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## Monetary–Fiscal Policy Interactions under Implementable Monetary Policy Rules

This paper examines the implications of forward- and backward-looking monetary policy rules in an environment with monetary–fiscal interactions. We find that the unique stationary rational expectations equilibrium (REE) is always non-Ricardian under simple implementable monetary policy rules.

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A FOCUS OF RECENT research is the design of monetary policy rules under particular fiscal policy regimes. In most cases it is assumed that fiscal policy is Ricardian and so it is up to monetary policy to determine prices and inflation.<sup>1</sup> Papers that explicitly model monetary–fiscal interactions and highlight the role fiscal policy plays in price level determination include Leeper (1991) and Woodford (1995).<sup>2</sup> These approaches study the interactions under contemporaneous monetary policy rules; however, some authors have questioned whether rules conditioning on current inflation or output are implementable (McCallum 1999, Clarida, Gali, and Gertler 2000, Orphanides 2001, Benhabib, Schmitt-Grohe, and Uribe 2001).

1. See Woodford (2003) for an overview.

2. Recent papers on this topic include Leeper and Yun (2006), Davig and Leeper (2007), and Cochrane (2006).

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This paper addresses an important gap in the literature on monetary policy rules. We examine the implications of simple, implementable monetary policy rules in an environment with monetary–fiscal interactions. In particular, we focus on a model where these interactions matter for price-level determination. We assume that monetary policy is characterized by an interest rate rule that is a linear feedback function of either lagged or expected inflation; this extends Leeper (1991), where the nominal interest rate is a function of the contemporaneous rate of inflation.

We find that the alternative policy rules produce new determinacy results. When monetary policy is forward-looking, determinacy obtains provided fiscal policy is active. With a backward-looking interest rate rule, determinacy obtains provided the policy mix is active fiscal/passive monetary. As a corollary, we find that for both forward- and backward-looking rules, determinacy implies that the unique rational expectations equilibrium (REE) is non-Ricardian.

## 1. THE MODEL

This paper adopts the representative agent endowment economy in Leeper (1991), also employed by Evans and Honkapohja (2007). This model has (linearized) reduced-form equations

$$E_t \pi_{t+1} = \beta R_t, \quad (1)$$

$$b_t = -\phi_1 \pi_t - \phi_2 R_t - \phi_3 R_{t-1} + \beta^{-1} b_{t-1} - \tau_t, \quad (2)$$

where  $\pi_t$  is the inflation rate,  $b_t$  is real bond holdings,  $R_t$  is the nominal interest rate, and  $\tau_t$  is lump-sum taxes. Equation (1) is the (linearized) Fisher relation and (2) is the (linearized) intertemporal budget constraint.  $\beta$  is the discount rate, and  $\phi_1$ ,  $\phi_2$ , and  $\phi_3$  are functions of the model's deep parameters. We refer the reader to these other papers for details on the derivations.

We use the flexible-price endowment economy of Leeper (1991) because it is the most parsimonious model capable of illustrating our results. Woodford (1995) and Sims (1994) find that assuming a New Keynesian-type model does not alter the basic qualitative fiscalist result. This is because the essential ingredient for modeling monetary-fiscal policy interaction is the intertemporal budget constraint, which must bind in an REE.<sup>3</sup>

To close the model, we assume that  $R_t$  and  $\tau_t$  are simple, implementable reaction functions. We follow Leeper (1991) in assuming that tax policy is set according to

$$\tau_t = \gamma b_{t-1} + \psi_t. \quad (3)$$

3. There is an extensive debate in the literature over whether satisfaction of the intertemporal budget constraint is an equilibrium condition. This debate is orthogonal to our aim of exploring the implications of implementable monetary policy rules for determinacy in the Leeper (1991) framework.

Leeper (1991) also assumes a contemporaneous interest rate rule of the form

$$R_t = \alpha\pi_t + \theta_t, \quad (4)$$

where  $\psi_t$  and  $\theta_t$  are independent (mean-zero) white noise shocks with bounded support. Interest rate rules of this form have been criticized by McCallum (1999) among others as not being implementable. To address this concern, instead we assume that policy is implemented using rules conditional on observable data. Specifically,

$$R_t = \alpha E_t \pi_{t+j} + \theta_t \quad j = -1, 1, \quad (5)$$

which imposes that interest rates are set using either forward- or backward-looking rules.

Leeper (1991) provides the following definition.

**DEFINITION:** *Monetary policy is active if  $|\alpha\beta| > 1$  and passive otherwise. Fiscal policy is active if  $|\beta^{-1} - \gamma| > 1$  and passive otherwise.*

Intuitively, monetary policy is active if a rise in inflation results in a more than one-for-one rise in the nominal rate and fiscal policy is active if taxes do not adjust to fully offset debt-financed tax changes.

A *stationary rational expectations equilibrium* (stationary REE) is any stationary stochastic process satisfying (1)–(3) and (4) or (5).<sup>4</sup> If there is a unique stationary REE then the model is said to be (locally) determinate, if there are multiple stationary REE then the model is said to be (locally) indeterminate, and if no stationary REE exist, we say that no REE exists locally. We note that no REE exist locally if and only if all solutions to the linearized model are explosive. Also, in the sequel, when we write “REE” we will always mean “stationary REE.”

Using the above definition, Leeper (1991) identifies equilibrium determinacy with active/passive regimes.<sup>5</sup> We summarize his findings as follows:

- (i) The model (1)–(4) has a (locally) unique stationary REE for all  $(\alpha, \gamma)$  that satisfy  $|\alpha\beta| > 1$  and  $|\beta^{-1} - \gamma| < 1$ . The unique REE satisfies the restriction  $\pi_t = -\alpha^{-1}\theta_t$  and is referred to as the monetarist solution because the inflation path depends only on monetary shocks.
- (ii) The model (1)–(4) has a (locally) unique stationary REE for all  $(\alpha, \gamma)$  that satisfy  $|\alpha\beta| < 1$  and  $|\beta^{-1} - \gamma| > 1$ . The unique REE satisfies the restriction  $\pi_t = K_1 b_t + K_2 \theta_t$  for appropriately defined constants  $K_i, i = 1, 2$ . This

4. Models that explicitly include a transversality condition may yield rational expectations equilibria that are bounded but non-stationary. Because we have not explicitly included a transversality condition in our formulation of Leeper’s (1991) model, we focus on stationary solutions to (1)–(3) and (5). We note, however, that in a stationary REE the transversality condition will be satisfied.

5. In the monetary policy literature, activist policy has also been taken to have the precise opposite meaning. For instance, activist monetary policy has also been used to describe policy primarily concerned with output and not inflation stabilization. See Orphanides (2001) for a discussion.

solution is referred to as the fiscalist solution because inflation depends on the path of real bonds.

These results emphasize that a unique REE exists provided one policy authority takes an active stance and the other a passive stance. In the case of active monetary and passive fiscal policy, the inflation process is driven entirely by white noise monetary policy shocks. When fiscal policy is active and monetary policy is passive, the stochastic process for inflation depends on the stochastic process for bonds—in this instance, fiscal policy pins down the price level.

## 2. IMPLEMENTABLE POLICY RULES

We now analyze the determinacy properties of the model when closed with policy rules conditioning on observable proxies of inflation, and we compare our results with those in Leeper (1991).

### 2.1 A Forward-Looking Interest Rate Rule

Consider the model (1)–(3) closed with the following forward-looking monetary policy rule:

$$R_t = \alpha E_t \pi_{t+1} + \theta_t. \quad (6)$$

We have the following result.

**PROPOSITION 1:** *Assume monetary policy is forward looking and set according to (6). The model (1)–(3) is determinate if and only if policy  $(\alpha, \gamma)$  satisfies  $|(\beta^{-1} - \gamma)| > 1$ . The equilibrium inflation process is given by*

$$\pi_t = G_1 \theta_t + G_2 \theta_{t-1} + G_2 \psi_t, \quad (7)$$

where the determination of the  $G_i$ 's is described in the Appendix.

Because of the model's expectational structure, an REE always exists; therefore, if  $|(\beta^{-1} - \gamma)| < 1$  then there exists multiple REE, many exhibiting dependence on extrinsic, "sunspot" processes. Notice also that in case of determinacy, the unique stationary REE takes the "fiscalist" form in part 2 of Leeper's result, but unlike the contemporaneous interest rate rule, there does not exist a "monetarist" solution. In particular, with a forward-looking policy rule, the unique REE (7) is non-Ricardian regardless of the stance of monetary policy.

### 2.2 A Backward-Looking Interest Rate Rule

We now turn to policy rules of the form

$$R_t = \alpha \pi_{t-1} + \theta_t. \quad (8)$$

We have the following result.

PROPOSITION 2: *Assume monetary policy is backward looking and set according to (8).*

1. *The model (1)–(3) is determinate if and only if policy  $(\alpha, \gamma)$  satisfies  $|\alpha\beta| < 1$  and  $|\beta^{-1} - \gamma| > 1$ .*
2. *The model (1)–(3) is indeterminate if and only if policy  $(\alpha, \gamma)$  satisfies  $|\alpha\beta| < 1$  and  $|\beta^{-1} - \gamma| < 1$ .*
3. *No REE of the model (1)–(3) exist locally if and only if policy  $(\alpha, \gamma)$  satisfies  $|\alpha\beta| > 1$ .*

*In case of determinacy, the unique equilibrium path satisfies*

$$\pi_t = H_1 b_t + H_2 \theta_{t-1} + H_3 \theta_t, \quad (9)$$

*where the determination of the  $H_i$ 's is described in the Appendix.*

As above, Proposition 2 shows that in the case of determinacy the inflation rate is determined, in part, by fiscal policy. Moreover, active fiscal policy is again a necessary condition for determinacy. Unlike the forward-looking case, monetary policy is restricted to be passive, as in Leeper (1991). Because of the backward-looking behavior of the policy rule, active monetary policy leads to explosive behavior, and so we again find that a monetarist solution does not exist.

A monetary authority that responds aggressively to lagged inflation will place the economy on an explosive inflationary path when fiscal policy is also active. A thought experiment provides an intuitive interpretation to our results: suppose there is an unanticipated positive shock to the nominal interest rate. This change in the relative return of nominal bonds to nominal money balances will induce the representative agent to substitute nominal bonds for nominal money. For the government's budget constraint to be satisfied, outstanding nominal debt will be revalued through a discrete jump in the price level so that discounted future primary surpluses and seigniorage equal current real debt. Since the monetary authority reacts to inflation with a lag, no action is taken to counter this contemporaneous increase in inflation. Next period, however, the monetary authority will react aggressively and increase nominal interest rates more than inflation. However, this leads to another substitution of bonds for money and places inflation on an explosive path. So to ensure stationarity, the monetary authority must react passively to lagged inflation. This contrasts with the case of the forward-looking rule, where monetary policy does not face a restriction on its response to expected inflation.

### 2.3 Further Discussion

The results in this paper demonstrate that in a flexible-price endowment economy with forward- or backward-looking monetary policy rules, active fiscal policy is a necessary condition for local determinacy. This finding and motivation for this paper

are related to Schmitt-Grohe and Uribe (2007), who compute optimal monetary and fiscal policy within the class of simple, implementable rules in a production economy with capital and sticky prices.<sup>6</sup> In a cashless version of their economy, the optimal implementable forward- and backward-looking rules are superinertial. They report that non-inertial forward-looking rules under passive fiscal policy yield indeterminacy for reasonable degrees of activism by the central bank. This result is consistent with our findings concerning non-inertial forward-looking rules, indicating our results are robust to deviations from the endowment economy assumption.<sup>7</sup> Schmitt-Grohe and Uribe report that the optimal backward-looking monetary policy rule yielding determinacy under passive fiscal policy is active and superinertial. This differs from our result that a backward-looking interest rate rule that yields determinacy must be passive in the flexible-price endowment economy. In this case, the implications for monetary policy are sensitive to assumptions concerning the presence of frictions and whether output is endogenous. An open question then is how interest rate inertia, frictions and production aspects of the economy interact to deliver determinacy under a backward-looking rule.

### 3. CONCLUSION

This paper extends Leeper (1991) by studying the implications of simple implementable interest rate rules in a flexible-price endowment economy. Specifically, we analyze the local determinacy results in a model with monetary–fiscal interactions, where monetary policy is set according to a forward- or backward-looking nominal interest rate rule. We show that interest rate rules responding to expected inflation yield the existence of a locally unique stationary REE if and only if fiscal policy is active. Under a backward-looking rule, a locally unique stationary REE exists when fiscal policy is active and monetary policy is passive. The results show that there does not exist an REE in the flexible-price endowment framework with forward- or backward-looking rules that is purely monetarist, meaning that inflation depends on monetary and fiscal shocks.

### APPENDIX

PROOF OF PROPOSITION 1: The policy rule and Fisher relation combine to imply  $R_t = \frac{1}{1-\alpha\beta}\theta_t$ . Writing  $\xi_t = \pi_t - E_{t-1}\pi_t$  yields  $\pi_t = \frac{\beta}{1-\alpha\beta}\theta_{t-1} + \xi_t$ . Imposing this and the expressions for  $R_t$ ,  $\tau_t$  into the intertemporal constraint provides

6. They define implementable rules as those delivering a determinate equilibrium. We also seek rules delivering determinacy, but require that the rules be a function of variables observable to the central bank.

7. Woodford (2003) shows that  $\alpha + \rho > 1$  yields a determinate equilibrium under a contemporaneous monetary rule with passive fiscal policy in a flexible-price endowment economy, where  $\rho$  is the degree of interest rate inertia.

$$b_t = \delta b_{t-1} - A_1 \theta_t - A_2 \theta_{t-1} - \phi_1 \xi_t - \psi_t, \tag{A1}$$

where  $\delta = \beta^{-1} - \gamma$ ,  $A_1 = \frac{\phi_2}{1-\alpha\beta}$ , and  $A_2 = \frac{\phi_1\beta + \phi_3}{1-\alpha\beta}$ . If  $|\delta| < 1$  then this expression for  $b_t$  is non-explosive for all martingale difference sequences  $\xi_t$ : this is the indeterminate case. If  $|\delta| > 1$  then  $\xi_t$  must be chosen so that the state of the dynamic system lies in the associated contracting eigenspace: this is the determinate case. Here, notice that  $b_t = \Omega \theta_t$  for some  $\Omega$ . The lag structure of the intertemporal constraint then implies that  $\Omega = \frac{A_2}{\delta}$ , where  $A_1 \theta_t - \phi_1 \xi_t - \psi_t = \Omega \theta_t$ . It follows that  $\xi_t = -\frac{1}{\phi_1}((\Omega + A_1)\theta_t + \psi_t)$ . This may be used to compute the  $G_t$ s.  $\square$

PROOF OF PROPOSITION 2: The policy rule and reduced form equations may be stacked as  $y_t = M y_{t-1} + N \eta_t$ , where  $y = (b_t, \pi_t, \pi_{t-1}, \theta_t)'$ ,  $\eta_t = (\xi_t, \theta_t, \psi_t)'$ , and  $\xi_t$  is the inflation forecast error. Now diagonalize  $M$ :  $M = S \Lambda S^{-1}$ , where  $\Lambda$  is the diagonal matrix of eigenvalues, which are assumed ordered in decreasing magnitude. Changing coordinates to  $z = S^{-1}y$ , the dynamic system decouples as  $z_t = \Lambda z_{t-1} + \tilde{\eta}_t$ , where  $\tilde{\eta}_t = S^{-1}N \eta_t$ . The eigenvalues of  $M$  are  $\{\delta, \sqrt{\alpha\beta}, \sqrt{\alpha\beta}, 0\}$ . Determinacy obtains when precisely one of these eigenvalues has modulus larger than one. Since  $\sqrt{\alpha\beta}$  is a repeated eigenvalue, determinacy can only obtain if  $|\delta| > 1$  and  $|\sqrt{\alpha\beta}| < 1$ . If  $|\delta| < 1$  and  $|\sqrt{\alpha\beta}| < 1$  then the dynamic system is non-explosive for all  $\xi_t$ : this is the indeterminate case; if  $|\sqrt{\alpha\beta}| > 1$  then the dynamic system will be explosive for all  $\xi_t$ : this is the explosive case. In case of determinacy,  $\xi_t$  must be chosen so that  $\tilde{\eta}_t = 0$ . This allows  $z_{1t} = 0$ , which can then be solved for  $\pi_t$  to obtain the relation in the proposition.  $\square$

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