Monetary and Fiscal Interactions without Commitment and the Value of Monetary Conservatism*

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Abstract

We study monetary and fiscal policy games in a dynamic sticky price economy where monetary policy sets nominal interest rates and fiscal policy provides public goods financed with distortionary labor taxes. We compare the Ramsey outcome to non-cooperative policy regimes where one or both policymakers lack commitment power. Absence of fiscal commitment gives rise to a public spending bias, while lack of monetary commitment generates the well-known inflation bias. An appropriately conservative monetary authority can eliminate the steady state distortions generated by lack of monetary commitment and may even eliminate the distortions generated by lack of fiscal commitment. The costs associated with the central bank being overly conservative seem small, but insufficient conservatism may result in sizable welfare losses.

Keywords: optimal monetary and fiscal policy, sequential policy, discretionary policy, time consistent policy, conservative monetary policy

JEL Classification: E52, E62, E63

1 Introduction

The difficulties associated with executing optimal but time-inconsistent policy plans have received much attention following the seminal work of Kydland and Prescott (1977) and Barro and Gordon (1983). Time inconsistency problems, however, have hardly been analyzed in a dynamic setting where monetary and

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fiscal policymakers are separate authorities engaged in a non-cooperative policy game. This may appear surprising given that the institutional setup in most developed countries suggests such an analysis to be of relevance.

In this paper we analyze non-cooperative monetary and fiscal policy games assuming that policymakers cannot commit to future policy choices. We identify the policy biases emerging from sequential and non-cooperative decision making and assess the desirability of installing a central bank that is conservative in the sense of Rogoff (1985). In other terms, we analyze the desirability of central bank conservatism in a setting with endogenous fiscal policy.

Presented is a dynamic sticky price economy without capital along the lines of Rotemberg (1982) and Woodford (2003) where output is inefficiently low due to market power by firms. The economy features two independent policymakers, i.e., a fiscal authority deciding about the level of public goods provision and a monetary authority determining the short-term nominal interest rate. Public goods generate utility for private agents and are financed by distortionary labor taxes under a balanced budget constraint. Monetary and fiscal authorities are assumed benevolent, i.e., maximize the utility of the representative agent.

The natural starting point for our analysis is the Ramsey allocation, which assumes full policy commitment and cooperation among monetary and fiscal policymakers. The Ramsey allocation is second-best and thus provides a useful benchmark against which one can assess the welfare costs of sequential and non-cooperative policymaking.

In the presence of sticky prices and monopolistic competition monetary and fiscal authorities both face a time-inconsistency problem. While price setters are forward-looking, policymakers that decide sequentially fail to perceive the implications of their current policy decisions on past price setting decisions, since past prices can be taken as given at the time policy is determined. As a result, policymakers underestimate the welfare costs of generating inflation today and find it attractive to try to move output closer to its first-best level. Sequential monetary policy, e.g., seeks to lower real interest rates so as to increase private consumption and output. Similarly, sequential fiscal policy finds it optimal to increase output via increased spending on public goods.

We then characterize the non-cooperative Markov-perfect Nash equilibrium where both policymakers determine their policies sequentially.[1] To discover the implications of relaxing monetary and fiscal commitment, it is useful to proceed in steps. In particular, we first consider intermediate equilibria where one policymaker can commit while the other behaves in accordance with the reaction function that would be optimal in the Markov-perfect Nash equilibrium. These intermediate cases are self-confirming equilibria, rather than strict Nash

[1] Markov-perfect Nash equilibria are a standard refinement used in the applied dynamic games literature, e.g., Klein et al. (2004).

equilibria, but prove helpful for understanding the biases emerging in a situation where both policymakers act sequentially.[2] In addition, they provide natural benchmarks for assessing the welfare gains from monetary conservatism.

First, we consider an intermediate regime with sequential fiscal policy (SFP) and monetary commitment. We show that, provided monetary policy implements price stability, sequential fiscal policy engages in excessive public spending. Yet, the fiscal spending becomes less severe as inflation rises and this induces a fully committed monetary authority to allow for positive inflation rates. This interaction between a commited monetary authority and a sequential fiscal authority indicates that an overly conservative central bank may potentially be harmful, since it amplifies fiscal policy distortions.

We then consider the reverse situation with sequential monetary policy (SMP) but time zero commitment by the fiscal authority. Sequential monetary policy is shown to generate the familiar inflation bias. Since a reduction in public spending can reduce the size of the monetary inflation bias, a committed fiscal authority deviates from the Ramsey solution in the self-confirming equilibrium by spending and taxing less.

Finally, we determine the Markov-perfect Nash equilibrium with sequential monetary and sequential fiscal policy (SMFP). This equilibrium features an inflation bias as well as a government spending bias, and tends to cause welfare losses that are considerably larger than in either the SFP or SMP regime. We then investigate whether a conservative central bank, that maximizes a weighted sum of an inflation loss term and the representative agent's utility, is able to avoid the steady state welfare losses generated by sequential monetary policy. In models that abstract from fiscal policy or in which fiscal policy is exogenous, central bank conservatism has been shown to be an effective tool for eliminating the policy biases generated by lack of monetary commitment, e.g., Rogoff (1985) and Svensson (1997). We show that these results fully extend to a setting with endogenous fiscal policy. Moreover, with endogenous fiscal policy a conservative monetary authority may undo not only the distortions generated by lack of monetary commitment but potentially also those stemming from lack of fiscal commitment.

More specifically, with sequential monetary and fiscal policy, an appropriate degree of monetary conservatism is found to recoup at least the losses from lack of monetary commitment. Welfare in the resulting Markov-perfect Nash equilibrium increases from the level associated with SMFP to that with SFP, or even further. When fiscal policy is determined before monetary policy, a conservative monetary authority could even undo the steady state losses associated

[2] See Fudenberg and Levine (1993) or Sargent (1999) for an account of the concept of 'self-confirming equilibrium'.

with lack of fiscal commitment. Sufficient monetary conservatism then approximately implements the Ramsey steady state, even though both policymakers lack commitment power.

Although determining the optimal degree of monetary conservatism might be difficult in practice, we find the losses associated with suboptimal degrees of conservatism to be fairly asymmetric. While an overly conservative central bank amplifies the fiscal spending bias, we find the associated welfare losses to be fairly small for the considered model calibrations. At the same time, the inflation bias associated with insufficient monetary conservatism gives rise to substantial welfare losses.

The remainder of this paper is structured as follows. After discussing the related literature in section 2, section 3 introduces the economic model and derives the implementability constraints. Section 4 presents the monetary and fiscal policy regimes with and without commitment and analytically interprets the steady state biases. After calibrating the model in section 5, section 6 provides a quantitative assessment of the steady state effects generated by the various policy regimes under consideration. The case of a conservative central bank is analyzed in section 7. A conclusion briefly summarizes the results and provides an outlook for future work.

2 Related Literature

Problems of optimal monetary and fiscal policy are traditionally studied within the optimal taxation framework introduced by Frank Ramsey (1927). In the so-called Ramsey literature, monetary and fiscal authorities are treated as a 'single' authority and decisions are taken at time zero, e.g., Chari and Kehoe (1998). In seminal contributions, Kydland and Prescott (1977) and Barro and Gordon (1983) show that time zero optimal choices might be time-inconsistent, i.e., reoptimization in successive periods would suggest a different policy to be optimal than the one initially envisaged.

The monetary policy literature has extensively studies time-inconsistency problems in dynamic settings and potential solutions to it, e.g., Rogoff (1985), Svensson (1997) and Walsh (1995). However, in this literature fiscal policy is typically absent or assumed exogenous to the model. Similarly, a number of contributions analyze sequential fiscal decisions and the time-consistency of optimal fiscal plans in dynamic general equilibrium models, e.g., Lucas and Stokey (1983), Chari and Kehoe (1990) or Klein, Krusell, and Ríos-Rull (2004). This literature typically studies real models without money.

An important strand of the literature, developed by Sargent and Wallace (1981), Leeper (1991), and Woodford (1998b), studies monetary and fiscal policy interactions using policy rules, e.g., Schmitt-Grohé and Uribe (2004b). This literature, however, does not consider optimal policy and time-inconsistency problems, as it assumes policymakers to be fully committed to simple rules.

A range of papers discusses monetary and fiscal policy interactions with and without commitment in a static framework where monetary and fiscal policymakers interact only once. Alesina and Tabellini (1987), e.g., consider a model where the monetary authority chooses the inflation rate and the fiscal authority sets the tax rate to finance government expenditure. When policymakers disagree about the trade-off between output and inflation, then monetary commitment may not be welfare improving. Reduced seigniorage leads to increased fiscal taxation and this might more than compensate the gains from reduced inflation. Instead, our paper considers a cashless limit economy so abstracts from seigniorage as a source of government revenue.

In a series of papers Dixit and Lambertini investigate the interaction between monetary and fiscal policymakers with and without commitment. Namely, Dixit and Lambertini (2001, 2003b) analyze the case of a monetary union but in a setting where the monetary authority does not face a time-inconsistency problem. Dixit and Lambertini (2003a) consider a situation where monetary and fiscal policymakers are both subject to a time-inconsistency problem. While the fiscal authority maximizes social welfare, the monetary authority has a more conservative output and inflation target and does not take into account the distortions generated by fiscal policy instruments. In such a setting, monetary commitment is 'negated' by sequential fiscal policy, i.e., the equilibrium outcome with monetary commitment turns out to be the same as in the case with sequential monetary leadership.

This paper goes beyond these earlier contributions by studying a dynamic model where current economic outcomes are influenced also by expectations on future policy. Recently, Díaz-Giménez et al. (2004) study sequential monetary policy in a cash-in-advance economy with government debt. They consider a flexible price economy with exogenous fiscal spending and study the implications of indexed and nominal debt for monetary policy choices with and without commitment. Interactions between monetary and fiscal policy in their model operate through the government budget constraint and the seigniorage revenues raised by monetary policy. Our paper abstracts from seigniorage as a source of government revenue and instead considers the interactions arising from the presence of nominal rigidities.

3 The Economy

The next sections introduce a sticky price economy model, similar to the one studied in Schmitt-Grohé and Uribe (2004a), and derive the private sector equilibrium for given monetary and fiscal policy choices.

3.1 Private Sector

There is a continuum of identical households with preferences given by

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, h_t, g_t) \tag{1}$$

where c_t denotes consumption of an aggregate consumption good, $h_t \in [0,1]$ denotes the labor supply, and g_t public goods provision by the government in the form of aggregate consumption goods. Throughout the paper we impose the following conditions.

Condition 1 *$u(c,h,g)$ is separable in c, h, g and $u_c > 0$, $u_{cc} < 0$, $u_h < 0$, $u_{hh} \leq 0$, $u_g > 0$, $u_{gg} < 0$.*

Each household produces a differentiated intermediate good. Demand for that good is given by

$$y_t d(\frac{\widetilde{P}_t}{P_t})$$

where y_t denotes (private and public) demand for the aggregate good, $\widetilde{P}_t$ is the price of the good produced by the household, and P_t is the price of the aggregate good. The demand function $d(\cdot)$ satisfies

$$d(1) = 1$$

$$\frac{\partial d}{\partial(\widetilde{P}_t/P_t)}(1) = \eta$$

where $\eta < -1$ denotes the elasticity of substitution between the goods of different households. The household chooses $\widetilde{P}_t$ then hires the necessary amount of labor $\widetilde{h}_t$ to satisfy the resulting product demand, i.e.,

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

Following Rotemberg (1982) we describe sluggish nominal price adjustment by assuming that firms face quadratic resource costs for adjusting prices according to

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

where $\theta > 0$. The flow budget constraint of the household is

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

where B_t denotes nominal bonds that pay $B_t R_t$ in period $t+1$, w_t is the real wage paid in a competitive labor market, and τ_t is a labor income tax.[3]

Although bonds are the only available financial instrument, assuming complete financial markets instead would make no difference for the analysis, since households have identical incomes in a symmetric price setting equilibrium. One should note that we also abstract from money holdings. This should be interpreted as the 'cashless limit' of an economy with money, see Woodford (1998a). Money thus imposes only a lower bound on the gross nominal interest rate, i.e.,

$$R_t \geq 1 \tag{4}$$

each period. Abstracting from money entails that we ignore seigniorage revenues generated in the presence of positive nominal interest rates. Given the size of these revenues in relation to GDP in industrialized economies, this does not seem to be an important omission for the analysis conducted here.[4]

Finally, we impose a no Ponzi scheme constraint on household behavior, i.e.,

$$\lim_{j \to \infty} E_t \left[\left(\prod_{i=0}^{t+j-1} \frac{1}{R_i} \right) B_{t+j} \right] \geq 0 \tag{5}$$

The household's problem consists of choosing $\{c_t, h_t, \widetilde{h}_t, \widetilde{P}_t, B_t\}_{t=0}^{\infty}$ so as to maximize (1) subject to (2), (3), and (5) taking as given $\{y_t, P_t, w_t, R_t, g_t, \tau_t\}$. Using equation (2) to substitute $\widetilde{h}_t$ in (3) and letting the multiplier on (3) be λ_t / P_t, the first order conditions of the household's problem are then equations (2), (3), and (5) holding with equality and also

$$u_c(c_t, h_t, g_t) = \lambda_t \tag{6}$$

$$u_h(c_t, h_t, g_t) = -\lambda_t w_t (1 - \tau_t) \tag{7}$$

$$\lambda_t = \beta E_t \lambda_{t+1} \frac{R_t}{\Pi_{t+1}} \tag{8}$$

$$\begin{aligned} 0 = \lambda_t & \left(y_t d(r_t) + r_t y_t d'(r_t) - w_t y_t d'(r_t) - \theta(\Pi_t \frac{r_t}{r_{t-1}} - 1) \frac{\Pi_t}{r_{t-1}} \right) \\ & + \beta \theta E_t \left[\lambda_{t+1} (\frac{r_{t+1}}{r_t} \Pi_{t+1} - 1) \frac{r_{t+1}}{r_t^2} \Pi_{t+1} \right] \end{aligned}$$

[3] Considering income or consumption taxes, instead, would be equivalent to a labor income tax plus a lump sum tax (on profits). An earlier version of the paper, which is available upon request, considered the case with lump sum taxes.

[4] As emphasized by Leeper (1991), however, in a stochastic model seigniorage may nevertheless be an important marginal source of revenue. Since our paper abstracts from shocks, one can safely ignore this issue.

where

$$r_t = \frac{\widetilde{P}_t}{P_t}$$

denotes the relative price. Furthermore, there is the transversality constraint

$$\lim_{j\to\infty} E_t \left(\beta^{t+j} u_c(c_{t+j}, h_{t+j}, g_{t+j}) \frac{B_{t+j}}{P_{t+j}} \right) = 0 \tag{9}$$

which has to hold each period.

3.2 Government

The government consists of two authorities, a monetary authority choosing short-term nominal interest rates and a fiscal authority deciding on government expenditures and labor income taxes.

Government expenditures consist of spending related to the provision of public goods g_t and socially wasteful expenditure x that does not generate utility for private agents. The level of public goods provision g_t is a choice variable, while x is taken to be exogenous.

The government budget constraint is then given by

$$\frac{B_t}{P_t} = \frac{B_{t-1}}{P_{t-1}} \frac{R_{t-1}}{\Pi_t} + g_t + x - \tau_t w_t h_t$$

To simplify the analysis we eliminate government debt as a state variable by assuming that the government budget is balanced period-by-period and that $B_{-1} = 0$.[5] The government budget constraint then reduces to

$$\tau_t w_t h_t = g_t + x \tag{10}$$

Importantly, the assumption of a balanced budget is not restrictive, since we limit attention to the steady state of the economy. Assuming $B_{-1} = 0$, however, implies that we abstract from monetary and fiscal interactions that operate through the government budget constraint, as analyzed by Díaz-Giménez et al. (2004). In particular, we ignore the monetary inflation bias arising from the attempt to decrease the real value of outstanding government debt with 'surprise' inflation. Abstracting from nominal debt thus implies that we understate the size of the monetary inflation bias and the role for a conservative monetary authority. In future work we plan to explore the effects of incorporating also government debt dynamics.

We note that the absence of government debt could also be interpreted as the fiscal authority not being able to commit to repay outstanding debt in the future. Moreover, abstracting from debt insures that the no Ponzi scheme constraint (5) and the transversality constraint (9) are always satisfied.

[5] Fiscal policy is thus 'passive' in the sense of Leeper (1991).

3.3 Private Sector Equilibrium

In a symmetric equilibrium the relative price is given by $r_t = 1$ for all t. Using the government budget constraint (10), the first order conditions of households can be condensed into the following price setting equation

$$u_{c,t}(\Pi_t - 1)\Pi_t = \frac{u_{c,t}h_t}{\theta}\left(1 + \eta + \eta\left(\frac{u_{h,t}}{u_{c,t}} - \frac{g_t + x}{h_t}\right)\right) + \beta E_t\left[u_{c,t+1}(\Pi_{t+1} - 1)\Pi_{t+1}\right] \tag{11}$$

and a consumption Euler equation

$$\frac{u_{c,t}}{R_t} = \beta E_t\left[\frac{u_{c,t+1}}{\Pi_{t+1}}\right] \tag{12}$$

Conveniently, the previous equations do not make reference to taxes and real wages, while equations (6), (7), and (10) imply

$$\tau_t = \frac{g_t + x_t}{g_t + x_t - h_t\frac{u_{h,t}}{u_{c,t}}} \tag{13}$$

$$w_t = \frac{g_t + x_t}{h_t} - \frac{u_{h,t}}{u_{c,t}} \tag{14}$$

A rational expectations equilibrium is then a set of plans $\{c_t, h_t, P_t\}$ satisfying equations (11) and (12) and also the feasibility constraint

$$c_t + \frac{\theta}{2}(\Pi_t - 1)^2 + g_t + x = h_t \tag{15}$$

given the policies $\{g_t, R_t \geq 1\}$, the value of x, and the initial conditions $B_{-1} = 0$ and P_{-1}.

4 Monetary and Fiscal Policy Regimes

This section introduces the policy regimes analyzed in the remaining part of the paper. We consider policymakers that maximize the utility of the representative agent. While the descriptive realism of this assumption is open to debate, importantly it allows us to identify the inefficiencies generated by sequential policy decisions.

4.1 Ramsey Policy

As a benchmark we consider the Ramsey equilibrium, which assumes commitment to policies at time zero and full cooperation between monetary and fiscal policymakers. The Ramsey equilibrium is second-best and given by the solution to the following maximization problem:

$$\max_{\{c_t,h_t,\Pi_t,R_t,g_t\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, h_t, g_t) \tag{16}$$
$$\text{s.t.}$$
$$\text{Equations } (11), (12), (15) \text{ for all } t$$
$$R_t \geq 1 \text{ for all } t$$

The Ramsey planner thus maximizes the utility function of the representative agent subject to the implementability constraints (11) and (12), the feasibility constraint (15), and the lower bound on nominal interest rates.[6] We thus propose the following definition.

Definition 1 (Ramsey) *A Ramsey equilibrium is a sequence* $\{c_t, h_t, \Pi_t, R_t, g_t\}_{t=0}^{\infty}$ *solving problem (16).*

Since optimal policy is time-inconsistent, the Ramsey equilibrium is initially non-stationary. We will abstract from initial non-stationarities by defining a Ramsey steady state as follows.

Definition 2 (Ramsey SS) *Let* $\{c_t, h_t, \Pi_t, R_t, g_t\}_{t=0}^{\infty}$ *be a Ramsey equilibrium, then the Ramsey steady state is given by* $\lim_{t\to\infty}(c_t, h_t, \Pi_t, R_t, g_t)$*.*

One should note that the Ramsey steady state corresponds to the 'timeless perspective' commitment solution of Woodford (2003).

4.2 Sequential Policymaking

We now consider separate monetary and fiscal authorities that cannot commit to future policy plans at time zero but rather decide upon policies at the time of implementation, i.e., period-by-period.

To facilitate the exposition we assume that a sequentially deciding 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 prove the rationality of this assumption at the end of this section.

[6] The balanced budget constraint (10) and the initial condition $B_{-1} = 0$ are implicit in the Phillips curve (11). The initial condition P_{-1} can be ignored as it only normalizes the resulting price path.

4.2.1 Sequential Fiscal Policy

We consider here sequential fiscal policymaking. Given the assumptions made above, the fiscal authority's maximization problem in period t is:

$$\max_{\{c_{t+j},h_{t+j},\Pi_{t+j},g_{t+j}\}} E_t \sum_{j=0}^{\infty} \beta^j u(c_{t+j}, h_{t+j}, g_{t+j}) \tag{17}$$

$$\text{s.t.}$$
$$\text{Equations } (11), (12), (15) \text{ for all } t$$
$$R_t \text{ given}$$
$$E_t \left(c_{t+j}, h_{t+j}, \Pi_{t+j}, g_{t+j}, R_{t+j}\right) \text{ given for } j \geq 1$$
$$R_{t+j} \geq 1 \text{ for all } j \geq 0$$

Eliminating Lagrange multipliers, the first order conditions associated with problem (17) deliver the fiscal reaction function

$$\frac{1}{u_{g,t}} = \frac{-1}{u_{h,t}} \frac{1}{(1 - \frac{\Pi_t - 1}{2\Pi_t - 1}\eta)} \left(1 - \frac{(\Pi_t - 1)\left(1 + \eta + \frac{u_{h,t} + h_t u_{hh,t}}{u_{c,t}}\eta\right)}{2\Pi_t - 1}\right) \tag{FRF}$$

Interestingly, for $\Pi_t = 1$ the fiscal reaction function simplifies to[7]

$$u_{g,t} = -u_{h,t} \tag{18}$$

Thus, provided monetary policy implements price stability, discretionary fiscal policy equates the marginal utility of public consumption to the marginal disutility of work. Clearly, this leads to a suboptimally high level of public spending because condition (18) fails to take into account that

1. fiscal taxation has a negative wealth effect that crowds out private consumption;

2. public consumption is financed with labor income taxes, which distort the labor supply decision.

Both of these effects are ignored by the fiscal authority, since the current monetary policy choice and all future choices are taken as given so the Euler equation (12) suggests that private consumption is determined. This makes it optimal to equate the marginal utility of public consumption to the marginal disutility of work.

The FRF also implies

$$\frac{\partial\left(1/u_{g,t}\right)}{\partial \Pi_t} < 0 \tag{19}$$

[7] For $\Pi_t = 1$ the Lagrange multiplier on the Phillips curve (11) is zero in problem (17).

which shows that, ceteris paribus, the fiscal spending bias is less severe with positive inflation rates. For $\Pi_t > 1$ the marginal resource costs of generating additional inflation through increased fiscal spending fail to be zero, see equation (15). Fiscal policy takes these costs into account and reduces public spending correspondingly.[8]

The previous result suggests that a conservative monetary authority that implements price stability may increase the distortion generated by sequential fiscal policy decisions. The distortions generated by monetary conservatism are even larger, if monetary conservatism also leads to reduced labor input.

4.2.2 Sequential Monetary Policy

We now consider sequential monetary policy. Given the assumptions made above, the monetary authority's maximization problem in period t is:

$$\max_{\{c_{t+j}, h_{t+j}, \Pi_{t+j}, R_{t+j}\}} E_t \sum_{j=0}^{\infty} \beta^j u(c_{t+j}, h_{t+j}, g_{t+j}) \tag{20}$$

$$\text{s.t.}$$

$$\text{Equations (11),(12),(15) for all } t$$

$$g_t \text{ given}$$

$$E_t \left(c_{t+j}, h_{t+j}, \Pi_{t+j}, g_{t+j}, R_{t+j}\right) \text{ given for } j \geq 1 \tag{21}$$

$$R_{t+j} \geq 1 \text{ for all } j \geq 0 \tag{22}$$

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

$$\begin{aligned} -\frac{u_{c,t}}{u_{h,t}}\left(1+\eta-\frac{2\Pi_t-1}{\Pi_t-1}\right)-\eta\left(1+\frac{h_t u_{hh,t}}{u_{h,t}}\right)+\frac{2\Pi_t-1}{\Pi_t-1} \\ -\frac{u_{cc,t}}{u_{c,t}}\left[\theta(\Pi_t-1)\Pi_t-h_t\left(1+\eta-\frac{g_t+x_t}{h_t}\frac{\eta}{z_t}\right)\right]=0 \end{aligned} \tag{MRF}$$

Monetary policy sets the nominal interest rate R_t such that MRF is satisfied each period. Appendix A.1 proves the following result

Lemma 1 *Provided the discount factor β is sufficiently close to 1, satisfying MRF requires a strictly positive steady state inflation rate.*

Sequential monetary policy generates the familiar inflation bias, e.g., Barro and Gordon (1983). Intuitively, monetary policy is tempted to stimulate demand by reducing interest rates. Since price adjustments are costly, the price

[8] For $\Pi_t < 1$ the fiscal bias is larger because higher fiscal spending increases inflation, thereby reduces the resource costs of inflation. Interestingly, inflation could continue to have a moderating effect on fiscal spending as prices become flexible ($\theta \to 0$). While the marginal costs of generating additional inflation decrease as $\theta \to 0$, the Phillips curve (11) implies that any given increase in government spending generates larger and larger inflation.

level will not fully adjust to the demand increase. At the same time, nominal wages are flexible and can increase so as to induce the additional labor supply required to serve the demand increase. While the resulting real wage increase generates inflation, see the Phillips curve (11) and equation (14), the welfare costs of generating inflation are not fully taken into account, for reasons discussed before. 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.

4.2.3 Sequential Monetary and Fiscal Policy

We are now in a position to define a Markov-perfect Nash equilibrium with sequential monetary and fiscal policy (SMFP).

We first verify the rationality of our initial assumption that future choices can be taken as given. The private sector optimality conditions, (11) and (12), the feasibility constraint (15), as well as the policy reactions functions (FRF) and (MRF) all depend on current and future variables only. This suggests the existence of an equilibrium where current play depends on current and future economic conditions only and justifies taking as given future equilibrium play. If, in addition, monetary and fiscal policies are determined simultaneously each period, Nash equilibrium requires to take the other players' decisions as given. This rationalizes all of our assumptions and provides the following definition.

Definition 3 (SMFP) *A Markov-perfect equilibrium with sequential monetary and fiscal policy is a sequence* $\{c_t, h_t, \Pi_t, R_t, g_t\}_{t=0}^{\infty}$ *solving equations (11),(12),(15), (FRF) and (MRF).*

A steady state with SMFP is a stationary Markov-perfect equilibrium (c, h, Π, R, g).

We now show that assuming Stackelberg leadership by one of the policy authorities, instead of simultaneous decision making, does not affect the equilibrium outcome.

While the policy problem of the Stackelberg follower remains unchanged, the Stackelberg leader must take into account the reaction function of the follower and maximize over all policy choices. Importantly, however, the Lagrange multipliers associated with imposing MRF on the sequential fiscal problem (17) or with imposing FRF on sequential monetary problem (20) are zero. This follows from the fact that 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 monetary and fiscal policymakers pursue the same objectives. Differences to the Ramsey solution thus arise exclusively by relaxing the assumption of commitment. The non-cooperative aspect of monetary and fiscal policy interactions, and the sequence of moves, will matter only in section 7 when we introduce a central bank that is more inflation averse than the fiscal authority.

From Lemma 1 and the MRF, the steady state with sequential monetary and fiscal policy features an inflation bias, i.e., $\Pi > 1$. Whether there is also a positive 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 4.2.1; yet, for sufficiently high steady state inflation rates one cannot exclude that fiscal spending falls short of the Ramsey steady state level.

4.3 Intermediate Cases

As mentioned earlier, it is helpful to consider also intermediate cases where one policymaker can commit but the other behaves according to its sequential reaction function.

In the case with monetary commitment, the monetary authority internalizes the fiscal reaction function (FRF). The monetary policy problem at time zero is thus given by:

$$\max_{\{c_t, h_t, \Pi_t, R_t, g_t\}} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, h_t, g_t) \tag{23}$$
$$\text{s.t.}$$
$$\text{Equations (11),(12),(15),(FRF) for all } t$$
$$R_t \geq 1 \text{ for all } t$$

We can provide the following definition.

Definition 4 (SFP) *A self-confirming equilibrium with sequential fiscal policy and monetary commitment is a sequence* $\{c_t, h_t, \Pi_t, R_t, g_t\}_{t=0}^{\infty}$ *solving problem (23).*

We note that the solution to problem (23) fails to be a Markov-perfect Nash equilibrium because the derivation of the FRF assumes the fiscal authority takes future monetary policy decisions as given. Under commitment the monetary authority, however, can condition current play on past play of the fiscal authority and rationality requires the fiscal agent to take this fully into account.[9] By taking future play as given, the fiscal authority fails to correctly anticipate the off-equilibrium behavior of monetary authority. At the same time, the fiscal authority holds rational beliefs about equilibrium play, which implies that

[9]When the sequential authority is rational in this sence, it is easy to show that the commiting player can sustain the Ramsey outcome via appropriate trigger strategies.

beliefs are never contradicted by outcomes. The solution to (23) is thus still a self-confirming equilibrium, see Fudenberg and Levine (1993) or Sargent (1999).

As in the Ramsey case, a steady state with sequential fiscal policy (SFP) is defined as the limit for $t \to \infty$ of the self-confirming equilibrium with SFP.

With fiscal commitment and sequential monetary policy (SMP), fiscal policy anticipates the monetary reaction function and the policy problem at time zero is given by:

$$\max_{\{c_t, h_t, \Pi_t, R_t, g_t\}} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, h_t, g_t) \tag{24}$$
$$\text{s.t.}$$
$$\text{Equations (11),(12),(15),(MRF) for all } t$$
$$R_t \geq 1 \text{ for all } t$$

We thus have the following definition.

Definition 5 (SMP) *A self-confirming equilibrium with sequential monetary policy and fiscal commitment is a sequence* $\{c_t, h_t, \Pi_t, R_t, g_t\}_{t=0}^{\infty}$ *solving problem (24).*

A steady state with sequential monetary policy (SMP) is defined as the limit for $t \to \infty$ of the self-confirming equilibrium with SMP.

5 Model Calibration

To assess the quantitative relevance of the policy biases associated with the different policy arrangements, we consider the utility function to be

$$u(c_t, h_t, g_t) = \frac{c_t^{1-\sigma} - 1}{1 - \sigma} + \omega_0 \log(1 - h_t) + \omega_1 \log(g_t) \tag{25}$$

where $\omega_0 > 0$, $\omega_1 \geq 0$ and $\sigma > 0$. We then calibrate the model as is summarized in table 1.

The quarterly discount factor is chosen to match the average ex-post U.S. real interest rate, 3.5%, during the period 1983:1-2002:4. The value for the elasticity of demand implies a gross mark-up equal to 1.2, and consumption utility is assumed logarithmic. The values of ω_0 and ω_1 are chosen such that in the Ramsey steady state agents work 20% of their time and spend 20% of output on public goods.[10] The price stickiness parameter is chosen such that the

[10] The values of ω_0 and ω_1 are set according to equations (32) and (38), resepectively, derived in appendix A.2.

log-linearized version of the Phillips curve (11) is consistent with the estimates of Sbordone (2002), as in Schmitt-Grohé and Uribe (2004a). We abstract from wasteful fiscal spending.

To test the robustness of our results, we consider also alternative model parameterizations. And to increase comparability across parameterizations, the values of the utility parameters ω_0 and ω_1 are adjusted in a way that the Ramsey steady state remains unaffected.

6 Steady State Outcomes

Using the calibrated model from the previous section, we now investigate the quantitative impact of the various policy arrangements on the endogenous variables and welfare. The robustness of the results to various changes in the parameterization of the model is also discussed.

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.[11] The table also reports the steady state tax level and welfare losses. The latter are expressed as the percentage reduction in private consumption that would entail the Ramsey steady state to be welfare equivalent to the considered policy regime.

First, consider the sequential fiscal policy regime (SFP) in table 2. As suggested by the discussion in section 4.2.1, sequential fiscal decisions result in excessive fiscal spending and a crowding out of private consumption. Despite monetary commitment, the monetary authority allows for positive rates of inflation. This for two reasons. On the one hand, inflation is associated with an increase in the real wage. This helps to sustain labor supply and ameliorates the fiscal spending bias, since fiscal policy (approximately) equates the marginal disutility of labor to the marginal utility of private consumption, see equation (18). On the other hand, with positive inflation rates the marginal costs of creating additional inflation is positive and this restrains fiscal spending, see equation (19). Despite monetary commitment, the welfare losses from sequential fiscal policy are substantial, i.e., 6.5% of Ramsey steady state consumption.

Second, consider the opposite case with sequential monetary policy and fiscal commitment (SMP). This arrangement generates the familiar inflation bias associated with sequential monetary policy decisions in sticky price economies, see the corresponding 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

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

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 are sizable and of about the same size as those generated by sequential fiscal policy.

Finally, consider the case with sequential monetary and fiscal policy (SMFP) in table 2. In this setting a fiscal spending bias as well as an inflation bias emerge. Since inflation is associated with a labor supply increase and a rise in the marginal disutility of work, the fiscal spending bias turns out to be smaller than with sequential fiscal policy alone (SFP). The losses generated by both policymakers acting sequentially, however, are much larger than in the case where only one policymaker lacks commitment power. This illustrates that commitment by one authority alone would generate sizable welfare gains. Importantly, inflation with SMFP turns out to be higher than in the case with SFP. This suggests that an appropriately conservative monetary authority may be able to improve welfare.

Table 3 explores the robustness of these findings to different parameterizations of the model.[12] 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.

The findings are fairly robust to assuming higher or lower degrees of nominal rigidity ($\theta = 10, 25$). In particular, 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 ($\theta \to 0$), however, 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.[13] As a result, the welfare gains from monetary commitment disappear, see the case with $\theta = 0.1$ reported in table 3.

Moreover, table 3 illustrates that the findings are also robust to changing the degree of competition ($\eta = -5, -7$) and to assuming fiscal expenditure to be in part socially wasteful ($x = 0.02$).

However, results are sensitive to assuming different degrees of risk aversion. In particular, when the coefficient of relative risk aversion falls below one, the

[12] For each parameterization in table 4 we choose ω_0 and ω_1 such that the Ramsey steady state is identical to the one emerging in the baseline calibration. When considering fiscal waste we parameterize the model in a way that in steady state the overall fiscal spending $g + x$ remains unchanged compared to the baseline calibration.

[13] The steady state inflation rate, however, does not converge to zero 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, see the discussion in section 4.2.1.

fiscal spending bias becomes more and more severe. This induces a committed monetary authority to implement higher and higher rates of inflation, so as to restrain fiscal spending. For $\sigma = 0.4$ the committing monetary authority implements approximately the same rate of inflation as a sequential monetary policymaker. SFP then generates roughly the same welfare level as SMFP, see table 3. For even lower values of risk aversion, e.g., $\sigma = 0.35$, the equilibrium inflation rate *falls* when relaxing monetary commitment. It then seems unlikely that monetary conservatism would be able to improve welfare. Such degrees of relative risk aversion, however, seem to lie on the lower end of plausible values. Moreover, our model tends to understate the overall size of the monetary inflation bias arising from sequential monetary policymaking, since it abstracts from the presence of nominal debt. We may conjecture that once the existence of nominal debt is taken into account, equilibrium inflation always increases when relaxing monetary commitment.

7 Conservative Central Bank

This section analyzes whether the steady state distortions stemming from sequential monetary and fiscal decisions can be reduced if the central bank is more inflation averse than society. Svensson (1997) and Rogoff (1985) have shown that an appropriately conservative central bank eliminates the steady state distortions from lack of monetary commitment when fiscal policy is assumed to be exogenous.

We consider a 'weight conservative' monetary policymaker along the lines of Rogoff (1985) that maximizes

$$E_t \sum_{j=0}^{\infty} \beta^j \left(u(c_{t+j}, h_{t+j}, g_{t+j}) - \frac{\alpha}{2}(\Pi_t - 1)^2 \right) \tag{26}$$

where $\alpha \geq 0$ is a measure of monetary conservatism. For $\alpha > 0$ the monetary authority dislikes inflation (and deflation) more than society.

Replacing the objective function of the sequential monetary policy problem (20) with the conservative objective (26), one can then use the first order conditions to derive the conservative monetary reaction function:

$$\begin{aligned} 0 = & -\frac{\frac{u_{c,t}}{u_{h,t}}\left[1+\eta-\frac{2\Pi_t-1}{\Pi_t-1}\right]+\eta\left(1+\frac{h_t u_{hh,t}}{u_{h,t}}\right)}{1-\frac{1}{u_{h,t}}\frac{\alpha}{\theta}} \\ & + \frac{\frac{2\Pi_t-1}{\Pi_t-1}-\frac{u_{cc,t}}{u_{c,t}}\left[\theta(\Pi_t-1)\Pi_t-h_t\left(1+\eta-\frac{g_t+x_t+i_t}{h_t}\frac{\eta}{z_t}\right)\right]}{1+\frac{\alpha}{u_{c,t}\theta}} \end{aligned} \tag{MRF-C}$$

For $\alpha = 0$ this monetary reaction function reduces to the one without conservatism (MRF). As before, MRF-C 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.

7.1 Fiscal Commitment

We first consider the case with fiscal commitment and a sequential yet conservative central bank. The fiscal authority rationally anticipates the conservative monetary reaction function (MRF-C), which implies that the fiscal policy problem at time zero is given by:

$$\max_{\{c_t,h_t,\Pi_t,R_t,g_t\}} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t,h_t,g_t) \tag{27}$$
$$\text{s.t.}$$
$$\text{Equations (11),(12),(15),(MRF-C) for all } t$$
$$R_t \geq 1 \text{ for all } t$$

We thus proposes the following definition.

Definition 6 (SCMP) *A self-confirming equilibrium with sequential and conservative monetary policy and fiscal commitment is a sequence* $\{c_t, h_t, \Pi_t, R_t, g_t\}_{t=0}^{\infty}$ *solving problem (27).*

A steady state with SCMP is again defined as the limit for $t \to \infty$ of the self-confirming equilibrium with SCMP.

Figure 1 depicts the welfare losses associated with various degrees of monetary conservatism α for the baseline calibration in section 5. For large values of α the welfare losses disappear and the steady state with SCMP approaches the Ramsey steady state. For $\alpha \to \infty$ the conservative monetary reaction function (MRF-C) becomes consistent with the Ramsey steady state, since the Lagrange multiplier associated with MRF-C in problem (27) approaches zero.[14] As a result, for $\alpha \to \infty$ the fiscal authority's policy problem (27) approaches the Ramsey problem (16).[15] In a setting with fiscal commitment, a sufficiently conservative central bank thus eliminates the steady state distortions stemming from lack of monetary commitment.

7.2 Sequential Fiscal Policy

We now consider the case with sequential monetary and fiscal policy. Since the monetary and fiscal authorities now pursue different objectives, it matters for the equilibrium outcome whether fiscal policy is determined before, after, or simultaneously with monetary policy. It remains to be ascertained, however,

[14] This holds only from a 'steady state' or 'timeless' perspective. Initially, the Lagrange multiplier associated with MRF-C in (27) is non-zero.

[15] See the previous footnote.

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.

7.2.1 Defining Nash and Leadership Equilibria

This section defines the various equilibria then briefly discusses them. For the case with simultaneous decisions we propose the following definition.

Definition 7 (SCMFP-Nash) *A 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 (11), (12), (15), (FRF), and (MRF-C).*

Next, consider the case with monetary leadership. The conservative monetary authority then has to take into account the fiscal reaction function (FRF). The monetary authority's policy problem at time t is thus given by:

$$\max_{\{c_{t+j},h_{t+j},\Pi_{t+j},R_{t+j},g_{t+j}\}} E_t \sum_{j=0}^{\infty} \beta^j \left(u(c_{t+j}, h_{t+j}, g_{t+j}) - \frac{\alpha}{2}(\Pi_{t+j} - 1)^2 \right) \quad (28)$$

$$\text{s.t.:}$$
$$\text{Equations (11),(12),(15),(FRF) for all } t$$
$$E_t \left(c_{t+j}, h_{t+j}, \Pi_{t+j}, g_{t+j}, R_{t+j}\right) \text{ given for } j \geq 1$$
$$R_{t+j} \geq 1 \text{ for all } j \geq 0$$

Eliminating Lagrange multipliers from the first order conditions of problem (28) delivers the conservative monetary reaction function with monetary leadership that we denote by (MRF-C-ML).

Definition 8 (SCMFP-ML) *A 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 (11), (12), (15), (FRF), and (MRF-C-ML).*

Finally, we consider the case with fiscal leadership. Fiscal policy must then take into account the conservative monetary reaction function(MRF-C):

$$\max_{\{c_{t+j},h_{t+j},\Pi_{t+j},R_{t+j},g_{t+j}\}} E_t \sum_{j=0}^{\infty} \beta^j u(c_{t+j}, h_{t+j}, g_{t+j}) \quad (29)$$

$$\text{s.t.}$$
$$\text{Equations (11),(12),(15), (MRF-C) for all } t$$
$$E_t \left(c_{t+j}, h_{t+j}, \Pi_{t+j}, g_{t+j}, R_{t+j}\right) \text{ given for } j \geq 1$$
$$R_{t+j} \geq 1 \text{ for all } j \geq 0$$

Solving for the first order conditions of problem (29) and eliminating Lagrange multipliers delivers the fiscal reaction function in the presence of a conservative monetary authority and fiscal leadership that we denote by (FRF-C-FL).

Definition 9 (SCMFP-FL) *A 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 (11), (12), (15), (FRF-C-FL), and (MRF-C).*

As before, the steady states corresponding to the equilibrium definitions 7, 8, and 9 are defined as the stationary values (c, h, Π, R, g) solving the equations listed in the respective definitions.

We now briefly comment on the previous definitions. First, note that for the case $\alpha = 0$ all three equilibria reduce to the one emerging under SMFP without conservatism: MRF-C and MRF-C-ML are then identical to MRF and FRF-C-FL is identical to FRF. Second, for the Nash and monetary leadership cases, there exists a theoretical upper bound on the welfare gains that monetary conservatism is able to generate. Since in these cases the fiscal authority takes monetary decisions as given, welfare maximizing monetary behavior is the one consistent with the self-confirming equilibrium with sequential fiscal policy (SFP) considered in section 4.2.1. Third, in the case with fiscal leadership, the fiscal authority anticipates the monetary reaction function and conservatism can then lead outcomes that are welfare superior outcomes to the one emerging with SFP.

7.2.2 The Implications of Central Bank 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 5. The upper and lower horizontal lines shown in the figure indicate the welfare losses associated with SFP and SMFP, respectively.

For $\alpha = 0$, i.e., the case without any monetary conservatism, all equilibria deliver the welfare losses associated with SMFP. This is just a restatement of the fact that the leadership structure does not matter when both policymakers pursue the same objectives.

With SCMFP-Nash and SCMFP-ML we find that an appropriately conservative central bank can fully recover the steady state associated with monetary commitment and sequential fiscal policy (SFP). 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. Interestingly, the costs associated with being overly conservative appear small, while an insufficient degree of conservatism may result in large welfare losses. The intuition for this finding is provided below.

The case for a conservative monetary authority is even stronger with SCMFP-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 $\alpha \to \infty$ 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 $\alpha \to \infty$ 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. Thus, in this setting the fiscal authority anticipates that fiscal spending results in a crowding out of private consumption and this disciplines the fiscal authority's 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 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 4.2.1. This explains why in the Nash and monetary leadership cases an overly conservative central bank reduces welfare, see figure 2. The gains from lowering inflation at some point start to be outweighed by the losses from increased fiscal spending and the resulting crowding out of private consumption.

Figure 3 also explains why insufficient monetary conservatism is rather costly in welfare terms, while an overly conservative central bank does not cause much welfare losses in the Nash and monetary leadership cases. With too much monetary conservatism, the public spending increase and the resulting crowding out of private consumption roughly offset each other in utility terms. At the same time, there are large initial welfare gains from monetary conservatism, which arise from correcting the monetary inflation bias. Unlike in the case with exogenous fiscal policy, however, the inflation bias has to be defined as the inflation increase associated with a transition from the SFP regime to the SMFP regime.

8 Conclusions

This paper analyzes monetary and fiscal policy interactions in a dynamic general equilibrium model when policymakers lack the ability to credibly commit to policies ex-ante.

It is shown that lack of fiscal commitment leads to excessive fiscal spending on public goods while lack of monetary commitment results in the well-known inflation bias. The welfare losses generated by lack of monetary or fiscal commitment appear to be substantial. In the absence of monetary commitment, independently of whether or not fiscal policy can commit, making the monetary authority appropriately conservative completely eliminates the steady state distortions associated with sequential monetary policy. The case for a conservative monetary authority is even stronger because monetary conservatism may also eliminate the steady state losses associated with lack of fiscal commitment.

A number of important questions remain to be addressed in further research. First, the paper considers steady state effects only. In a fully stochastic model, however, welfare losses also depend on the conditional response to shocks. Exploring the effects of monetary conservatism on these policy responses seems to be of interest. Second, the paper abstracts from capital stock and government bond dynamics, which would allow for additional interactions between policymakers. We plan to extend the analysis to such richer settings in future work.

A Appendix

A.1 Proof of Lemma 1

Suppose the steady state inflation rate is given by $\Pi \in [\beta, \beta^{-1}]$. For β sufficiently close to 1, the sign of the l.h.s. of MRF is determined by the sign of

$$\begin{aligned}&\left(1+\frac{u_c}{u_h}\right)\frac{2\Pi-1}{\Pi-1}\\&=\left(1-w(1-\tau)\right)\frac{2\Pi-1}{\Pi-1}\end{aligned} \tag{30}$$

Monopolistic competition implies $w < 1$. Since $\tau \geq 0$, it follows that $1 - w(1 - \tau) \neq 0$, which shows that MRF cannot be satisfied for a steady state inflations rate $\Pi \in [\beta, \beta^{-1}]$, provided β is sufficiently close to one. The Euler equation (12) and the constraint $R \geq 1$ imply that $\Pi \geq \beta$ in any steady state. Thus, it must be that $\Pi > \beta^{-1} > 1$, as claimed.

A.2 Utility Parameters and Ramsey Steady State

Here we show how the utility parameters ω_0 and ω_1 are determined by the Ramsey steady state values. Let variables without subscripts denote their steady state values and consider a steady state where $\Pi = 1$. The Phillips curve (11) then implies

$$1+\eta-\frac{\omega_0\eta}{(1-h)\,c^{-\sigma}}-\frac{g+x}{h}\eta=0 \tag{31}$$

which delivers

$$\omega_0=\frac{(1-h)\left(1+\eta-\frac{g+x}{h}\eta\right)}{\eta c^{\sigma}} \tag{32}$$

Let $\gamma_t^1, \gamma_t^2, \gamma_t^3$ be the Lagrange multipliers associated with (11), (12), and (15), respectively, in problem (16). The first order condition (FOC) of (16) with respect to R_t implies

$$\gamma^2 = 0 \tag{33}$$

The FOC with respect to c_t together with equations (31) and (33) deliver

$$c^{-\sigma} + \gamma^1 \frac{h\omega_0 \eta \sigma}{(1-h)\, c} - \gamma^3 = 0 \tag{34}$$

The FOC with respect to h_t and equation (31) imply

$$-\frac{\omega_0}{1-h} + \gamma^1 \left(\frac{h\omega_0 \eta}{(1-h)^2} - \frac{g+x}{h} \eta c^{-\sigma} \right) + \gamma^3 = 0 \tag{35}$$

Equations (34) and (35) determine

$$\gamma^1 = \frac{\frac{\omega_0}{1-h} - c^{-\sigma}}{\frac{h\omega_0\eta}{(1-h)^2} + \frac{h\omega_0\eta\sigma}{(1-h)c} - \frac{g+x}{h}\eta c^{-\sigma}} \tag{36}$$

$$\gamma^3 = c^{-\sigma} + \gamma^1 \frac{h\omega_0 \eta \sigma}{(1-h)\, c} \tag{37}$$

From the FOC with respect to g_t it then follows that

$$\omega_1 = g(\gamma^3 - \gamma^1 c^{-\sigma} \eta) \tag{38}$$

Given steady state values for c, h, g and x consistent with the resource constraint (15), equations (32), and (36)-(38) determine ω_0 and ω_1.

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Variable	**Assigned Value**
discount factor	$\beta = 0.9913$
elasticity of demand	$\eta = -6$
adjustment cost parameter	$\theta = 17.5$
elasticity of substitution	$\sigma = 1$
utility weight on leisure	$\omega_0 = 4.1\overline{6}$
utility weight on the public good	$\omega_1 = 0.2755$
fiscal waste	$x = 0$

Table 1: Baseline calibration

Policy regime	c (percentage deviations relative to Ramsey)	h	g	Π	τ (level)	Welfare equivalent consumption losses
SFP	-16.6%	0.7%	55.0%	2.6%	36.8%	**-6.5%**
SMP	5.9%	10.5%	-16.9%	4.6%	17.9%	**-7.6%**
SMFP	-6.6%	14.8%	29.6%	5.7%	26.9%	**-11.0%**

Table 2: Steady state effects

	Welfare equivalent consumption losses SFP	SMP	SMFP	$\Pi^{SMFP} - \Pi^{SFP}$
Baseline calibration	-6.5%	-7.6%	-11.0%	3.1%
more sticky prices ($\theta = 25$)	-6.8%	-8.2%	-11.9%	2.8%
less sticky prices ($\theta = 10$)	-5.8%	-6.6%	-9.5%	3.5%
almost flexible prices ($\theta = 0.1$)	-0.5%	-0.5%	-0.6%	2.0%
more competition ($\eta = -7$)	-4.6%	-6.2%	-8.7%	2.9%
less competition ($\eta = -5$)	-9.8%	-9.4%	-14.2%	2.8%
fiscal waste ($x = 0.02$)	-3.0%	-7.8%	-9.5%	4.3%
higher risk aversion ($\sigma = 2$)	-1.2%	-3.3%	-4.2%	2.9%
lower risk aversion ($\sigma = 0.4$)	-37.2%	-19.8%	-37.2%	0.0%
very low risk aversion ($\sigma = 0.35$)	-43.8%	-22.4%	-45.4%	-0.6%

Table 3: Robustness of steady state effects

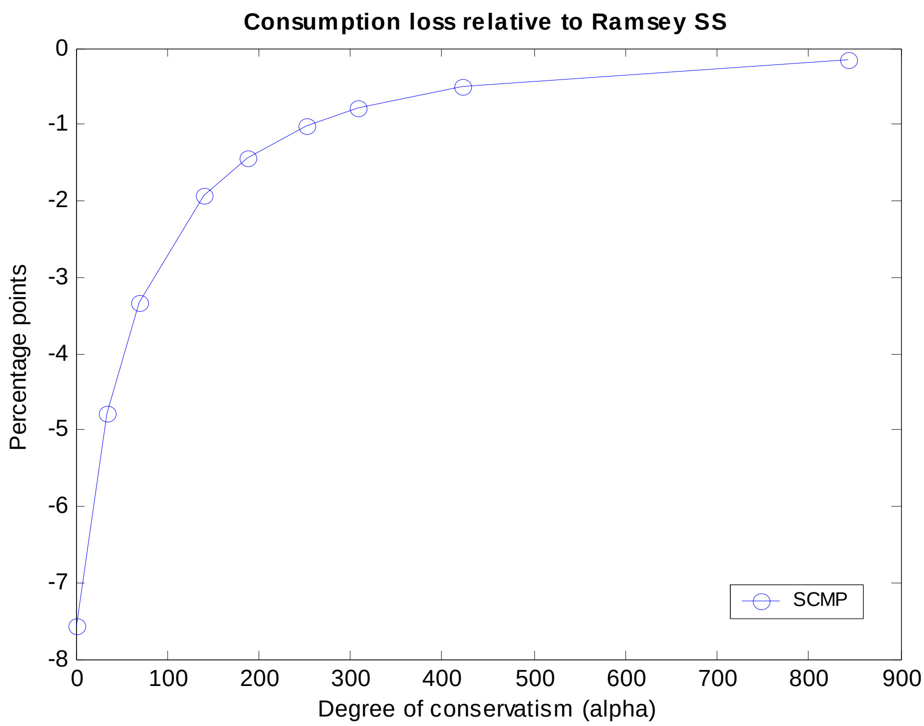

Figure 1: Welfare gains from monetary conservatism with fiscal commitment

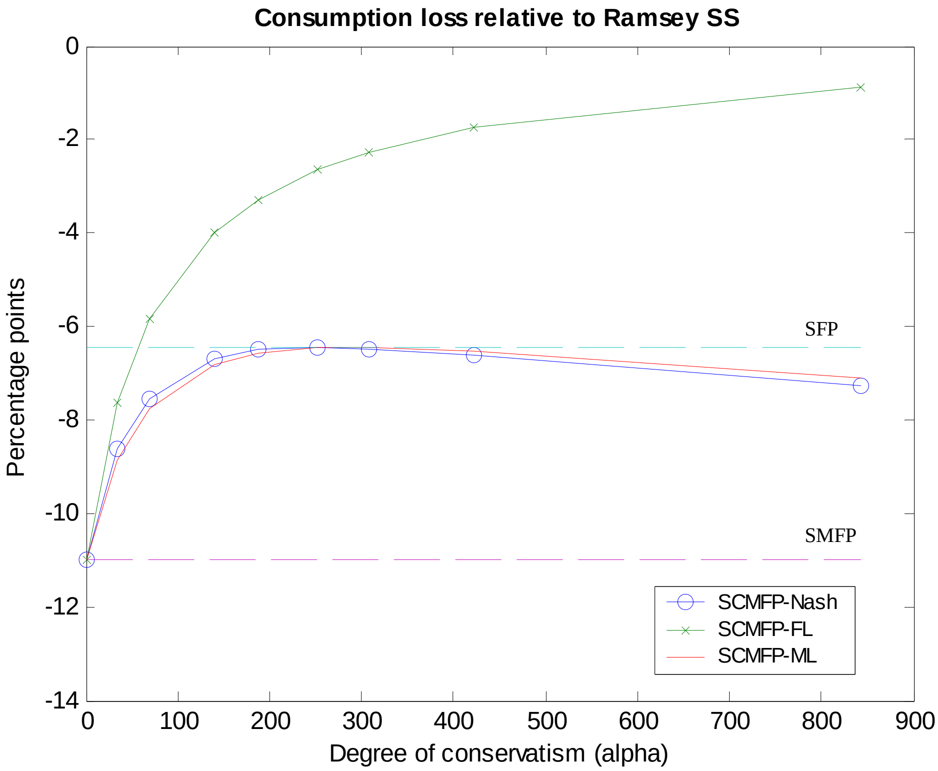

Figure 2: Welfare gains from monetary conservatism with sequential fiscal policy

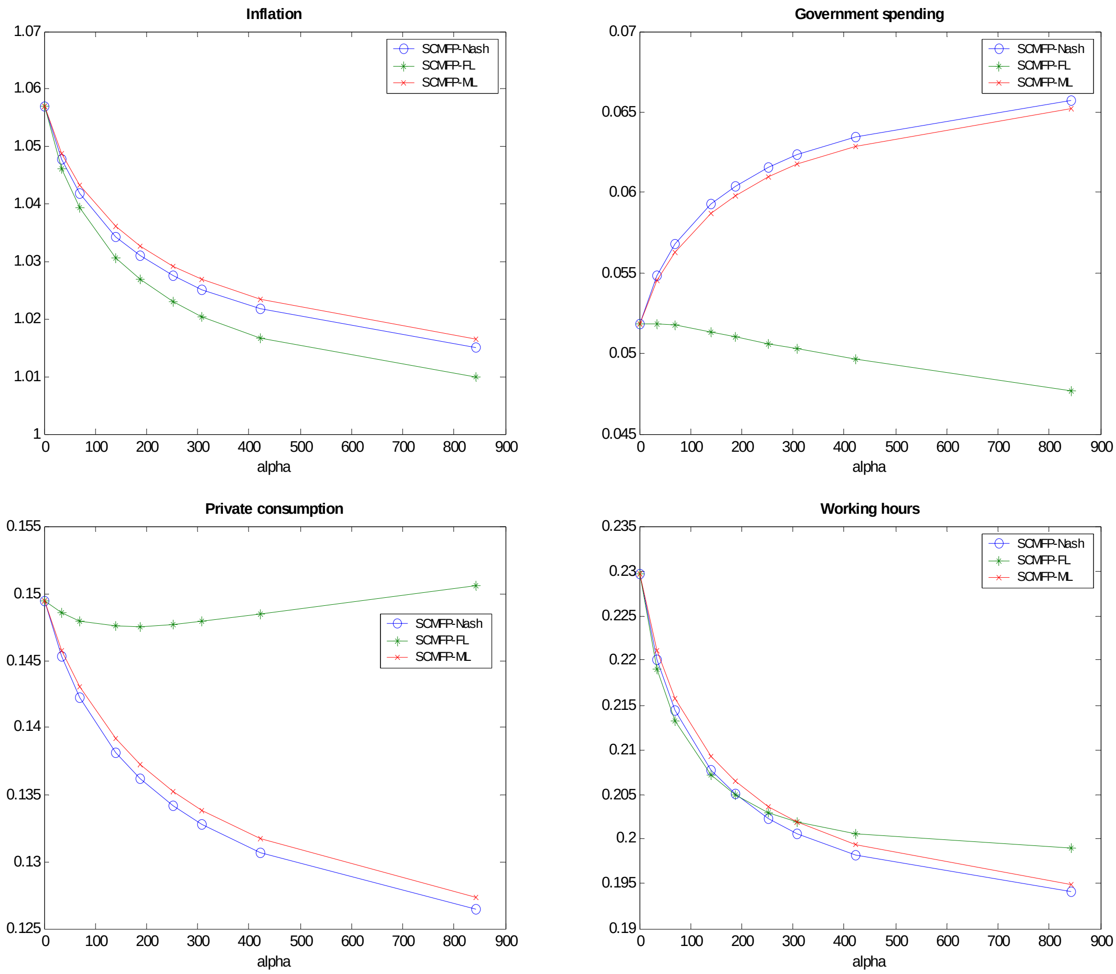

Figure 3: The effects of central bank conservatism