Monetary Conservatism and Fiscal Policy: The Case of Distortionary Taxes*

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Abstract

The analysis of Adam and Billi (2008) is robust to distortionary taxation.

1 Introduction

We show that the main findings of Adam and Billi (2008), who analyze an economy with lump sum taxes, carry over to an economy with distortionary labor income taxes. Specifically, sequential monetary policy gives rise to an inflation bias and sequential fiscal policy leads to overspending on public goods. Our numerical exercises show that steady state welfare is significantly higher if the monetary authority is much more averse to inflation than society. Moreover, monetary conservatism is socially desirable independent of whether fiscal policy is determined before or after monetary policy. When fiscal policy is determined before monetary

*The views expressed herein are solely those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Kansas City or the Federal Reserve System.

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policy each period, however, monetary conservatism may eliminate the policy biases from sequential monetary *and* fiscal policy, i.e., solve the monetary and fiscal commitment problems. Monetary conservatism then recovers the Ramsey steady state. We restrict attention to the steady state analysis of the alternative policy regimes.

2 The Model

We adopt the sticky-price model of Adam and Billi (2008) and introduce distortionary labor income taxes.

2.1 Private Sector

There is a continuum of identical households with preferences given by

$$\sum_{t=0}^{\infty} \beta^t u(c_t, h_t, g_t) \tag{1}$$

where c_t is consumption of an aggregate consumption good, $h_t \in [0, 1]$ labor effort, g_t public goods provision by the government in the form of aggregate consumption goods, and $\beta \in (0, 1)$ the discount factor. Utility is separable in c, h, g and $u_c > 0$, $u_{cc} < 0$, $u_h < 0$, $u_{hh} \leq 0$, $u_g > 0$, $u_{gg} < 0$, and $\left|\frac{cu_{cc}}{u_c}\right|, \left|\frac{hu_{hh}}{u_h}\right|$ are bounded.

Each household produces a differentiated intermediate good. Demand for this good is $y_t d(\widetilde{P}_t/P_t)$, where y_t is (private and public) demand for the aggregate good and $\widetilde{P}_t/P_t$ the relative price of the intermediate good compared to the aggregate good. The demand function $d(\cdot)$ satisfies $d(1) = 1$ and $d'(1) = \eta$, where $\eta < -1$ is the price elasticity of demand for the different goods. The demand function is consistent with optimizing individual behavior when private and public consumption goods are a Dixit-Stiglitz aggregate of the goods produced by different households. The household chooses $\widetilde{P}_t$, then hires the necessary amount of labor effort $\widetilde{h}_t$ to satisfy the resulting product demand, i.e.,

$$\widetilde{h}_t = y_t d \left(\frac{\widetilde{P}_t}{P_t} \right) \tag{2}$$

Following Rotemberg (1982), sluggish nominal price adjustment by firms is described by quadratic resource costs for adjusting prices according to

$$\frac{\theta}{2} \left(\frac{\widetilde{P}_t}{\widetilde{P}_{t-1}} - 1 \right)^2$$

where $\theta > 0$ indexes the degree of price stickiness.[1] The households' budget constraint is

$$P_t c_t + B_t = R_{t-1} B_{t-1} + P_t \left[\frac{\widetilde{P}_t}{P_t} y_t d \left(\frac{\widetilde{P}_t}{P_t} \right) - w_t \widetilde{h}_t - \frac{\theta}{2} \left(\frac{\widetilde{P}_t}{\widetilde{P}_{t-1}} - 1 \right)^2 \right] + P_t w_t h_t (1 - \tau_t) \tag{3}$$

where R_t is the gross nominal interest rate, B_t are nominal bonds that pay $R_t B_t$ in period $t+1$, w_t is the real wage paid in a competitive labor market, and τ_t is a labor income tax.[2]

Although bonds are the only available financial instrument, having complete financial markets would not matter for the analysis because households have identical incomes in a symmetric price setting equilibrium.[3]

Finally, the no-Ponzi scheme constraint on household behavior is

$$\lim_{j \to \infty} \prod_{i=0}^{t+j-1} \frac{1}{R_i} B_{t+j} \geq 0 \tag{4}$$

The household's problem consists of choosing $\{c_t, h_t, \widetilde{h}_t, \widetilde{P}_t, B_t\}_{t=0}^{\infty}$ to maximize (1) subject to (2), (3) and (4) taking as given $\{y_t, P_t, w_t, R_t, g_t, \tau_t\}_{t=0}^{\infty}$. The first order conditions of the household's problem are then equations (2), (3) and (4) holding with equality and also

[1] Using instead the Calvo approach to nominal rigidities would considerably complicate matters because price dispersion then becomes an endogenous state variable.

[2] Considering instead income or consumption taxes would be equivalent to having a labor income tax together with a lump sum tax (on profits).

[3] We abstract from money holdings and thus seigniorage by considering a 'cashless limit' economy à la Woodford (1998); money only imposes a lower bound on nominal interest rates ($R_t \geq 1$).

$$
\begin{aligned}
-\frac{u_{ht}}{u_{ct}} =& w_t(1-\tau_t) \qquad (5)\\
\frac{u_{ct}}{R_t} =& \beta\frac{u_{ct+1}}{\Pi_{t+1}}\\
0 =& u_{ct}\left[y_t d(r_t) + r_t y_t d'(r_t) - \frac{w_t}{z_t} y_t d'(r_t) - \theta\left(\Pi_t \frac{r_t}{r_{t-1}} - 1\right)\frac{\Pi_t}{r_{t-1}}\right]\\
&+ \beta\theta u_{ct+1}\left(\frac{r_{t+1}}{r_t}\Pi_{t+1} - 1\right)\frac{r_{t+1}}{r_t^2}\Pi_{t+1}
\end{aligned}
$$

where $r_t \equiv \frac{\widetilde{P}_t}{P_t}$ is the relative price and $\Pi_t \equiv \frac{P_t}{P_{t-1}}$ the gross inflation rate. Furthermore, the transversality condition $\lim_{j\to\infty}\left(\beta^{t+j}u_{ct+j}B_{t+j}/P_{t+j}\right) = 0$ has to hold at all contingencies.

2.2 Government

The government consists of a monetary authority setting nominal interest rates R_t and a fiscal authority determining the level of public good provision g_t. The fiscal authority cannot commit to future policies or to repay government debt. As a result, in each period government expenditure must be financed with current taxes. The budget constraint is

$$
\tau_t w_t h_t = g_t \qquad (6)
$$

We will also consider the case where the fiscal authority can commit to future policies and thereby could credibly promise to repay debt. Yet, we impose the balanced-budget condition (6) also under commitment to make the cases with and without commitment more easily comparable. This can be interpreted as normalizing the initial government debt level B_{-1} to 0 in the cases with a without commitment: under commitment policymakers will then have no incentive to issue debt in the resulting Ramsey steady state. Overall, lack of government debt implies that we abstract from monetary and fiscal interactions that operate directly through the government budget constraint, as analyzed in Díaz-Giménez et al. (2008).

2.3 Private Sector Equilibrium

In a symmetric price setting equilibrium the relative price is given by $r_t = 1$ for all t. From the assumptions made, it follows that the first order conditions of households behavior can be condensed into a price setting equation

$$u_{ct}(\Pi_t - 1)\Pi_t = \frac{u_{ct}h_t}{\theta}\left(1 + \eta + \eta\left(\frac{u_{ht}}{u_{ct}} - \frac{g_t}{h_t}\right)\right) + \beta u_{ct+1}(\Pi_{t+1} - 1)\Pi_{t+1} \tag{7}$$

often referred to as a 'Phillips curve', and a consumption Euler equation

$$\frac{u_{ct}}{R_t} = \beta\frac{u_{ct+1}}{\Pi_{t+1}} \tag{8}$$

Conveniently, the last two equations do not make reference to taxes and real wages, while equations (5) and (6) give

$$\tau_t = \frac{g_t}{g_t - h_t\frac{u_{ht}}{u_{ct}}} \tag{9}$$

$$w_t = \frac{g_t}{h_t} - \frac{u_{ht}}{u_{ct}} \tag{10}$$

We make the natural assumption that private bonds are in zero aggregate net supply, which implies that in a symmetric equilibrium $B_t = 0$ for each household. The no-Ponzi scheme constraint (4) and the transversality condition are then always satisfied and can be ignored from now on.

A private-sector rational expectations equilibrium consists of plans $\{c_t, h_t, \Pi_t\}$ satisfying equations (7) and (8) and the market-clearing condition, i.e., the feasibility constraint,

$$c_t + \frac{\theta}{2}(\Pi_t - 1)^2 + g_t = h_t \tag{11}$$

given the policies $\{g_t, R_t \geq 1\}$ and the initial condition P_{-1}.

3 Monetary and Fiscal Policy Regimes

This section describes the policy regimes. We consider benevolent policymakers, who maximize the welfare of the representative agent. Although the descriptive realism of this assumption is open to debate, importantly it enables us to isolate the inefficiencies stemming from the lack of commitment to future policies.

3.1 First-Best and Ramsey Allocation

Along the lines of Adam and Billi (2008), the first-best allocation, which accounts only for preferences and technological constraints, satisfies

$$u_g = u_c = -u_h$$

where the marginal utility of private and public consumption and the marginal disutility of labor effort are equated.

The Ramsey allocation, however, is second-best because it takes into account also the presence of price setting and monopoly distortions as well as the distortions from labor income taxes. Specifically, the Ramsey allocation solves

$$\max_{\{c_t, h_t, \Pi_t, R_t \geq 1, g_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t u(c_t, h_t, g_t) \tag{12}$$

$$\text{s.t. Equations } (7), (8), (11) \text{ for all } t$$

Note that the Ramsey allocation still allows for commitment to policies at time zero and full cooperation between monetary an fiscal policymakers. As shown in appendix A.1, the Ramsey steady state satisfies

$$\Pi = 1 \tag{13}$$

as well as the marginal conditions

$$-u_h < u_g \tag{14}$$

$$-u_h = \left(\frac{1+\eta}{\eta} - \frac{g}{h} \right) u_c \tag{15}$$

Equation (13) shows that it is optimal to achieve price stability. Instead, equation (14) shows that public spending in the Ramsey allocation is below the first-best level because at the same time equation (15) shows that there is a wedge between the marginal utility of private consumption and the marginal disutility of work. This wedge has two components. The first component is due to the monopoly distortions and the second stems from the distortionary taxes levied to finance public spending. As a result, public spending below the first-best level reduces labor taxes and shrinks the wedge between private consumption and leisure.

3.2 Sequential Policymaking

We now consider separate monetary and fiscal authorities that cannot commit to future policy plans and decide about policies at the time of implementation. To facilitate the exposition, each policymaker takes as given the current policy choice of the other policymaker as well as all future policy choices and future private-sector choices. We verify the rationality of these assumptions at the end of this section.

3.2.1 Sequential Fiscal Policy: Spending Bias

Given the assumptions made above, the fiscal authority's problem in period t is

$$\max_{\{c_{t+j},h_{t+j},\Pi_{t+j},g_{t+j}\}} \sum_{j=0}^{\infty} \beta^j u(c_{t+j}, h_{t+j}, g_{t+j}) \tag{16}$$

$$\text{s.t. Equations } (7), (8), (11) \text{ for all } t$$

$$\{c_{t+j}, h_{t+j}, \Pi_{t+j}, R_{t+j-1} \geq 1, g_{t+j}\} \text{ given for } j \geq 1$$

Eliminating Lagrange multipliers from the first order conditions of this problem delivers the fiscal reaction function

$$u_{gt} = -u_{ht} \frac{2\Pi_t - 1 - \eta(\Pi_t - 1)}{2\Pi_t - 1 - (\Pi_t - 1)\left(1 + \eta + \eta\frac{u_{ht}}{u_{ct}} + \eta h_t \frac{u_{hht}}{u_{ct}}\right)} \tag{FRF}$$

When $\Pi_t = 1$, the fiscal reaction function then simplifies to

$$u_{gt} = -u_{ht} \tag{17}$$

Thus, provided monetary policy achieves price stability ($\Pi_t = 1$), sequential fiscal policy equates the marginal utility of public consumption to the marginal disutility of work, as would be optimal in the first-best allocation in the absence of monopoly distortions and distortionary taxes. Such behavior is suboptimal, however, as it does not take into account the distortions from labor taxation. Equation (8) shows that the fiscal authority perceives current private consumption as determined by the current monetary policy choice (R_t) and future decisions (c_{t+1}, Π_{t+1}), which are taken as given today. As a result, the fiscal authority perceives output and thereby labor effort to move one-for-one with public spending. We have the following result:

Proposition 1 *Sequential fiscal policy implies excessive fiscal spending in the presence of price stability.*

The fiscal reaction function (FRF) also implies

$$\frac{\partial \left(1/u_{gt}\right)}{\partial \Pi_t} < 0 \tag{18}$$

which shows that, all else equal, the fiscal spending bias is smaller when the monetary authority aims at positive inflation rates. For $\Pi_t > 1$, the marginal resource cost of generating higher inflation through increased fiscal spending is not zero, see equation (11). The fiscal authority thus reduces public spending because it takes these resource costs into account.[4]

The previous result suggests that a conservative monetary authority that achieves price stability could increase the distortion due to sequential fiscal policy. Such distortion is even larger if monetary conservatism also leads to reduced labor input.

[4] For $\Pi_t < 1$, the fiscal spending bias is larger because public spending generates inflation and thereby lowers the marginal resource cost of inflation.

3.2.2 Sequential Monetary Policy: Inflation Bias

Given the previous assumptions, the monetary authority's problem in period t is

$$\max_{\{c_{t+j},h_{t+j},\Pi_{t+j},R_{t+j}\geq 1\}} \sum_{j=0}^{\infty} \beta^j u(c_{t+j}, h_{t+j}, g_{t+j}) \tag{19}$$

$$\text{s.t. Equations (7),(8),(11) for all } t$$

$$\{c_{t+j}, h_{t+j}, \Pi_{t+j}, R_{t+j} \geq 1, g_{t+j-1}\} \text{ given for } j \geq 1$$

Eliminating Lagrange multipliers from the first order conditions delivers the monetary reaction function

$$\begin{aligned} &-\frac{u_{ct}}{u_{ht}}\left(\eta\left(\Pi_t - 1\right) - \Pi_t\right) - \left(\Pi_t - 1\right)\eta\left(1 + h_t\frac{u_{hht}}{u_{ht}}\right) \\ &+ 2\Pi_t - 1 - \frac{u_{cct}}{u_{ct}}\left(\Pi_t - 1\right)\left(\theta(\Pi_t - 1)\Pi_t - h_t\left(1 + \eta - \eta\frac{g_t}{h_t}\right)\right) = 0 \end{aligned} \tag{MRF}$$

Appendix A.4 proves the following result:

Proposition 2 *For β sufficiently close to 1, sequential monetary policy implies a strictly positive rate of inflation in steady state.*

Sequential monetary policy generates the familiar 'inflation bias' as in Barro and Gordon (1983). Intuitively, the monetary authority is tempted to stimulate demand by lowering nominal interest rates. Since price adjustments are costly, the price level will not fully adjust, and real interest rates fall, which stimulates demand. The real wage increase required to satisfy this additional demand generates inflation, see the Phillips curve (7) and equation (10), but the welfare costs of inflation are not fully taken into account for reasons discussed at length in Adam and Billi (2008). Ultimately, monetary policy increases real wages and inflation to the point where the marginal utility of an additional unit of consumption is equal to the marginal disutility of work and the perceived costs of inflation.

3.2.3 Sequential Monetary and Fiscal Policy

We now define a Markov-perfect Nash equilibrium with sequential monetary and fiscal policy. We also verify the rationality of our initial assumptions that sequentially deciding policymakers can take as given the current policy choice of the other policymaker, as well as all future policies and future private-sector decisions.

The private sector's optimality conditions, (7) and (8), the feasibility constraint (11), as well as the policy reactions functions FRF and MRF, all depend on current and future variables only. This observation suggests the existence of an equilibrium where current play is a function of current economic conditions only, which justifies taking as given future equilibrium play. If each period, in addition, monetary and fiscal policy are determined simultaneously, Nash equilibrium requires taking the other players' current decisions as given. This justifies the assumptions made in deriving FRF and MRF, it also motivates the following definition.

Definition 3 (SP) *A stationary Markov-perfect Nash equilibrium with sequential monetary and fiscal policy is a steady state* $\{c, h, \Pi, R \geq 1, g\}$*, such that the sequence* $\{c_t = c, h_t = c, \Pi_t = \Pi, R_t = R, g_t = g\}_{t=0}^{\infty}$ *satisfies equations (7),(8),(11), FRF and MRF.*

We now show that assuming Stackelberg leadership by one of the policy authorities (with regard to the within-period moves), instead of simultaneous decisions, is consistent with the same equilibrium outcome. While the policy problem of the Stackelberg follower remains unchanged, the Stackelberg leader takes into account the reaction function of the follower. Yet, the Lagrange multipliers associated with additionally imposing MRF on the sequential fiscal problem (16) or with imposing FRF in the sequential monetary problem (19) are zero. These reaction functions can be derived from the first order conditions of the leader's policy problem even when the follower's reaction function is not being imposed.

Intuitively, the leadership structure does not matter for the equilibrium outcome because both authorities are pursuing the same policy objective. Any departure from the Ramsey solution is thus entirely due to sequential decision making. The presence of different policymakers and the sequence of moves will start to matter in section 6 when we consider a monetary authority that is more inflation averse than the fiscal authority.

From proposition 2 and MRF, the steady state with sequential monetary and fiscal policy features an inflation bias. Whether there is also a fiscal spending bias depends on the severity of the inflation bias. For inflation rates close to one, public spending will be larger than in the Ramsey steady state, see the discussion in section 3.2.1; however, for sufficiently high inflation fiscal spending may fall short of the Ramsey steady state level.

3.3 One-Sided Commitment

In the case with monetary commitment and sequential fiscal policy, the monetary authority takes into account the fiscal reaction function when determining monetary policy. The monetary authority's problem in period t is

$$\max_{\{c_t, h_t, \Pi_t, R_t \geq 1, g_t\}} \sum_{t=0}^{\infty} \beta^t u(c_t, h_t, g_t) \tag{OI}$$

$$\text{s.t. Equations (7),(8),(11),FRF for all } t$$

We refer to the steady state solution of this problem as the optimal inflation (OI) regime, as it allows the monetary authority to commit to its preferred steady state inflation rate.[5]

The OI regime is not a Markov-perfect Nash equilibrium because FRF implies that the fiscal authority takes future monetary policy decisions as given. Under commitment, however, the monetary authority can condition current play on the past play of the fiscal authority which rationally takes this fully into account.[6] By taking future play as given, the fiscal authority fails to correctly anticipate the off-equilibrium behavior of the monetary authority. At the

[5] Equation (8) shows that commitment to a steady state interest rate determines the steady state inflation rate.

[6] When the sequential policymaker is rational, the committed policymaker can then sustain the Ramsey equilibrium via appropriate trigger strategies.

same time, the fiscal authority holds rational beliefs about equilibrium play, which implies that beliefs are never contradicted by outcomes. The solution to the OI regime is thus a self-confirming equilibrium, see Fudenberg and Levine (1993) or Sargent (1999).

We now consider the polar case with fiscal commitment and sequential monetary policy, where the fiscal authority takes into account the monetary reaction function when determining fiscal policy. The fiscal authority's problem in period t is

$$\max_{\{c_t,h_t,\Pi_t,R_t\geq 1,g_t\}} \sum_{t=0}^{\infty} \beta^t u(c_t,h_t,g_t) \tag{OS}$$

$$\text{s.t. Equations (7),(8),(11),MRF for all } t$$

We refer to the steady state solution of this problem as the optimal spending (OS) regime, as it allows the fiscal authority to commit to its preferred steady state government spending and taxes.

4 Calibration

To quantify the policy biases associated with the different policy regimes, we consider the following preference specification, which is consistent with balanced growth,

$$u(c_t,h_t,g_t) = \log(c_t) - \omega_h \frac{h_t^{1+\varphi}}{1+\varphi} + \omega_g \log(g_t) \tag{20}$$

with $\omega_h > 0$, $\omega_g \geq 0$ and $\varphi \geq 0$. The calibration of the model follows Adam and Billi (2008) and is summarized in table 1.

The quarterly discount factor β is set to 0.9913 implying an annual real interest rate of 3.5%. The price elasticity of demand η is set at -6, which implies a 20% mark-up over marginal costs. The degree of price stickiness θ is chosen to be 17.5, such that the log-linearized version of the Phillips curve (7) is consistent with the estimates of Sbordone (2002), as in Schmitt-Grohé and Uribe (2004). Labor supply elasticity is set to $\varphi^{-1} = 1$ and the utility weights

ω_h and ω_g are chosen such that in the Ramsey steady state agents work 20% of their time ($h = 0.2$) and spend 20% of output on public goods ($g = 0.04$).[7]

We tested the robustness of our numerical results by considering a wide range of alternative model parameterizations and by using different starting values. To keep the Ramsey steady state invariant to the parametrization, we adjusted the weights ω_h and ω_g.

5 Steady State Results

Table 2 summarizes the steady state effects of the different policy arrangements on private consumption, working hours, fiscal spending, and inflation rates, with variables expressed in terms of percentage deviations from the Ramsey steady state.[8] The table also reports the steady state tax level and welfare losses. The latter are expressed as the percentage reduction in private consumption each period that would entail the Ramsey steady state to be welfare equivalent to the considered policy regime.

First, consider the case with sequential monetary and fiscal policy (SP) in table 2. This setting is characterized by a strong fiscal spending bias and a large inflation bias, as suggested by propositions 1 and 2. As suggested by the discussion in section 3.2.1, excessive fiscal spending results in a crowding out of private consumption. The welfare losses generated by both policymakers acting sequentially are significant.

Next, consider the optimal inflation regime (OI) in table 2. Monetary policy finds it beneficial to implement considerably lower inflation rates than under sequential policy (SP). At the same time, the fiscal spending bias is significantly larger than in the SP regime. This explains why monetary policy refrains from bringing inflation rates even closer to zero. As is clear from the discussion following equation (18), this would increase the fiscal spending bias even further. While monetary commitment eliminates about half of the welfare losses

[7] See equations (47) and (51) in appendix A.5.

[8] In the Ramsey steady state $c = 0.16$, $h = 0.2$, $g = 0.04$, $\Pi = 1$ and $\tau = 0.24$.

emerging in the SP regime, the overall losses remain substantial, i.e., more than 4% of Ramsey steady state consumption.

Finally, consider the opposite case with sequential monetary policy and optimal spending (OS), i.e., fiscal commitment. This arrangement generates the familiar inflation bias associated with sequential monetary policy decisions in sticky price economies, see the last row in table 2. Monetary policy thereby increases real wages and the inflation rate to the point where the perceived marginal costs of inflation and the disutility of supplying additional labor balance the marginal utility of private consumption. Fiscal policy can reduce the incentives to inflate by reducing public consumption and taxes. These measures increase private consumption and working hours and thus dampen the monetary inflation bias. Yet, despite fiscal commitment the welfare losses from sequential monetary policy remain sizable and are even larger than those generated by sequential fiscal policy.

The results in table 2 illustrate that commitment by one authority alone can generate sizable welfare gains. Importantly, inflation with SP turns out to be higher than in the OI regime, which suggests that an appropriately conservative monetary authority may be able to improve welfare. Table 3 explores the robustness of this finding to different parameterizations of the model. The table reports the welfare losses associated with the various policy regimes and the change in inflation resulting from a relaxation of monetary commitment in a situation with sequential fiscal policy.

Table 3 shows that the baseline findings are fairly robust to assuming higher or lower degrees of nominal rigidity ($\theta = 5, 50$), higher or lower degrees of competition ($\eta = -5, -9$) and more or less elastic labor supply ($\varphi = 0.1, 3$). In all these cases, large welfare losses arise when relaxing monetary commitment in the presence of sequential fiscal policy. Moreover, lack of monetary commitment still leads to a sizable increase in equilibrium inflation, see the last column of table 3.

In the flexible price limit (low values of θ), when markets become very competitive (low values of η), or when labor supply becomes very inelasts, the time-inconsistency problems of monetary and fiscal policy disappear and real allocations approach the Ramsey steady state, independently of the policy arrangement in place.[9] As a result, the welfare gains from monetary commitment also disappear in these cases. Table 3 illustrates these findings by reporting the outcomes for $\theta = 0.1$, $\eta = -30$, and $\varphi = 0.1$

6 Conservative Monetary Authority

This section analyzes whether the distortions stemming from sequential monetary and fiscal policy decisions can be reduced by installing a monetary authority that is more inflation averse than society. Rogoff (1985) and Svensson (1997) have shown this to be the case if fiscal policy is treated as exogenous. Following Rogoff (1985), we consider a 'weight conservative' monetary authority with period objective function

$$(1-\alpha)u(c_{t+j}, h_{t+j}, g_{t+j}) - \alpha\frac{(\Pi_{t+j}-1)^2}{2} \tag{21}$$

where $\alpha \in [0, 1]$ is a measure of monetary conservatism. For $\alpha > 0$ the monetary authority dislikes inflation (and deflation) more than society; if $\alpha = 1$ the policymaker cares about inflation only. The preferences of the fiscal authority remain unchanged.

Replacing this conservative objective function (21) in the monetary authority's problem (19), the first order conditions deliver the monetary reaction function

[9] The gross steady state inflation rate, however, does not converge to one as $\theta \to 0$. Instead, numerical simulation show that Π approaches a value of approximately 1.18. Inflation becomes costless in the flexible price limit but it is required to eliminate the fiscal spending bias emerging under price stability.

$$
-\frac{u_{ct}}{u_{ht}}\left(\eta\left(\Pi_t-1\right)-\Pi_t\right)-\left(\Pi_t-1\right)\eta\left(1+h_t\frac{u_{hht}}{u_{ht}}\right)
$$
$$
+\left[2\Pi_t-1-\frac{u_{cct}}{u_{ct}}(\Pi_t-1)\left(\theta(\Pi_t-1)\Pi_t-h_t\left(1+\eta-\eta\frac{g_t}{h_t}\right)\right)\right]\frac{\left(1-\alpha\right)\theta-\alpha\frac{1}{u_{ht}}}{\left(1-\alpha\right)\theta+\alpha\frac{1}{u_{ct}}}=0 \tag{CMRF}
$$

For $\alpha = 0$, CMRF reduces to the monetary reaction function without conservatism (MRF). As before, CMRF implies that current interest rates depend on current economic conditions only, which validates the conjecture that future policy choices can be taken as given in a Markov-perfect Nash equilibrium.

6.1 Fiscal Commitment

We first consider the case with fiscal commitment and a sequential yet conservative monetary authority, where the fiscal authority takes into account the conservative monetary reaction function (CMRF) when determining fiscal policy. The fiscal authority's problem is

$$
\max_{\{c_t,h_t,\Pi_t,R_t\geq 1,g_t\}}\sum_{t=0}^{\infty}\beta^t u(c_t,h_t,g_t) \tag{OS-C}
$$
$$
\text{s.t. Equations (7),(8),(11),CMRF for all } t
$$

We refer to the steady state solution of this problem as the optimal spending regime with a conservative central bank (OS-C), as it allows the fiscal authority to commit to its preferred steady state level of public spending and taxes, while monetary policy pursues its conservative objective sequentially.

Figure 1 depicts the welfare losses associated with various degrees of monetary conservatism α for the baseline calibration in section 4. As $\alpha \to 1$ the welfare losses disappear and the steady state of the OS-C regime approaches the Ramsey steady state. For $\alpha \to 1$ the conservative monetary reaction function (CMRF) becomes consistent with the Ramsey steady state, since the Lagrange multiplier associated with CMRF in problem (OS-C) approaches zero.[10] As a result, for $\alpha \to 1$ the fiscal authority's policy problem (OS-C) approaches the Ramsey problem (12).[11] In a setting with fiscal commitment, a sufficiently conservative central bank thus eliminates the steady state distortions stemming from lack of monetary commitment.

6.2 Sequential Fiscal Policy

We now consider the case with sequential monetary and fiscal policy. When the monetary and fiscal authorities are pursuing different objectives, it matters for the equilibrium outcome whether fiscal policy is determined before, after, or simultaneously with monetary policy each period. It remains to be ascertained, however, which of these timing structures is the most relevant one for actual economies. While it might take long to implement fiscal policies, the time lag between a monetary policy decision and its effect on the economy can also be substantial. We thus consider Nash as well as leadership equilibria.

6.2.1 Nash and Leadership Equilibria

This section defines and briefly discusses the various equilibria in the presence of a conservative central banker. For the case with simultaneous decisions by the two policymakers, we propose the following definition.

Definition 4 (CSP-Nash) *A stationary Markov-perfect equilibrium with sequential and conservative monetary policy, sequential fiscal policy, and simultaneous policy decisions is a sequence* $\{c_t, h_t, \Pi_t, R_t, g_t\}_{t=0}^{\infty}$ *solving (7), (8), (11), FRF and CMRF.*

Next, we consider the case with monetary leadership. The conservative monetary authority takes into account the fiscal reaction function (FRF). The monetary authority's problem in

[10] This holds only from a 'steady state' or 'timeless' perspective. Initially, the Lagrange multiplier associated with CMRF in (OS-C) is non-zero.

[11] See the previous footnote.

period t is

$$\max_{\{c_{t+j},h_{t+j},\Pi_{t+j},R_{t+j}\geq 1,g_{t+j}\}} \sum_{j=0}^{\infty} \beta^j \left((1-\alpha)\left(u(c_{t+j},h_{t+j},g_{t+j}) - \alpha \frac{(\Pi_{t+j}-1)^2}{2}\right) \right. \tag{22}$$

s.t. Equations (7),(8),(11), FRF for all t

$\{c_{t+j}, h_{t+j}, \Pi_{t+j}, R_{t+j} \geq 1, g_{t+j}\}$ given for $j \geq 1$

Eliminating Lagrange multipliers from the first order conditions of this problem delivers the conservative monetary reaction function with monetary leadership that we denote with CMRF-ML.

Definition 5 (CSP-ML) *A stationary Markov-perfect equilibrium with sequential and conservative monetary policy, sequential fiscal policy, and monetary policy deciding before fiscal policy is a sequence* $\{c_t, h_t, \Pi_t, R_t, g_t\}_{t=0}^{\infty}$ *solving (7), (8), (11), FRF and CMRF-ML.*

Finally, we consider the case with fiscal leadership. The fiscal authority takes into account the conservative monetary reaction function (CMRF). The fiscal authority's problem in period t is

$$\max_{\{c_{t+j},h_{t+j},\Pi_{t+j},R_{t+j}\geq 1,g_{t+j}\}} \sum_{j=0}^{\infty} \beta^j u(c_{t+j},h_{t+j},g_{t+j}) \tag{23}$$

s.t.

Equations (7),(8),(11), CMRF for all t

$(c_{t+j}, h_{t+j}, \Pi_{t+j}, R_{t+j} \geq 1, g_{t+j})$ given for $j \geq 1$

Eliminating Lagrange multipliers from the first order conditions of this problem delivers the fiscal reaction function with a conservative monetary authority and fiscal leadership that we denote by CFRF-FL.

Definition 6 (CSP-FL) *A stationary Markov-perfect equilibrium with sequential and conservative monetary policy, sequential fiscal policy, and fiscal policy deciding before monetary policy is a sequence* $\{c_t, h_t, \Pi_t, R_t, g_t\}_{t=0}^{\infty}$ *solving (7), (8), (11), CFRF-FL and CMRF.*

As before, the steady states corresponding to the equilibrium definitions 4, 5, and 6 are defined as the stationary values (c, h, Π, R, g) solving the equations listed in the respective definitions.

We now briefly comment on these definitions. First, for $\alpha = 0$ all three equilibria reduce to the one emerging under SP without conservatism because CMRF and CMRF-ML are then identical to MRF and CFRF-FL is identical to FRF. Second, for the Nash and monetary leadership cases, there is a theoretical upper bound on the welfare gains from monetary conservatism. When the fiscal authority takes monetary decisions as given, welfare maximizing monetary policy is the one consistent with the optimal inflation (OI) regime considered in section 3.2.1. Third, in the case with fiscal leadership, the fiscal authority anticipates the monetary reaction function and thereby conservatism can then lead to outcomes that are welfare superior to SP.

6.2.2 Effects of Monetary Conservatism

Figure 2 displays the welfare gains associated with different degrees of monetary conservatism under the various leadership assumptions for the baseline calibration in section 4. The horizontal line shown in the figure indicates the welfare losses associated with the OI regime. For $\alpha = 0$, i.e., the case without any monetary conservatism, all equilibria deliver the welfare losses associated with SP. This is just a restatement of the fact that the leadership structure does not matter when both policymakers pursue the same objectives.

With CSP-Nash and CSP-ML we find that an appropriately conservative central bank can fully recover the steady state associated with the OI regime, i.e., a regime with monetary commitment and sequential fiscal policy. The Nash and the monetary leadership equilibria thus suggest that the gains from monetary conservatism can be substantial and that one can fully recover the welfare losses resulting from lack of monetary commitment with an appropriate degree of monetary conservatism. The optimal degree of conservatism thereby turn out to be very close but slightly below 1. Interestingly, the costs associated with being fully conservative ($\alpha = 1$) can become significant. The economic intuition for this finding will be provided below.

The case for a conservative monetary authority is even stronger with fiscal leadership (CSP-FL). As shown in figure 2, a conservative monetary authority then not only eliminates the welfare losses from sequential monetary decisions but also those emerging from lack of fiscal commitment. In the limiting case of $\alpha \to 1$ monetary conservatism fully recovers the Ramsey steady state.

Fiscal leadership differs from the Nash and monetary leadership cases because the fiscal authority anticipates the within-period off-equilibrium behavior of the conservative monetary authority. For $\alpha = 1$ the monetary authority is determined to implement price stability at all costs. A fiscal expansion above the Ramsey spending level, which generates inflation, then triggers a strong increase in interest rates so as to reduce private consumption. The fiscal authority thus anticipates that fiscal spending results in a crowding out of private consumption and this disciplines its behavior.

Figure 3 displays the steady state values associated with various degrees of monetary conservatism for the different timing assumptions. While monetary conservatism unambiguously reduces the inflation bias, its effect on the fiscal spending bias and private consumption depends on whether or not fiscal policy anticipates the monetary policy decision. If fiscal policy takes the monetary decision as given, monetary conservatism results in an increased fiscal spending bias for the reasons discussed in section 3.2.1. This explains why in the Nash and monetary leadership cases becoming too inflation conservative may start to generate welfare losses after some point: the gains from lowering inflation then start to be outweighed by the losses from increased fiscal spending and the resulting crowding out of private consumption.

7 Conclusions

We extend the setting of Adam and Billi (2008) to the case with distortionary taxation and analyze monetary and fiscal policy interactions in a general equilibrium model when policymakers lack the ability to credibly commit to policies ex-ante.

We show that lack of fiscal commitment leads to excessive fiscal spending on public goods, while lack of monetary commitment results in an inflation bias. The welfare losses due to lack of monetary or fiscal commitment are substantial and significantly larger than in the case where lump sum taxes are available. Independent of whether fiscal policy can commit, installing a conservative monetary authority can completely eliminate the steady state losses due to lack of monetary commitment. If the fiscal authority determines policy before the monetary authority, the case for a conservative monetary authority is even stronger because monetary conservatism can also eliminate the steady state losses due to lack of fiscal commitment.

References

Adam, K., and R. Billi (2008): "Monetary Conservatism and Fiscal Policy," *resubmitted to Journal of Monetary Economics*.

Barro, R., and D. B. Gordon (1983): "A Positive Theory of Monetary Policy in a Natural Rate Model," *Journal of Political Economy*, 91, 589–610.

Díaz-Giménez, J., G. Giovannetti, R. Marimon, and P. Teles (2008): "Nominal Debt as a Burden on Monetary Policy," *Review of Economic Dynamics*, 11, 493–514.

Fudenberg, D., and D. Levine (1993): "Sef-Confirming Equilibrium," *Econometrica*, 61, 523–545.

Leeper, E. M. (1991): "Equilibria under Active and Passive Monetary and Fiscal Policies," *Journal of Monetary Economics*, 27, 129–147.

Rogoff, K. (1985): "The Optimal Degree of Commitment to an Intermediate Monetary Target," *Quarterly Journal of Economics*, 100(4), 1169–89.

Rotemberg, J. J. (1982): "Sticky Prices in the United States," *Journal of Political Economy*, 90, 1187–1211.

Sargent, T. J. (1999): *The Conquest of American Inflation*. Princeton Univ. Press, Princeton.

Sbordone, A. (2002): "Prices and Unit Labor Costs: A New Test of Price Stickiness," *Journal of Monetary Economics*, 49, 265–292.

Schmitt-Grohé, S., and M. Uribe (2004): "Optimal Fiscal and Monetary Policy under Sticky Prices," *Journal of Economic Theory*, 114(2), 198–230.

Svensson, L. E. O. (1997): "Optimal Inflation Targets, 'Conservative' Central Banks, and Linear Inflation Contracts," *American Economic Review*, 87, 98–114.

Woodford, M. (1998): "Doing Without Money: Controlling Inflation in a Post-Monetary World," *Review of Economic Dynamics*, 1, 173–209.

A Appendix

A.1 Ramsey Steady State

The Lagrangian of the Ramsey problem (12) is

$$
\max_{\{c_t,h_t,\Pi_t,R_t,g_t\}} E_0 \sum_{t=0}^{\infty} \beta^t \Big\{ u(c_t,h_t,g_t)
$$

$$
+ \gamma_t^1 \left[u_{ct}(\Pi_t - 1)\Pi_t - \frac{u_{ct} h_t}{\theta} \left(1 + \eta + \eta \left(\frac{u_{ht}}{u_{ct}} - \frac{g_t}{h_t} \right) \right) - \beta u_{ct+1}(\Pi_{t+1} - 1)\Pi_{t+1} \right]
$$

$$
+ \gamma_t^2 \left[\frac{u_{ct}}{R_t} - \beta \frac{u_{ct+1}}{\Pi_{t+1}} \right]
$$

$$
+ \gamma_t^3 \left[h_t - c_t - \frac{\theta}{2}(\Pi_t - 1)^2 - g_t \right] \Big\}
$$

The first-order conditions w.r.t. $(c_t, h_t, \Pi_t, R_t, g_t)$, respectively, are given by

$$
u_{ct} + \gamma_t^1 \left(u_{cct}(\Pi_t - 1)\Pi_t - \frac{u_{cct} h_t}{\theta} \left(1 + \eta - \eta \frac{g_t}{h_t} \right) \right)
$$

$$
-\gamma_{t-1}^1 u_{cct}(\Pi_t - 1)\Pi_t + \gamma_t^2 \frac{u_{cct}}{R_t} - \gamma_{t-1}^2 \frac{u_{cct}}{\Pi_t} - \gamma_t^3 = 0 \tag{24}
$$

$$
u_{ht} - \gamma_t^1 \frac{u_{ct}}{\theta} \left(1 + \eta + \eta \left(\frac{u_{ht}}{u_{ct}} + h_t \frac{u_{hht}}{u_{ct}} \right) \right) + \gamma_t^3 = 0 \tag{25}
$$

$$
\left(\gamma_t^1 - \gamma_{t-1}^1 \right) u_{ct}(2\Pi_t - 1) + \gamma_{t-1}^2 \frac{u_{ct}}{\Pi_t^2} - \gamma_t^3 \theta (\Pi_t - 1) = 0 \tag{26}
$$

$$
-\gamma_t^2 \frac{u_{ct}}{R_t^2} = 0 \tag{27}
$$

$$
u_{gt} + \gamma_t^1 \frac{u_{ct}}{\theta} \eta - \gamma_t^3 = 0 \tag{28}
$$

where $\gamma_{-1}^j = 0$ for $j = 1, 2$. We denote the Ramsey steady state by dropping time subscripts. Equation (27), $u_{ct} > 0$ and $R_t \geq 1$ imply

$$
\gamma^2 = 0
$$

This and (26) gives

$$
\Pi = 1
$$

From (8) it then follows

$$
R = \frac{1}{\beta}
$$

Equation (7) gives the Ramsey wedge between private consumption and labor effort

$$
-\frac{u_h}{u_c} = \frac{1+\eta}{\eta} - \frac{g}{h} < 1 \tag{29}
$$

Equations (24), (25) and (28) simplify to

$$u_c - \gamma^1 \frac{u_{cc}h}{\theta}\left(1+\eta-\eta\frac{g}{h}\right) - \gamma^3 = 0 \tag{30}$$

$$u_h - \gamma^1 \frac{u_c}{\theta}\left(1+\eta+\eta\left(\frac{u_h}{u_c}+h\frac{u_{hh}}{u_c}\right)\right) + \gamma^3 = 0 \tag{31}$$

$$u_g + \gamma^1 \frac{u_c}{\theta}\eta - \gamma^3 = 0 \tag{32}$$

Using (31) and (32) to eliminate γ^3 delivers

$$\frac{u_h + u_g}{\frac{u_c}{\theta}\left(1+\eta\frac{u_h}{u_c}+\eta h\frac{u_{hh}}{u_c}\right)} = \gamma^1 \tag{33}$$

showing that $u_g > -u_h$, as claimed, provided $\gamma^1 > 0$. We now show that $\gamma^1 \leq 0$ leads to a contradiction. Equation (33) then implies

$$u_g \leq -u_h$$

and (32)

$$\gamma^3 \leq u_g$$

Equation (30) gives

$$\begin{aligned} u_c &= \gamma^3 + \gamma^1 \frac{u_{cc}h}{\theta}\left(1+\eta-\eta\frac{g}{h}\right) \\ &< \gamma_3 \\ &\leq u_g \\ &\leq -u_h \end{aligned}$$

where the first inequality uses (29) which shows that $1+\eta-\eta\frac{g}{h} < 0$. The above implies $-\frac{u_h}{u_c} \geq 1$ which contradicts (29).

A.2 Sequential Fiscal Reaction Function

The fiscal problem (16) is

$$\max_{\{c_{t+j},h_{t+j},\Pi_{t+j},g_{t+j}\}} E_t \sum_{j=0}^{\infty} \beta^j \Big\{ u(c_{t+j}, h_{t+j}, g_{t+j})$$

$$+ \gamma^1_{t+j} \left[u_{ct+j}(\Pi_{t+j} - 1)\Pi_{t+j} - \frac{u_{ct+j}h_{t+j}}{\theta} \left(1 + \eta + \eta \left(\frac{u_{ht+j}}{u_{ct+j}} - \frac{g_{t+j}}{h_{t+j}} \right) \right) \right.$$

$$\left. - \ \beta u_{ct+j+1}(\Pi_{t+j+1} - 1)\Pi_{t+j+1} \right]$$

$$+ \gamma^2_{t+j} \left[\frac{u_{ct+j}}{R_{t+j}} - \beta \frac{u_{ct+j+1}}{\Pi_{t+j+1}} \right]$$

$$+ \gamma^3_{t+j} \left[h_{t+j} - c_{t+j} - \frac{\theta}{2}(\Pi_{t+j} - 1)^2 - g_{t+j} \right] \Big\}$$

taking as given R_{t+j-1} and other variables dated $t + j$ for $j \geq 1$. The first order conditions w.r.t. (c_t, h_t, Π_t, g_t), respectively, are given by

$$u_{ct} + \gamma^1_t \left(u_{cct}(\Pi_t - 1)\Pi_t - \frac{u_{cct}h_t}{\theta} \left(1 + \eta - \eta \frac{g_t}{h_t} \right) \right) + \gamma^2_t \frac{u_{cct}}{R_t} - \gamma^3_t = 0 \tag{34}$$

$$u_{ht} - \gamma^1_t \frac{u_{ct}}{\theta} \left(1 + \eta + \eta \frac{u_{ht}}{u_{ct}} + \eta h_t \frac{u_{hht}}{u_{ct}} \right) + \gamma^3_t = 0 \tag{35}$$

$$\gamma^1_t u_{ct}(2\Pi_t - 1) - \gamma^3_t \theta(\Pi_t - 1) = 0 \tag{36}$$

$$u_{gt} + \gamma^1_t \frac{u_{ct}}{\theta} \eta - \gamma^3_t = 0 \tag{37}$$

From equations (36) and (37) one gets

$$\gamma^1_t = \frac{u_{gt}\theta(\Pi_t - 1)}{u_{ct}(2\Pi_t - 1 - \eta(\Pi_t - 1))}$$

Using the previous result and (37) to substitute the Lagrange multipliers in (35) delivers FRF shown in the main text.

A.3 Sequential Monetary Reaction Function

The monetary problem (19) is

$$
\begin{aligned}
&\max_{\{c_{t+j},h_{t+j},\Pi_{t+j},R_{t+j}\}} E_t \sum_{j=0}^{\infty} \beta^j \Big\{ u(c_{t+j}, h_{t+j}, g_{t+j}) \\
&+ \gamma^1_{t+j} \left[u_{ct+j}(\Pi_{t+j}-1)\Pi_{t+j} - \frac{u_{ct+j}h_{t+j}}{\theta}\left(1+\eta+\eta\left(\frac{u_{ht+j}}{u_{ct+j}} - \frac{g_{t+j}}{h_{t+j}}\right)\right)\right. \\
&- \left. \beta u_{ct+j+1}(\Pi_{t+j+1}-1)\Pi_{t+j+1}\right] \\
&+ \gamma^2_{t+j}\left[\frac{u_{ct+j}}{R_{t+j}} - \beta\frac{u_{ct+j+1}}{\Pi_{t+j+1}}\right] \\
&+ \gamma^3_{t+j}\left[h_{t+j} - c_{t+j} - \frac{\theta}{2}(\Pi_{t+j}-1)^2 - g_{t+j}\right]\Big\}
\end{aligned}
$$

taking as given g_{t+j-1} and other variables dated $t+j$ for $j \geq 1$. The first order conditions w.r.t. (c_t, h_t, Π_t, R_t), respectively, are given by

$$u_{ct} + \gamma^1_t\left(u_{cct}(\Pi_t-1)\Pi_t - \frac{u_{cct}h_t}{\theta}\left(1+\eta-\eta\frac{g_t}{h_t}\right)\right) + \gamma^2_t\frac{u_{cct}}{R_t} - \gamma^3_t = 0 \tag{38}$$

$$u_{ht} - \gamma^1_t\frac{u_{ct}}{\theta}\left(1+\eta+\eta\frac{u_{ht}}{u_{ct}} + \eta h_t\frac{u_{hht}}{u_{ct}}\right) + \gamma^3_t = 0 \tag{39}$$

$$\gamma^1_t u_{ct}(2\Pi_t - 1) - \gamma^3_t\theta(\Pi_t - 1) = 0 \tag{40}$$

$$-\gamma^2_t\frac{u_{ct}}{R_t^2} = 0 \tag{41}$$

Equation (41), $u_{ct} > 0$ and $R_t \geq 1$ imply

$$\gamma^2_t = 0$$

Then solving (38), (39) and (40) for γ^3_t delivers, respectively,

$$\gamma^3_t = u_{ct} + \gamma^1_t\left(u_{cct}(\Pi_t-1)\Pi_t - \frac{u_{cct}h_t}{\theta}\left(1+\eta-\eta\frac{g_t}{h_t}\right)\right) \tag{42}$$

$$\gamma^3_t = -u_{ht} + \gamma^1_t\frac{u_{ct}}{\theta}\left(1+\eta+\eta\frac{u_{ht}}{u_{ct}} + \eta h_t\frac{u_{hht}}{u_{ct}}\right) \tag{43}$$

$$\gamma^3_t = \gamma^1_t\frac{u_{ct}\,(2\Pi_t-1)}{\theta\,(\Pi_t-1)} \tag{44}$$

Equations (42) and (44) imply

$$\gamma_t^1 = \frac{\theta}{\frac{2\Pi_t - 1}{\Pi_t - 1} - \frac{u_{cct}}{u_{ct}}\left(\theta(\Pi_t - 1)\Pi_t - h_t\left(1 + \eta - \eta\frac{g_t}{h_t}\right)\right)} \tag{45}$$

While equations (43) and (44) give

$$\gamma_t^1 = \frac{\theta}{\frac{u_{ct}}{u_{ht}}\left[1 + \eta - \frac{2\Pi_t - 1}{\Pi_t - 1} + \eta\frac{u_{ht}}{u_{ct}} + \eta h_t \frac{u_{hht}}{u_{ct}}\right]} \tag{46}$$

From (45) and (46) one obtains MRF shown in the main text.

A.4 Proof of Proposition 2

Taking the limit $\Pi \to 1$ of the steady state version of MRF shows that this requires

$$\frac{-u_h}{u_c} = 1$$

but from (7) follows that $\frac{-u_h}{u_c}$ is bounded away from 1 when $\Pi = 1$. The steady state inflation rate consistent with MRF must thus be bounded away from $\Pi = 1$. The Euler equation (8) and the constraint $R \geq 1$ imply that $\Pi \geq \beta$ in any steady state. Therefore, for β sufficiently close to 1 it must be that $\Pi > 1$ in any steady state, as claimed.

A.5 Utility Weights

We denote the Ramsey steady state by dropping time subscripts. For the preference specification (20), the Ramsey policy marginal condition (15) delivers

$$\omega_h = \frac{1}{ch^{\varphi}}\left(\frac{1+\eta}{\eta} - \frac{g}{h}\right) \tag{47}$$

The first-order conditions (24), (25) and (28), respectively, give

$$u_c - \gamma^1\left(\frac{u_{cc}h}{\theta}\left(1 + \eta - \eta\frac{g}{h}\right)\right) - \gamma^3 = 0 \tag{48}$$

$$u_h - \gamma^1\frac{u_c}{\theta}\left(1 + \eta + \eta\left(\frac{u_h}{u_c} + h_t\frac{u_{hh}}{u_c}\right)\right) + \gamma^3 = 0 \tag{49}$$

$$u_g + \gamma^1\frac{u_c}{\theta}\eta - \gamma^3 = 0 \tag{50}$$

Eliminating γ^3 from (48) and (49) implies

$$\gamma^1 = \frac{u_c + u_h}{\frac{u_{cc}h}{\theta}\left(1+\eta-\eta\frac{g}{h}\right) + \frac{u_c}{\theta}\left(1+\eta+\eta\left(\frac{u_h}{u_c}+h_t\frac{u_{hh}}{u_c}\right)\right)}$$

Equation (48) also gives

$$\gamma^3 = u_c - \gamma^1\left(\frac{u_{cc}h}{\theta}\left(1+\eta-\eta\frac{g}{h}\right)\right)$$

For the preference specification (20), then (50) delivers

$$\omega_g = g\left(\gamma^3 - \gamma^1\frac{1}{c}\frac{\eta}{\theta}\right) \tag{51}$$

A.6 Consumption Losses Relative to Ramsey

Let $u(c,h,g)$ denote the period utility for the Ramsey steady state and let $u\left(c^A,h^A,g^A\right)$ represent the period utility for the steady state of an alternative policy regime. The permanent reduction in private consumption that would imply the Ramsey steady state to be welfare equivalent to the alternative policy regime $\mu^A \leq 0$ is implicitly defined by

$$\begin{aligned}\frac{1}{1-\beta}u\left(c^A,h^A,g^A\right) &= \frac{1}{1-\beta}u\left(c(1+\mu^A),h,g\right)\\ &= \frac{1}{1-\beta}\left[u(c,h,g)+\log\left(1+\mu^A\right)\right]\end{aligned}$$

where the second equality uses equation (20). Therefore, one obtains

$$\mu^A = \exp\left[u\left(c^A,h^A,g^A\right) - u(c,h,g)\right] - 1$$

A.7 Conservative Monetary Reaction Function

The conservative monetary problem (21) is

$$
\begin{aligned}
&\max_{\{c_{t+j},h_{t+j},\Pi_{t+j},R_{t+j}\}} E_t \sum_{j=0}^{\infty} \beta^j \Big\{ (1-\alpha)\, u(c_{t+j},h_{t+j},g_{t+j}) - \frac{\alpha}{2}\left(\Pi_{t+j}-1\right)^2 \\
&+ \gamma^1_{t+j} \left[u_{ct+j}(\Pi_{t+j}-1)\Pi_{t+j} - \frac{u_{ct+j}h_{t+j}}{\theta} \left(1+\eta+\eta\left(\frac{u_{ht+j}}{u_{ct+j}} - \frac{g_{t+j}}{h_{t+j}}\right)\right)\right. \\
&- \left. \beta u_{ct+j+1}(\Pi_{t+j+1}-1)\Pi_{t+j+1} \right] \\
&+ \gamma^2_{t+j} \left[\frac{u_{ct+j}}{R_{t+j}} - \beta \frac{u_{ct+j+1}}{\Pi_{t+j+1}} \right] \\
&+ \gamma^3_{t+j} \left[h_{t+j} - c_{t+j} - \frac{\theta}{2}(\Pi_{t+j}-1)^2 - g_{t+j} \right] \Big\}
\end{aligned}
$$

taking as given g_{t+j-1} and other variables dated $t+j$ for $j \geq 1$. The first order conditions w.r.t. (c_t, h_t, Π_t, R_t), respectively, are given by

$$
(1-\alpha)\, u_{ct} + \gamma^1_t \left(u_{cct}(\Pi_t-1)\Pi_t - \frac{u_{cct}h_t}{\theta}\left(1+\eta-\eta\frac{g_t}{h_t}\right)\right) + \gamma^2_t \frac{u_{cct}}{R_t} - \gamma^3_t = 0 \tag{52}
$$

$$
(1-\alpha)\, u_{ht} - \gamma^1_t \frac{u_{ct}}{\theta}\left(1+\eta+\eta\frac{u_{ht}}{u_{ct}} + \eta h_t \frac{u_{hht}}{u_{ct}}\right) + \gamma^3_t = 0 \tag{53}
$$

$$
\gamma^1_t u_{ct}(2\Pi_t - 1) - \gamma^3_t \theta(\Pi_t - 1) - \alpha\,(\Pi_t - 1) = 0 \tag{54}
$$

$$
-\gamma^2_t \frac{u_{ct}}{R^2_t} = 0 \tag{55}
$$

Equation (55), $u_{ct} > 0$ and $R_t \geq 1$ imply

$$
\gamma^2_t = 0
$$

Then solving (52), (53) and (54) for γ^3_t delivers, respectively,

$$
\gamma^3_t = (1-\alpha)\, u_{ct} + \gamma^1_t \left(u_{cct}(\Pi_t-1)\Pi_t - \frac{u_{cct}h_t}{\theta}\left(1+\eta-\eta\frac{g_t}{h_t}\right)\right) \tag{56}
$$

$$
\gamma^3_t = -(1-\alpha)\, u_{ht} + \gamma^1_t \frac{u_{ct}}{\theta}\left(1+\eta+\eta\frac{u_{ht}}{u_{ct}} + \eta h_t \frac{u_{hht}}{u_{ct}}\right) \tag{57}
$$

$$
\gamma^3_t = \gamma^1_t \frac{u_{ct}(2\Pi_t-1)}{\theta(\Pi_t-1)} - \frac{\alpha}{\theta} \tag{58}
$$

Equations (56) and (58) imply

$$\gamma_t^1 = \frac{\theta\left(1 - \alpha + \frac{1}{u_{ct}}\frac{\alpha}{\theta}\right)}{\frac{2\Pi_t - 1}{\Pi_t - 1} - \frac{u_{cct}}{u_{ct}}\left(\theta(\Pi_t - 1)\Pi_t - h_t\left(1 + \eta - \eta\frac{g_t}{h_t}\right)\right)} \tag{59}$$

While equations (57) and (58) give

$$\gamma_t^1 = \frac{\theta\left(1 - \alpha - \frac{1}{u_{ht}}\frac{\alpha}{\theta}\right)}{\frac{u_{ct}}{u_{ht}}\left(1 + \eta - \frac{2\Pi_t - 1}{\Pi_t - 1} + \eta\frac{u_{ht}}{u_{ct}} + \eta h_t \frac{u_{hht}}{u_{ct}}\right)} \tag{60}$$

From (59) and (60) one obtains CMRF shown in the main text.

Parameter Definition	**Assigned Value**
quarterly discount factor	$\beta = 0.9913$
price elasticity of demand	$\eta = -6$
degree of price stickiness	$\theta = 17.5$
labor supply elasticity	$\varphi^{-1} = 1$
labor income tax	$\tau = 24\%$
utility weight on labor effort	$\omega_h = 19.7917$
utility weight on public goods	$\omega_g = 0.2656$

Table 1: Baseline Calibration

Policy Regime	c	h	g	Π	τ (Level)	**Consumption Losses Relative to Ramsey SS**
	(Deviations from Ramsey)					
SP	-7.08%	5.90%	14.21%	4.47%	25.71%	-8.26%
OI	-13.73%	-0.05%	44.89%	2.11%	34.67%	-4.76%
OS	3.42%	4.44%	-19.72%	3.59%	18.35%	-5.88%

Table 2: Steady State Effects

	Consumption Losses Relative to Ramsey SS			$\Pi^{SP} - \Pi^{OI}$
	SP	**OI**	**OS**	
Baseline Calibration	-8.26%	-4.76%	-5.88%	2.35%
more sticky prices ($\theta = 50$)	-11.70%	-5.92%	-8.22%	2.04%
less sticky prices ($\theta = 5$)	-4.20%	-2.94%	-3.20%	2.13%
almost flexible prices ($\theta = 0.1$)	-0.13%	-0.13%	-0.13%	0.15%
very high competition ($\eta = -30$)	-0.16%	-0.15%	-0.16%	0.06%
more competition ($\eta = -9$)	-3.28%	-1.92%	-2.60%	1.31%
less competition ($\eta = -5$)	-11.90%	-7.56%	-8.14%	2.61%
very low labor supply elasticity ($\varphi = 8$)	-0.66%	-0.62%	-0.62%	0.07%
low labor supply elasticity ($\varphi = 3$)	-3.14%	-2.39%	-2.57%	0.73%
high labor supply elasticity ($\varphi = 0.1$)	-11.60%	-6.89%	-7.85%	3.27%

Table 3: Robustness of Steady State Effects

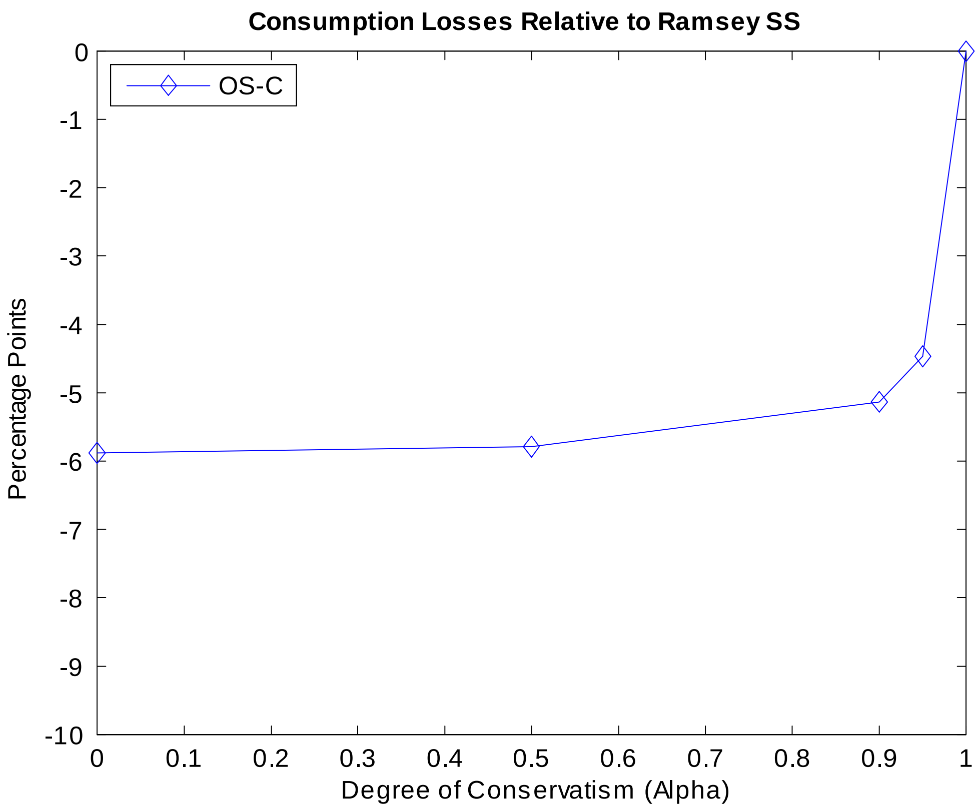

Figure 1: Welfare Gains from Monetary Conservatism under Fiscal Commitment

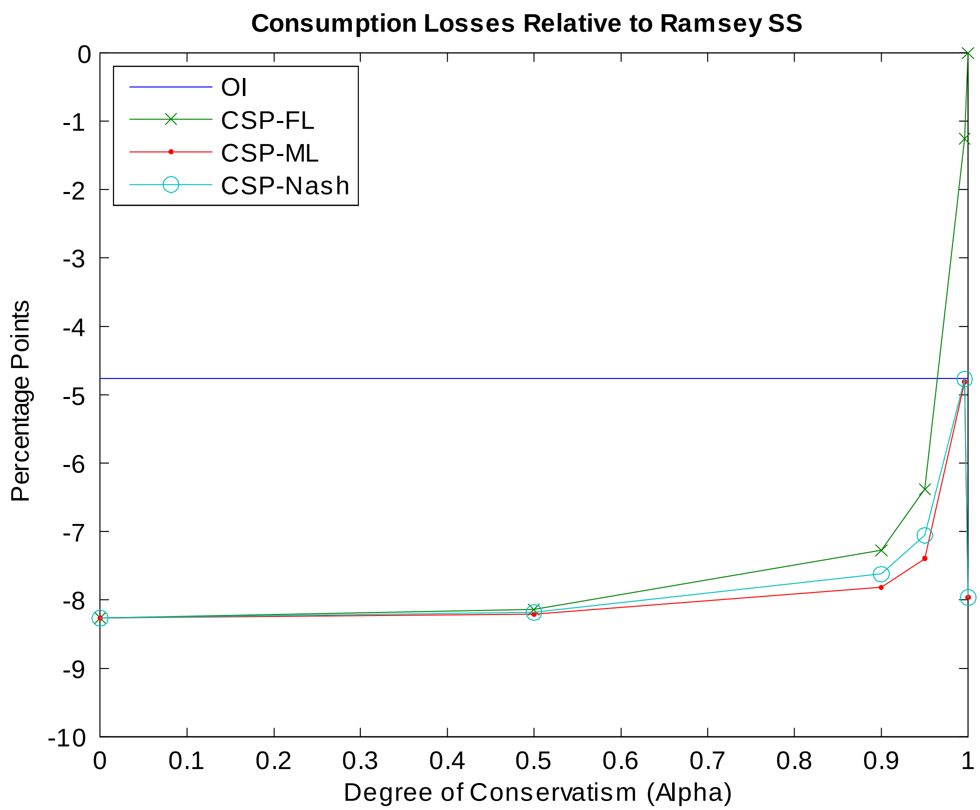

Figure 2: Welfare Gains from Monetary Conservatism under Sequential Fiscal Policy

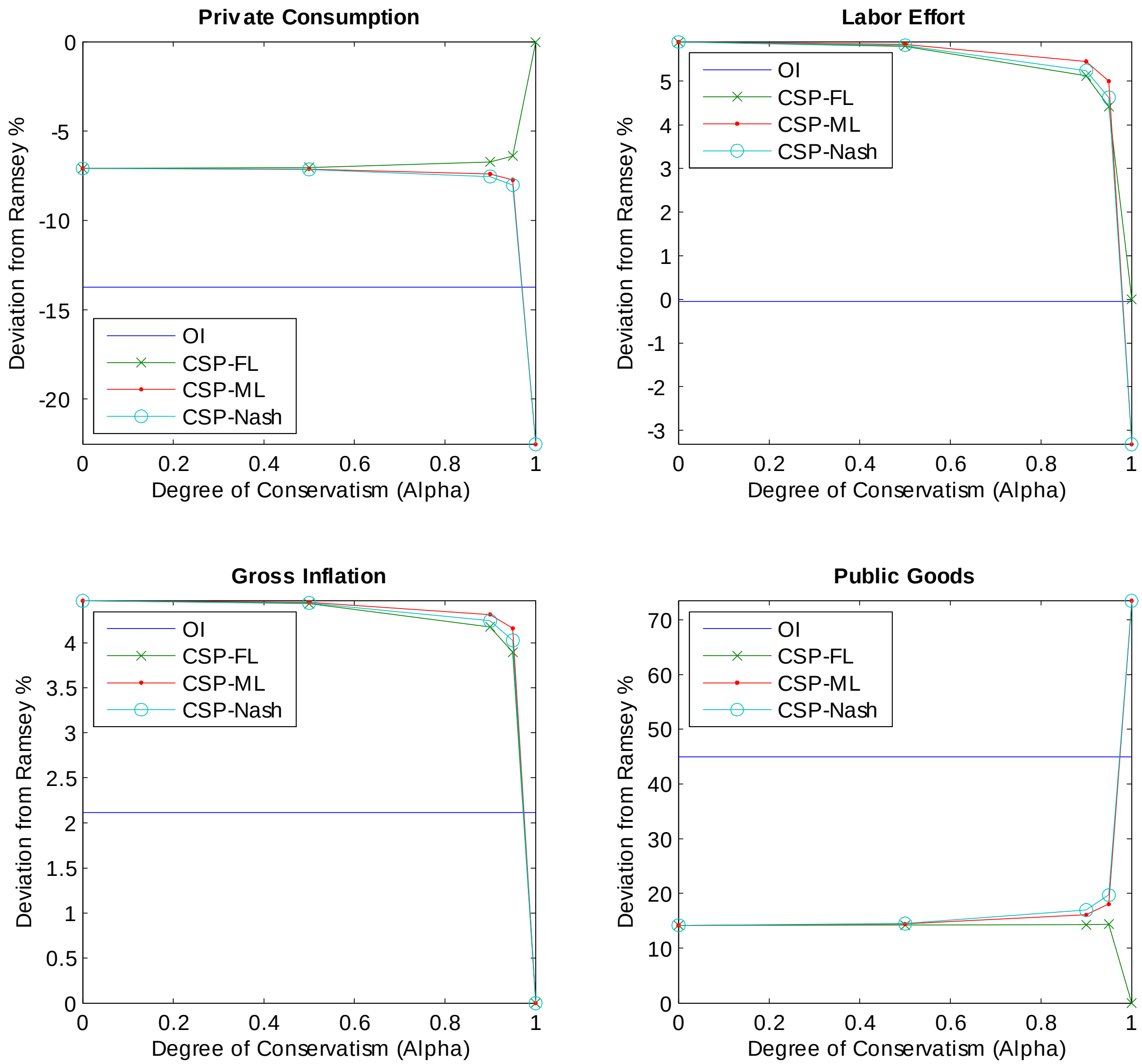

Figure 3: Steady State Effects of Monetary Conservatism