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The role of liquid government bonds in the great transformation of American monetary policy

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A fundamental shift in monetary policy occurred around 1980: the Fed went from a “passive” policy to an “active” policy. We study a model in which government bonds provide transactions services. We present two calibrations of our model, using pre- and post-1980 data. We show that estimates of pre- and post-1980 policy rules all lie within our determinacy regions. But, the pre-1980 policy was a very bad monetary policy, even if it avoided sunspot equilibria. Model simulations suggest that household welfare would have increased by 3.3 percent of permanent consumption in this period under an active policy.

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1. Introduction

A profound change in monetary policy is generally thought to have occurred in the United States around 1980: the Fed became much more responsive to inflation with the arrival of Paul Volcker. The pre-Volcker policy has been strongly criticized by Clarida et al. (2000) and many others who argued that the policy violated the Taylor principle, raising the specter of indeterminacy and sunspot equilibria, and indeed inflation was volatile during the 1970s. However, Leeper (1991) and others argued that indeterminacy problems need not arise when monetary policy violates the Taylor principle if that monetary policy is accompanied by an appropriate fiscal policy; that is, the Fiscal Theory of the Price Level (FTPL) can explain away the possibility of sunspot equilibria in the 1970s.

Here, we offer an alternative to both sunspots and the FTPL. We assume that government bonds have a liquidity value and are an imperfect substitute for money, and we show that this fact in and of itself can rule out sunspot equilibria during the pre-Volcker era. There is therefore no need to resort to the FTPL if one doubts the likelihood of sunspot equilibria. Our approach has several advantages over the FTPL as an explanation of the inflationary 1970s. In addition to avoiding the many controversies surrounding the FTPL, our approach eliminates a thorny coordination problem that arises with the FTPL’s explanation.1

But does that mean that Fed’s policy in the pre-Volcker period has gotten a bum rap, that it was not so bad after all? Our model suggests that the answer to that question is emphatically no. The weak response to inflation may not have led to

1 Canzoneri et al. (2001) argue that the FTPL does not provide a plausible explanation of the surplus and debt dynamics observed in US data. Canzoneri et al. (forthcoming) discuss is some detail the FTPL and many of the controversies it has generated.
sunspot equilibria, but it was prone to in-flationary responses to the supply shocks of the 1970s, and according to our model, it was disastrous for welfare. Our simulations suggest that a stronger policy would have raised household welfare by the equivalent of three and a third percent of permanent consumption during the pre-Volcker era.

It is helpful at this point to be more specific about the theoretical and empirical literature that provides the background for our paper. Using Leeper’s (1991) terminology, Fed’s interest rate policy was “passive” – or violated the Taylor Principle – prior to 1980; then it became “active” – or satisfied the Taylor Principle – during the Volcker–Greenspan era.2 Clarida et al. (2000) and Lubik and Schorfheide (2004) documented this shift in monetary policy and expressed the conventional view of its import: the pre-Volcker policy was bad monetary policy because conventional models implied that the price level would not be pinned down, raising the specter of sunspot equilibria.

The FTPL challenged the conventional view’s assumption (often implicit) that fiscal policy is “passive”; that is, when the public debt increases, the primary surplus rises by enough to stabilize debt dynamics. Leeper (1991) raised the possibility that fiscal policy might have been “active” in the pre-Volcker era; that is, the response might have been insufficient to stabilize debt dynamics. He (and the literature that followed) studied the combinations of monetary and fiscal policies that would achieve a unique, locally stable, solution for inflation. Generally speaking, an inactive monetary policy has to be paired with an active fiscal policy, and an active monetary policy has to be paired with an inactive fiscal policy.3 Pairing a passive monetary policy with a passive fiscal policy – the conventional view of the pre-Volcker period – would generally lead to sunspot equilibria. On the other hand, if the passive monetary policy was paired with an active fiscal policy, then the sunspot equilibria would be eliminated. But, when monetary policy shifted from passive to active around 1980, fiscal policy would have had to shift from active to passive, or explosive solutions would have been possible. This is the FTPL’s coordination problem.4

In Canzoneri and Diba (2005), we showed that both active and passive monetary policies can achieve price determinacy, even if fiscal policy is passive, as long as government bonds provide transactions services.5 Fiscal deficits increase total transactions balances, providing a new link between inflation and debt dynamics.6 This dramatically changes the combinations of monetary and fiscal policies that result in a unique, locally stable, equilibrium. In this paper, we complete the analysis of the 1980 transformation in monetary policy. We present two calibrations of our model, using pre- and post-1980 datasets, and we illustrate the range of monetary and fiscal policies that would have achieved price determinacy. Lubik and Schorfheide (2004) estimates of the pre- and post-1980 interest rate rules and Bohn’s (1998, 2004) estimates of passive fiscal reaction functions fall within our determinacy regions. This is why we say that there appears to have been no need for fiscal policy to have shifted in 1980.

Before we begin our analysis, we should mention some alternative views and approaches to the issues we discuss here. Orphanides (2004) finds that monetary policy in the pre-Volcker period did not actually violate the Taylor Principle; if one accepts his results, there is no indeterminacy problem to be explained. Gali et al. (2004) and Bilbiie and Straub (2006) add “rule of thumb” households to their models and find that, if there are enough of them, the Taylor Principle can be violated without creating an indeterminacy problem.7 Bilbiie and Straub (2006) find that a passive monetary policy is optimal in their model when there are enough “rule of thumb” households. Woodford (2001), using the FTPL, argues that an interest rate peg is a good characterization of US policy between 1942 and the Treasury-Fed “Accord” of 1951, and he seems to think that this was a reasonable policy at that time; he says that “This sort of relationship between a central bank and the treasury is not uncommon in wartime, …[and in other] cases where the perceived constraints on fiscal policy have been similarly severe.”

The rest of the paper is organized as follows: In Section 2, we outline our model, and we present our two calibrations of it: one to the 1970s and the other to the Volcker–Greenspan era. In Section 3, we graph the policy regions for stable equilibria, sunspot equilibria and explosive solutions under the two calibrations. The regions have shifted over time, but as noted above they suggest that the systematic part of fiscal policy need not have changed when monetary policy shifted from passive to active. In Section 4, we argue that the passive policy of the pre-Volcker period was indeed bad monetary policy, even if it did avoid sunspot equilibria. Finally, Section 5 concludes with some caveats and some suggestions for future research.

2. The model and its pre- and post-1980 calibrations

We assume a standard NNS environment – with fixed, firm specific capital, Calvo price setting, and flexible wages – except for the fact that we allow government bonds to be an imperfect substitute for money.8 In previous work, Canzoneri et al.,
we have modeled banks that use both money and bonds to manage the liquidity of their deposits. Here, we employ a simpler, reduced form structure. We model transactions costs as in Schmitt-Grohe and Uribe (2004), but we define “effective transactions balances” to be a CES aggregate of money and bonds. This simplification makes it easier to build a quantitative model because we can pin down a number of important parameters by matching the sample averages of some key monetary and fiscal variables in US data.

We begin with the model, and then proceed to its calibration. Details of the (log) linearization of our model, which is required for Section 3, are relegated to an appendix that is available from the authors upon request.

2.1. The model

2.1.1. Households

There is a continuum of households of measure one. We assume that each household supplies labor to every firm; so, in a symmetric equilibrium their behavior will be identical and we can dispense with household indices. The utility of a representative household is

\[
U_t = E_t \sum_{j=1}^{\infty} \beta^{j-t} \left[ \log(c_t) - (1 + \gamma)^{-1} n_t^{1+\gamma} \right]
\]

(1)

where \(c_t\) is the consumption of a composite good defined below and \(n_t\) is the hours of work. The household’s budget constraint is

\[
m_t + b_t + (1 + \tau_t)k_t = w_t n_t + (m_{t-1} + R_{t-1} b_{t-1})/\Pi_t - t_t + \text{div}_t
\]

(2)

\(m_t\) and \(b_t\) are the real money and bond holdings, \(w_t n_t\) is the real wage income, \(R_{t-1}\) is the gross nominal interest rate on period \(t-1\) bonds, \(\Pi_t = P_t/P_{t-1}\) is the gross inflation rate, \(t_t\) is a lump sum tax and \(\text{div}_t\) represents dividends. \(\tau_t, c_t\) are transactions costs, which will be described next.

Following Schmitt-Grohe and Uribe et al. (2004), we assume that transactions costs are proportional to consumption and the factor of proportionality is an increasing function of velocity

\[
\tau_t = \left\{ \begin{array}{ll}
(A/v_t)(v_t - v^*)^2 & \text{for } v_t > v^* \\
0 & \text{for } v_t \leq v^*
\end{array} \right.
\]

(3)

where \(v^*\) is the satiation level of velocity. The new element here is in our definition of velocity

\[
v_t = c_t/\bar{m}_t
\]

(4)

where effective transactions balances – \(\bar{m}_t\) – are a CES bundle of money and bonds

\[
\bar{m}_t^\varphi = a^{1-\rho}m_t^\rho + (1-a)^{1-\rho}b_t^\rho
\]

(5)

\(a \in [0, 1]\) is a parameter that measures the importance of money in effective transactions balances, and \(1/(1-\rho)\) is the elasticity of substitution between money and bonds. If \(0 < \rho < 1\), money and bonds are “substitutes”; and if \(\rho < 0\), money and bonds are “complements”. In much of what follows, we will assume the elasticity is one (or \(\rho=0\)).

The household’s first order conditions are

\[
w_t \lambda_t = n_t^\rho
\]

(6)

\[
1/c_t = \lambda_t [1 + 2A(v_t - v^*)]
\]

(7)

\[
1 - A[v_t^2 - (v^*)^2](am_t/\bar{m}_t)^{1-\rho} = 1/R_t^\varphi
\]

(8)

\[
1 - A[v_t^2 - (v^*)^2][(1-a)(\bar{m}_t/b_t)]^{1-\rho} = R_t/R_t^\varphi
\]

(9)

where \(\lambda_t\) is the marginal utility of wealth and \(R_t^\varphi\) is the CCAPM interest rate; that is, \(1/R_t^\varphi = \beta E_t[\lambda_{t+1}/\lambda_t/\Pi_{t+1}]\). It will facilitate our discussion to think of \(R_t^\varphi\) as the rate of return on a hypothetical bond, \(b_t^\varphi\), that does not provide transactions services.

Eq. (7) defines the marginal value of wealth. When real resources are depleted in the purchase of consumption goods, the marginal value of wealth is less than the marginal utility of consumption. Eqs. (8) and (9) are the first-order conditions for money and bonds; they can be combined to show that

\[
\frac{S_t}{R_t^\varphi - 1} = \left(\frac{1-a}{a}\right)^{1-\rho} \left(\frac{m_t}{R_t}\right)^{1-\rho}
\]

(10)

where \(S_t = R_t^\varphi - R_t\) is the spread between the CCAPM rate and the return on government bonds. Since \(b\) provides transactions services, it will be held at a lower rate of return than \(b^\varphi\); the spread, \(S_t\), will be positive in equilibrium. \(S_t\) is the pecuniary opportunity cost of holding the bond that does provide transactions services, and \(R_t^\varphi - 1\) is the opportunity cost of holding money. So, Eq. (10) says that in the optimal portfolio, the relative price of \(m\) and \(b\) is equated to the marginal rate of substitution of \(m\) and \(b\) in the “effective transactions services” aggregator, (5). Note that as bonds lose their usefulness in the aggregator \((a \to 1)\), the required spread, \(S_t\), falls to zero; and as bonds become perfect substitutes for money \((\rho \to 1)\), the required return on bonds must fall to the fixed return on money \((R_t \to 1)\).
2.1.2. Firms

There is a continuum of firms indexed by \( f \) on the unit interval. Each firm has a fixed, firm specific, capital stock, \( K \). At time \( t \), the firm hires labor, \( n_t(f) \), at the competitive wage rate, \( \omega_t \), and produces a differentiated product using a decreasing returns to scale technology

\[
y_t(f) = z_t K n_t(f)^{\alpha}, \quad 0 < \alpha < 1
\]

(11)

Total factor productivity, \( z_t \), follows a process that is common to all firms

\[
\ln(z_t) = (1 - \rho_z) \ln(z) + \rho_z \ln(z_{t-1}) + \sigma z_t
\]

(12)

where \( 0 < \rho_z < 1 \) and \( z \) is the steady-state value of \( z \).

The modeling of monopolistic competition is standard in the NNS literature. A competitive bundler acquires the firms’ products, paying the prices \( P_t(f) \) set by the firms, and assembles a composite good

\[
y_t = \int_0^1 y_t(f) f^{1-\alpha} df
\]

(13)

The bundler then sells the composite good to households and the government at the price \( P_t \). Cost minimization and the zero profit condition imply that the aggregate price is

\[
P_t = \left[ \int_0^1 P_t(f) f^{1-\alpha} df \right]^{1/(1-\alpha)}
\]

(14)

and the bundler’s demand for the product of firm \( f \) is

\[
y_t(f) = (P_t/P_t(f))^{\alpha} y_t
\]

(15)

Firms set prices in staggered price ‘contracts’ of random duration. In any given period, the firm gets to announce a new price contract with probability \( (1 - \theta) \); otherwise, its old contract remains in effect, and the firm’s price is simply updated by steady-state inflation, \( \pi_c \). With this scheme, the average duration of a price contract is \( (1 - \theta)^{-1} \) periods (quarters).

If a firm gets to announce a new contract in period \( t \), it chooses a new contract price, \( P_t(f) \), to maximize the value (measured in units of household utility) of its profit stream over the states of nature in which the new price holds. The firm’s problem is to

\[
\max_{P_t} \sum_{t=0}^{\infty} (\theta)^{t-1} \ln \left( \frac{(P_t^{\pi_t})^{1-\alpha}}{P_t} \right) y_t(f) - \omega_t n_t(f)
\]

(16)

subject to (11) and (15).

2.1.3. Aggregate employment and output

We will want to express our model in terms of economy wide aggregates. As has already been mentioned, households are identical, and their per capita incomes and demands are equal to aggregate supplies and demands. Firms are not identical since staggered price setting implies that they may be charging different prices. Following Yun (1996), however, we can keep track of price dispersion and derive an aggregate production function.

The production function (11) implies that the firm’s demand for labor is

\[
n_t(f) = \left[ \frac{y_t(f)}{z_t K} \right]^{1/\alpha}
\]

(17)

So, making use of the firm’s demand curve (15), aggregate labor demand is

\[
n_t = \int_0^1 n_t(f) df = (1/z_t K)^{1/\alpha} \int_0^1 y_t(f)^{1/\alpha} df = (y_t/z_t K)^{1/\alpha} \int_0^1 (P_t/P_t(f))^{\alpha} df
\]

(18)

Letting \( \text{Disp}_t = \int_0^1 (P_t/P_t(f))^{\alpha} df \), we arrive at the aggregate production function

\[
y_t = z_t K n_t^{\alpha} / (\text{Disp}_t)^{\alpha}
\]

(19)

Aggregate output, \( y_t \), is defined by the aggregator (13); it is not the simple sum of firm outputs. And while Eq. (19) bears a striking resemblance to the firm’s production function, it does indicate that price dispersion lowers aggregate output; \( \text{Disp}_t \geq 1 \), and falls to 1 as prices become flexible (or \( \theta \to 0 \)). This is the welfare reducing distortion created by Calvo price setting.

Finally, since resources are used up in transacting, market clearing requires

\[
y_t = (1 + \gamma_t) C_t + g_t
\]

(20)

We assume that government spending follows an exogenous AR(1) process

\[
\ln(g_t) = (1 - \rho_g) \ln(\overline{g}) + \rho_g \ln(g_{t-1}) + \epsilon_{g,t}
\]

(21)

where \( 0 < \rho_g < 1 \) and \( \overline{g} \) is the steady-state value of \( g_t \).
2.1.4. Monetary and fiscal policy

Monetary policy will be characterized by an interest rate rule

$$\ln(R_t) = \rho_m \ln(R_{t-1}) + (1 - \rho_m) \left[ \ln(\mathcal{R}) + \phi_R \ln(P_t) + \phi_y \ln(Y_t) \right]$$

(22)

where steady-state values are denoted by a bar. Note that the central bank’s instrument is the money market rate, the interest rate on the bond that provides transactions services. If $\phi_R > 1$, the rule is active, as in the Volcker–Greenspan era; if $\phi_R < 1$, the rule is passive, as in the pre-Volcker period. In Section 3, we drop the interest rate smoothing (setting $\rho_m = 0$); in Sections 4 and 5, we reintroduce smoothing to accommodate estimated policy rules for the two periods.

The government’s flow budget constraint is

$$m_t + b_t = (m_{t-1} + R_{t-1} b_{t-1}) / P_t + g_t - t_t$$

(23)

Letting $l_t = m_t + b_t$ represent total government liabilities, Eq. (23) can be rewritten as

$$l_t = l_{t-1} / P_t + d_t$$

(24)

where $d_t$ is the total deficit (inclusive of interest payments).

As noted earlier, government spending is an exogenous process. We assume the government’s instrument is the lump sum tax, $t_t$, and we assume fiscal policy is characterized by a tax rule

$$t_t = \bar{t} + \phi_d (b_{t-1} - \bar{b})$$

(25)

When $\phi_d > \mathcal{R} / \mathcal{P} - 1$, fiscal policy is stabilizing since tax increases are more than sufficient to pay the interest on any increase in the debt; this is a passive fiscal policy. Eschewing the FTPL, we will always assume that fiscal policy is passive.

2.2. Two calibrations of the model

We cannot pin down the parameters in our specification of transactions costs and the transactions technology in a standard way. So, the particular way we solve for the steady-state equilibrium is motivated by our calibration strategy. First we discuss our strategy and then we discuss our calibrations to the volatile 1970s and the Volcker–Greenspan era.

2.2.1. Calibration strategy

Our strategy is to set these parameters to match key monetary and fiscal statistics in the data. Specifically, we begin by setting the steady-state values $\mathcal{P}$, $\mathcal{R}$, $\bar{b} / \tau$, $\bar{b} / \mathcal{m}$, and $\mathcal{g} / \mathcal{P}$ equal to their sample averages; these averages may of course differ across the two periods. Then, $\bar{R} = (\mathcal{P} / \bar{b})$ and $\bar{R}$ is calibrated from the data. Eq. (24) implies a steady-state relationship between monetary and fiscal policy:

$$\bar{d} / \tau = \left[ (\mathcal{P} - 1) / \mathcal{P} \right] \left[ (\mathcal{m} / \tau) + (\bar{b} / \mathcal{m}) \right]$$

(26)

which pins down the steady-state deficit to consumption ratio. This is the easy part of the calibrations.

It turns out that, given values of $\rho$ and $\tau$ (and the values specified above), the steady-state equations pin down the remaining parameters in the transactions technology—$a$, $\nu^*$, $\bar{v}$, $\bar{A}$, and $\bar{\tau}$. So, we must first choose values for $\rho$ and $\tau$. In our benchmark calibrations, we let total transactions costs be 0.1% of consumption. We think that this is a rather conservative estimate, and we will raise it when we do robustness checks in Section 3. We do not have much intuition about the elasticity of substitution between money and bonds, $(1 - \rho)^{-1}$. So, we set it equal to one ($\rho = 0$) in our benchmark calibrations. We will also consider a higher value when we do robustness checks.

Armed with these numbers, we can calculate the values of $a$, $\nu^*$, $\bar{v}$, $\bar{A}$ and $\bar{\tau}$ from the steady-state equations:

$$a = \frac{\mathcal{m} / \bar{b}}{[\mathcal{m} / \bar{b} + \beta \mathcal{S} (\mathcal{P} / \bar{b} - \beta)]^{1/(1 - \rho)}}$$

(27)

$$\bar{v} = (\mathcal{m} / \tau)^{-1} \left[ a^{-1 - \rho} (\mathcal{m} / \tau)^{\rho} + (1 - \bar{\tau}) (1 - \rho) (\bar{b} / \mathcal{m})^{\rho} \right]^{-1/(1 - \rho)}$$

(28)

$$\frac{\nu^*}{\bar{v}} = \left( \frac{1 - \beta / \mathcal{P}}{a (\mathcal{m} / \mathcal{m})^{(1 - \rho) (\bar{v} / \mathcal{m})^{1 - \rho}} \bar{v}^{-\tau}} + \bar{\tau} \right)$$

(29)

---

9 Earlier work does not offer us much guidance in setting these parameters. In particular, Schmitt-Grohe and Uribe’s (2004) calibration of transactions costs was based on estimated money demand equation. Once we introduce bonds into the transactions technology, we lose the money demand interpretation.

10 This in turn pins down the ratio of taxes to consumption in the steady state equilibrium. Later, we derive an equation for steady-state consumption, and this determines taxes in the steady state.
\[
A = \frac{1 - \beta / \bar{P}}{a (\bar{m} / \bar{m})^{1 - \rho} (\bar{v}^2 - \nu^2)}
\]

(30)

\[
\pi = \left[ \frac{\alpha (\bar{c} - 1)}{\bar{c} (1 - \bar{y} / \bar{y})} \right] \left[ \frac{1 + \bar{A}}{1 + 2 \bar{A} (\bar{v} - \nu^2)} \right]^{1 / (\gamma + 1)}
\]

(31)

\[
\bar{y} = \kappa \bar{y}
\]

(32)

\[
c = \frac{1 - (\bar{y} / \bar{y})}{1 + \bar{r}}
\]

(33)

2.2.2. Calibration to the Volcker–Greenspan era

This calibration is based on quarterly US data from 1985 to 2004. We use sample averages to estimate the steady-state values of \(\bar{P}, \bar{R}, \bar{b}/\bar{c}, \bar{b}/\bar{m}, \) and \(\bar{g}/\bar{y}\): we set \(\beta\) equal to 0.99 (as is usual in quarterly models) to calibrate \(\bar{R}\). The second column of Table 1 reports these estimates, along with the values for \(a, \nu^*, \bar{v}, A\) and \(c\) that are implied by Eqs. (27) through (33).

Table 1 also specifies the other parameters in the model; they are standard in the literature: \(\theta = 0.75\) implies that the average duration of prices is four quarters; \(\varepsilon = 7\) implies that the steady-state markup is 1.17; \(\omega = 1\) implies that the disutility of work is quadratic; \(\alpha = 0.66\) implies that capital’s share is one-third. The last two rows give parameters in the stochastic processes for government spending and productivity; see Canzoneri et al. (2007) for a discussion of our approach to their estimation.

### Table 1 Calibration parameters.

<table>
<thead>
<tr>
<th>Fig. 1 Benchmark</th>
<th>Fig. 2 (\rho=0.5)</th>
<th>Fig. 3 Increasing (\tau)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Volcker</td>
<td>Volcker–Greenspan</td>
</tr>
<tr>
<td><strong>Hard wired parameters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\tau)</td>
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<td>0.001</td>
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<tr>
<td>(\bar{P}) (quarterly)</td>
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<td>(\bar{R}) (quarterly)</td>
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<td>(a)</td>
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<tr>
<td>(\rho_{\bar{g}}, \sigma_{\bar{g}})</td>
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<td>0.93, 0.01</td>
</tr>
</tbody>
</table>

### 2.2.3. Calibration to the 1970s and robustness exercises

For the pre-Volcker period, we re-calibrate the model to fit the more inflationary 1970s, using the method described above. The parameters for this calibration appear in the first column of Table 1. Steady state inflation rises from 2.8% (on an annual basis) to 4%. And the steady-state spread between the CCAPM rate and the T-Bill rate rises from 1.6% (again, on an annual basis) to 1.8%.

We also want to check the robustness of our basic results to changes in various parameter values. There is no really clean way of performing these exercises: we can change one parameter value while holding all of the other parameters constant, or we can require our perturbations in the parameter space to be model consistent. We have chosen to do the latter. So, when for example we change the value of \(\tau\) or \(\rho\), the parameters in the transactions technology \(-a, \bar{v}, \nu^*\) and \(A\) will shift in accordance with Eqs. (27) through (33). These parameterizations are shown in the remaining columns of Table 1.

---

11 Data on CPI inflation and federal funds rate from 1985 to 2004 were averaged to estimate \(\bar{P}\) and \(\bar{R}\). We rounded the sample average of the ratio of the monetary base to personal consumption expenditure to obtain its steady-state value. Due to the large swings in the ratio of the publicly held Federal debt to personal consumption expenditures during this period, we chose a value reflecting the ratio near the end of the sample.
3. What policy coordination was needed for the great transformation?

In this section, we discuss the policy coordination necessary to achieve a unique, locally stable solution. And in particular, we will ask if fiscal policy had to shift when monetary policy became active around 1980. What coordination (if any) was needed to avoid the pathological behavior of sunspot equilibria or explosive paths for inflation?

The condition for local determinacy is that the number of eigenvalues outside the unit circle, \(N_o\), be equal to the number of jumping variables, \(N_j\). If \(N_o < N_j\), the jumping variables are not uniquely determined and sunspot equilibria are possible; if \(N_o > N_j\), there are not enough jumping variables to suppress explosive behavior.

In this section, we ignore the smoothing and the gap term in the interest rate rule. (22), by setting \(\rho_m = \rho_p = 0.12\) So, the policy pair \((\phi_x, \phi_d)\) completely characterizes the systematics components of monetary and fiscal policy. The first step is to calculate the set of policy pairs \((\phi_x, \phi_d)\) for which \(N_o = N_j\); we will call this the determinacy region of the policy space. The sunspot region is the set of \((\phi_x, \phi_d)\) for which \(N_o < N_j\); and the explosive region is the set of \((\phi_x, \phi_d)\) for which \(N_o > N_j\). We do this for both calibrations of the model. Then, we can consider the shift in \(\phi_x\) that was thought to occur around 1980, and ask what constraints that put on \(\phi_d\) to remain in the stable region.

3.1. Calculating policy regions for the two calibrations of our model

First, we (log) linearize the model and calculate its eigenvalues. It turns out that the linearized model can be reduced to three dynamic equations with two jumping variables: consumption and inflation. The third variable is a linear combination of debt, consumption and inflation; this is the state variable representing debt dynamics. We compute the number of stable and unstable eigenvalues for a fine grid of values of the policy pairs \((\phi_x, \phi_d)\).

Fig. 1 illustrates the three regions for the benchmark calibrations of our model. The pre-Volcker period is represented by the top panel; the Volcker–Greenspan era is in the bottom. The axes in Fig. 1 are set at \(\phi_x = 1\), the cutoff point for the Taylor Principle, and \(\phi_d = 0.006\), which is the quarterly real interest rate in the steady state. Points to the right of the vertical axis represent passive fiscal policies, and points above the horizontal axis represent active monetary policies. The determinacy region in Fig. 1 is the area between the two shaded areas. The lighter shaded area is the sunspot region, and the darker shaded area is the explosive region.

Three basic features of Fig. 1 should be noted. First, our model suggests that the regions have shifted over time; ironically, as inflation has come down, and (as we will argue) monetary policy has become better, the determinacy region has shrunk. Second, there is an explosive area for small values of \(\phi_d\); a strong monetary policy (large \(\phi_x\)) must be accompanied by a strong fiscal policy (large \(\phi_d\)) if price stability is to be achieved; this is a rather unusual implication of our model. And third, a large portion of the SE quadrant is in the determinacy region: passive monetary policies, or even an interest rate peg, can be paired with passive fiscal policies.

To put these basic features in perspective, we review some of the literature associated with the FTPL. For Leeper (1991), the determinacy region was the NE and SW quadrants, while the explosive region was the NW quadrant and the sunspot region was the SE quadrant. For him, the labels active and passive defined the regions. And for him, an active monetary policy had to be paired with a passive fiscal policy, and a passive monetary policy had to be paired with an active fiscal policy. The latter case is associated with the FTPL. If monetary policy shifted from passive to active, then fiscal policy had to shift from active to passive; there was a severe coordination problem that the great transformation of US monetary policy had to deal with. Leeper’s (1991) model had flexible prices, and of course no transactions services of bonds. Adding Calvo pricing to Leeper’s model does not matter much, but as Fig. 1 indicates, adding liquid bonds changes the regions dramatically. We no longer have to resort to the FTPL to discuss passive monetary policies (without the possibility of sunspot equilibria). We can restrict our attention to passive fiscal policies for both active and passive monetary policies.

Now we can focus directly on the shift in monetary policy that is thought to have occurred around 1980, and ask whether an accompanying shift in fiscal policy was necessary. Typical estimates of \(\phi_x\) range from about 1.5 to 2 for the Volcker–Greenspan era, and from 0.8 to 0.9 for the period that preceded it.\(^{13}\) Estimates of \(\phi_d\) are harder to come by, but Bohn (1998, 2004) puts it between 0.013 and 0.030. Fig. 1 suggests that no shift in fiscal policy was needed. The whole rectangle of these \((\phi_x, \phi_d)\) estimates falls within the determinacy region in both panels, except perhaps for the lowest values of Bohn’s estimates for \(\phi_d\).

In Fig. 2, we increase the elasticity of substitution from one to two; the solid lines show the regions from Fig. 1. Increasing the elasticity augments the sunspot region, but shrinks the explosive region. The regions are clearly sensitive to changes in this parameter, but the basic results described above still hold. We also tried lowering the elasticity to one-half; again the basic results seem to hold.

We suggested that our steady-state cost of transacting was on the conservative side. In Fig. 3, we increase the cost from 0.1% of consumption to 0.5% of consumption; the solid lines show the regions from Fig. 1. Once again, the sunspot region gets bigger and the explosive region gets smaller. And once again, this perturbation leaves our basic results unchanged.

So, the three regions are sensitive variations in parameters in the transactions technology. However, our basic results seem rather robust. We also varied the Calvo parameter, \(\theta\). The regions in Fig. 1 hardly moved.

\(^{12}\) We do this for simplicity and to facilitate comparisons with Leeper (1991).

\(^{13}\) There is a large literature on the estimation of interest rate rules for monetary policy. Prominent examples include: Taylor (1999) who estimated \(\phi_x\) to be 0.81 for the period 1960:1–1979.4, and 1.53 for the period 1987:1–1997:3; Clarida et al. (2000) who estimated \(\phi_x\) to be 0.83 for the period 1960:1–1979.2, and 2.15 for 1970:1–1996:4; and Lubik and Schorfheide (2004) who estimated \(\phi_x\) to be either 0.77 or 0.89 for the period 1960:1–1979:2 and 2.19 for 1982:4–1997:4.
Fig. 1. Determinacy, sunspot and explosive regions for our two benchmark calibrations.

Fig. 2. Determinacy with money and bonds as substitutes.
4. Was the pre-Volcker policy as bad as the conventional wisdom suggests?

The inactive monetary policy that preceded the Volcker–Greenspan era has been strongly criticized by Clarida et al. (2000), Taylor (1999) and many others. And for good reason: Inflation was high and volatile during the 1970s, while it was much more stable in the period that followed.

Stochastic simulations of our model capture remarkably well the declines in both inflation and interest rate volatility in the US data after monetary policy began reacting more aggressively to inflation. Using our parameterizations of the pre-Volcker and Volker–Greenspan eras, and using the interest rate rules

Rule 1:

\[ \ln(R_t) = 0.6 \ln(R_{t-1}) + (1 - 0.6) \ln(\bar{R}) + 0.8 \ln(\Pi_t/\Pi) + 0.15 \ln(y_t/y) \]

Rule 2:

\[ \ln(R_t) = 0.6 \ln(R_{t-1}) + (1 - 0.6) \ln(\bar{R}) + 2 \ln(\Pi_t/\Pi) + 0.15 \ln(y_t/y) \]

to characterize monetary policy in the two periods, we find that inflation volatility was 2.9 times higher in the pre-Volcker era, and interest rate volatility was 1.8 times higher. How does this compare with the US data? Using Stock and Watson’s (2003) decade-by-decade volatility comparisons, inflation was 3 times as volatile in the 1970s as in the 1990s, while Treasury bill rate volatility was 1.5 times higher. These results are summarized in Table 2.

A (sometimes implicit) assumption in the oft repeated criticism of the pre-Volcker policy was that fiscal policy was passive during the period; so, by conventional wisdom, an interest rate rule that violated the Taylor Principle could easily have resulted in sunspot equilibria. Our model suggests that if bonds provide transactions services, the inactive monetary policy of the 1970s need not have raised the specter of sunspot equilibria. But does this mean that the conventional wisdom was wrong, and that the inactive policy was not so bad after all? We think not. It was bad monetary policy, but not because it raised the specter of sunspots: the response to inflation was simply too weak, and with very regrettable consequences.

To illustrate this in our model, we will consider four interest rate rules (the first two being those used earlier), and we will stick to the pre-Volcker parameterization of our model

Rule 1:

\[ \ln(R_t) = 0.6 \ln(R_{t-1}) + (1 - 0.6) \ln(\bar{R}) + 0.8 \ln(\Pi_t/\Pi) + 0.15 \ln(y_t/y) \]

Rule 2:

\[ \ln(R_t) = 0.6 \ln(R_{t-1}) + (1 - 0.6) \ln(\bar{R}) + 2 \ln(\Pi_t/\Pi) + 0.15 \ln(y_t/y) \]

\[ \text{Fig. 3. Determinacy with greater transactions costs.} \]

14 These results come purely from the difference in parameters, and not from any change in the volatilities of the shocks.
we pass from Rule 1 to Rule 3. Filtering the model’s data, the (quarterly) unconditional standard deviation of inflation is 0.023 with cuts inflation by three quarters. Clearly, the inflationary consequences of this shock could have been much reduced. active cuts the inflation by half. Finally, the dotted lines are for Rule 3. Switching to an active rule and eliminating the gap term, real interest rate to fall, and inflation rises by about 7%. The dashed lines are for Rule 2. Simply changing the rule from passive to from our model for our estimated productivity shock. The solid lines are for Rule 1. The weak response to inflation allows the would have been under active monetary policies. This is illustrated in Fig. 5, which shows IRFs for an increase in government 4.2. The potency of fiscal policy under the passive pre-Volcker policy in the 1970s

Here, we look at the volatility of inflation implied by our model under the various rules specified above. And as a case study, we show the inflationary impact of the 1978 oil price shock under the various rules.

Our simple model does not have oil prices in it. So, we estimated a negative productivity shock for the year 1979, and using it as a proxy, our model is able to capture the inflationary impact of the 1978 oil price shock. To estimate the shock, we estimated an AR(1) process for log detrended TFP and took the residuals from that regression to be our TFP shocks.16 If we add the shocks for the four quarters of 1979, and treat them as one shock, we get a shock of about – 3 percent. Between the first quarter of 1978 and the first quarter of 1980, inflation rose about 7% (from 6.8% to 13.9%). Fig. 4 shows IRFs from our model for our estimated productivity shock. The solid lines are for Rule 1. The weak response to inflation allows the real interest rate to fall, and inflation rises by about 7%. The dashed lines are for Rule 2. Simply changing the rule from passive to active cuts the inflation by half. Finally, the dotted lines are for Rule 3. Switching to an active rule and eliminating the gap term, cuts inflation by three quarters. Clearly, the inflationary consequences of this shock could have been much reduced. More generally, considering both productivity and government spending shocks, inflation volatility goes down dramatically as we pass from Rule 1 to Rule 3. Filtering the model’s data, the (quarterly) unconditional standard deviation of inflation is 0.023 with Rule 1, 0.008 with Rule 2, and 0.004 with Rule 3. The volatility of inflation was also higher than it needed to have been.

4.2. The potency of fiscal policy under the passive pre-Volcker policy

On the other hand, the passive pre-Volcker policy would have allowed discretionary fiscal policy to be more potent than it would have been under active monetary policies. This is illustrated in Fig. 5, which shows IRFs for an increase in government spending. Once again, the solid line is for Rule 1. The weak response to inflation actually allowed real interest rates to fall, further stimulating aggregate demand, and making for a big impact on output. The dashed line is for Rule 2; the IRF for Rule 3 is virtually identical. The active monetary policies raise real interest rates, curtailing the effect on aggregate demand. The impact on output is only a fourth as large.

4.3. Household welfare

Inflation in the pre-Volcker period was clearly more volatile than it had to have been. But was that necessarily bad? Under an active monetary policy, the oil price shock would have made output fall even further than it did. On the other hand, we know since Rotemberg and Woodford (1997), and probably long before, that income smoothing in response to a productivity shock is harmful to welfare (even if it is politically soothing). How do we add all this up?

One advantage of our model is that we can simulate the expected present discounted value of household welfare under any of the four policy rules; in each case, we will assume that there is firm commitment to the rule under consideration, and in each case we use the pre-Volcker calibration of the model. And the AR(1) processes for productivity and government spending are both in effect. As is now standard, we will evaluate utility gains and losses in units of permanent consumption. Household welfare steadily increases as we move through the Rules in the order in which they were given:

| Welfare gain going from Rule 1 to Rule 2 | 3.31% of permanent consumption |
| Welfare gain going from Rule 2 to Rule 3 | 0.18% of permanent consumption |
| Welfare gain going from Rule 3 to Rule 4 | 0.52% of permanent consumption |

15 As shown in the last section, we cannot let $\varphi_1$ be too big while remaining in the determinacy region. The standard deviation of (HP filtered) inflation is 13 times larger with Rule 1 than it is with Rule 4. So, Rule 4 may be viewed as a strict inflation targeting rule.

16 The estimated value of the AR coefficient is 0.93.

Table 2
The fall in inflation and interest rate volatilities (in our model and in the data).

<table>
<thead>
<tr>
<th>Ratios of volatilities across the pre- and post-Volcker periods</th>
<th>Inflation rate</th>
<th>Interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock and Watson (2003)</td>
<td>3.02</td>
<td>1.82</td>
</tr>
<tr>
<td>Our Model</td>
<td>2.89</td>
<td>1.47</td>
</tr>
</tbody>
</table>
The last two results are quite consistent with the previous literature on monetary policy. As already mentioned, we know that reacting to the output gap is damaging to welfare in model in which productivity shocks play an important role.\footnote{Note that our output gap is defined as a deviation from steady state output, and not say the flexible price output. Households would want consumption and output to rise following a positive productivity shock.} And many studies have found that strict inflation targeting is optimal in models in which sticky prices are the only nominal rigidity. The welfare gains from these modifications in the policy rule are rather modest—only half a percent of permanent consumption; this too is consistent with the literature.

What really is surprising is the magnitude of the first result. Simply changing Lubik and Schorfheide (2004) estimate of the rule for the pre-Volcker period from passive to active raises welfare by 3.3 percent of permanent consumption. The differences between good and bad active rules are an order of magnitude less important to welfare than the difference between any of the active rules and the passive rule.

5. Conclusion

In this paper, we modified a standard NNS model by letting government bonds be an imperfect substitute for money. This modification brings a new – and very direct – mechanism for debt dynamics to feed into inflation dynamics: deficits increase “effective” transactions balances, and this affects inflation. The probable existence of this mechanism has a number of important implications for NNS modeling. It alters our views on the coordination of monetary and fiscal policy that is required to provide a stable nominal anchor. The Taylor Principle is no longer sacrosanct; and breaking with the FTPL, a weak fiscal response to debt is no longer the panacea for a weak monetary policy.

These basic notions were already known from the work of Canzoneri and Diba (2005) and Linnemann and Schabert (2009, 2010). Here, we concentrated on a fundamental transformation in US monetary policy that occurred around 1980. We calibrated our model to pre- and post-1980 data and showed how, in policy parameter space, the regions for determinacy,
sunspots and explosive solutions have shifted over time. But typical estimates of interest rate policy rules before and after the break, combined with typical estimates of fiscal reaction functions (all passive), all fall in the determinacy region for both calibrations. This suggests that there was no need for a shift in fiscal policy around 1980. In this respect, our interpretation of the transformation of monetary policy may be more plausible than FTPL’s: the FTPL interpretation requires an accompanying change in fiscal policy, and this coordination of monetary and fiscal policies has not been documented.\textsuperscript{18}

We also argued that the pre-Volcker policy was bad monetary policy, even if it did not raise the specter of sunspot equilibria. Model simulations showed that simply making the passive policy active would increase household welfare by over three percent of permanent consumption. This welfare gain dwarfs the welfare differences between active policy rules.

Finally, we showed that the passive policy of the pre-Volcker period allowed a government spending shock to pass more forcefully to output than an active policy would. This in and of itself is not very surprising: an active policy raises real interest rates, choking off the effect on aggregate demand. However, the result does suggest that our model might shed light on a transformation in the government spending multipliers that is also thought to have occurred around 1980. Perotti’s (2004) VAR analysis shows that the multipliers were strong (in the US anyway) prior to 1980, and weak to negligible after 1980.\textsuperscript{19} To link the transition in monetary policy to the transition in government multipliers in a convincing way, however, we would have to model investment. We leave this for future work.

\textsuperscript{18} Indeed, from the prospective of the FTPL, one might argue that the Reagan Administration’s tax cuts were a continuation of an active fiscal policy. But this, when combined with a newly active monetary policy, would have implied an explosive solution that did not occur.

\textsuperscript{19} Perotti also documented a transformation in government spending multipliers for consumption: they were positive prior to 1980 (at least in the US), and much weaker post-1980. It has been difficult to model positive multipliers in a new-Keynesian framework. See Bilbiie et al. (2008) for one resolution to this problem. Our model might also speak to this issue.
References


