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

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Abstract

What are the macroeconomic consequences of a government 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? I address this question in a dynamic stochastic sticky-price model with 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. This inflation bias is increasing in the real value of government debt. Regime-switching probabilities are not invariant to policy. The central bank can attenuate the risk of a shift to the fiscally-dominant regime by raising the real interest rate sufficiently moderately when inflation increases. Lower fiscal dominance risk, in turn, mitigates the inflation bias.

Keywords: monetary policy, fiscal policy, fiscal dominance, inflation bias, endogenous regime shifts (*JEL*: E31, E52, E62, E63)

Non-technical summary

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 government debt levels which, already at elevated levels, had risen sharply after the outbreak of the COVID-19 pandemic. 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). What would be the economic consequences if central banks gave in to such pressures? Can the goal of price stability occasionally take a back seat without jeopardizing price stability more generally? And, if not, what, if anything, can central banks do to preserve price stability without putting fiscal stability at risk?

I address these questions in a dynamic stochastic sticky-price model that gives rise to *endogenous* policy regime shifts. The public sector consists of a fiscal authority and a central bank. Fiscal policy is governed by a feedback rule for the primary surplus with an upper limit. When the real value of government debt is sufficiently low, an increase in the debt level begets an increase in the primary surplus and vice versa. Monetary policy focuses on its price stability goal and sets the policy rate according to a conventional Taylor rule. That is the "orthodox" policy regime. When government debt is high, the surplus limit binds. An increase in the debt level does not beget a rise in the primary surplus. The central bank, worried about the implications of high interest rates for fiscal stability, deviates from the conventional Taylor rule and—in the spirit of the concerns echoed by Weidmann—keeps the policy rate below some upper bound. That is when the economy is in the "fiscally-dominant" regime.[1]

In the model, the *occasional* subordination of the goal of price stability to the goal of fiscal stability results 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. The size of the *inflation bias* increases with the real value of government debt.

Suppose that the primary 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 public debt is high to begin with and the inflationary shock is sufficiently large, 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 generically 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

[1] Sargent (1982) defines "fiscal dominance" as a policy configuration where "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".

real interest rate declines, both, when the economy is hit by a deflationary shock and when it is hit by a (sufficiently large) inflationary shock. A lower real interest rate relaxes the fiscal authority's debt burden—the central bank helps to maintain fiscal stability. At the same time, the asymmetric monetary policy gives rise to an asymmetric inflation response. Inflation increases more in response to an inflationary shock than it declines in response to a deflationary shock of the same magnitude.

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 link between inflation and government debt has features of a vicious cycle: A higher debt level, ceteris paribus, raises the risk of a 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.

Hence, we are left with the final question raised at the outset of the paper—is there anything the central bank can do to preserve price stability or at least mitigate the inflation bias without putting fiscal stability at risk? According to the model, the answer is yes. Since policy regime shifts arise endogenously, the probability of a regime shift is not invariant to policy. A central bank can reduce the risk of a shift to the fiscally-dominant regime by responding more *moderately* to inflation in normal times while making sure to abide by the Taylor principle consistent with its price stability goal. A more moderate nominal interest rate response to inflation implies that real interest rates will increase less in the wake of an inflationary shock, thereby mitigating the fiscal consequences of the monetary policy tightening. A lower risk of shifting to the fiscally-dominant regime helps to anchor inflation expectations at the central bank's target. The inflation bias shrinks accordingly, and may even disappear. In addition, inflation volatility may decline. While a more modest response to inflation, ceteris paribus, increases inflation volatility, lowering the risk of fiscal dominance reduces inflation volatility. I show that the second effect may dominate in equilibrium.

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 government debt levels which, already at elevated levels, had risen sharply after the outbreak of the COVID-19 pandemic.[2] 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).[3] What would be the economic consequences if central banks gave in to such pressures? Can the goal of price stability occasionally take a back seat without jeopardizing price stability more generally? And, if not, what, if anything, can central banks do to preserve price stability without putting fiscal stability at risk?

I address these questions in a dynamic stochastic sticky-price model that gives rise to *endogenous* policy regime shifts. The public sector consists of a fiscal authority and a central bank. Fiscal policy is governed by a feedback rule for the primary surplus with an upper limit. When the real value of government debt is sufficiently low, an increase in the debt level begets an increase in the primary surplus and vice versa. Monetary policy focuses on its price stability goal and sets the policy rate according to a conventional Taylor rule. That is the "orthodox" policy regime. When government debt is high, the surplus limit binds. An increase in the debt level does not beget a rise in the primary surplus. The central bank, worried about the implications of high interest rates for fiscal stability, deviates from the conventional Taylor rule and—in the spirit of the concerns echoed by Weidmann—keeps the policy rate below some upper bound. That is when the economy is in the "fiscally-dominant" regime.[4]

In the model, the *occasional* subordination of the goal of price stability to the goal of fiscal stability results 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. The size of the *inflation bias* increases with the real value of government debt.

Suppose that the primary 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 public debt is high to begin with and the inflationary shock is sufficiently large, 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 generically

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

[3] See also Goodhart (2020). 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).

[4] Sargent (1982) defines "fiscal dominance" as a policy configuration where "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".

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 real interest rate declines, both, when the economy is hit by a deflationary shock and when it is hit by a (sufficiently large) inflationary shock. A lower real interest rate relaxes the fiscal authority's debt burden—the central bank helps to maintain fiscal stability. At the same time, the asymmetric monetary policy gives rise to an asymmetric inflation response. Inflation increases more in response to an inflationary shock than it declines in response to a deflationary shock of the same magnitude.

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 link between inflation and government debt has features of a vicious cycle: A higher debt level, ceteris paribus, raises the risk of a 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.

Hence, we are left with the final question raised at the outset of the paper—is there anything the central bank can do to preserve price stability or at least mitigate the inflation bias without putting fiscal stability at risk? According to the model, the answer is yes. Since policy regime shifts arise endogenously, the probability of a regime shift is not invariant to policy. A central bank can reduce the risk of a shift to the fiscally-dominant regime by responding more *moderately* to inflation in normal times while making sure to abide by the Taylor principle consistent with its price stability goal. A more moderate nominal interest rate response to inflation implies that real interest rates will increase less in the wake of an inflationary shock, thereby mitigating the fiscal consequences of the monetary policy tightening. A lower risk of shifting to the fiscally-dominant regime helps to anchor inflation expectations at the central bank's target. The inflation bias shrinks accordingly, and may even disappear. In addition, inflation volatility may decline. While a more modest response to inflation, ceteris paribus, increases inflation volatility, lowering the risk of fiscal dominance reduces inflation volatility. I show that the second effect may dominate in equilibrium.

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. Several subsequent studies consider the possibility of occasional shifts in monetary and fiscal policy regimes (e.g. Davig and Leeper, 2006; Chung et al., 2007; Bianchi and Melosi, 2017, 2019; 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 macroeconomic outcomes, regime change risk, and policy.[5] Finally, while in the present paper the central bank relaxes the fiscal authority's debt burden in the fiscally-dominant regime by implementing a sufficiently low real interest rate, there are, in principle, other means by which the central bank could attempt to attenuate fiscal stability risks. Reis (2019) provides a comprehensive discussion of some of these alternative policies.

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

$$\hat{y}_t = \mathrm{E}_t\hat{y}_{t+1} - \sigma\left(\hat{R}_t - \mathrm{E}_t\hat{\pi}_{t+1}\right) \tag{1}$$

$$\hat{\pi}_t = \beta\mathrm{E}_t\hat{\pi}_{t+1} + \kappa\hat{y}_t + \mu_t, \tag{2}$$

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.[6]

The cost-push shock follows a stationary autoregressive process

$$\mu_t = \rho\mu_{t-1} + \epsilon_t, \tag{3}$$

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.

[5] Davig and Leeper (2008) study endogenous changes in monetary policy rules. They do not consider fiscal policy.

[6] 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 elasticity of demand.

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

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

where b_t denotes the real value of one-period nominal government bonds at the end of period t, and s_t is the real primary budget surplus.[7] 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 $1 > \phi > 1 - \beta$; in the terminology of Leeper (1991), fiscal policy is (locally) passive when the economy is in the orthodox regime.[8]

The central bank sets the one-period nominal interest rate, also referred to as the policy rate, and has a price stability goal. When the surplus limit is not binding, interest-rate policy is governed by a standard Taylor rule. When, instead, the government debt burden is sufficiently high that 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—the price stability goal takes a back seat. 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.[9] Notice that while the central bank adjusts its policy *rule* when the economy switches from the orthodox to the fiscally-dominant regime, the regime shift does not necessarily have an immediate effect on the central bank's interest-rate *response* to inflation for as long as $\hat{R}_t < \bar{R}$, the central bank continues to raise the policy rate more than one-for-one with inflation.[10]

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

[8] I restrict attention to the empirically plausible case of $\phi < 1$, so that end-of-period government debt is an increasing function of beginning-of-period government debt.

[9] 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.

[10] Hence, one could, alternatively, think of the monetary-fiscal configuration as giving rise to three regimes. The orthodox regime, a "conflicting" regime that arises when $\tilde{s}_t = \bar{s}$ and $\hat{R}_t < \bar{R}$, and the fiscally-dominant regime

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). Suppose, the economy is in the fiscally-dominant regime. Then, $\tilde{s}_t = \bar{s}$, and $\tilde{b}_{t-1} \geq \bar{b}$, where $\bar{b} \equiv \bar{s}/\phi$. When $\tilde{b}_{t-1} > \bar{s}/(1-\beta) > \bar{b}$ and $\hat{R}_t - \hat{\pi}_t/\beta \geq 0$, the debt burden keeps growing. Monetary policy rule (6) puts an effective upper bound on the inflation-adjusted policy rate $\hat{R}_t - \hat{\pi}_t/\beta$. When $\tilde{s}_t = \bar{s}$,

$$\hat{R}_t - \hat{\pi}_t/\beta \leq \frac{\alpha - 1/\beta}{\alpha}\bar{R}. \tag{7}$$

While the upper bound on the inflation-adjusted policy rate is strictly positive, both, deflationary *and inflationary* shocks can push the inflation-adjusted policy rate below the upper bound and into negative territory, so as to relax the government's debt burden.

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.

2.3 Equilibrium, parameterization and solution

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), (4)-(6) and the household's transversality condition hold for all $t \geq 0$.

While the primary objective of this paper is to provide a qualitative assessment of the model, I have to solve the model numerically. Table 1 reports the baseline parameterization. One period corresponds to one quarter. The assigned parameter values for the private-sector block are standard. A discount factor of 0.995 is tantamount to an annualized steady-state interest rate of 2%. The intertemporal elasticity of substitution σ equals unity, and the slope coefficient of the Phillips curve κ equals 0.0093.

Turning to the public-sector block, I set the response coefficient on inflation in the Taylor rule to 2.5, and the response coefficient on government debt in the fiscal rule 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, consistent with the idea that fiscal space is limited due to the high government debt burden, 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

with $\hat{R}_t = \bar{R}$. I am grateful to Huixin Bi for pointing this out. For ease of exposition, I stick to the two-regime perspective in the remainder of the paper.

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

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.[11]

3 Results

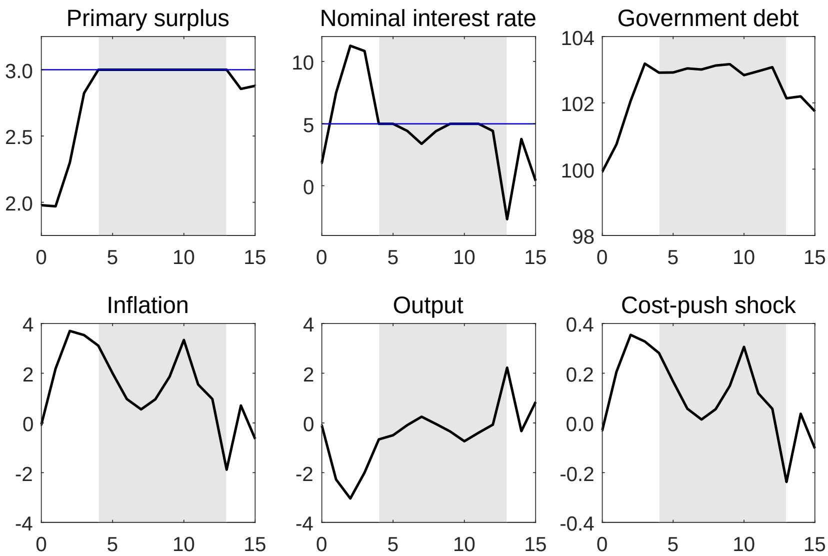
First, I show how the model gives rise to endogenous policy regime shifts. Then I explore how the policy regimes, and the state-dependent risk of a regime shift, impinge on the macro economy. Finally, I discuss how the central bank can mitigate the macroeconomic consequences of fiscal dominance risk.

3.1 Endogenous policy regime shifts

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

[11]The existence of a finite, sufficiently low $\bar{R}$ matters. If I solve the system of equations (1) - (6) with $\bar{R} \to \infty$, i.e. assuming that the central bank always follows a standard Taylor rule, then the real value of government debt explodes along some simulation paths, violating the transversality condition. If, instead, $\bar{R}$ is finite and sufficiently low, government debt remains stable in the model simulations.

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).

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

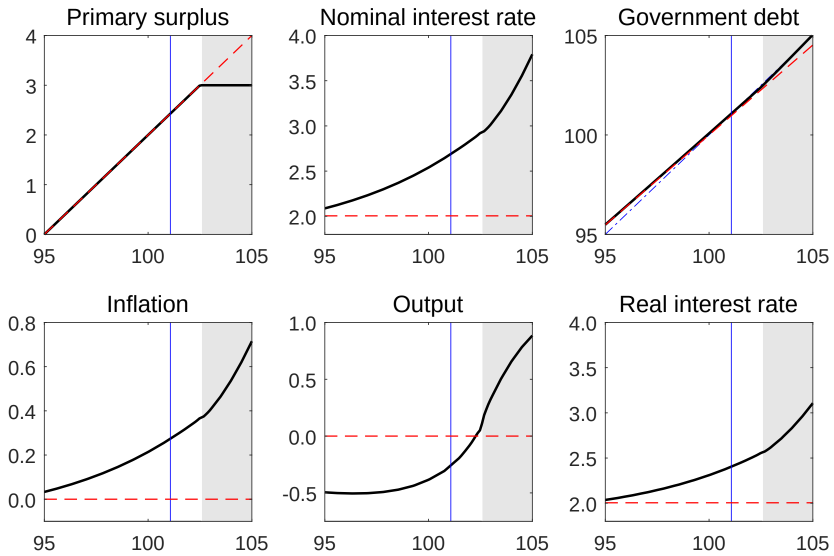
Based on 3000 simulations over 1100 quarters. For each simulation the observations corresponding to the first 100 quarters are discarded.

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 State-dependent 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).[12] When beginning-of-period government debt is higher than the threshold

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.

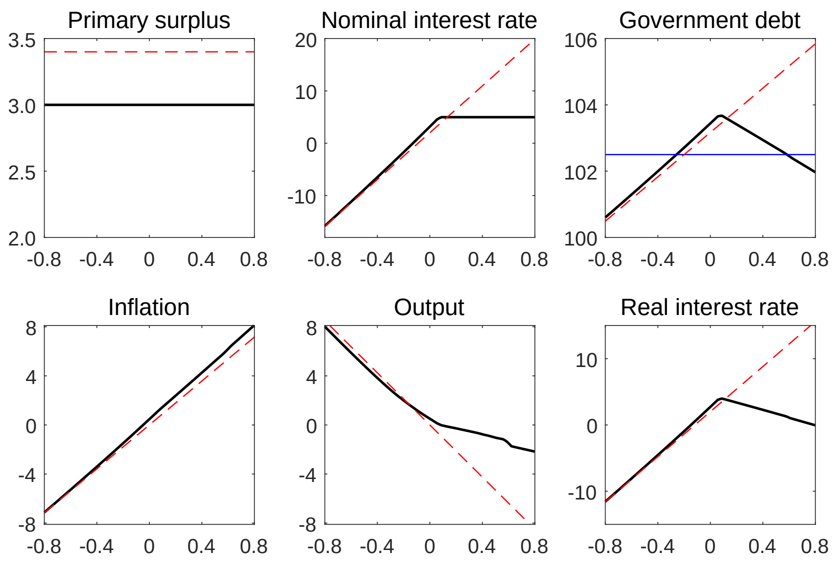
$\bar{b}$, the economy is in the fiscally-dominant policy regime (gray-shaded area), and it is in the orthodox policy regime (non-shaded area) otherwise.

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 (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. This asymmetric monetary policy

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

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 $\bar{b}$.

response has a stabilizing effect on government debt. The real value of government debt falls, both, in response to dis-inflationary and inflationary shocks.[13] At the same time, the asymmetric monetary policy translates into an asymmetric inflation response. Inflation increases more in response to an inflationary shock than it declines in response to a dis-inflationary shock of the same size.

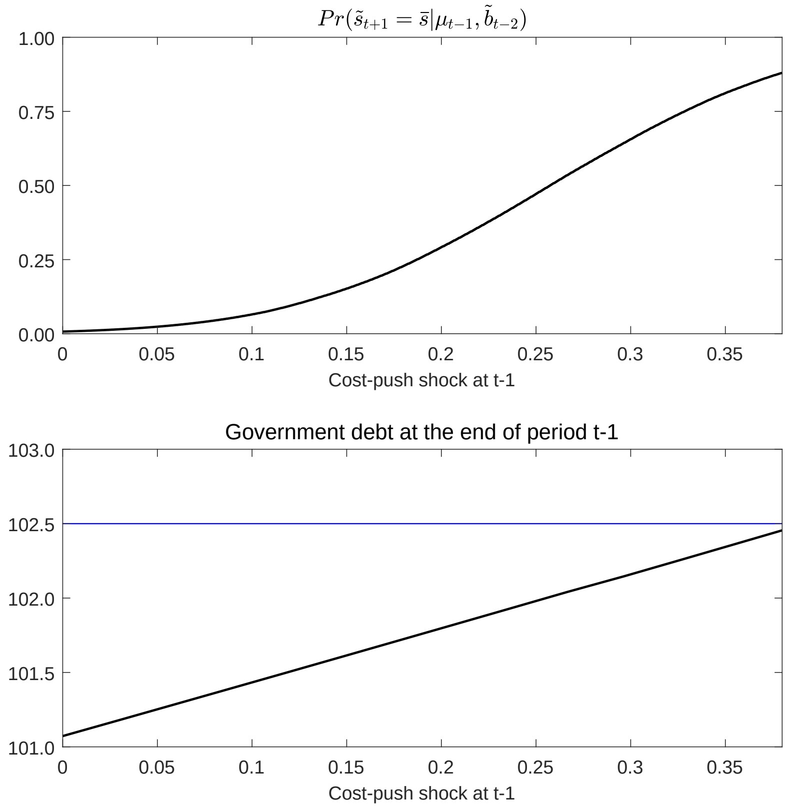
This asymmetric inflation profile impinges on private-sector expectations, and, therefore, on private-sector behavior in all states of the world. Consider again Figure 2 and suppose that the beginning-of-period government debt level is sufficiently low that the economy is in the orthodox regime. In this 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 regimes in periods $t+1, t+2, ...$ 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 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-

[13]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.

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

Figure 4: **State-dependent fiscal dominance 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 $\bar{b}$.

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).[14] The risky steady state, marked by the vertical blue lines in Figure 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

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.

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, and raises debt servicing costs. In the risky steady state, output is 0.26 percentage points lower, and the government debt to steady-state output ratio is 1.07 percentage points higher, than in the deterministic steady state.

3.3 Preserving price stability without jeopardizing fiscal stability

Can the central bank counteract the inflation bias without jeopardizing fiscal stability? If the central bank had simply refrained from imposing a conditional upper bound on its policy rate, and had further raised its policy rate with no corresponding adjustment in the primary surplus, it would have put fiscal stability at risk.[15]

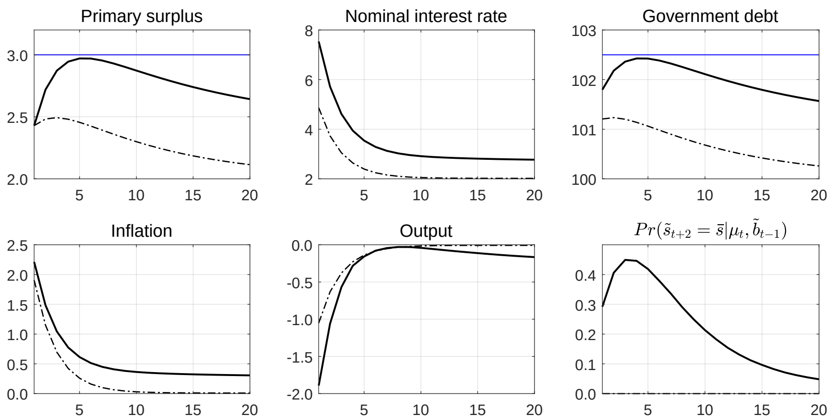
However, the central bank is not impotent. Unlike in exogenous regime-switching models, in the present model it can influence the *probability* of a shift to the fiscally-dominant regime. In particular, the central bank can lower the risk of a shift towards the fiscally-dominant regime by responding *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.

[14] Hills et al. (2019) assess how the risk of a binding *lower* bound on nominal interest rates affects inflation in states of nature where the lower bound constraint is not binding.

[15] Barthelemy et al. (2021) provide a game-theoretic analysis of monetary-fiscal policy interactions in an environment with government default. See also footnote 11.

Figure 5 shows impulse responses to an inflationary cost-push shock of one unconditional standard deviation for the baseline parameterization of the monetary policy rule ($\alpha = 2.5$, solid black lines) and for the case with a smaller response coefficient on inflation ($\alpha = 1.5$, dash-dotted black lines).[16] In both cases, I set the real value of government debt prior to the occurrence of the shock equal to the risky steady state of the baseline parameterization. Hence, both economies start from the same debt level. Although the central bank responds less aggressively to inflation under the alternative parameterization, inflation remains lower than under the baseline parameterization. The lower-right panel plots the probability of a shift towards the fiscally-dominant regime in period $t + 2$ conditional on information available in period t. Whereas this measure of fiscal dominance risk increases to more than 40% under the baseline parameterization, it remains zero under the alternative parameterization.

Figure 5: **Impulse responses to a cost-push shock**



Solid black lines: baseline parameterization. Dash-dotted black lines: smaller Taylor rule response coefficient on inflation. The initial government debt level is set equal to the risky steady state of the baseline parameterization (see Table 3). The horizontal solid blue lines in the upper-left and upper-right panels indicate the primary surplus limit $\bar{s}$ and the debt threshold $\bar{b}$, respectively.

The first row of Table 4 reports the risky steady states of inflation and government debt, and the frequency of the fiscally-dominant regime for the alternative parameterization. Consistent with the impulse responses, 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.

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.

Figure 6 provides a more systematic assessment of this trade-off, showing how household welfare (solid black line, left axis) and the frequency of the fiscally-dominant regime (solid blue line, right axis) vary with the monetary policy response coefficient α. The welfare measure results from a linear-quadraric approximation to the representative household's expected

[16]The responses are shown in levels, or, in case of output, in deviation from the deterministic steady state, rather than in deviation from the risky steady state.

Table 4: **Additional results**

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

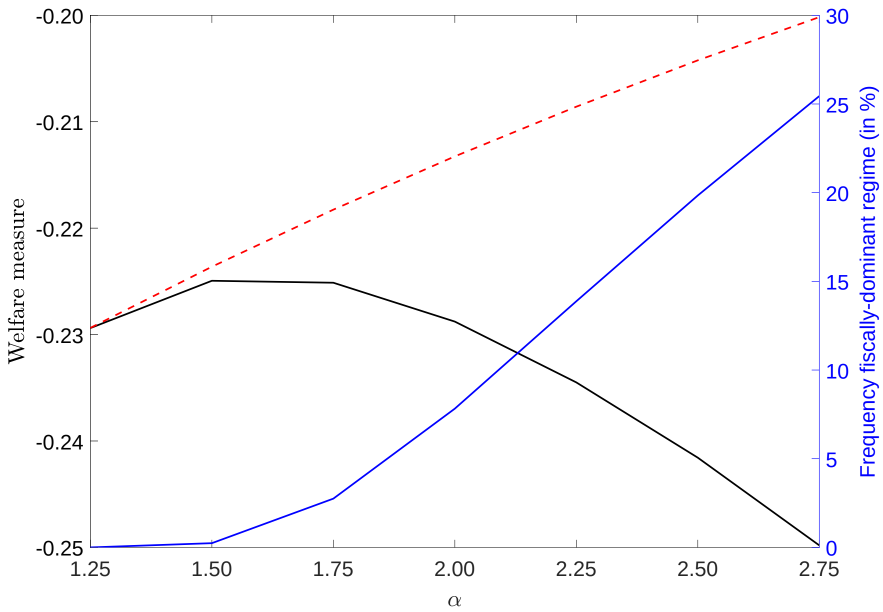
Inflation is expressed in annualized percent. The frequency of binding constraints is expressed in percent.

lifetime utility

$$W = -\mathrm{E}\left(\hat{\pi}_t^2 + \lambda \hat{y}_t^2\right), \tag{8}$$

where $\lambda = \kappa/\theta$.[17] A large response coefficient on inflation, e.g. $\alpha = 2.75$, is associated

Figure 6: **Optimal response coefficient on inflation**



Solid black line: welfare under policy configuration with regime shifts (left axis). Dashed red line: welfare under benchmark policy configuration (left axis). Solid blue line: frequency of the fiscally-dominant regime under configuration with regime shifts (right axis). The welfare measure is defined in equation (8).

with a high frequency of the fiscally-dominant regime. In this case, there is a welfare gain from lowering the response coefficient so as to reduce the frequency of the fiscally-dominant regime. For a sufficiently low response coefficient on inflation, e.g. $\alpha = 1.5$, the risk of fiscal dominance is negligible, and (further) lowering the response coefficient raises inflation volatility and reduces welfare. These welfare implications are very different from those of the benchmark policy configuration (dashed red line, left axis). When the primary surplus

[17]See Woodford (2003) for details. Here, I focus on unconditional welfare.

always responds to variations in government debt and the central bank always focuses on price stability, welfare falls monotonically as we lower α from 2.75 to 1.25.[18]

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

$$\hat{\pi}_t = \beta \mathrm{E}_t \hat{\pi}_{t+1} + \kappa \left(\hat{y}_t + \frac{Y}{(1-\tau^L)(\sigma^{-1}+\eta)} \tilde{\tau}_t^L \right) + \mu_t, \tag{9}$$

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

$$\tilde{\tau}_t^L = \min \left(\phi \tilde{b}_{t-1}, \bar{\tau}^L \right), \tag{10}$$

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

$$\tilde{s}_t = \frac{Y}{(1-\tau^L)^2} \tilde{\tau}_t^L + \frac{\tau^L}{1-\tau^L} \left(1 + \sigma^{-1} + \eta \right) \hat{Y}_t. \tag{11}$$

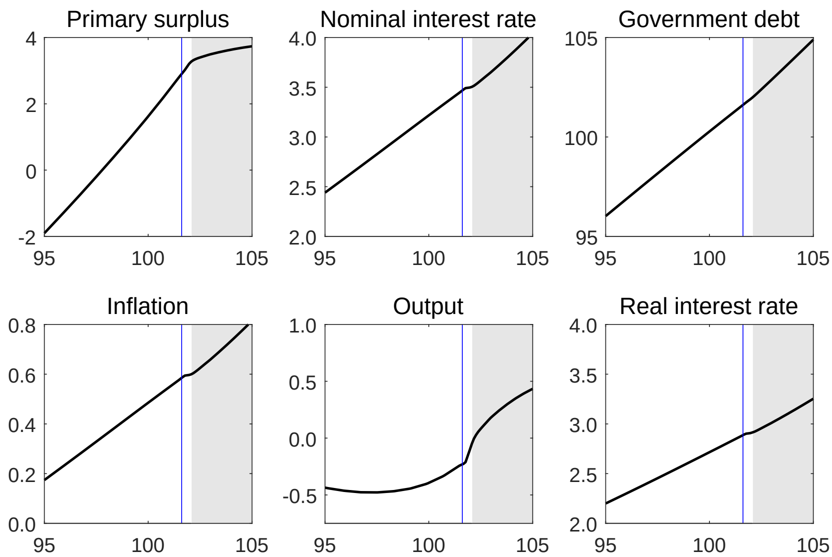
Where applicable, I use the same parameterization as for the baseline model (see Table 1). I set the steady-state labor income tax rate τ^L equal to 24% and the upper limit to 25%.[19]

[18]Under the benchmark policy regime, the presence of cost-push shocks gives rise to a policy trade-off between inflation and output gap stabilization. Hence, there exists an interior solution for the optimal value of α, which, however, is larger than 2.75.

[19]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 $\bar{\tau}^L = \bar{s}/(wY) = 0.0076$.

The second row of Table 4 reports the risky steady state of inflation, and the frequency of the fiscally-dominant regime. As in the baseline setup, the model gives rise to an inflation 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 7: **Equilibrium responses to lagged government debt - distortionary taxation**



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 7 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 (11). 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.

4.2 Passive monetary policy in the fiscally-dominant regime

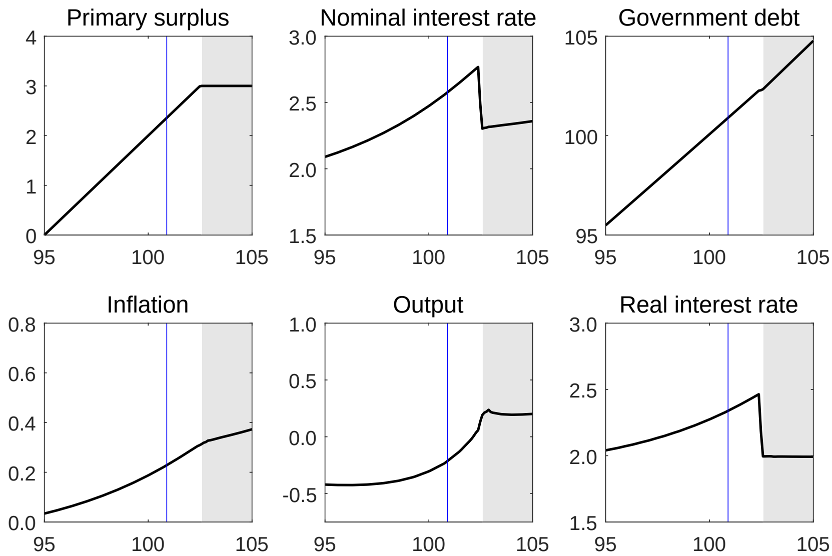
Suppose that, instead of imposing an upper bound on the nominal interest rate, the central bank switches to a passive interest-rate rule when the economy is in the fiscally-dominant regime. We replace monetary policy rule (6) with

$$\hat{r}_t = \begin{cases} \alpha \hat{\pi}_t & \text{if } \tilde{s}_t < \bar{s} \\ \alpha_F \hat{\pi}_t & \text{else,} \end{cases} \tag{12}$$

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 is somewhat smaller, and the frequency of the economy being in the fiscally-dominant regime is lower than under the baseline setup.

Figure 8 shows the equilibrium responses to beginning-of-period government debt when the contemporaneous cost-push shock is set to zero. The nominal interest rate increases with

Figure 8: **Equilibrium responses to lagged government debt - passive monetary policy**



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.

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

What are the macroeconomic consequences of a government that is limited in its willingness or ability to raise primary surpluses, and a central bank that accommodates its policy to the fiscal conditions? I addressed this question in a dynamic stochastic general equilibrium model with sticky prices that gives rise to *endogenous* policy regime shifts. I showed that fiscal dominance risk begets an inflation bias that is increasing in the real value of government debt.

Regime change risk is, however, not invariant to policy. Both, the risk of a shift to the fiscally-dominant regime and the inflation bias can be mitigated if the central bank responds sufficiently moderately to inflation without violating the Taylor principle, i.e. without giving up on its price stability goal. Two caveats are in order. First, in the model, agents have perfect knowledge of the central bank's policy rule. In practice, the private sector may misinterpret a moderate response to inflation as a violation of the Taylor principle and may question the central bank's price stability goal. Second, in the model, the fiscal authority's policy rule is invariant to the central bank's policy rule, whereas in practice the fiscal authority could be tempted to exploit, and, thereby, (partly) undo the central bank's attenuation of fiscal dominance risk.

The analysis presented in this paper was primarily conceptual in nature. 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.[20] Hence, the solution to

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

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

[20] 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.

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

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

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