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JEL Classification: E31, E52, E62, E63

Keywords: Monetary policy, Fiscal policy, Fiscal dominance, Inflation bias

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Monetary-fiscal policy interactions when price stability occasionally takes a back seat*

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March 2023

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Can a central bank occasionally subordinate its price stability objective to the goal of fiscal sustainability without jeopardizing price stability more generally? This paper suggests that the answer is no. I build a model with a fiscal authority that is limited in its willingness or ability to raise primary surpluses and a central bank that accommodates its interest-rate policy to the fiscal conditions. The model generates endogenous shifts between an orthodox and a fiscally-dominant policy regime. The risk of future regime shifts has encompassing effects on equilibrium. Inflation is systematically higher than it would be if fiscal policy always adjusted its primary surplus sufficiently and monetary policy was solely concerned with price stability.

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1 Introduction

Recent economic events have once again brought to the forefront the interdependence of monetary and fiscal policies. After a decade of low inflation and low interest rates, the global economy experienced a strong surge in inflation, and central banks embarked on a path of rising policy rates. The prospect of rising interest rates, in turn, has sparked concerns about fiscal policy and the sustainability of elevated government debt levels.[1] Some observers have warned that "[p]olitical pressures could arise and grow to keep interest rates lower than the rationale of price stability would call for" (Weidmann, 2020).[2] What would be the economic consequences if monetary policymakers gave in to such pressures? Can the goal of price stability occasionally take a back seat without jeopardizing price stability more generally?

To shed light on these questions, I study a monetary-fiscal policy configuration whereby the fiscal authority's efforts to stabilize government debt only go so far, and the central bank accommodates its interest-rate policy to the fiscal conditions. This configuration is consistent with the notion of fiscal dominance put forward in Sargent (1982), in the sense that "the fiscal authorit[y] select[s] a path or policy for government expenditures and explicit taxes implying growth rates of total government indebtedness to which the monetary authority must adjust".[3] Using a model with sticky prices, I show that an *occasional* subordination of the goal of price stability to the goal of fiscal stability may result in a *systematic* failure to achieve the price stability goal. Under the considered monetary-fiscal configuration, inflation is generically higher than it would be if fiscal policy always adjusted its primary surplus sufficiently to variations in government debt and monetary policy was solely concerned with inflation stabilization. This *inflation bias*, in turn, begets an upward bias in government debt in those states of the world where the conventional dichotomy between fiscal and monetary policy holds.

In the model, fiscal policy is governed by a feedback rule for the primary surplus with an upper limit. Monetary policy follows a conventional Taylor rule, but when the primary surplus is at its limit, the central bank keeps the policy rate below some upper bound. This setup gives rise to *endogenous* policy regime shifts. Suppose that the fiscal surplus is below its limit—the economy is in the "orthodox" policy regime—when the economy is buffeted by an inflationary shock. The central bank raises the nominal interest rate aggressively so as to engineer an increase in the real interest rate (i.e. it abides by the so-called Taylor principle). Debt servicing costs increase, and in response the fiscal authority raises its primary surplus. When the inflationary shock is sufficiently large, or when there is a series of shocks, the surplus limit becomes binding—the economy transitions to the "fiscally-dominant" regime.

In the fiscally-dominant regime, the monetary policy response to shocks is generi-

[1]See, for instance, The Economist, "How higher interest rates will squeeze government budgets", 12 July 2022.

[2]Central banks are frequently subject to political pressure, even if they enjoy high legal independence, and mostly in favor of more accommodative monetary policy (e.g. Binder, 2021).

[3]Sargent (1982), page 386.

cally asymmetric. The central bank always lowers the nominal interest rate in response to deflationary shocks, but because of the interest-rate upper bound it increases the interest rate less aggressively, if at all, in response to sufficiently large inflationary shocks. Consequently, the increase in inflation in the latter case is larger in absolute magnitude than the decline in inflation in the former case.

This asymmetric inflation profile gets baked into agents' expectations. The mere possibility of a binding upper bound on the nominal interest rate in the fiscally-dominant regime shifts inflation expectations upwards in all states of the world, i.e. both in the fiscally-dominant regime and in the orthodox regime. Higher inflation expectations, in turn, put upward pressure on actual inflation. Under conventional parameterizations of the monetary policy rule, the central bank does not fully offset these inflationary pressures, giving rise to the aforementioned inflation bias.

The change in the monetary policy rule when the economy enters the fiscally-dominant regime helps to stabilize the real value of government debt and thereby ensures that the economy will eventually escape from the fiscally-dominant regime. At the same time, the inflation bias resulting from the change in the policy rule begets a *government debt bias* in the orthodox policy regime. So long as the government surplus limit is slack the inflation bias goes along with a higher real interest rate, reflecting the central bank's adherence to the Taylor principle. The higher real interest rate, in turn, leads, in equilibrium, to a higher stock of government debt. Hence, although monetary policy helps to stabilize government debt in the fiscally-dominant regime, the occasional subordination of the price stability goal to the goal of fiscal stability leads to a higher level of government debt in the orthodox policy regime.

The paper belongs to the literature on monetary-fiscal policy interactions. Sargent and Wallace (1981) show that if a central bank is forced to finance government budget deficits by providing sufficient seigniorage it will loose control over inflation. My paper emphasizes that the mere possibility of a (temporary) subordination of price stability to the goal of fiscal sustainability can give rise to inflationary pressures that make it more complicated for the central bank to attain its price stability goal.

Several studies consider the possibility of occasional shifts in monetary and fiscal policy regimes (e.g. Davig and Leeper, 2006, 2007; Bianchi and Melosi, 2017; Bianchi and Ilut, 2017; Chen et al., 2022). The present paper shares with these studies the observation that the risk of a future policy regime shift affects agents' expectations formation and, therefore, equilibrium outcomes. The present paper differs from these studies in that in my model, regime changes, and the probability of their occurrence, are determined endogenously whereas regime changes are exogenous in the aforementioned studies. Endogenizing policy regime shifts allows me to study the *interactions* between government debt, regime change risk and inflation bias. Davig and Leeper (2008) study endogenous changes in monetary policy rules. They do not consider fiscal policy.

The remainder of the paper is organized as follows. Section 2 describes the model and the monetary-fiscal policy configuration. Section 3 presents the main results, and Section 4 considers some extensions. Section 5 concludes.

2 A model of the macro economy

The economy is represented by a rational-expectations model with sticky prices and formulated in discrete time. I first describe the private sector, and then the public sector.

2.1 Private sector

The private-sector block of the model is standard. A representative household consumes, works, saves in government bonds, and pays taxes. Goods-producing firms act under monopolistic competition and are subject to nominal rigidities. A detailed textbook description can be found in Woodford (2003). Aggregate private-sector behavior is summarized by a consumption Euler equation and a forward-looking Phillips curve. Log-linearizing them around a zero-inflation deterministic steady state, we have

$$\hat{y}_t = \mathrm{E}_t \hat{y}_{t+1} - \sigma \left(\hat{R}_t - \mathrm{E}_t \hat{\pi}_{t+1} \right) \quad (1)$$
$$\hat{\pi}_t = \beta \mathrm{E}_t \hat{\pi}_{t+1} + \kappa \hat{y}_t + \mu_t, \quad (2)$$

where y_t is output in period t, R_t is the one-period gross nominal interest rate between periods t and $t+1$, π_t denotes gross inflation between periods $t-1$ and t, and μ_t is an exogenous cost-push shock. A hat indicates that the variable is expressed in percentage deviations from its deterministic steady state, e.g. $\hat{R}_t \equiv (R_t - R)/R$. E_t is the rational expectations operator conditional on information available in period t, $\sigma > 0$ is the intertemporal elasticity of substitution, and $\kappa > 0$ is the "slope" of the Phillips curve.[4]

Te cost-push shock follows a stationary autoregressive process

$$\mu_t = \rho \mu_{t-1} + \epsilon_t, \quad (3)$$

where $0 \leq \rho < 1$, and ϵ_t is an *i.i.d.* random variable with a normal distribution with zero mean and standard deviation of σ_μ.

2.2 Public sector

The public sector consists of a fiscal authority and a central bank. The fiscal authority issues nominal bonds, collects taxes and provides transfers. It faces the following flow budget constraint

$$\tilde{b}_t = \frac{1}{\beta} \left(\tilde{b}_{t-1} - \frac{b}{y} \hat{\pi}_t - \tilde{s}_t \right) + \frac{b}{y} \hat{R}_t, \quad (4)$$

[4]Assuming that prices are sticky a la Calvo (1983), and that labor is firm-specific, it holds $\kappa = \frac{(1-\beta\omega)(1-\omega)}{\omega} \frac{\sigma^{-1}+\eta}{1+\eta\theta}$, where ω is the share of firms that keep their price unchanged in a given period, η is the inverse of the elasticity of labor supply, and θ is the price elasticty of demand.

where b_t denotes the real stock of one-period nominal government bonds at the end of period t, and s_t is the real primary budget surplus.[5] A tilde indicates that the variable is expressed as a share of steady state output in deviation from its steady state ratio, e.g. $\tilde{b}_t \equiv (b_t - b)/y$.

The fiscal authority sets the primary surplus. It lowers the primary surplus when the real value of government debt falls and it raises the primary surplus when the real value of government debt rises, provided that the surplus remains moderate. The fiscal authority is, however, unable or unwilling to raise the primary surplus above some upper limit. Formally,

$$\tilde{s}_t = \min\left(\phi \tilde{b}_{t-1}, \bar{s}\right), \tag{5}$$

where $\bar{s} > 0$, i.e. the upper limit on the primary surplus is slack in the deterministic steady state around which the model is linearized. I will refer to the policy configuration where $\tilde{s}_t < \bar{s}$ as the *orthodox policy regime*, and to the configuration where $\tilde{s}_t = \bar{s}$ as the *fiscally-dominant policy regime*. I assume that $\phi > 1/\beta - 1$; in the terminology of Leeper (1991), fiscal policy is (locally) passive when the economy is in the orthodox regime.

The central bank sets the one-period nominal interest rate, also referred to as the policy rate. When the surplus limit is not binding, interest-rate policy is governed by a standard Taylor rule. When the surplus limit is binding, the central bank, worried about the fiscal consequences of high interest rates, keeps the policy rate below some upper bound. Formally,

$$\hat{R}_t = \begin{cases} \alpha \hat{\pi}_t & \text{if } \tilde{s}_t < \bar{s} \\ \min\left(\alpha \hat{\pi}_t, \bar{R}\right) & \text{else,} \end{cases} \tag{6}$$

where $\bar{R} > 0$, and $\alpha > 1/\beta$; in the terminology of Leeper, monetary policy is active in the orthodox regime.[6]

The central bank's interest-rate policy has fiscal effects. The level of the policy rate impinges on the real value of government debt, both, directly and indirectly through its effect on inflation, see equation (4). All else equal, a higher policy rate raises debt servicing costs, whereas a higher inflation rate erodes the real value of legacy debt.

For future reference, let us also define an alternative monetary-fiscal policy configuration that serves as a useful *benchmark*. Under this benchmark policy configuration, the fiscal authority always adjusts its primary surplus sufficiently to variations in government debt, and the central bank is solely concerned with inflation stabilization. From the perspective of the fiscal and monetary policy rules (5) and (6), we can think of the benchmark configuration as the limiting case where $\bar{s} \to \infty$. In this limiting case, the economy is always in the orthodox policy regime.

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[5] In the baseline model, taxes and transfers are lump sum. See Section 4 for an extension with distortionary taxation.

[6] In Section 4, I consider an alternative monetary policy configuration where the central bank switches to a rule that responds less than one-for-one to inflation—a passive monetary policy rule—when the government surplus limit is binding.

2.3 Equilibrium

A rational expectations equilibrium consists of sequences of allocations $\{\hat{y}_t\}_{t=0}^{\infty}$, prices $\{\hat{\pi}_t\}_{t=0}^{\infty}$ and policies $\{\hat{R}_t, \tilde{s}_t, \tilde{b}_t\}_{t=0}^{\infty}$ such that for a given initial level of government debt $\tilde{b}_{-1}$ and a process $\{\mu_t\}_{t=0}^{\infty}$, equations (1)-(2) and (4)-(6) hold for all $t \geq 0$.

2.4 Parameterization and solution

Table 1 reports the baseline parameterization. One period corresponds to one quarter. The assigned parameter values are standard in the literature. A discount factor of 0.995

Table 1: **Parameterization**

Parameter	Value	Economic interpretation
β	0.995	Subjective discount factor
σ	1	Intertemporal elasticity of substitution in consumption
η	1	Inverse labor supply elasticity
θ	10	Price elasticity of demand
ω	0.8	Share of firms per period keeping prices unchanged
α	2.5	Monetary policy rule coefficient
ϕ	0.1	Fiscal policy rule coefficient
$b/(4y)$	1	Government debt to output ratio in deterministic steady state
$\bar{s}$	0.01	Surplus limit (in deviation from steady state)
$\bar{R}$	0.0074	Cond. upper bound on policy rate (in % dev. from steady state)
ρ	0.6	AR coefficient cost-push shock
σ_μ	$\frac{0.16}{100}$	Standard deviation cost-push shock innovation

is tantamount to an annualized steady state interest rate of 2%. The slope coefficient of the Phillips curve κ equals 0.0093. The response coefficient on inflation in the Taylor rule is set to 2.5, and the response coefficient on government debt in the fiscal rule is set to 0.1. In the deterministic steady state, the real stock of government debt equals 100% of annualized output, consistent with our focus on episodes of elevated government debt levels. The debt ratio and the discount factor together imply a steady state primary surplus of 2% of output. I set the surplus limit to 3% of steady state output, and the conditional upper bound on the nominal interest rate to 5% in annualized terms. Finally, I set the AR coefficient for the cost-push shock process equal to 0.6, and the standard deviation of the innovation equal to 0.16/100 (e.g. Coenen et al., 2018).

Since the fiscal and monetary policy feedback rules render the model non-linear, I solve the model globally using a projection method. Let $x_t = h^x(\mu_t, \tilde{b}_{t-1})$ be the policy function for the control variable x_t, $x \in \{\hat{y}, \hat{\pi}, \hat{R}, \tilde{s}, \tilde{b}\}$. The unknown function $h^x(\cdot)$ is then approximated by a linear combination of basis functions. Details are provided in the Appendix.

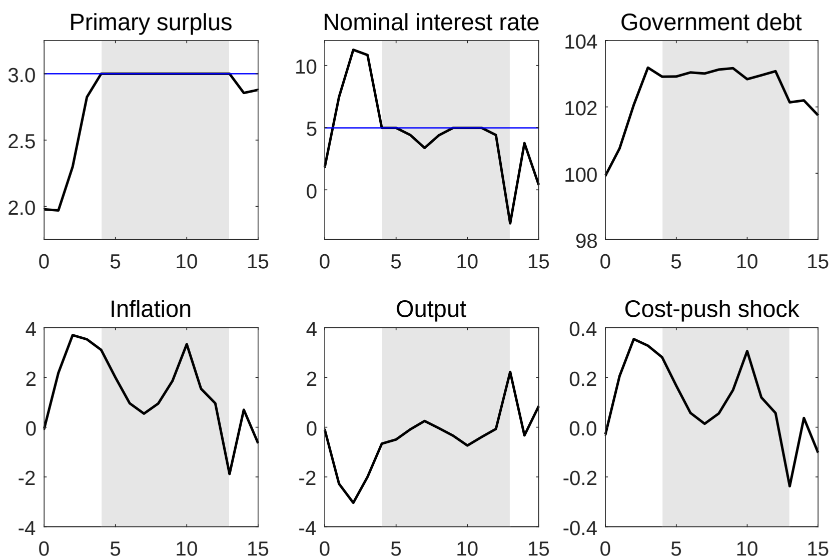
3 Putting the model to work

First, I show how the model gives rise to endogenous policy regime shifts. Then I explore how the policy regimes, and the risk of a future regime shift, impinge on the macro economy in general, and the inflation rate and government debt in particular.

3.1 Endogenous policy regime shifts

Figure 1 shows an excerpt from a model simulation. At the outset of the simulation

Figure 1: **Model simulation**



The surplus is expressed as percent of steady state output. The interest rate and inflation are expressed in annualized percent. Government debt is expressed as percent of annualized steady state output. Output and the cost-push shock are expressed in percentage deviations from steady state. The horizontal blue line in the first (second) panel indicates the surplus limit (conditional upper bound on the policy rate).

excerpt, the economy is in the orthodox policy regime (non-shaded area), and close to its deterministic steady state. Then, a series of inflationary cost-push shocks materialize, and inflation moves upwards. In response to the surge in inflation, the central bank aggressively raises the policy rate with a view to increase the real interest rate. The increase in the real interest rate depresses output, and raises debt servicing costs. Consequently, the fiscal authority raises the primary surplus. After a few periods of rising primary surpluses, the surplus limit becomes binding. The economy has transitioned from the orthodox policy regime to the fiscally-dominant policy regime—indicated by the gray-shaded area in Figure 1. As a result of the regime shift, the central bank lowers the nominal interest rate to the conditional upper bound. The policy rate reduction attenuates government borrowing costs. Nevertheless, government debt remains at an elevated level, and the surplus limit remains binding. Only when the economy is buffeted by a series of dis-inflationary cost-push shocks, accompanied by an aggressive reduction in the policy rate, does the government debt level decline sufficiently to relax the upper limit on primary surpluses, and the economy moves back to the orthodox regime.

Table 2 reports the frequency with which the fiscally-dominant regime occurs and its average duration. The economy is in the fiscally-dominant policy regime in 20% of the simulated periods, and it stays in the fiscally-dominant regime on average for 3.6 quarters. The table also shows that the conditional upper bound on the policy rate is binding in 10% of the simulated periods for an average of 1.8 quarters.

Table 2: **Frequency and duration of fiscally-dominant regime**

	$\tilde{s}_t = \bar{s}$	$\tilde{s}_t = \bar{s}$ and $\hat{R}_t = \bar{R}$
Frequency in %	20	10
Average duration in quarters	3.6	1.8

Based on 3000 simulations over 1100 quarters. For each simulation the observations corresponding to the first 100 quarters are discarded.

To summarize, monetary and fiscal policy in the model are intertwined, and variations in the economy's fundamentals give rise to endogenous shifts in the policy regime. Next, we take a more systematic look at how these regime changes impinge on the macro economy.

3.2 Regime change risk and inflation bias

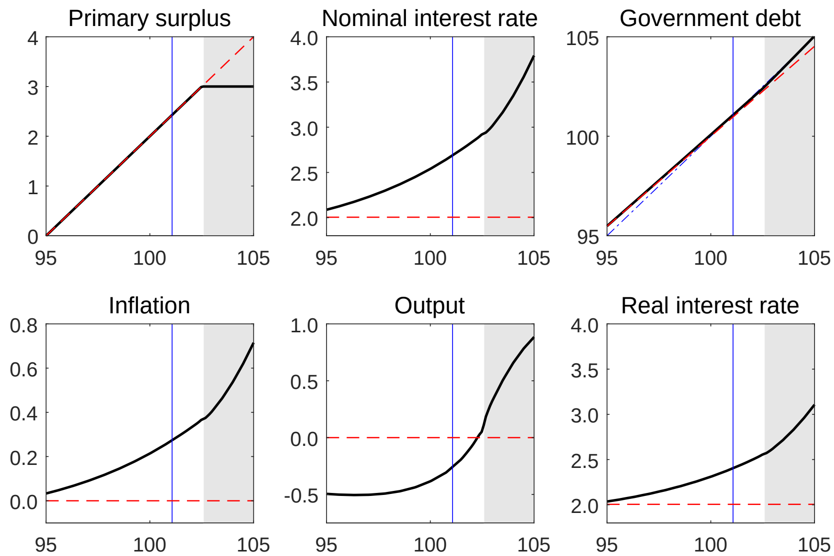
Figure 2 shows equilibrium responses of the model's endogenous variables to the beginning-of-period government debt level when the contemporaneous cost-push shock equals zero (solid black lines).[7] We can translate the primary surplus limit of the fiscal authority into a threshold for government debt $\bar{b} \equiv \bar{s}/\phi$. When beginning-of-period government debt is higher than $\bar{b}$, the economy is in the fiscally-dominant policy regime (gray-shaded area), and it is in the orthodox policy regime (non-shaded area) otherwise.

In both policy regimes and for all levels of government debt, the equilibrium response of inflation is strictly positive. The size of the inflation response is increasing in the debt level. This is very different from the response of inflation under the benchmark configuration (dashed red lines). When the primary surplus always responds to variations in government debt, the inflation rate is invariant to the debt level, and it is perfectly stabilized at its deterministic steady state. Hence, the configuration with occasional policy regime shifts gives rise to a systematic inflation bias.

At the heart of the inflation bias is the central bank's willingness to accommodate its interest-rate policy to the fiscal stability goal when the latter is at risk. Figure 3 shows equilibrium responses to the cost-push shock in the fiscally-dominant regime

[7] While the contemporaneous cost-push shock is zero, agents take into account the risk associated with future shocks.

Figure 2: **Equilibrium responses to beginning-of-period government debt**



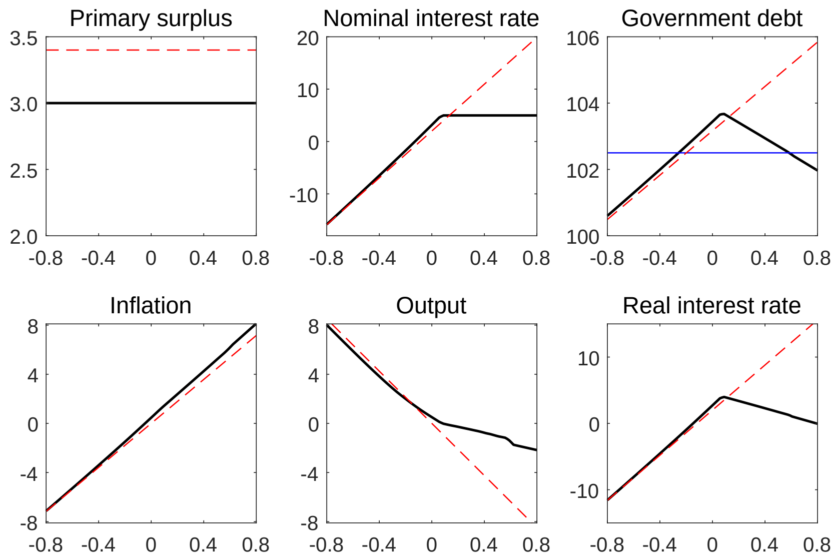
Solid black lines: policy configuration with regime shifts. Dashed red lines: benchmark configuration. The real interest rate is expressed in annualized percent. For the other variables see Figure 1. The vertical solid blue lines indicate the risky steady state. The thin dash-dotted blue line in the upper-right panel is the 45-degree line. The contemporaneous cost-push shock is set equal to zero.

(solid black lines). Beginning-of-period government debt is set to 103.5% of annualized steady-state output, above the debt threshold $\bar{b}$. In the fiscally-dominant regime, the central bank unequivocally lowers the policy rate in response to dis-inflationary shocks, but raises the policy rate only up to the upper bound in response to inflationary shocks. Hence, the real interest rate falls, both, in response to dis-inflationary and inflationary shocks. Consequently, inflation increases more in response to an inflationary shock than it declines in response to a dis-inflationary shock, i.e. the inflation response is asymmetric.

This asymmetric inflation profile impinges on private-sector expectations, and, therefore, on private-sector behavior in all states of the world. Consider again Figure 2 and suppose that the beginning-of-period government debt level is sufficiently low that the economy is in the orthodox regime. In this case, the mere possibility of a future shift to the fiscally-dominant regime puts upward pressure on inflation expectations, and, thereby, on actual inflation, see equation (2). Under conventional parameterizations of parameter α, the central bank does not fully counteract these inflationary pressures, so that an inflation bias arises in equilibrium.

Let us now try to understand why the inflation bias increases with the debt level. Recall that the economy switches from the orthodox policy regime to the fiscally-dominant regime when the real value of government debt crosses the threshold value $\bar{b}$ from below. While at period $t-1$ agents know with certainty the policy regime in period t, they are uncertain about the policy regime in periods $t+1, t+2, ...$ Let

Figure 3: **Equilibrium responses to cost-push shock in the fiscally-dominant regime**



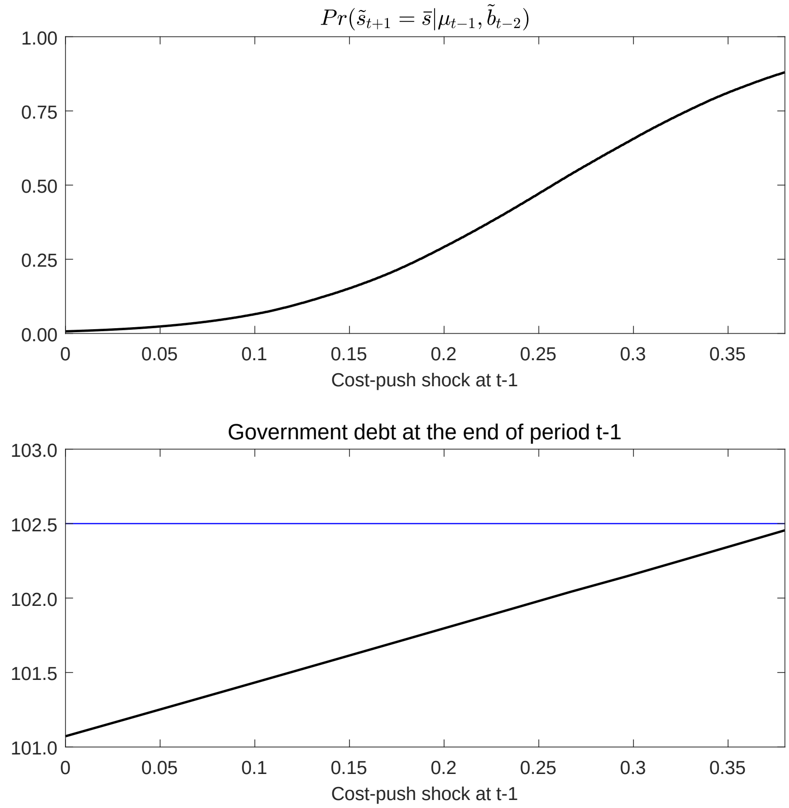
Solid black lines: policy configuration with regime shifts. Dashed red lines: benchmark configuration. Beginning-of-period government debt amounts to 103.5% of annualized steady-state output. The horizontal solid blue line in the upper-right panel indicates the debt threshold $\bar{b}$.

$Pr\left(\tilde{s}_{t+1} = \bar{s} | \mu_{t-1}, h^{\tilde{b}}(\mu_{t-1}, \tilde{b}_{t-2} < \bar{b}) < \bar{b}\right)$ be the probability of a shift to the fiscally-dominant regime in period $t+1$ given information available in period $t-1$, and conditional on the economy being in the orthodox policy regime in periods $t-1$ and t, i.e. $\tilde{b}_{t-1}, \tilde{b}_{t-2} < \bar{b}$. The top panel of Figure 4 plots $Pr\left(\tilde{s}_{t+1} = \bar{s} | \mu_{t-1}, h^{\tilde{b}}(\mu_{t-1}, \tilde{b}_{t-2} < \bar{b}) < \bar{b}\right)$ as a function of the cost-push shock at $t-1$ (μ_{t-1}) for a given level of beginning-of-period $t-1$ government debt ($\tilde{b}_{t-2}$). Details on the calculation are provided in the Appendix. The bottom panel plots the real value of government debt at the end of period $t-1$ ($\tilde{b}_{t-1}$). Government debt increases with the cost-push shock. In the orthodox policy regime the central bank raises the policy rate more than one for one with inflation, leading to an increase in debt servicing costs. Hence, the larger the cost-push shock μ_{t-1}, the smaller is the buffer between the debt threshold $\bar{b}$ (horizontal solid blue line in the bottom panel) and the real value of government debt at the end of period $t-1$. The smaller the fiscal buffer, the more likely it is that *future* cost-push shocks will lead to a regime shift. This, in turn, implies that the probability of a future shift towards the fiscally-dominant regime increases with the cost-push shock at $t-1$, as shown in the top panel. Agents internalize this link when forming expectations, implying that in equilibrium the inflation bias increases with the debt level and the cost-push shock.

A useful summary statistic capturing the effect of *regime change risk* on economic outcomes can be obtained by comparing the economy's deterministic and risky steady states (Hills et al., 2019).[8] The risky steady state, marked by the vertical blue lines in Fig-

[8] Hills et al. (2019) assess how the risk of a binding *lower* bound on nominal interest rates affects inflation

Figure 4: **State-dependent regime change risk**



Top panel: Probability of a shift to the fiscally-dominant regime in period $t+1$ given information available in period $t-1$ as a function of the cost-push shock at $t-1$, and conditional on the real value of end-of-period $t-2$ government debt being at the risky steady state. Bottom panel: The real value of end-of-period $t-1$ government debt as a function of the cost-push shock at $t-1$. The horizontal solid blue line indicates the debt threshold $\bar{b}$.

ure 2, is the point to which the economy converges when contemporaneous shocks have receded, but, unlike in case of the deterministic steady state, agents take into account the risk associated with *future* shocks, and, therefore, *future* regime shifts. Table 3 reports the deterministic steady state (first row) and the risky steady state (second row) for the baseline parameterization. Note that at the risky steady state, the economy is in the orthodox policy regime. In the risky steady state inflation is 27 basis points higher than in the deterministic steady state. In the orthodox policy regime, heightened inflation translates into a tighter monetary policy stance. The real interest rate is 41 basis points higher in the risky steady state than in the deterministic steady state. The tighter monetary policy stance attenuates the inflation bias, but it also depresses economic activity. In the risky steady state, output is 0.26 percentage points lower than in the deterministic steady state.

in states of nature where the lower bound constraint is not binding.

Table 3: **Deterministic and risky steady states**

	Inflation	Output	Real interest rate	Government debt
Deterministic steady state	0	0	2	100
Risky steady state	0.27	−0.26	2.41	101.07

Inflation and the real interest rate are expressed in annualized percent. Output is expressed in percentage deviations from the deterministic steady state. Government debt is expressed in percent of annualized steady state output.

3.3 From inflation bias to debt bias

Let us now turn to the fiscal side of the model. Figure 3 shows that in the fiscally-dominant regime monetary policy helps to stabilize government debt. Government debt falls in response to both, inflationary and dis-inflationary shocks. In case of inflationary shocks, the stabilizing effect of a rising inflation rate on the real value of government debt is accommodated by a non-increasing policy rate. In case of dis-inflationary shocks, the reduction in the policy rate more than compensates for the decline in inflation and lowers the real value of government debt. When the shock is sufficiently large in absolute magnitude, government debt declines sufficiently to trigger a shift to the orthodox policy regime in the *next* period. In the upper-right panel showing the equilibrium response of government debt, the threshold $\bar{b}$ is indicated by a horizontal solid blue line.

Next, consider the behavior of fiscal variables in the orthodox regime. At the risky steady state, the government debt to steady-state output ratio is 1.07 percentage points higher than in the deterministic steady state; see the last column in Table 3. This upward bias in government debt is a direct consequence of the elevated real interest rate in the risky steady state, which, in turn, emerges as a result of the inflation bias. Hence, the debt bias and the inflation bias are two sides of the same coin.

The link between inflation and government debt in the orthodox policy regime has features of a vicious cycle: A higher debt level begets a higher primary surplus and raises the risk of a future shift to the fiscally-dominant regime. The higher the risk of a shift to the fiscally-dominant regime, the larger is the inflation bias and, as a result of the monetary policy tightening, the real interest rate. A higher real interest rate, in turn, puts upward pressure on the debt level.

3.4 Can the central bank alleviate the inflation bias?

It may be tempting to conclude from the previous analysis that the central bank could have avoided the inflation bias if it had refrained from imposing a conditional upper bound on its policy rate. However, if the central bank had further raised its policy rate with no corresponding adjustment in the primary surplus, it would have put government solvency at risk, or, if it had continued to stand ready to buy government bonds, the price level would have risen anyway so as to realign the real value of government liabilities with the expected present discounted value of primary surpluses—an example of the "stepping on a rake" conundrum discussed in Sims (2011).[9]

Nevertheless, even if the central bank is occasionally forced to succumb its price stability goal to the fiscal sustainability goal, it may still be able to mitigate the inflation bias. The central bank can lower the risk of a shift towards the fiscally-dominant regime by responding *less* aggressively to inflation in normal times than implied by the baseline parameterization while still abiding by the Taylor principle. If the central bank raises the policy rate less aggressively in response to an inflationary shock, debt servicing costs will increase less and it will require larger inflationary shocks than under the baseline parameterization for the economy to shift from the orthodox regime to the fiscally-dominant regime. If the probability of a shift to the fiscally-dominant regime is small, then economic outcomes in the fiscally-dominant regime will have less of an effect on agents' expectations and decisions in the orthodox regime.

The first row of Table 4 reports the risky steady states of inflation and government debt, and the frequency of the fiscally-dominant regime when $\alpha = 1.5$ (compare to $\alpha = 2.5$ in the baseline parameterization). With the smaller response coefficient to inflation, the economy is only rarely shifting to the fiscally-dominant regime, and, consequently, the risky steady state of inflation is very close to the deterministic steady state. In the absence of a quantitatively meaningful inflation bias, there is also no government debt bias.

Table 4: **Additional results**

Extension	Riksy steady state		Frequency of fiscally-dominant regime	
	Inflation	Gov. debt	$\tilde{s}_t = \bar{s}$	$\tilde{s}_t = \bar{s}$ and $\hat{R}_t = \bar{R}$
Smaller Taylor rule coefficient	0.01	100.01	0	0
Distortionary taxation	0.59	101.61	29	16
Passive monetary policy	0.23	100.89	15	-

Notes: Inflation is expressed in annualized percent. Government debt is expressed in percent of annualized steady state output. The frequency of binding constraints is expressed in percent.

Remarkably, the reduction of the inflation bias does not come at the cost of higher inflation volatility. The standard deviation of annualized inflation is 1.93% when $\alpha = 2.5$, and 1.89% when $\alpha = 1.5\%$. Hence, the volatility-reducing effect from avoiding the fiscally-dominant regime in the case of $\alpha = 1.5$ more than offsets the volatility-enhancing effect of a less aggressive response to inflation.

How effective a reduction in α is in lowering the probability of policy regime shifts, however, is likely to depend on the type of shocks that buffet the economy. In the model used here, an inflationary cost-push shock raises the real value of government debt,

[9]See Barthelemy et al. (2021) for a game-theoretic analysis of monetary-fiscal policy interactions in an environment with government default.

and, hence, the probability of a shift to the fiscally-dominant regime only because of the monetary policy response to inflation. A reduction in α may have much less of an effect on the probability of a policy regime shift, and, hence, on the inflation bias once we consider other shocks. Consider, for instance, a fiscal shock. A fiscal shock has a direct impact on the government debt level, and, therefore, the probability of a regime shift, regardless of the interest-rate response to inflation.

4 Extensions

This section considers two modifications of the model. The first modification extends the model to include distortionary taxation. The second extension modifies the way in which monetary policy accommodates fiscal policy in the fiscally-dominant regime.

4.1 Distortionary taxation

Suppose that households pay taxes on their labor income. The labor income tax rate τ^L then shows up in the linearized Phillips curve, and we replace equation (2) with

$$\hat{\pi}_t = \beta \mathrm{E}_t \hat{\pi}_{t+1} + \kappa \left(\hat{y}_t + \frac{Y}{(1-\tau^L)(\sigma^{-1}+\eta)} \tilde{\tau}_t^L \right) + \mu_t, \tag{7}$$

where $\tilde{\tau}_t^L \equiv (\tau_t^L - \tau^L)/Y$.

Suppose, furthermore, that the government adjusts the labor income tax rate, rather than lump-sum taxes and transfers, in response to fluctuations in government debt. We thus replace the surplus rule (5) with the following labor income tax rule

$$\tilde{\tau}_t^L = \min \left(\phi \tilde{b}_{t-1}, \bar{\tau}^L \right), \tag{8}$$

where $\bar{\tau}^L > 0$. In the spirit of the baseline model, I will refer to the policy configuration where $\tilde{\tau}_t^L < \bar{\tau}^L$ as the orthodox policy regime, and to the configuration where $\tilde{\tau}_t^L = \bar{\tau}^L$ as the fiscally-dominant regime.

In addition to labor income taxes, the government continues to levy lump-sum taxes. Lump-sum taxes consist of two components. The first component is time-varying and finances an employment subsidy that offsets the distortions from monopolistic competition and distortionary taxation in the deterministic steady state so as to facilitate comparison with the baseline model in Section 2. The second component is constant, and negative, allowing me to choose a plausible steady-state labor income tax rate. With these assumptions, the primary surplus equals

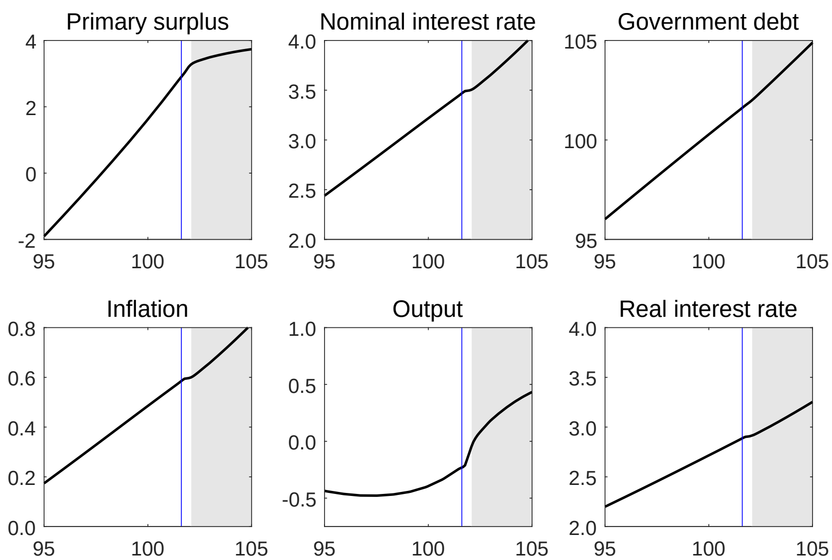
$$\tilde{s}_t = \frac{Y}{(1-\tau^L)^2} \tilde{\tau}_t^L + \frac{\tau^L}{1-\tau^L} \left(1 + \sigma^{-1} + \eta \right) \hat{Y}_t. \tag{9}$$

Where applicable, I use the same parameterization as for the baseline model (see Table

1). I set the steady-state labor income tax rate τ^L equal to 24% and the upper limit to 25%.[10]

The second row of Table 4 reports the risky steady states of inflation and government debt, and the frequency of the fiscally-dominant regime. As in the baseline setup, the model gives rise to an inflation bias and a government debt bias. At the risky steady state, the annualized inflation rate is 0.59 percentage points above the deterministic steady state. The economy is in the fiscally-dominant regime in 29% of the simulated periods, and in 16% of the periods the conditional upper bound on the nominal interest rate is binding.

Figure 5: **Equilibrium responses to lagged government debt - distortionary taxation**



Notes: The real interest rate is expressed in annualized percent. For the other variables see Figure 1. The vertical solid blue lines indicate the risky steady state. The contemporaneous cost-push shock is set equal to zero.

Figure 5 shows the equilibrium responses to government debt when the cost-push shock is fixed at zero. The responses are similar to those in Figure 2, except that the primary surplus keeps rising with beginning-of-period government debt in the fiscally-dominant regime. That is because the upper limit is imposed on the labor income tax rate rather than on the primary surplus. The latter is not only a function of the tax rate, but also of output, see equation (9). Output is increasing with beginning-of-period government debt, because a higher debt level makes it more likely that the upper bound on the nominal interest rate becomes binding and the real interest rate declines.

[10] I assume that the constant component of lump-sum taxes equals $T^A/Y = -0.3$ so that the primary surplus equals 2% of steady state output as in the baseline model. Note that $S = \tau^L wY + T^A$, where w is the steady-state real wage rate. With the appropriate employment subsidy in place, it holds $w = 1/(1-\tau^L)$. I map the surplus limit from the baseline model into a limit for the labor income tax rate as follows $\bar{\tau}^L = \bar{s}/(wY) = 0.0076$.

4.2 Passive monetary policy in the fiscally-dominant regime

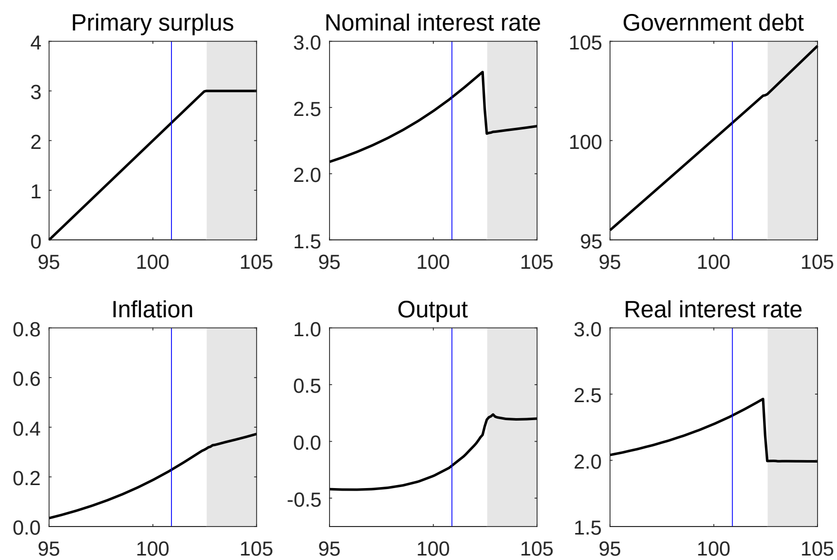
Suppose that, instead of imposing an upper bound on the nominal interest rate, the central bank switches to a passive interest-rate rule when the economy is in the fiscally-dominant regime. We replace monetary policy rule (6) with

$$\hat{r}_t = \begin{cases} \alpha \hat{\pi}_t & \text{if } \tilde{s}_t < \bar{s} \\ \alpha_F \hat{\pi}_t & \text{else,} \end{cases} \tag{10}$$

where $\alpha > 1/\beta$, as before, and $\alpha_F < 1$. I set $\alpha_F = 0.95$, and keep all parameter values from the baseline model unchanged (see Table 1). The third row of Table 4 reports the results. The inflation bias and the debt bias are somewhat smaller, and the frequency of the economy being in the fiscally-dominant regime is lower than under the baseline setup.

Figure 6 shows the equilibrium responses to beginning-of-period government debt when the contemporaneous cost-push shock is set to zero. The nominal interest rate in-

Figure 6: **Equilibrium responses to lagged government debt - passive monetary policy**



Notes: The real interest rate is expressed in annualized percent. For the other variables see Figure 1. The vertical solid blue lines indicate the risky steady state. The contemporaneous cost-push shock is set equal to zero.

creases with beginning-of-period government debt in the orthodox regime, jumps down when switching to the fiscally-dominant regime, and increases with beginning-of-period debt in the fiscally-dominant regime, although at a slower pace than in the orthodox regime. As in the baseline model, inflation is systematically positive and increasing in the real value of beginning-of-period government debt.

5 Conclusion

Monetary and fiscal policy are intricately interlinked. If the fiscal authority is limited in its willing or ability to raise primary surpluses, the central bank may be forced to occasionally subordinate the goal of price stability to the goal of fiscal stability. I show that such a policy configuration may deal a blow to price stability more generally.

The analysis presented in this paper is primarily conceptual in nature, using a simple model of the macro economy to shed light on the key mechanisms behind the inflation bias arising from the considered monetary-fiscal interactions. Extending the analysis to a full-fledged quantitative model with multiple shocks is an interesting endeavor for future work.

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Appendix

A Solution algorithm

I solve the model using the collocation method. For the basis functions I use linear splines. The algorithm proceeds in the following steps:

1. Construct the collocation nodes. Use a Gaussian quadrature scheme to discretize the normally distributed innovation to the cost-push shock. Form a guess for the basis coefficients.

2. Use the current guess for the basis coeffcients to approximate the expectation terms.

3. Solve the system of equilibrium conditions at the collocation nodes for the jump variables assuming that the economy is in the orthodox policy regime. For those nodes where the upper limit on the primary surplus is violated, solve the equilibrium conditions associated with the fiscally-dominant regime. For those nodes where the conditional upper bound on the policy rate is violated, solve the equilibrium conditions associated with the fiscally-dominant regime and a binding upper bound on the policy rate.

4. Update the guess for the basis coeffcients. If the new guess is suffciently close to the old one, the algorithm has converged. Otherwise, go back to step 2.

The collocation nodes have a support covering $\pm$ 4 unconditional standard deviations of the cost-push shock. I use MATLAB routines from the CompEcon toolbox of Miranda and Fackler (2002) to obtain the Gaussian quadrature approximation of the innovations to the exogenous shocks, and to evaluate the basis functions.

B Probability of policy regime shift

We can characterize the probability of a future shift from the orthodox policy regime to the fiscally-dominant policy regime as follows. Let $Pr\left(\tilde{s}_{t+1} = \bar{s} | \mu_{t-1}, h^{\tilde{b}}(\mu_{t-1}, \tilde{b}_{t-2} < \bar{b}) < \bar{b}\right)$ be the probability of the economy shifting to the fiscally-dominant regime in period $t+1$ given information available in period $t-1$, and conditional on the economy being in the orthodox policy regime in periods $t-1$ and t, $\tilde{b}_{t-2}, \tilde{b}_{t-1} < \bar{b}$. For $\tilde{b}_{t-1} < \bar{b}$, the function $h^{\tilde{b}}(\mu_t, \tilde{b}_{t-1})$ is increasing in the innovation to the cost-push shock ϵ_t.[11] Hence, the solution to

$$\underset{\epsilon_t}{\operatorname{argmin}}\, h^{\tilde{b}}\left(\rho\mu_{t-1} + \epsilon_t, h^{\tilde{b}}(\mu_{t-1}, \tilde{b}_{t-2})\right) \text{ s.t. } \tilde{b}_t \geq \bar{b}, \tilde{b}_{t-1}, \tilde{b}_{t-2} < \bar{b} \tag{B.1}$$

[11]This is not necessarily the case for $\tilde{b}_{t-1} > \bar{b}$. In the fiscally-dominant regime, the equilibrium response of government debt to the cost-push shock is non-monotonic. See Figure 3.

gives us the smallest innovation to the cost-push shock that triggers a shift from the orthodox to the fiscally-dominant policy regime. The probability of a shift from the orthodox regime in period t to the fiscally-dominant regime in period $t+1$ given information available in period $t-1$ then is

$$Pr\left(\tilde{s}_{t+1} = \bar{s} | \mu_{t-1}, h^{\tilde{b}}(\mu_{t-1}, \tilde{b}_{t-2} < \bar{b}) < \bar{b}\right) = 1 - F_{\epsilon}(\epsilon^{*}), \tag{B.2}$$

where ϵ^{*} is the solution to (B.1), and $F_{\epsilon}(\cdot)$ is the cumulative distribution function of ϵ.