,t}} (1 + \pi_t) \quad (\text{A.18})$$

$$x_{1,t} = \lambda_t m c_t Y_t + \omega \beta \mathbb{E}_t (1 + \pi_{t+1})^\epsilon x_{1,t+1}, \quad (\text{A.19})$$

$$x_{2,t} = \lambda_t Y_t + \omega \beta \mathbb{E}_t (1 + \pi_{t+1})^{\epsilon-1} x_{2,t+1}, \quad (\text{A.20})$$

$$\log(A_t) = (1 - \rho_a) \log(A) + \rho_a \log(A_{t-1}) + \xi_t^a, \quad A = 1. \quad (\text{A.21})$$

## B Appendix: Data

The following data are obtained from the Federal Reserve Bank of St. Louis, FRED. Sample period: 2006:Q1 - 2021:Q4.

- Gross Domestic Product. Billions of Dollars, Quarterly, Seasonally Adjusted Annual Rate (name: GDP).
- GDP Implicit Price Deflator in United States, Index 2015=100, Quarterly, Seasonally Adjusted (name: USAGDPDEFQISMEI).
- Federal government budget surplus or deficit (-), Billions of Dollars, Quarterly, Not Seasonally Adjusted (name: M318501Q027NBEA).
- Short-term debt. General Government; Short-Term Debt Securities; Liability, Level, Millions of Dollars, Quarterly, Not Seasonally Adjusted (name: BOGZ1FL364122405Q).
- Long-term debt. General Government; Long-Term Debt Securities; Liability, Level, Millions of Dollars, Quarterly, Not Seasonally Adjusted (name: BOGZ1FL364122605Q).
- Current transfer payments. Federal government current transfer payments: Government social benefits: to persons, Billions of Dollars, Quarterly, Seasonally Adjusted Annual Rate (name: B087RC1Q027SBEA).
- Monetary Base. Millions of Dollars, Quarterly, Not Seasonally Adjusted (name: BOGMBASE).
- M2. Billions of Dollars, Quarterly, Seasonally Adjusted (name: M2SL).
- 3-Month Treasury Bill Secondary Market Rate, Percent, Quarterly, Not Seasonally Adjusted (name: DTB3).
- Market Yield on U.S. Treasury Securities at 10-Year Constant Maturity, Percent, Quarterly, Not Seasonally Adjusted (name: DGS10).