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Simple Monetary Rules under Fiscal Dominance

This paper asks whether interest rate rules that respond aggressively to inflation, following the Taylor principle, are feasible in countries that suffer from fiscal dominance. We find that if interest rates are allowed to also respond to government debt, they can produce unique equilibria. But such equilibria are associated with extremely volatile inflation. The resulting frequent violations of the zero lower bound make such rules infeasible. Even within the set of feasible rules the welfare optimizing response to inflation is highly negative. The welfare gain from responding to government debt is minimal compared to the gain from eliminating fiscal dominance.

JEL codes: E61, E62
Keywords: optimal simple policy rules, fiscal dominance.

> "A central bank charged with maintaining price stability cannot be indifferent as to how fiscal policy is determined" (Woodford 2001). "Ideally, where fiscal policy that undermines central bank control of inflation is a real possibility, this should be accounted for, discussed in inflation reports, and reflected in central bank projections" (Sims 2005).

IS A MONETARY authority's commitment to fighting inflation aggressively a sufficient condition for ensuring price stability? It has long been held that the answer to this question should be negative. The reason is that the central

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bank's inflation objective may collide with an inflexible, or dominant, stance of fiscal policy that is unable or unwilling to adjust primary surpluses to stabilize government debt. Fiscal dominance was analyzed by Sargent and Wallace (1981) in an economy with real debt, where an unrealistic inflation objective leads to insufficient seigniorage revenue in the short run that has to be made up by higher seigniorage, and therefore inflation, in the long run. The fiscal theory of the price level of Woodford (1996, 1998, 2001)[1] considers an economy with nominal debt and shows that nonexplosive government debt in the face of dominant fiscal policy can only be guaranteed by ensuring that real interest rates fall when inflation rises.[2] This is the opposite of the Taylor (1993) principle for stabilizing inflation, which requires higher real interest rates in response to higher inflation, and which is generally taken to represent the notion of fighting inflation aggressively. The Taylor principle is derived in a standard New Keynesian setup for monetary policy analysis by assuming that the fiscal authority sets lump sum taxes that satisfy a balanced budget requirement.

In this paper, we focus on inflation targeting under fiscal dominance as in Woodford (2001), motivated by the belief that this framework may be appropriate to describe the pressures facing at least some of the developing countries that have recently started to adopt inflation targeting.[3] The reasons for fiscal dominance include some combination of a weak fiscal revenue base, a rudimentary tax collection system that encourages tax evasion, the contingent bailout liabilities attached to weak banking systems, and simple overspending at the federal or regional level. Under such conditions, if the government has issued nominal debt denominated in local currency, fiscal difficulties are often resolved not through an increase in tax revenues but instead through high inflation that erodes the real value of government liabilities.[4] The assumptions underlying the policy recommendations of the inflation targeting literature are therefore clearly not satisfied.

But the recent literature has shown that this alone does not settle the question of whether fiscal dominance unambiguously prevents a central bank from fighting inflation. On the one hand, Loyo (1999) and Sims (2005) hold that a lack of fiscal adjustment could make inflation targeting completely infeasible. But on the other hand, Benigno and Woodford (2006) argue that while inflation volatility is higher under fiscal dominance, it need not be excessively high as long- and medium-term inflation expectations are anchored. To show this, they compute a Ramsey optimal policy where the monetary authority implicitly responds to fiscal variables.

1. Other key contributions to this literature are Cochrane (1998) and Sims (1994). A long list of additional references is contained in Cochrane (1998, 2000) and Woodford (2001).

2. This assumption implies that the out of equilibrium present value of budget surpluses is not equal to the real value of debt. This does not mean that the government does not care about satisfying the intertemporal budget constraint. It is that the level of surplus is set before the price level is determined.

3. In our view, the framework may now also have become appropriate to characterize the fiscal situation in a number of developed countries.

4. Daniel (2001) presents a detailed examination of the fiscal determinants of currency crisis. If all of an inflation targeting government's debt is denominated in foreign currency, the same circumstances would result in a balance of payments crisis, as shown by Kumhof, Li, and Yan (2007). Kumhof and Tanner (2008) present evidence on the size of local currency government debt markets in developing countries.

The result of a Ramsey optimal policy is a set of implied laws of motion for the main macroeconomic variables, but unfortunately there is no obvious mapping from such a policy to an *implementable policy rule*, which for a modern central bank would invariably take the form of an interest rate rule. It is therefore not immediately obvious whether the results of Benigno and Woodford (2006) should be interpreted as fighting inflation aggressively in the sense of the Taylor principle. Moreover, the Ramsey policymaker is assumed to formulate policies in response to a great deal of information that includes private agents' behavioral rules and expectations, while in practice policymakers have to set interest rates in response to *observable economic variables* and subject to practical *constraints*. The question of what constitutes an optimal policy therefore needs to be narrowed even further, and we attempt to do so in this paper. Specifically, we ask whether a benevolent monetary authority can substitute for fiscal adjustment if its only available policy instrument is the nominal interest rate, if that interest rate is restricted to respond in a linear fashion to observed macroeconomic variables, and if that interest rate may not hit its zero lower bound excessively often. The spirit of the exercise is similar to Schmitt-Grohé and Uribe's (2007) analysis of simple and implementable rules.

But we add one key innovation. It is based on the observation that under fiscal dominance, the monetary authority must be clearly aware that it is the only entity capable of ensuring not only price stability but also fiscal solvency. It is therefore natural to suppose that it would take fiscal variables such as government debt into account in formulating its policy and that this would increase its ability to react aggressively to inflation. We therefore allow the nominal interest rate to respond not only to inflation and output but also to government debt. We also briefly consider a response to government spending.

We then analyze the feasibility and desirability of an aggressive response of the interest rate to inflation by applying three successive criteria. First, we check for *determinacy* of equilibria. Second, we rule out determinate equilibria that violate the *zero lower bound* on nominal interest rates too frequently. Third, we rank the remaining equilibria by computing their *welfare* implications.

Equilibrium determinacy under different monetary and fiscal rules was the subject of Leeper's (1991) seminal contribution that will also form the benchmark of our study. Under a passive fiscal policy, the fiscal authority adjusts taxes in order to meet the government budget constraint. In this case, determinacy requires an active monetary policy that reacts strongly to inflation to achieve price stability. Under an active fiscal policy, the primary surplus does not respond to the level of government debt. Determinacy then requires a passive monetary policy so that inflation can balance the budget. Relative to active monetary policy this reduces price stability. All other combinations of fiscal and monetary policies do not lead to a unique equilibrium. Since the New Keynesian literature has assumed that the fiscal authority adjusts taxes appropriately, the usual policy recommendation is to have the monetary authority fight inflation aggressively. More recently, Schmitt-Grohé and Uribe (2007) have analyzed the combinations of fiscal and monetary rules that lead to a unique equilibrium when allowing for the more realistic case of distortionary taxation. They also add the zero lower bound criterion in checking for the implement ability of different rules. Their paper broadly confirms Leeper's results.

Our results first restate the case for the Taylor principle in the absence of fiscal dominance. We then turn to fiscal dominance, and show that adding government debt as an argument in the central bank's interest rate rule does have the advantage of expanding the determinacy region to include an inflation feedback coefficient greater than one, making aggressive inflation fighting theoretically possible. But that advantage disappears on closer inspection because the expanded part of the determinacy region displays extremely high inflation volatility, and it is ruled out by the zero lower bound constraint on nominal interest rates. Furthermore, even at the optimum of such rules inflation volatility and welfare losses are much higher than under a Ricardian policy, and they increase dramatically as the coefficient on inflation is increased away from its optimal, highly negative value. There is a welfare improvement over an interest rate rule that does not include government debt, but it is very small, especially compared to the gain from eliminating fiscal dominance altogether.

Our conclusion contains an important message for developing countries' central banks. This is that fiscal discipline must absolutely be established before committing to inflation targeting. Monetary policy alone cannot engineer a rescue.

The paper is organized as follows. Section 1 describes the model. Section 2 analyzes optimal monetary and fiscal policy when fiscal policy is not dominant. Section 3 determines optimal policy under fiscal dominance. Section 4 concludes.

1. THE MODEL

We take as our baseline case the model described in Schmitt-Grohé and Uribe (2004a). This model is simple but retains the necessary ingredients to evaluate fiscal and monetary policy interactions. Namely, monetary policy is nonneutral due to a transactions cost technology and due to sticky goods prices in a world of monopolistic competition. Financial markets are incomplete in that the government can only issue one-period nominal bonds.[5] The presence of nominal bonds gives the government an incentive to use inflation to make real returns state contingent as described in Chari and Kehoe (1999). In fact, if prices were fully flexible then the real, allocations would be the same as if markets were complete. In this model, market incompleteness does matter because there are price adjustment costs. The costs of changing prices can be motivated by costs of acquiring and processing information (Zbaracki et al. 2005). For the sake of realism the government can only use distortionary forms of taxation.

Households are indexed by $i \in [0, 1]$, and have the utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\ln \left(c_t^i \right) + \delta \ln \left(1 - h_t^i \right) \right), \tag{1}$$

5. Marcet and Scott (2001) provide arguments to support the assumption of incomplete markets.

where c_t^i is consumption of the composite good and h_t^i is labor effort. Consumption is in turn an aggregate of imperfectly substitutable varieties $c_t^i(j)$,

$$c_t^i = \left(\int_0^1 c_t^i(j)^{\frac{1+\eta}{\eta}} dj \right)^{\frac{\eta}{1+\eta}}, \tag{2}$$

so that cost minimization implies the set of goods demands

$$c_t^i(j) = c_t^i \left(\frac{P_t(j)}{P_t} \right)^{\eta}. \tag{3}$$

Money facilitates consumption purchases, which are subject to a proportional transactions cost

$$s\left(v_t^i\right) = Av_t^i + B/v_t^i - 2\sqrt{AB}, \tag{4}$$

where $v_t^i = P_t c_t^i / M_t^i$ is money velocity, P_t is the aggregate price level of the composite consumption good, and M_t^i is nominal money holdings.

Producers are indexed by $j \in [0, 1]$ and are identical to the set of households because each household is the sole producer of a single variety $y_t(j)$ of the composite good. These goods are produced with a linear technology

$$y_t(j) = z_t h_t(j), \tag{5}$$

where z_t is productivity and $h_t(j)$ is labor hired in a competitive labor market. The output market is monopolistically competitive, and each producer sets the price of the good it supplies subject to quadratic price adjustment costs of the form

$$\frac{\theta}{2} \left(\frac{P_t(j)}{P_{t-1}(j)} - 1 \right)^2 = \frac{\theta}{2} \left(\pi_t(j) - 1 \right)^2, \tag{6}$$

and taking the level of aggregate demand for its good as given. Aggregate demand consists of private consumption demand $c_t(j)$ and government demand $g_t(j)$, with

$$y_t(j) = c_t(j) + g_t(j). \tag{7}$$

Aggregate consumption demand is given by equation (3) aggregated over all demands i:

$$c_t(j) = c_t \left(\frac{P_t(j)}{P_t} \right)^{\eta}. \tag{8}$$

Government demands a composite g_t that consists of the same varieties as the consumption good, with the same elasticity of substitution, so that government demand for variety j is given by

$$g_t(j) = g_t \left(\frac{P_t(j)}{P_t} \right)^{\eta}. \tag{9}$$

Aggregate output is then naturally given by

$$y_t = \left(\int_0^1 y_t(j)^{\frac{1+\eta}{\eta}} dj \right)^{\frac{\eta}{1+\eta}}. \tag{10}$$

Financial assets include money and nonstate contingent one-period nominal government bonds held from period t to $t+1$, denoted by B_t^i, with gross nominal interest rate R_t. A borrowing constraint is imposed to prevent households from engaging in Ponzi schemes.

Nonfinancial income accrues to households in the form of net cash flows from their activity as producers and from wage income. The former is given by $P_t(i)y_t(P_t(i)/P_t)^{\eta} - W_t h_t(i) - (\theta/2)((P_t(i)/P_{t-1}(i)) - 1)^2$, and the latter by $W_t h_t^i(1-\tau_t)$, where W_t is the nominal wage (the real wage is denoted by w_t) and τ_t is the labor income tax rate.

The *household budget constraint*, combining the previous features, is given by

$$\begin{aligned} P_t c_t^i \left[1 + s\left(v_t^i\right)\right] + M_t^i + B_t^i \leq M_{t-1}^i + R_{t-1} B_{t-1}^i \\ + P_t \left[\left(\frac{P_t(i)}{P_t} \right) y_t(i) - w_t h_t(i) - \frac{\theta}{2} \left(\frac{P_t(i)}{P_{t-1}(i)} - 1 \right)^2 \right] + (1-\tau_t) P_t w_t h_t^i. \end{aligned} \tag{11}$$

The household maximizes equation (1) subject to equations (11), (4), (5), and (6). The first-order conditions for this problem are shown in Appendix A. Note that household superscripts and producer indices can be dropped in these conditions as all agents face identical decision problems and therefore obtain identical solutions in equilibrium.

The *government budget constraint* is given by

$$M_t + B_t = M_{t-1} + R_{t-1} B_{t-1} + P_t g_t - \tau_t P_t w_t h_t. \tag{12}$$

The monetary and fiscal authorities decide on the nominal interest rate and on the labor tax rate $\{R_t, \tau_t\}$. The precise form of the rules that determine these two policy instruments is of course critical for the presence and implications of fiscal dominance. Those rules will therefore be discussed in detail in the subsequent sections of the paper.

Shock processes are given by the following laws of motion for productivity and government spending:

$$\ln g_t = (1-\lambda^g) \ln g + \lambda^g \ln g_{t-1} + \varepsilon_t^g; \quad \varepsilon_t^g \sim N\left(0, \sigma_{\varepsilon^g}^2\right), \tag{13}$$

$$\ln z_t = (1-\lambda^z) \ln z + \lambda^z \ln z_{t-1} + \varepsilon_t^z; \quad \varepsilon_t^z \sim N\left(0, \sigma_{\varepsilon^z}^2\right). \tag{14}$$

TABLE 1

Model Calibration

β	0.96	A	0.0111
$\bar{\pi}$	0.9984	B	0.07524
$\bar{h}$	0.2	λ^g	0.9
$\overline{g/y}$	0.2	σ_{ε^g}	0.0302
$\overline{B/(PY)}$	0.44	λ^z	0.82
$\eta/(1+\eta)$	1.2	σ_{ε^z}	0.0229
θ	17.5/4		

Calibration follows Schmitt-Grohé and Uribe (2004a) and is summarized in Table 1. A bar over a variable indicates its steady state value. The time unit is 1 year.

2. MONETARY POLICY IN A RICARDIAN WORLD

In this section, we specify how the monetary authority can implement a desired equilibrium in a world of endogenous taxation that ensures budget balance. The monetary authority is assumed to specify an interest rate rule that responds to deviations of current inflation and output from their target values. We consider the rule[6, 7]

$$\ln\left(R_t/R^*\right) = \phi_\pi^R \ln\left(\pi_t/\pi^*\right) + \phi_y^R \ln\left(y_t/y^*\right), \tag{15}$$

where π^* and y^* are inflation and output target values of the monetary authority.

The fiscal authority is assumed to raise or lower labor taxation in response to deviations of government debt from a target value, thereby ensuring long-run government solvency. The deviations of government debt are lagged by 1 year, based on the realistic premise that it takes time to implement fiscal policy measures. Fiscal rules can be modeled in two different ways that have major implications for model dynamics and welfare. In the first version, the fiscal authority adjusts tax *revenue* $\rho_t = \tau_t w_t h_t$ in response to total lagged government debt $a_{t-1} = (M_{t-1} + R_{t-1}B_{t-1})/P_{t-1}$,

$$\rho_t = \rho^* + \phi_a^\rho\left(a_{t-1} - a^*\right), \tag{16}$$

6. Another Ricardian rule is sometimes considered in the literature, namely, $\ln(R_t/R_{t-1}) = \phi_\pi^R \ln(\pi_t/\pi^*) + \phi_y^R \ln(y_t/y_{t-1})$. This may be easier to implement, as the monetary authority does not need information on the steady state levels of the interest rate and output. However, we have found qualitatively very similar results between this rule and equation (15) and therefore concentrate our discussion on the latter.

7. Inflation forecast based rules would replace current inflation by expectations of inflation, but this presumes that the monetary authority can perfectly observe private agents' expectations. In practice, this could either mean extracting them from surveys or applying econometric techniques to extract them from financial data. As for the former, Nunes (2005) shows why survey expectations may not reflect actual expectations. As for the latter, in the developing countries that motivated this study the data required to use these techniques are generally not available.

while in the second version the fiscal authority adjusts the tax *rate* τ_t in response to a_{t-1},

$$\tau_t = \tau^* + \phi_a^\tau (a_{t-1} - a^*), \tag{17}$$

where τ^*, ρ^*, and a^* are tax and asset target values of the fiscal authority. We will refer to equation (16) as the tax revenue rule and to equation (17) as the tax rate rule. As in Schmitt-Grohé and Uribe (2007), we set the target values to be equal to the nonstochastic steady state of the associated Ramsey optimal policy problem. Note that we are departing from the most conventional monetary policy analysis because taxation is distortionary and is also an object of optimization.

We find that the parameter ϕ_y^R does not affect most of our key results in an important way, and we therefore show only results for the case $\phi_y^R = 0$.[8] Figure 1 shows our results, with the first block of four panels pertaining to the tax revenue rule and the second block to the tax rate rule. The first panels, labeled "Determinacy," show the equilibrium determinacy analysis. The vertical axis considers different values of the fiscal feedback coefficients on government debt ϕ_a^ρ and ϕ_a^τ, whereas the horizontal axis considers different values of the monetary feedback coefficient on inflation ϕ_π^R. White areas signal that the equilibrium exists and is unique. The panels display two white regions. One area is associated with a sufficiently large tax response (significantly greater than zero) and a strong response of interest rates to inflation ϕ_π^R (greater than one, the Taylor principle). In this constellation of parameters, the fiscal rule guarantees government solvency whereas the monetary rule fights inflation aggressively in order to pin down the price level. This confirms the results known from the New Keynesian literature with lump sum taxation. The second area corresponds to an active fiscal and passive monetary policy, in other words to fiscal dominance.

The coefficient values associated with fiscal dominance can be derived analytically by combining the government budget constraint (12) with either equation (16) or (17).[9] Appendix B discusses the details. We find that for the tax revenue rule, the path of debt is stable if the response of tax revenues to lagged government debt (ϕ_a^ρ) lies approximately[10] in the interval

$$\frac{1}{\pi^*} - \frac{1}{R^*} < \phi_a^\rho < \frac{1}{\pi^*} + \frac{1}{R^*}. \tag{18}$$

If the upper limit of the interval is not satisfied, then tax revenues are too responsive. In that case government debt alternates between being below and above target in a divergent path. This case is less likely to occur in practice. If the lower limit of the interval is not satisfied, then tax revenues are not responsive enough to prevent debt from becoming explosive. This is the more relevant case of fiscal dominance.

8. We considered three values of ϕ_y^R to characterize the solutions, namely, $\phi_y^R \in \{-0.5, 0, 0.5\}$.

9. We thank a referee for pointing this out.

10. The relationship is an approximation as it is only valid in the neighborhood of the optimum, and does not consider equilibrium responses of endogenous variables to changes in a_{t-1}. See Appendix B.

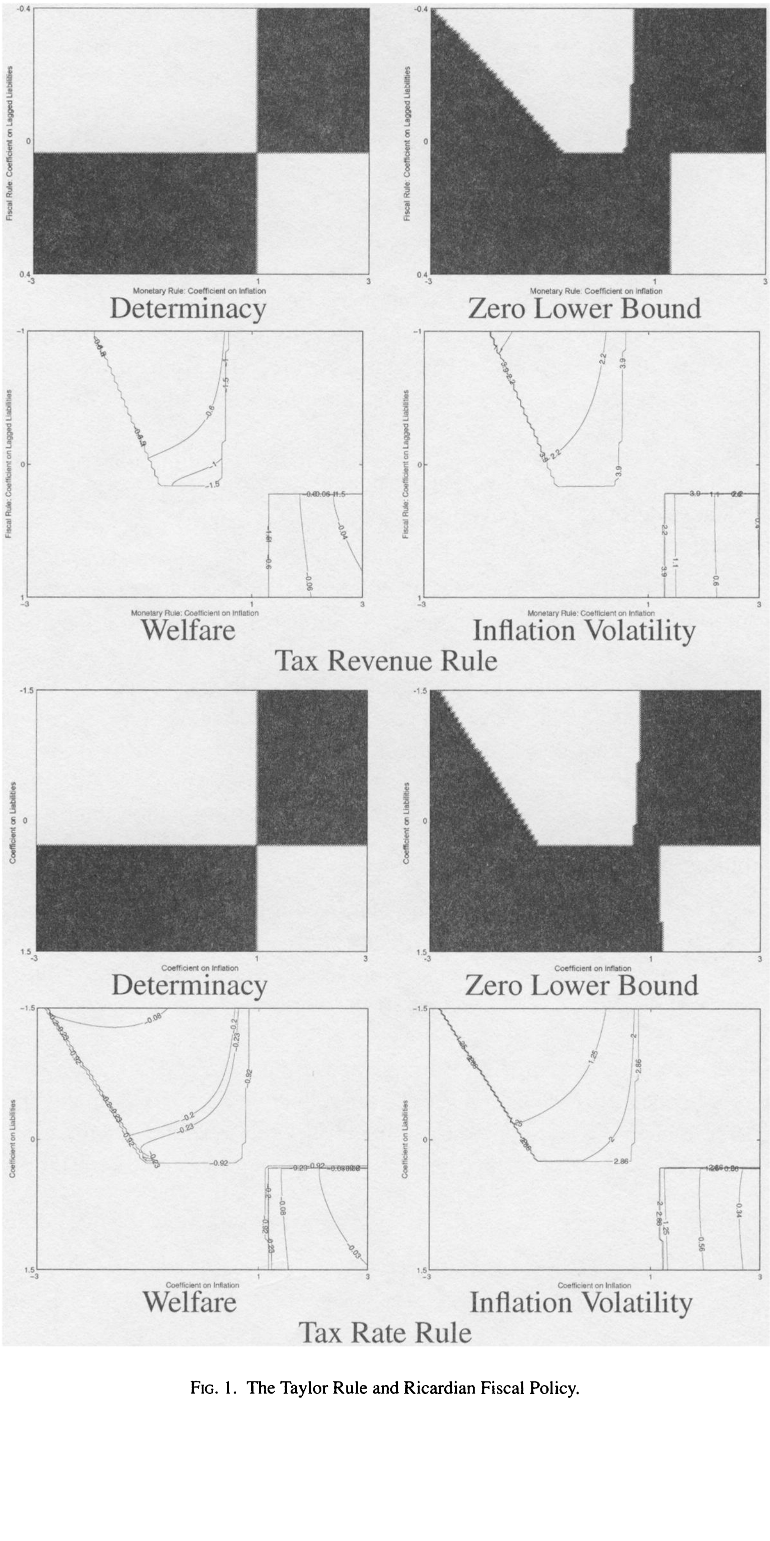


FIG. 1. The Taylor Rule and Ricardian Fiscal Policy.

Equation (18) shows that in this case tax revenues have to be more responsive, *ceteris paribus*, if the nominal interest rate is higher (to pay the additional interest charges), and can be less responsive if inflation is higher (because inflation erodes government debt in real terms). A similar relationship to equation (18) can be derived for the tax rate rule, see Appendix B for details. Based on these approximate formulas we find that fiscal dominance prevails at $\phi_a^\rho < 0.039$ and $\phi_a^\tau < 0.232$, respectively.

In the next panels in Figure 1, labeled "Zero Lower Bound," we plot in black all rules that are not consistent with either equilibrium determinacy or with the zero lower bound on nominal interest rates.[11] As in Schmitt-Grohé and Uribe (2007), the zero lower bound constraint is imposed by requiring that $E\ln(R) \geq 2\sigma_R$. By comparing the first and second panels, one can see that the zero bound does not eliminate many rules for either the tax revenue rule or the tax rate rule. Both in the top left and in the bottom right regions there are many rules that can lead to an implementable equilibrium.

The next panels "Welfare" plot welfare contours for combinations of coefficients that satisfy the determinacy and zero lower bound conditions. We compute welfare using a second-order approximation, as explained in detail in Schmitt-Grohé and Uribe (2004b).[12] Consider two policy regimes, a reference regime denoted by r, and an alternative regime denoted by a. The welfare loss is defined as the fraction of regime r's consumption that the household would be willing to forego while still being as well off as under regime a. We consider the Ramsey allocation to be the reference regime and the allocations induced by the simple rule to be the alternative regime. We observe that the welfare results for an active monetary and passive fiscal policy are generally far superior to those for active fiscal and passive monetary policy. Furthermore, welfare increases in the direction of a more aggressive monetary response to inflation.

The final panels of Figure 1, labeled "Inflation Volatility," show that the welfare results are closely related to the volatility of inflation (specifically its standard deviation) implied by the chosen policy mix. They show that an active monetary policy response to inflation stabilizes inflation volatility far better than an active fiscal policy. Furthermore, this effect, which works through agents' inflation expectations, is stronger for a more aggressive response to inflation. The coefficients, welfare losses, and inflation volatilities corresponding to the best rules in Figure 1 are shown in Table 2.[13]

For later comparison with fiscal dominance, Figures 2 and 3 show impulse responses for one standard deviation shocks to productivity and government spending. We observe that in a Ricardian world monetary policy responds to inflation in the short run, while tax revenue or tax rates are adjusted very gradually to stabilize debt

11. The reader is referred to Appendix C for details on these computations.

12. See also Collard and Juillard (2001). The reader is referred to Appendix D for a description of the welfare computations.

13. We limit our search to inflation coefficients $\phi_\pi^R \leq 3$. A further small welfare improvement would be attainable with even higher ϕ_π^R. The last row reports the results of a constrained optimization that is associated with an optimal inflation coefficient ϕ_π^R different from the one reported in the table.

TABLE 2

Optimal Rules in a Ricardian World

Type of fiscal rule	Tax revenue rule (ρ)	Tax rate rule (τ)
Optimal ϕ_π^R	3.0	3.0
Optimal ϕ_a^ρ/ϕ_a^τ	0.048	0.36
Welfare loss (%)	0.0339	0.0200
Inflation volatility	0.3959	0.2893
Welfare loss if $\phi_a^\rho/\phi_a^\tau = 0$	0.6606	0.2097

in the long run. The critical feature of fiscal dominance is that taxes are not available for this task.

In a Ricardian world, the fiscal authority can choose not only the coefficients of its rule but also its functional form, most importantly the variables that enter it. According to the welfare results in Figure 1 and Table 2, it would choose a tax rate rule over a tax revenue rule. Figures 2 and 3 show why this is so. Under a tax revenue rule an expansionary shock causes an endogenous increase in tax revenue that requires an immediate offsetting reduction in the tax rate. This induces highly volatile tax rates where smooth tax rates would be preferred. But more importantly it is very procyclical, by inducing an additional increase in labor supply and drop in inflation and real interest rates in an already expanding economy. By contrast, under a tax rate rule tax rates change very gradually and smoothly. This disadvantage of tax revenue rules relative to tax rate rules will carry over to our fiscal dominance scenarios.

3. MONETARY POLICY UNDER FISCAL DOMINANCE

3.1 A Modified Interest Rate Rule

We model fiscal dominance by assuming that either tax revenue ρ_t or the tax rate τ_t are sufficiently unresponsive to government debt, $\phi_a^\rho < 0.039$ or $\phi_a^\tau < 0.232$. Section 3.2 examines the special but most commonly assumed case where ρ_t or τ_t are constant, in other words, where $\phi_a^\rho = 0$ in equation (16) or $\phi_a^\tau = 0$ in equation (17). Section 3.3 examines the general case. With government spending specified as an exogenous stochastic process in equation (13), fiscal instruments are therefore not used to ensure that the intertemporal budget constraint of the government holds. In such a world, the central bank has no choice but to accommodate fiscal shocks. An important question is whether it can still fight inflation aggressively while doing so. The conventional answer is that it cannot, and this is based on using a monetary rule identical to equation (15) combined with exogenous taxes and spending. But we suggest that a monetary authority that knows it is the only institution capable of ensuring fiscal solvency (in addition to price stability) would not ignore fiscal variables in setting its policy. We therefore allow for monetary rules that may respond not only to inflation and output but also to fiscal variables, most importantly to government debt (scaled by steady state GDP). We establish whether such rules may make it

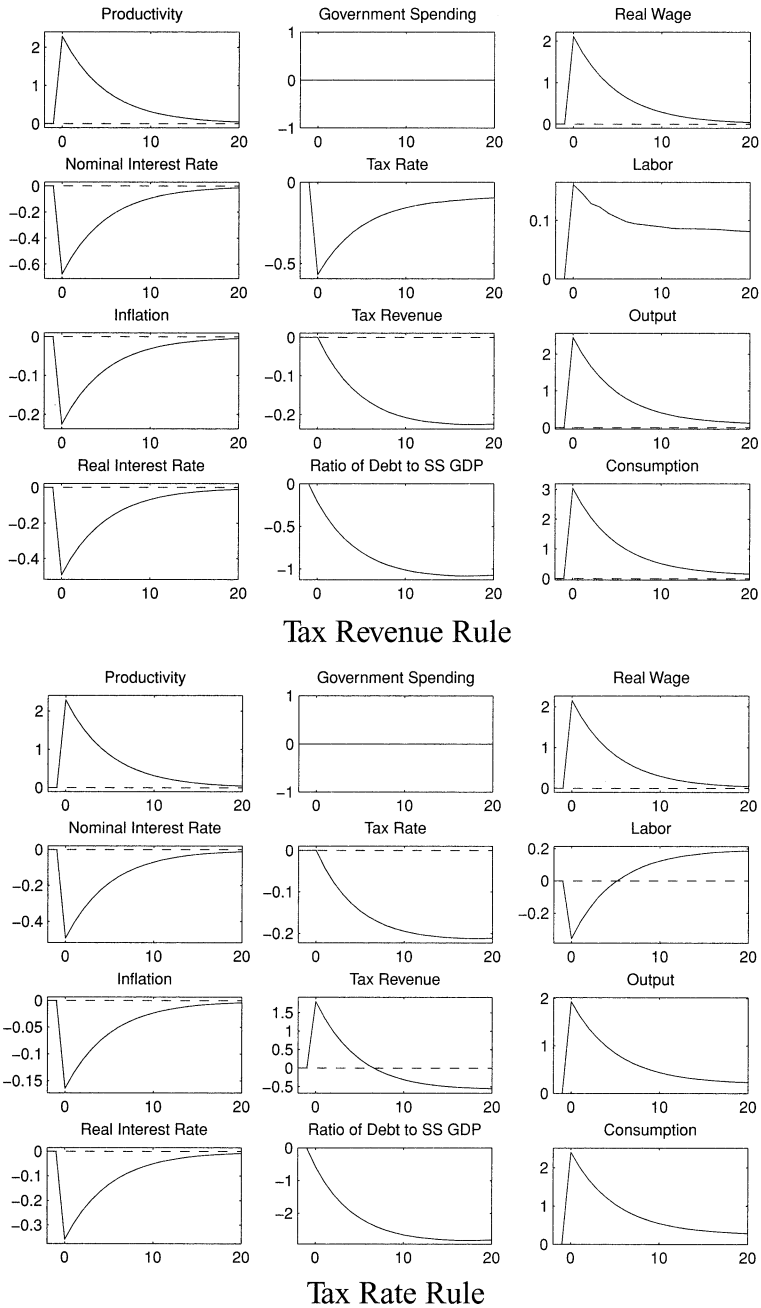
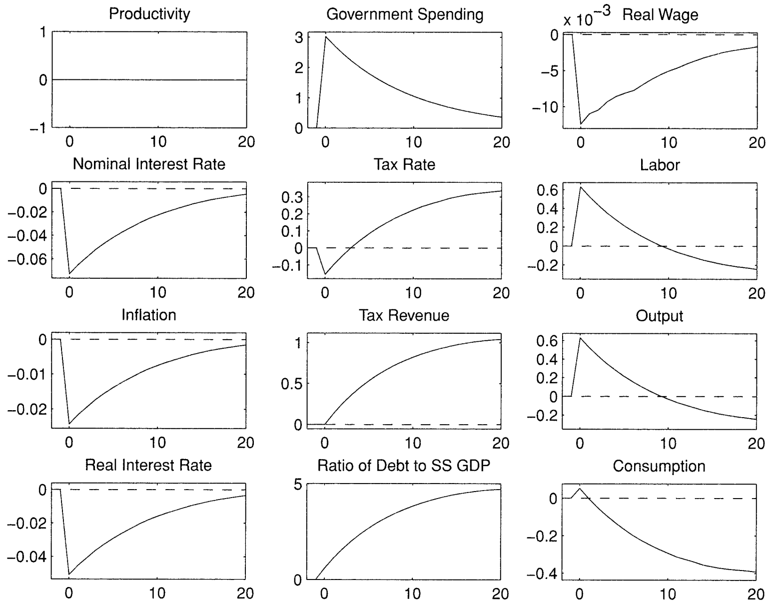
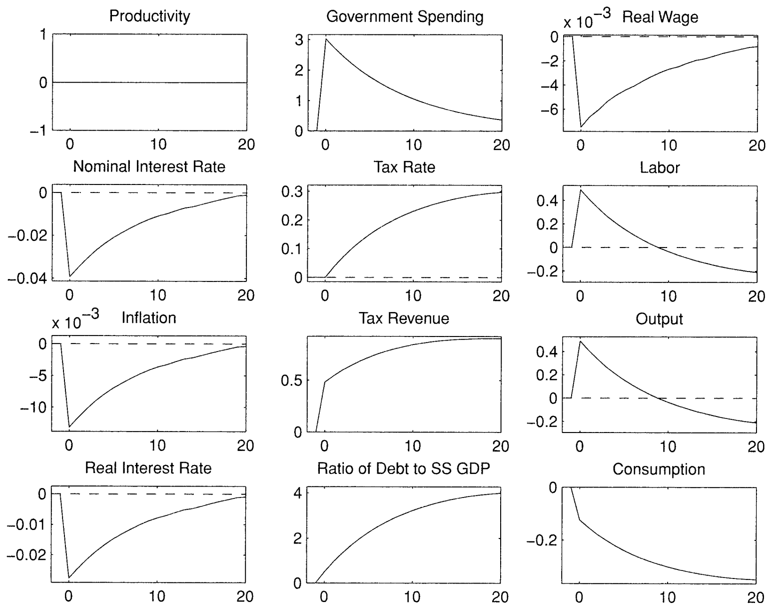


FIG. 2. Productivity Shock under Ricardian Fiscal Policy.



Tax Revenue Rule



Tax Rate Rule

FIG. 3. Government Spending Shock under Ricardian Fiscal Policy.

possible to respond aggressively to inflation and whether they lead to an improved welfare performance.

We divide our analysis into several different cases. First, as in a Ricardian world, it should matter whether fiscal policy is characterized by a tax revenue rule or by a tax rate rule. We therefore report on both cases. Second, it should also matter whether monetary policy can respond to information on government debt contemporaneously or with a lag, with better stabilizing properties expected if more recent information can be used. We again report on both cases.

Unlike for the Ricardian case, the question of whether the fiscal authority should be thought of as fixing tax revenue or tax rates cannot really be motivated by whether it leads to less volatility or higher *welfare* because the point of fiscal dominance is precisely that the fiscal authority is unable to choose its rule based on such criteria. But there is another argument, *plausibility*. Fiscal dominance invokes an environment where rigidities prevent the fiscal authorities from making frequent (or any) changes to their instruments. Fixing tax revenue, however, implies frequent large changes in the tax rate. Fixing the instrument itself, the tax rate, may look more plausible along this dimension. On the other hand, many developing countries have found that their tax revenue cannot be made to respond sufficiently to changes in tax rates, due to tax evasion and other factors. A tax revenue rule may capture this dimension better.

A monetary policy response to lagged debt might be indicated by symmetry with the fiscal rules (16) and (17). But monetary policy is generally credited with being able to respond much more quickly to new information than fiscal policy, and this difference is one of the major reasons why fiscal activism has only recently come back into favor. This would suggest that the response to government debt should be lagged for fiscal policy (in the Ricardian case) and instantaneous for monetary policy.

Formally, the general specification of fiscal policy under fiscal dominance is given by equations (16) or (17) under the abovementioned restrictions on coefficients. In the more restricted case considered in Section 3.2, it is given by either exogenous tax revenue

$$\tau_t w_t h_t = \rho^*, \tag{19}$$

or by exogenous tax rates

$$\tau_t = \tau^*. \tag{20}$$

Monetary policy is represented by the interest rate rule

$$\ln\left(R_t/R^*\right) = \phi_\pi^R \ln\left(\pi_t/\pi^*\right) + \phi_y^R \ln\left(y_t/y^*\right) + \phi_a^R\left(a_{t-j} - a^*\right)/y^*, \tag{21}$$

where $j = 0$ or 1 indicate a response to current or lagged debt. This rule assumes that if the ratio of government debt to output is 1 percentage point higher than target, then the interest rate will be raised by ϕ_a^R basis points.

3.2 Optimal Rules

In Figure 1, we can identify a special case of rule (21) for $\phi_a^R = 0$, namely, the horizontal line where $\phi_a^\rho = 0$ in equation (16) or $\phi_a^\tau = 0$ in equation (17). It shows that an aggressive response to inflation, $\phi_\pi^R > 1$, is impossible because of equilibrium indeterminacy. In Figures 4 and 5, we explore whether the general case of rule (21) overcomes this problem. At first sight these figures look a lot more promising than Figure 1. Most strikingly, as long as solvency is guaranteed by lowering interest rates sufficiently in response to excessive government debt, it is now possible to reach the region of determinacy even with an aggressive response to inflation. But this is an illusion, as the analysis of the zero lower bound conditions on nominal interest rates shows. All coefficient combinations that include an aggressive response to inflation violate the lower bound, which makes this rule impossible to implement in practice. For instance, for exogenous tax rates, if the coefficient on inflation were 1.5 and that on debt were -0.2, then the standard deviation of interest rates would be 4.1. Such volatility implies that interest rates would have to be higher than 8.2% on average to satisfy the lower bound condition, while in our economy the average interest rate is 3.8%. It is true that many developing economies experience high inflation and consequently high nominal interest rates. However, if a successful inflation targeting regime were to be implemented in developing countries then inflation and nominal interest rates would be lower.

The coefficients, welfare levels, and inflation volatilities corresponding to the optimal rules of Figures 4 and 5 are displayed in Table 3. The main observation is that welfare is very much lower under fiscal dominance than under a Ricardian regime. We also observe that including government debt in the rule does lead, in each case, to a better welfare performance. But that effect is not large, and furthermore maximizing welfare calls for highly negative coefficients on inflation, with Figures 4 and 5 showing that even pushing in the direction of a rule satisfying the Taylor principle, without actually getting there, is detrimental.

The last panels in Figures 4 and 5 show the implied inflation volatilities of each regime. These are a key concern of central banks, and in fact part of the desirability of inflation targeting stems from its ability to lower the volatility and not just the level of inflation. Furthermore, inflation volatility is easy to observe while welfare is not. Figures 4 and 5 show that the inflation volatility results correlate closely with the welfare results. For each rule considered here, inflation volatility is very much higher under fiscal dominance than under a Ricardian regime, where inflation volatility is only 0.29 for the optimal tax rate rule. Moreover, the volatility of inflation increases dramatically as a more aggressive inflation response is attempted. The implied volatility of the real interest rate and therefore of real variables explains why welfare deteriorates in this attempt.

Table 3 also shows that welfare is much lower if fiscal dominance is characterized by exogenous tax revenue rather than by exogenous tax rates. The addition of government debt to the interest rate rule improves welfare by a small but nonnegligible amount under exogenous tax revenue, but even at the optimal coefficients the welfare loss

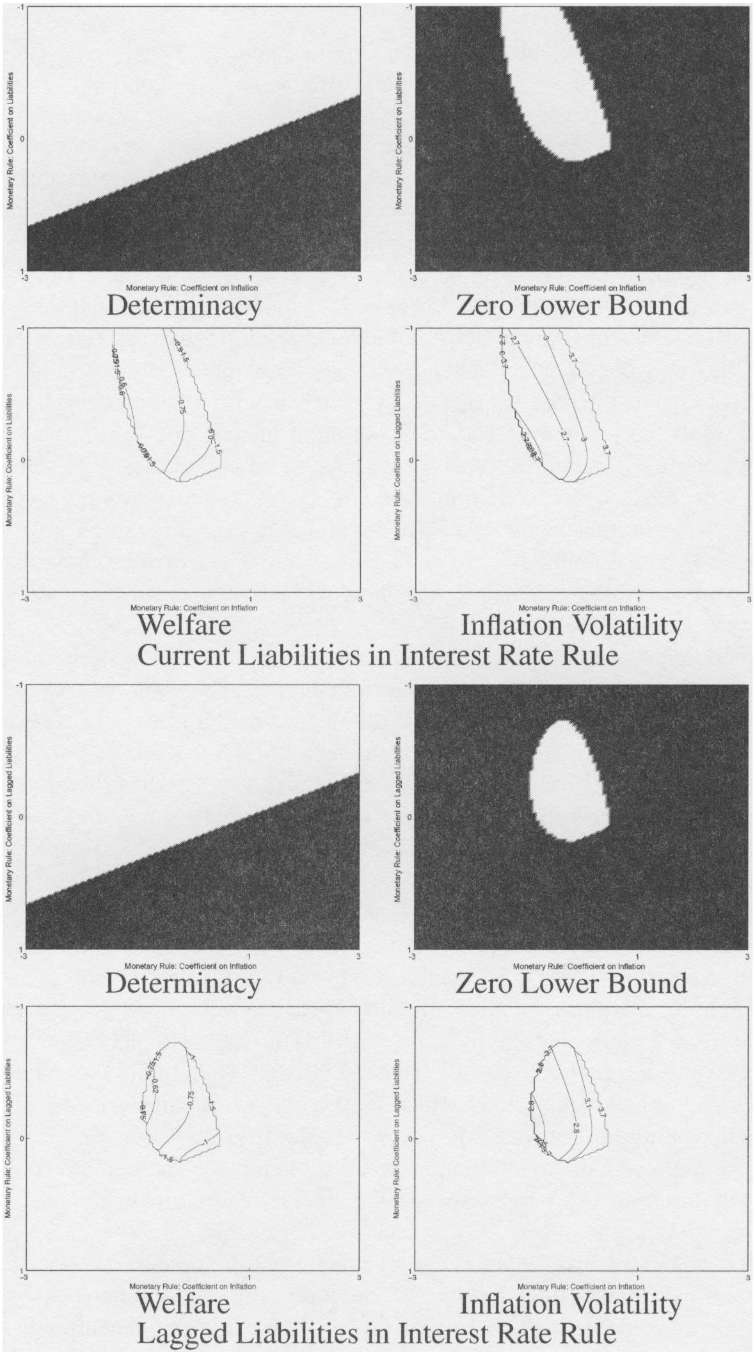


FIG. 4. Fiscal Dominance—Exogenous Tax Revenue.

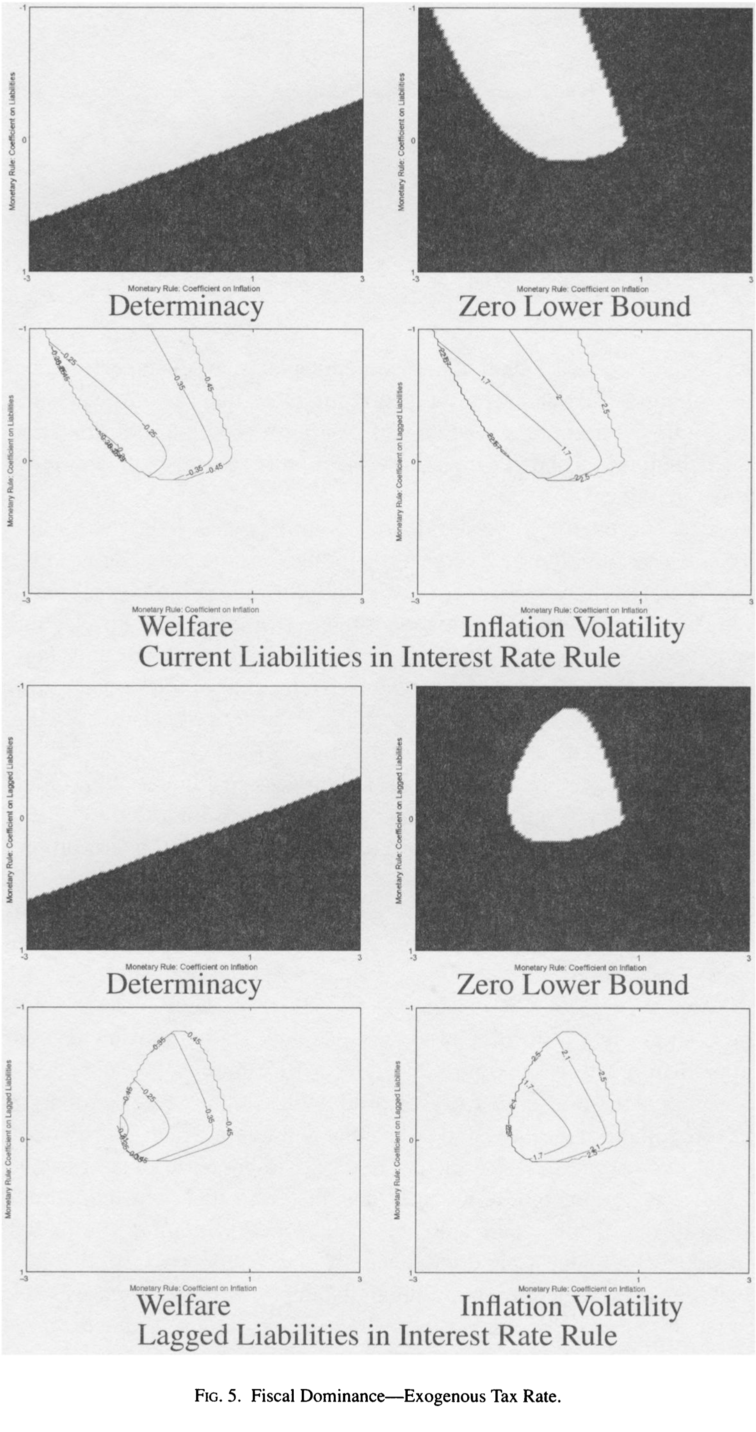


FIG. 5. Fiscal Dominance—Exogenous Tax Rate.

TABLE 3

Optimal Rules under Fiscal Dominance

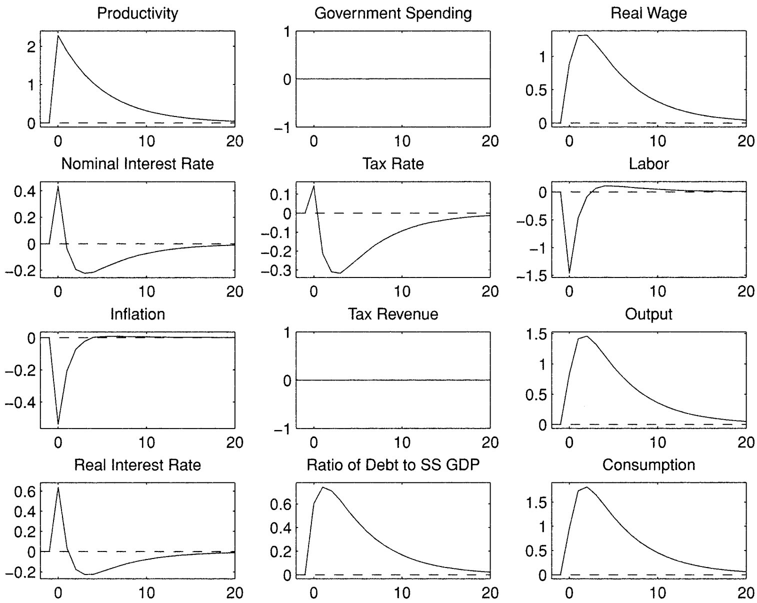
Type of fiscal dominance: Type of monetary rule:	Exogenous ρ Current a	Exogenous ρ Lagged a	Exogenous τ Current a	Exogenous τ Lagged a
Optimal ϕ_{π}^{R}	−1.26	−0.9	−1.5	−1.32
Optimal ϕ_{a}^{R}	−0.4	−0.34	−0.08	−0.08
Welfare loss (%)	0.5851	0.5865	0.2041	0.2045
Inflation volatility	2.3142	2.3454	1.4011	1.4061
Welfare loss if $\phi_{a}^{R} = 0$	0.6606	0.6606	0.2097	0.2097

is almost three times larger than under exogenous tax rates. The performance of the monetary rule under exogenous tax rates on the other hand is only very marginally improved by the addition of a government debt term. The intuition for these results will be seen in Figures 6 and 7, which show the impulse responses under the optimized rules shown in Table 3.

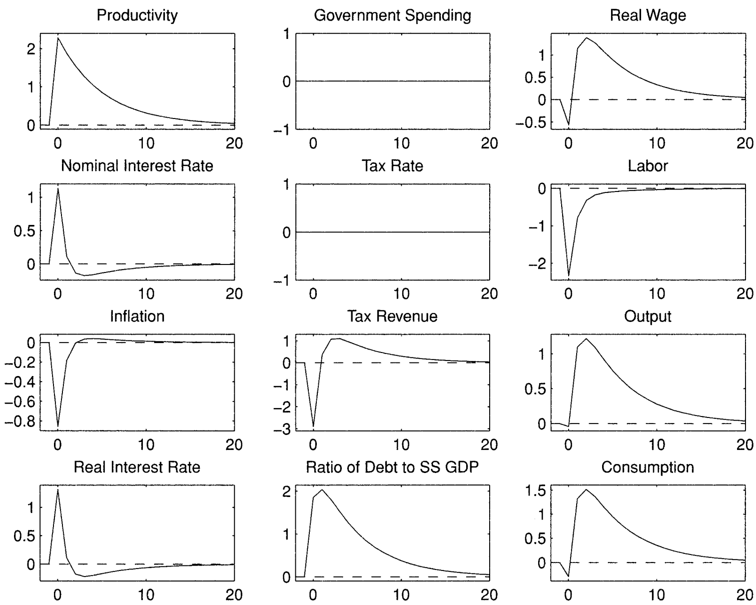
Impulse responses for interest rate rules with lagged debt are omitted from Figures 6 and 7 because they are very similar to those with current debt. This can also be seen in Table 3, where welfare is only slightly lower (and inflation volatility only slightly higher) if monetary policy responds to government debt with a lag rather than contemporaneously. Figures 4 and 5 show that the main problem with lagged debt in the rule is that they rule out a very aggressive (negative) interest rate response to higher government debt. But this is not a binding constraint because such a response is not even desirable with current debt in the rule.

The crucial difference between the Ricardian case in Figures 2 and 3 and fiscal dominance in Figures 6 and 7 is that in the latter case inflation and the nominal interest rate, rather than the tax rate, have to be used to control the evolution of debt. This reduces welfare for two interrelated reasons. First, more volatile inflation is costly due to the presence of nominal rigidities, as emphasized by Schmitt-Grohé and Uribe (2004a). Second, more volatile real interest rates lead to more volatile real allocations. The response of debt in each example is the opposite of the Ricardian case.

Figure 6 shows that a positive productivity shock leads to an increase in public debt rather than a fall as in Figure 2. Under a Ricardian policy debt is used as a shock absorber. This means that higher productivity, which reduces marginal cost, and therefore inflation, is allowed to reduce the real interest rate. The combination of a lower real interest rate and, for the tax rate rule, an increase in tax revenue causes debt to fall. The economy subsequently benefits from this debt reduction through a reduction of the distortionary labor tax rate, which *gradually* returns debt to its long-run value. But under fiscal dominance tax rates cannot perform that function. If there is an unexpected increase in productivity, debt therefore increases *immediately* as real interest rates increase rather than decrease in response to the drop in the rate of inflation, thereby raising the real cost of servicing the outstanding debt. Because this further reduces demand and marginal cost, the initial decrease in inflation is much

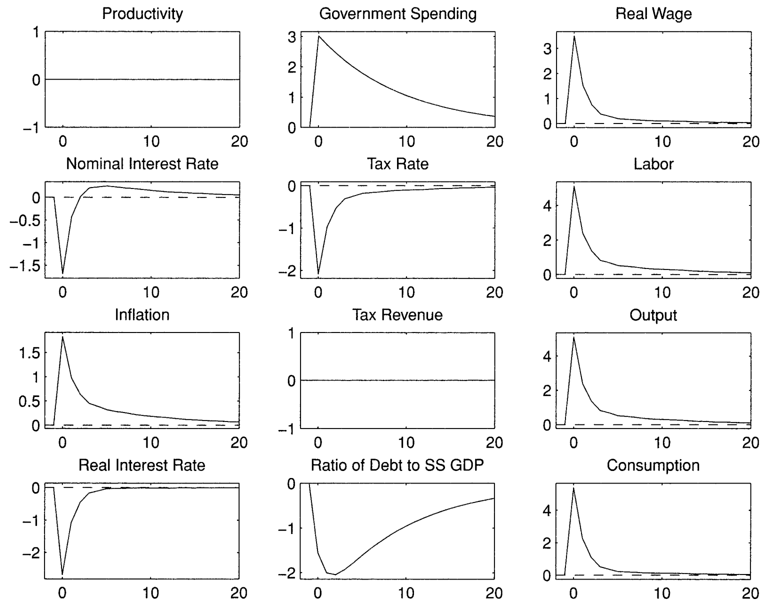


Exogenous Tax Revenue

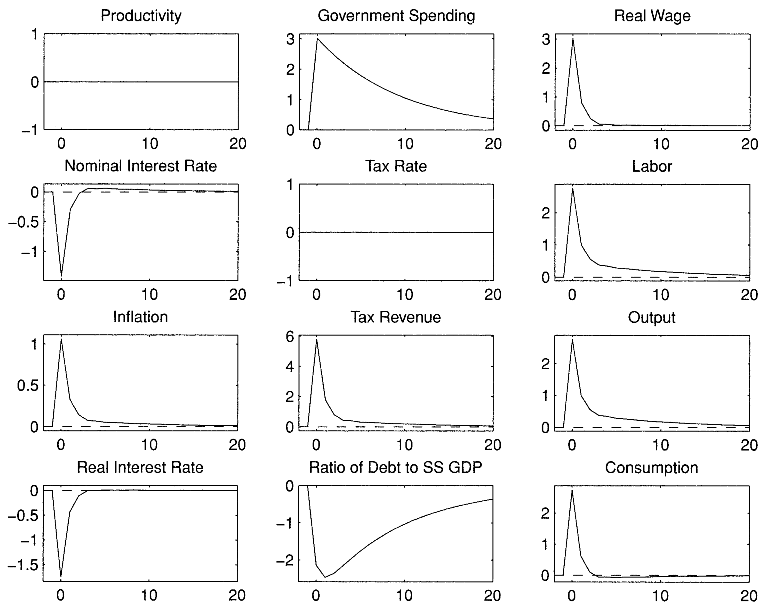


Exogenous Tax Rate

FIG. 6. Productivity Shock under Fiscal Dominance.



Exogenous Tax Revenue



Exogenous Tax Rate

FIG. 7. Government Spending Shock under Fiscal Dominance.

larger than under a Ricardian policy. Subsequently, the only way to return debt to its steady state level is through lower nominal and real interest rates.

Under exogenous tax rates, however, the second major factor in the evolution of debt is endogenous tax revenue. On impact, debt rises partly because of the endogenous decrease in labor income tax revenue as labor supply drops steeply following the initial shock. Subsequently, debt falls partly because labor tax revenue soon rises as real wages rise with productivity and labor supply recovers. Under exogenous tax revenue the tax rate becomes endogenous. Because a productivity shock increases the tax base after the first period, the tax rate has to drop starting after that period. This leads to intertemporal distortions and is procyclical by stimulating additional production relative to the case of exogenous tax rates. But on the other hand employment is less volatile under a tax revenue rule. The net effect on welfare is ambiguous, and it can be shown that most of the welfare difference between exogenous tax rates and exogenous tax revenue is due to the government spending shock rather than the productivity shock.[14]

Figure 7 shows that an increase in government spending leads to a fall in public debt rather than an increase as in Figure 3. Under a Ricardian policy higher government spending is translated, without any increase in inflation, into higher debt that is subsequently repaid very *gradually* through higher taxes. But under fiscal dominance tax rates cannot rise to deal with a higher debt level. If there is an unexpected increase in government spending and thus in aggregate demand, debt must therefore be eroded *immediately* with very sizable inflation. In addition the nominal and real interest rates are reduced, thereby lowering the real cost of servicing the debt. The lower real interest rate reinforces the demand shock coming from government spending by stimulating private consumption, which drives up inflation even further.

Under exogenous tax rates the government spending shock boosts demand for labor, which in turn increases tax revenue and leads to a primary surplus that further reduces debt. This makes it possible to rely much less on interest rates in controlling the evolution of debt, which in turn helps to stabilize consumption and employment. Because the real interest rate drop is quickly reversed and tax revenue quickly declines, while elevated government spending continues for some time, the initial primary surplus almost immediately turns into a primary deficit. At that point government debt starts to approach its long-run level from below.

Under exogenous tax revenue we again observe an extremely procyclical behavior of the labor tax rate, which falls and thereby generates additional inflation. The resulting much larger drop in the real interest rate makes the jumps in consumption and labor supply almost twice as large as in the case of exogenous tax rates. The optimal taxation literature prescribes that when government spending is high, tax revenues and debt should increase.[15] The exogenous tax revenue rule violates both of these key prescriptions. This of course has very negative implications for welfare.

14. These computations are available from the authors on request.

15. See Aiyagari et al. (2002) and Schmitt-Grohé and Uribe (2004a).

The impulse responses for a government spending shock in Figure 7 look qualitatively similar to those reported in Benigno and Woodford (2006) in their discussion of the exogenous taxation case. Our policy rule (21) may therefore be one simple way to implement the *target criterion* they have in mind. It implements their prescription that inflation expectations must be firmly anchored, in the sense that while inflation is much more volatile than in the Ricardian case, it also quickly returns to its long-run value.

But in practice, as shown in a large empirical literature covering many different countries, a firm anchoring of inflation expectations has only been successfully implemented in cases where monetary policy responds aggressively to inflation. Yet as we have seen, this is neither a feasible nor a desirable alternative in a world of fiscal dominance. This poses a severe problem for policymakers because it seems very doubtful that the public would interpret a monetary rule with a very negative inflation coefficient as providing a firm anchor for inflation. The inclusion of fiscal variables in the monetary rule makes very little difference to these results, either in terms of the optimal inflation coefficient or in terms of welfare outcomes. The welfare gains from removing fiscal dominance altogether are an order of magnitude greater than the gains from targeting fiscal variables through nominal interest rates.

We have also briefly considered alternative policy rules to equation (21), with a government response to deviations not of debt but of government spending from a long-run value. Because government spending is an exogenous variable, it is clear that this has no effect on the determinacy region, and the optimal coefficient on inflation remains highly negative. Including government spending as a third argument in the rule does improve welfare, but only very marginally so.

3.3 Generalized Fiscal Dominance

So far we have focused on one particular fiscally dominant regime, namely, the one characterized by $\phi_a^\rho = 0$ in equation (16) or $\phi_a^\tau = 0$ in equation (17). This is the natural choice, but there is of course a whole range of nonzero values of these coefficients for which the regime also displays fiscal dominance. In this subsection, we therefore trace out the dependence of the optimal values of the monetary rule coefficients ϕ_π^R and ϕ_a^R, and of welfare, on the exogenously specified fiscal coefficients ϕ_a^ρ or ϕ_a^τ.

Figure 8 shows our results. Each dot represents the optimum corresponding to the fiscal coefficients shown along the horizontal axis. Sufficiently high values of ϕ_a^ρ or ϕ_a^τ represent the Ricardian case, with positive coefficients on inflation and debt and very small welfare losses. As ϕ_a^ρ or ϕ_a^τ drops, the fiscal authority responds to higher debt levels by running ever larger deficits. We observe that a more negative coefficient on debt in the fiscal rule is associated with a more negative coefficient on inflation in the monetary rule. Perhaps surprisingly, however, given this highly unorthodox fiscal behavior, welfare improves relative to the conventional fiscal dominance case of $\phi_a^\rho = 0$ or $\phi_a^\tau = 0$ the more fiscally dominant the regime becomes. It does not however reach the levels of welfare observed under a Ricardian policy.

The impulse responses in Figure 9 shed some light on this result. They focus on the tax revenue rule and show the extreme fiscal dominance case of $\phi_a^\rho = -0.4$, which

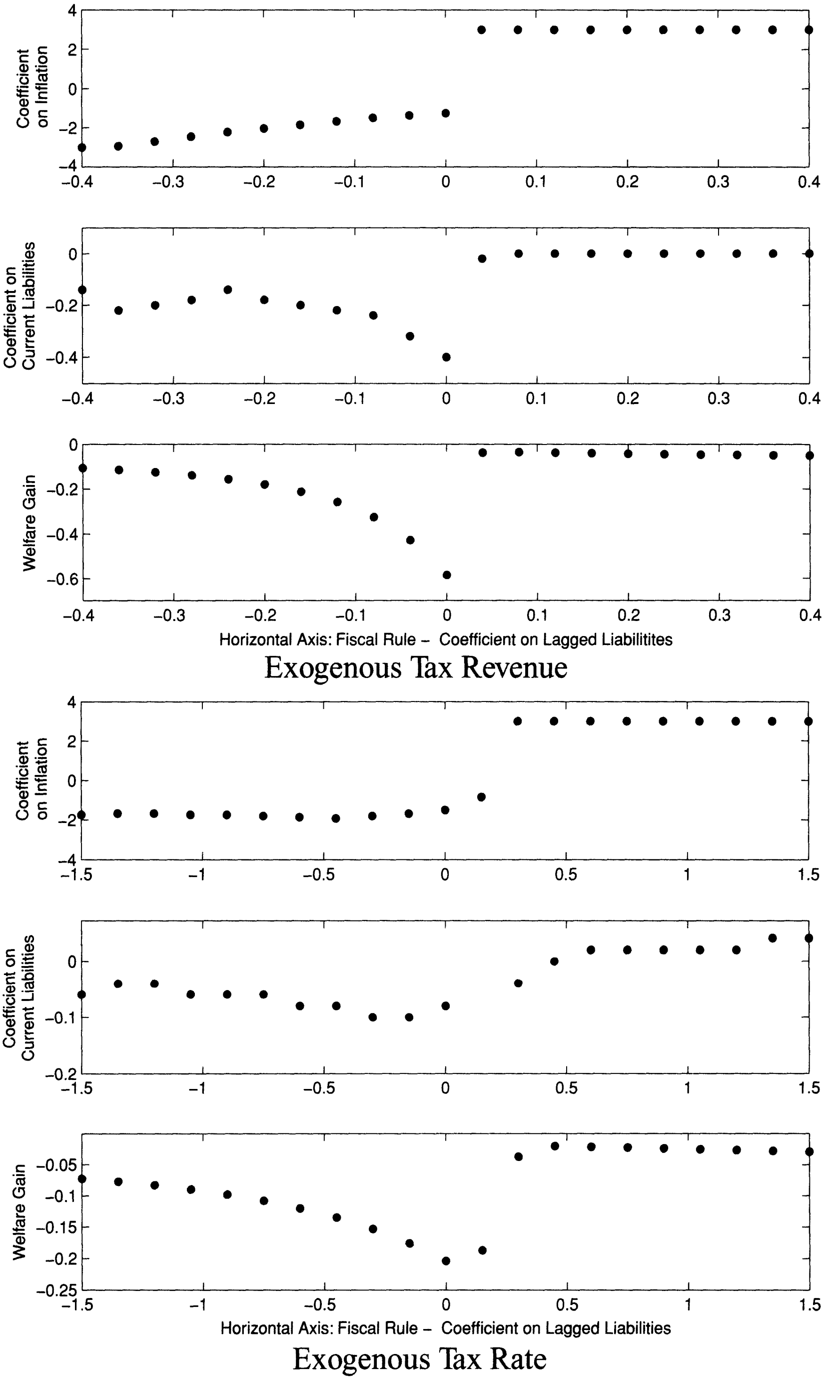


FIG. 8. Generalized Fiscal Dominance.

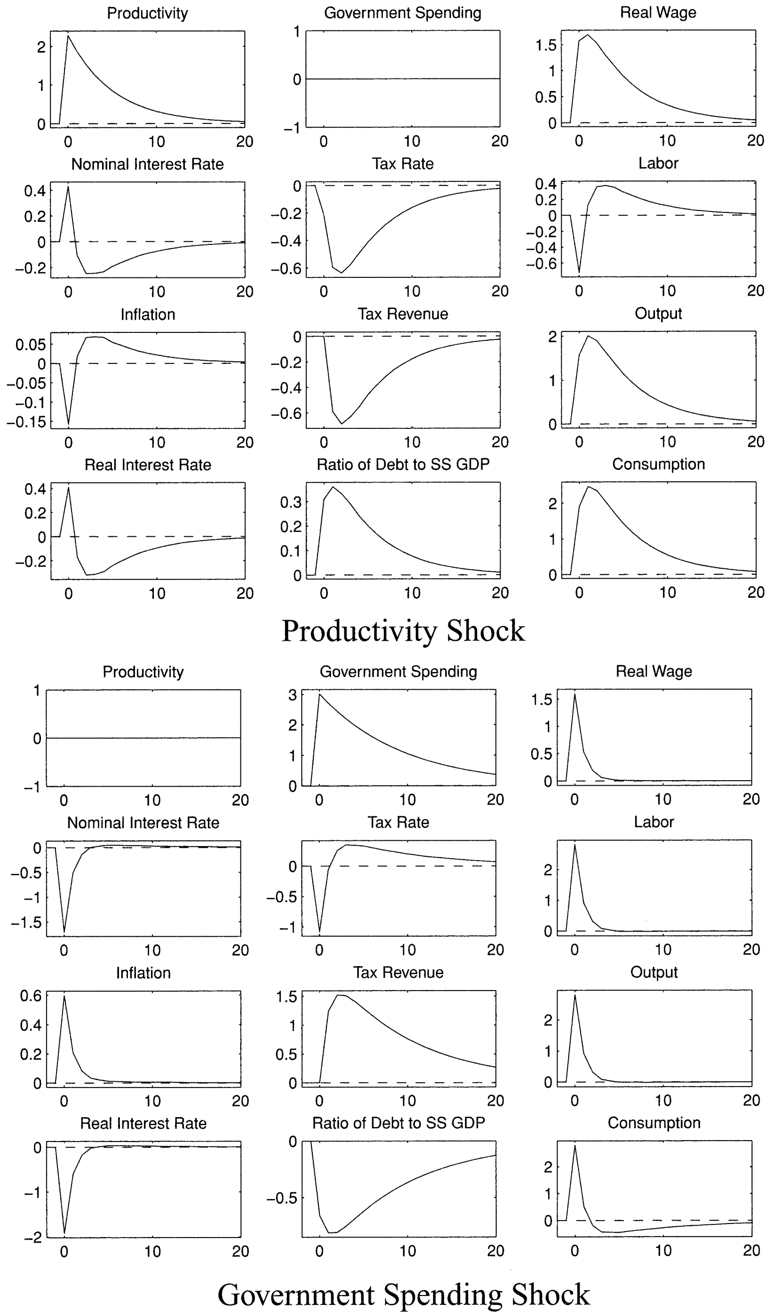


FIG. 9. Extreme Fiscal Dominance, $\phi_a^\rho = -0.4$.

can be compared with the top panels of Figures 6 and 7. It is instructive to start the discussion with a comparison with the Ricardian case. When fiscal policy is passive, welfare generally improves the more active monetary policy becomes. What Figure 8 shows is that when monetary policy is passive, and if we restrict attention to fiscal dominance characterized by $\phi_a^\rho \leq 0$ or $\phi_a^\tau \leq 0$, welfare improves the more active fiscal policy becomes. One feature of the solutions that helps to explain this is that under extreme fiscal dominance the behavior of the two policy instruments, interest rates and tax rates, ends up being significantly closer to the Ricardian case than under conventional fiscal dominance. We now turn to a comparison of the conventional and extreme fiscal dominance cases.

For a productivity shock, with extreme fiscal dominance a larger share of the initial increase in debt is accomplished through a fall in tax revenue rather than through lower inflation and higher real interest rates. After the initial period, lower tax rates stimulate output and inflation, which reduces real interest rates and stimulates demand further. While this slightly increases the volatility of consumption, it also reduces the volatility of employment. The net effect on welfare is ambiguous, and it can be shown that most of the welfare difference between conventional and extreme fiscal dominance is due to the government spending shock rather than the productivity shock.

For a government spending shock debt must be eroded immediately such that the government has sufficient assets to pay for current and future above average spending. Under extreme fiscal dominance the fiscal rule says that tax revenue should increase in response to the decrease in debt. This, however, is not destabilizing; to the contrary, the implied behavior of tax rates is highly countercyclical, thereby reducing the need for adjustments in inflation and interest rates to control the evolution of debt. This in turn reduces the volatility of consumption and employment by almost half, with obvious strong implications for welfare. In terms of the optimal taxation literature, extreme fiscal dominance comes closer to the key prescription that when government spending is high, tax revenues and debt should increase.[16]

We have already mentioned that the practicality of the kind of fiscal behavior illustrated in Figure 9 must be very doubtful. But quite apart from this, a rigid, exogenous fiscal response to debt is a poor substitute for an optimized Ricardian rule, with or without government debt entering the interest rate rule. The welfare results in Figure 8 make this very clear.

4. CONCLUSIONS

This paper has considered optimal monetary policy when the fiscal authority is unable, or unwilling, to sufficiently control tax revenues and spending in order to guarantee government solvency. Weak taxation systems, tax evasion, banking crises, or overspending are some of the factors that can undermine the control of fiscal deficits

16. Note that debt drops by far less in Figure 9 than in Figure 7.

in developing economies. Under such circumstances the usual prescription of the inflation targeting literature, a more than proportional interest rate response to inflation innovations known as the Taylor principle, becomes impractical and undesirable. The optimal coefficient on inflation is invariably highly negative.

It has not been clear from the literature whether this situation can be rescued by a central bank that adapts itself to fiscal dominance by conditioning its actions on fiscal variables such as government debt. This paper directly addresses that question. It finds that responding to government debt looks promising because it expands the set of unique equilibria to allow for an aggressive response to inflation that satisfies the Taylor principle. However, this promise vanishes on closer inspection. First, volatility of all variables is extremely high when an aggressive response to inflation is attempted. Second, and as a direct consequence, policies that follow the Taylor principle always violate the zero lower bound on nominal interest rates. Third, and also as a direct consequence of volatility, welfare considerations call for a highly negative coefficient on inflation.

The paper also presents results concerning the relative desirability of different types of fiscal rules. It finds that formulating a Ricardian or non-Ricardian fiscal rule in terms of tax revenue rather than tax rates is invariably inferior from a welfare point of view, and very substantially so under fiscal dominance. The reason is that such tax revenue rules imply procyclical movements in tax rates that destabilize the economy, with monetary policy having to deal with the consequences.

There is one positive result, which is that under fiscal dominance it does make sense for the central bank to include fiscal variables in its policy rule because doing so improves welfare. But that improvement is trivial compared to what could be accomplished by removing fiscal dominance altogether. Only solid fiscal fundamentals allow for both a benign outcome in terms of welfare and for the ability to fight inflation aggressively. Fiscal reform in developing countries is therefore an indispensable step before implementing inflation targeting regimes.

APPENDIX A: FIRST-ORDER CONDITIONS

Let the multiplier of the budget constraint (11) be given by Λ_t, and let $\lambda_t = \Lambda_t P_t$. Denote real money balances by $m_t = M_t/P_t$. Finally, use the fact that the equilibrium is symmetric, with $P_t(i) = P_t \ \forall i$. Then we have the following conditions for government debt, consumption, labor supply, money demand, and price setting:

$$\lambda_t = \beta E_t \left(\lambda_{t+1} \frac{R_t}{\pi_{t+1}} \right), \tag{A1}$$

$$\frac{1}{c_t} = \lambda_t \left(1 + \frac{2Ac_t}{m_t} - 2\sqrt{AB} \right), \tag{A2}$$

$$\frac{\delta}{1-h_t} = \lambda_t w_t (1-\tau_t), \tag{A3}$$

$$m_t = \left(\frac{A c_t^2}{B + 1 - \frac{1}{R_t}} \right)^{\frac{1}{2}}, \tag{A4}$$

$$y_t \left(1 - \frac{\eta}{1+\eta} \frac{w_t}{z_t} \right) = \frac{\theta}{1+\eta} \pi_t (\pi_t - 1) - \frac{\beta\theta}{1+\eta} E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \pi_{t+1} (\pi_{t+1} - 1) \right). \tag{A5}$$

APPENDIX B: FISCAL DOMINANCE REGIONS

Using the tax revenue rule (16), the government budget constraint (12) can be rewritten as

$$\frac{a_t}{R_t} = a_{t-1} \left(\frac{1}{\pi_t} - \phi_a^{\rho} \right) + g_t - m_t \left(1 - \frac{1}{R_t} \right) + \phi_a^{\rho} a^* - \rho^*. \tag{B1}$$

It follows that, in the neighborhood of the optimum and ignoring equilibrium responses of endogenous variables to changes in lagged debt, the path of debt is stable if

$$\left| \frac{\partial a_t}{\partial a_{t-1}} \right| \approx \left| R^* \left(\frac{1}{\pi^*} - \phi_a^{\rho} \right) \right| < 1. \tag{B2}$$

Hence, for stability the response of tax revenues to lagged government debt (ϕ_a^{ρ}) must lie in the interval

$$\frac{1}{\pi^*} - \frac{1}{R^*} < \phi_a^{\rho} < \frac{1}{\pi^*} + \frac{1}{R^*}. \tag{B3}$$

The same calculation can be performed for the tax rate rule (17). We obtain

$$\left(\frac{1}{\pi^*} - \frac{1}{R^*} \right) \frac{1}{w^* h^*} < \phi_a^{\rho} < \left(\frac{1}{\pi^*} + \frac{1}{R^*} \right) \frac{1}{w^* h^*}, \tag{B4}$$

where in this case the approximation involves stronger assumptions than equation (17) because it also ignores equilibrium responses of wages and hours to changes in lagged debt. For the calibration adopted in this paper, the economy would (approximately) be in a fiscal dominance regime under the tax revenue rule if $\phi_a^{\rho} < 0.039$, and under the tax rate rule if $\phi_a^{\tau} < 0.232$. Section 3.2 considers the cases $\phi_a^{\rho} = 0$ and $\phi_a^{\tau} = 0$. Section 3.3 extends the analysis to allow these coefficients to take a range of other values.

APPENDIX C: COMPUTATIONS FOR FIGURES 1, 4, AND 5

The plots in Figures 1, 4, and 5 are computed using 101 points both for the coefficients on the horizontal and on the vertical axis. The coefficient ϕ_y^R is assumed to belong to the set $\{-0.5, 0, 0.5\}$. Hence, for each rule we consider a grid of 30,603 points. The welfare evaluations may be inaccurate for points near the indeterminacy regions. To overcome this problem we only compute welfare for points lying in the interior of the unique equilibrium area. The statistics referred to in the paper were computed through 500 simulations of 100 periods. All computations have been done with the DYNARE toolkit.

APPENDIX D: WELFARE COMPUTATIONS

Following the Bellman equation one can define

$$VF_t = U_t + \beta E_t VF_{t+1}, \tag{D1}$$

where U_t is period utility and VF_t is lifetime utility. Conditional welfare is the value of lifetime utility taking into account that the initial starting point is a predetermined level. This value can be obtained from the a second-order approximation to the policy function of VF_t. With the policy function at hand, conditional welfare can be obtained by plugging the initial steady state into the policy function of VF_t. It is common to consider the initial steady state to be the nonstochastic steady state.

We conduct welfare comparisons of different rules. Consider the reference policy, denoted by r, and an alternative policy denoted by a. We have taken the reference policy to be the Ramsey policy. The conditional welfare of the reference regime is

$$VF_0^r = E_0 \sum_{t=0}^{\infty} \beta^t U\left(c_t^r, h_t^r\right), \tag{D2}$$

where c_t^r and h_t^r denote consumption and hours of work in the reference regime. Similarly, conditional welfare in the alternative regime is

$$VF_0^a = E_0 \sum_{t=0}^{\infty} \beta^t U\left(c_t^a, h_t^a\right). \tag{D3}$$

We denote by λ the welfare cost of following the alternative regime. It is defined as the fraction of regime r's consumption that the household would be willing to lose to be as well off under regime a as regime r:

$$VF_0^a = E_0 \sum_{t=0}^{\infty} \beta^t U\left((1+\lambda)c_t^r, h_t^r\right). \tag{D4}$$

For the specific utility function considered, the expression can be rearranged as

$$VF_0^a = VF_0^r + \frac{1}{1-\beta} ln(1+\lambda), \tag{D5}$$

where λ is defined as an implicit function, which we will approximate up to second order. Following Schmitt-Grohé and Uribe (2004b), we introduce a parameter σ that scales the variance of the exogenous stochastic processes g_t and z_t. Totally differentiating equation (D5) twice with respect to σ we can obtain $\lambda_{\sigma\sigma}$, which is the only term different from zero in the second-order approximation around the nonstochastic steady state. It easily follows that

$$\lambda = (1-\beta)\left(VF^a_{\sigma\sigma} - VF^r_{\sigma\sigma}\right)\frac{\sigma^2}{2}, \tag{D6}$$

or equivalently

$$\lambda = (1-\beta)\left(VF_0^a - VF_0^r\right)\frac{\sigma^2}{2}. \tag{D7}$$

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