This PDF is a selection from a published volume from the National Bureau of Economic Research

Volume Title: NBER Macroeconomics Annual 2006, Volume 21

Volume Author/Editor: Daron Acemoglu, Kenneth Rogoff and Michael Woodford, editors

Volume Publisher: The MIT Press

Volume ISBN: 0-262-01239-1; 978-0-262-01239-3

Volume URL: http://www.nber.org/books/acem06-1

Conference Dates: April 7-8, 2006

Publication Date: May 2007

Chapter Title: Fluctuating Macro Policies and the Fiscal Theory

Chapter Author: Troy Davig, Eric M. Leeper

Chapter URL: http://www.nber.org/chapters/c11180

Chapter pages in book: (247 - 316)

4

Fluctuating Macro Policies and the Fiscal Theory

Troy Davig, *Federal Reserve Bank of Kansas City*
Eric M. Leeper, *Indiana University and NBER*

1 Introduction

A popular approach to analyzing macroeconomic policy posits simple policy rules and characterizes how alternative policy specifications perform in dynamic stochastic general equilibrium models. This line of work has shown that simple rules seem to explain observed policy choices quite well and that those rules produce desirable outcomes in popular classes of dynamic monetary models. Most of the work makes convenient assumptions that allow monetary and fiscal rules to be studied separately. Because these assumptions are questionable, it has long been known that the resulting conclusions could be misleading. Recent work, particularly the fiscal theory of the price level, emphasizes that assumptions about how monetary and fiscal policies interact can be important.

Research on policy interactions has spawned a number of results that have become part of the standard reasoning about macroeconomic policy: (1) an active monetary policy that raises the nominal interest rate more than one-for-one with inflation—the "Taylor principle"—is necessary for stability of the economy (Taylor 1993); (2) the Taylor principle delivers good economic performance in widely used models (Rotemberg and Woodford 1997, Schmitt-Grohé and Uribe 2006); (3) high and variable inflation rates may be due to failure of central banks to obey the Taylor principle, leaving the price level undetermined and subject to self-fulfilling expectations (Clarida, Galí, and Gertler 2000, Lubik and Schorfheide 2004); (4) the combination of active monetary policy and passive tax policy insulates the economy from aggregate demand disturbances, such as those arising from tax-debt policies (Leeper 1991).

As with earlier work that focused on monetary or fiscal rules separately, the derivation of these results rests on a number of assumptions of convenience that simplify the nature of monetary and fiscal policy interactions. The authors usually note that different sets of equally plausible assumptions may lead to qualitatively different outcomes. For example, there is now a growing literature providing counter-examples to the desirability of the Taylor principle (Benhabib and Farmer 2000, Benhabib, Schmitt-Grohé, and Uribe 2001a, b, 2002, Zanna 2003).

Perhaps the least plausible assumption in this work is that policy regime is fixed. This implies that agents always expect the current policy regime to last forever; regime change, if it occurs, comes as a complete surprise. A major branch of the applied side of the literature consists of identifying periods of different policy regimes (Taylor 1999a, 2000, Clarida, Galí, and Gertler 2000, Auerbach 2002, Lubik and Schorfheide 2004, Sala 2004, Favero and Monacelli 2005). But, as Cooley, LeRoy, and Raymon (1984) argue, it makes little sense to assume policy makers are contemplating regime change when agents put zero probability on this event. Despite the empirical evidence and Cooley, LeRoy, and Raymon's compelling logic, there is little modeling of environments where recurring regime change is stochastic and the objects that change are the rules governing how policy authorities respond to the economy.[1]

Davig and Leeper (2006b) show the consequences of regime switching for determinacy of equilibrium in a simpler context in which lump-sum taxes passively adjust to satisfy the government budget constraint. When coefficients of a Taylor (1993) rule evolve stochastically, the region of determinacy for bounded solutions can expand dramatically relative to a constant-parameter specification. That paper also shows in analytically tractable environments that cross-regime spillovers can change the impacts of exogenous disturbances in quantitatively important ways.

This paper extends Davig and Leeper's (2006b) analysis to consider fiscal as well as monetary regime switching. It aims to bring the applied and theoretical lines of this literature closer together by studying a model with a simple, but empirically plausible, specification of regime changes. We estimate Markov-switching rules for monetary and fiscal policy. Monetary policy obeys a Taylor rule that makes the nominal interest rate depend on inflation and the output gap; fiscal policy adjusts taxes as a function of government debt and other variables. All the parameters of the rules, including the error variances, evolve according to a Markov process. After imposing the estimated policy process on a conventional calibrated dynamic stochastic general equilibrium (DSGE) model with nominal rigidities, we compute a solution that is a function of the minimum set of state variables and provide an interpretation of post-war macro policies.

There are five main findings.

First, the estimates uncover periods of active monetary/passive fiscal behavior, the policy mix typically assumed to prevail in monetary studies; there are also episodes of passive monetary/active fiscal behavior, the mix associated with the fiscal theory of the price level.[2] Remaining periods combine passive monetary with passive fiscal policy or active monetary with active fiscal behavior. Identification of estimated switching policy rules is corroborated by connecting estimated regime changes to narrative accounts of policy behavior.

Second, post-war U.S. data can be modeled as a locally unique equilibrium: Necessary and sufficient conditions for a solution to the optimum problem in a DSGE model are satisfied. While our empirical results are largely consistent with existing estimates from fixed-regime models, we avoid the necessary implication of those models that the economy lurched unexpectedly among periods of indeterminacy (passive/passive), non-existence of equilibrium (active/active), or unique equilibria with completely different characteristics (active monetary/passive fiscal or passive monetary/active fiscal) (see, for example, Clarida, Galí, and Gertler 2000, Lubik and Schorfheide 2004, or Sala 2004 for such interpretations). Instead, in a regime switching setup those periods are merely alternative realizations of the state vector over which agents' decision rules are defined. Consequently, in a switching model the policy episodes have strikingly different implications. For example, an empirical finding that over some sub-period monetary policy has been active and fiscal policy has been passive is perfectly consistent with there being important impacts from (lump-sum) tax shocks. A finding that both monetary and fiscal behaviors have been passive need not imply the equilibrium is indeterminate. And the economy can temporarily experience active/active policies without dire economic consequences.

Third, the fiscal theory of the price level is always operative. Shocks to (lump-sum) taxes always affect aggregate demand, even when the rules in place at a given moment would suggest that Ricardian equivalence should hold if regime were fixed. The fiscal theory is operating whenever economic agents believe it is possible for fiscal policy to become active. Then a cut in current taxes, financed by sales of nominal government debt, does not generate an expectation that future taxes will rise by at least enough to service the new debt. The tax reduction leaves households feeling wealthier, at initial prices and interest rates, and they perceive they can raise their consumption paths.[3] When nominal rigidities are present, the expansion in demand for goods raises output and inflation. Davig, Leeper, and Chung (2004) show analytically that in a related regime-switching environment, a unique bounded equilibrium exists; in that equilibrium, the fiscal theory is always at work, as long as agents believe there is a positive probability of moving to a regime with active fiscal policy.

Fourth, the fiscal theory mechanism is quantitatively significant in U.S. data, according to the model.[4] Through that mechanism alone, a surprise transitory tax cut of $1 raises the discounted present value of output in the long run by between 76 cents and $1.02, depending on which policy regime the simulation conditions. A temporary tax cut of 2 percent of output increases the long-run price level by between 1.2 percent and 6.7 percent, conditional on remaining in a given monetary-fiscal regime. Similar impacts arise from an anticipated cut in taxes. Stochastic simulations that draw from the estimated distribution for policy regime imply that the 80th percentile for the output multiplier ranges from 43 cents to $1.36 after six years, while a tax cut of 2 percent of output raises the price level between 0.53 to 2.27 percent after six years. These numbers suggest the fiscal theory mechanism may be quite potent in U.S. data, helping to reconcile a popular class of DSGE models for monetary policy with the empirical evidence that tax disturbances have important "demand-side" impacts (Blanchard and Perotti 2002, Mountford and Uhlig 2005, and Perotti 2004).

Fifth, viewing time series as generated by recurring regime change alters how those time series should be interpreted. Many estimates of policy rules use *a priori* information about policy behavior in order to condition on sub-samples in which a particular regime prevailed. This procedure can obtain accurate estimates of policy parameters and the impacts of policy disturbances. But embedding the estimated rules in fixed-regime DSGE models can lead to seriously misleading qualitative inferences when a regime-switching environment generates the data. Because long-run policy behavior determines the qualitative features of data, more accurate inferences can be gleaned from full-sample information than by conditioning on regime.

Taken together, the paper's findings lead to a fundamental reassessment of results (1)–(4) that guide macro policy research. The findings also lead us to argue that to understand macroeconomic policy effects, it is essential to model policy regimes (or rules) as governed by a stochastic process over which agents form expectations. This argument puts on the table a new interpretation of macro policies and their impacts.[5]

1.1 *Why Recurring Regime Change?*

Because this paper models regime change as recurring, some motivation for this modeling assumption is necessary.

Eugene Steuerle (2006), a close observer of U.S. fiscal policy, characterizes pendulum swings (or regime changes) in policy behavior as arising from two political views toward fiscal policy: The "bargain lunch" view, by which politicians try to make tax cuts or expenditure increases appear to be costless, and the "green eye-shade" view, by which decision makers are ever-wary of the balance-sheet requirements associated with fiscal choices. For our purposes, the "bargain lunch" view treats tax decisions as independent of the state of government debt, while the "green eye-shade" view makes taxes rise with increases in government debt. This perspective is echoed in the popular press. In response to rising federal government budget deficits, *New York Times* columnist David Brooks writes: "But what can't last won't last. Before too long, some new sort of leader is going to arise. . . . He's going to rail against a country that cannot control its appetites (Brooks 2005)." Eventually, when fiscal conditions deteriorate sufficiently, regime change will occur.

More dramatic recurring changes in both monetary and fiscal policies occur between wartime and peacetime. During wars—at least World War Two and the Korean War—spending rises rapidly with no immediate adjustment in taxes, while monetary policy supports debt financing by keeping bond prices high (Ohanian 1997, Woodford 2001). This combination of active fiscal policy and passive monetary policy tends to be reversed after the fiscal needs of the war have passed.

Some observers—including several participants at the conference—want to believe that since the appointment of Paul Volcker to be chairman of the Federal Reserve in 1979, U.S. monetary policy has been in an absorbing state with active policy. We don't share this sanguine view. Central bank governor appointments are political decisions, subject to the vagaries of the political process. The appointment of Volcker and subsequently of Alan Greenspan and Ben Bernanke did not grow out of institutional reform or legislative change designed to achieve and instill low and stable inflation. Indeed, leading up to Bernanke's appointment, several less-qualified candidates' names were floated. A different set of political realities at the time might well have produced a very different nominee whose policies exhibit appreciably less continuity.

Implicit in these examples is the notion that some regime changes are endogenous responses to the state of the economy—high inflation leading to the appointment of inflation-fighting central bank governors—and some changes are exogenous—wartime fiscal financing. But even endogenous changes have an important exogenous (political) component: Why wasn't an inflation hawk appointed Fed chairman earlier in the 1970s, when inflation had already reached double digits? This paper assumes policy regimes evolve exogenously, leaving endogenous change to future work.[6]

2 Identification and Estimation of Policy Rules

We seek empirical characterizations of policy behavior that use simple rules of the kind appearing in the policy literature, but allow for recurring changes in regime. Monetary and tax regimes can switch independently of each other. This section reports maximum likelihood estimates of policy rules whose parameters evolve according to a hidden Markov chain, as in Hamilton (1989) and Kim and Nelson (1999).

Estimates of simple interest rate rules for monetary policy and tax rules for fiscal policy are plagued by identification problems because other omnipresent equilibrium conditions involve similar variables. An empirical relationship that links a short-term nominal interest rate to inflation and some measure of output might be capturing monetary policy behavior or it might simply reflect the correlations that a Fisher equation induces among the nominal rate, the real rate, and expected inflation. Similarly, a regression of taxes on lagged debt might describe how fiscal authorities raise taxes in response to increases in government indebtedness or it might arise from the positive correlation that the government budget constraint creates between the value of debt and expected future primary surpluses.

These problems are particularly acute in single-equation regressions that assume policy follows simple rules with constant coefficients: nothing distinguishes a "policy rule" from some other equilibrium condition. Positing that policy behavior shifts discretely, as we do in our estimated policy rules and in the subsequent theory, can help to distinguish policy behavior from the other equilibrium conditions, which would not be expected to exhibit time variation that coincides with policy shifts.[7] A key step in identifying regime-switching policy rules corroborates the timing and nature of estimated regime changes with extra-sample evidence from other studies of policy behavior. This section also reports that evidence.

2.1 *Specifications*

For monetary policy, we estimate a standard Taylor (1993) specification, which Rotemberg and Woodford (1999) have shown is nearly optimal in the class of models we consider in section 3. The rule makes the nominal interest rate, r_t, depend only on inflation, π_t, and the output gap, y_t:

$$r_t = \alpha_0(S_t^M) + \alpha_\pi(S_t^M)\pi_t + \alpha_y(S_t^M)y_t + \sigma_r(S_t^M)\varepsilon_t^r, \tag{1}$$

where S_t^M is the monetary policy regime and $\varepsilon_t^r \sim N(0, \sigma_r^2)$. Regime evolves according to a Markov chain with transition matrix P^M. r and π are net rates. We allow for four states, with the parameters restricted to take only two sets of values, while the variance may take four different values. P^M is a 4×4 matrix.[8]

Unlike monetary policy, there is no widely accepted specification for fiscal policy.[9] We model some of the complexity of tax policy with a rule that allows for the revenue impacts of automatic stabilizers, some degree of pay-as-you-go spending, and a response to the state of government indebtedness. The rule links revenues net of transfer payments, τ_t, to current government purchases, g_t, the output gap, and lagged debt held by the public, b_{t-1}. The specification is:

$$\tau_t = \gamma_0(S_t^F) + \gamma_b(S_t^F)b_{t-1} + \gamma_y(S_t^F)y_t + \gamma_g(S_t^F)g_t + \sigma_\tau(S_t^F)\varepsilon_t^\tau, \tag{2}$$

where S_t^F is the fiscal policy regime, which obeys a Markov chain with transition matrix P^F, for the two fiscal states, and $\varepsilon_t^\tau \sim N(0, \sigma_\tau^2)$. Both (1) and (2) allow for heteroskedastic errors, which Sims and Zha (2006) emphasize are essential for fitting U.S. time series.

Let $S_t = (S_t^M, S_t^F)$ denote the joint monetary/fiscal policy state. The joint distribution of policy regimes evolves according to a Markov chain with transition matrix $P = P^M \otimes P^F$, whose typical element is $p_{ij} = \Pr[S_t = j \mid S_{t-1} = i]$, where $\Sigma_j p_{ij} = 1$. With independent switching, the joint policy process has eight states.

2.2 *Estimation Results*

We use quarterly U.S. data from 1948:2 to 2004:1. To obtain estimates of (1) that resemble those from the Taylor rule literature, we define π_t to be the inflation rate over the past four quarters. Similarly, estimates of (2) use the average debt-output ratio over the previous four quarters as a measure of b_{t-1}.

The nominal interest rate is the three-month Treasury bill rate in the secondary market. Inflation is the log difference in the GDP deflator. The output gap is the log deviation of real GDP from the Congressional Budget Office's measure of potential real GDP. All fiscal variables are for the federal government only. τ is federal tax receipts net of total federal transfer payments as a share of GDP, b is the Federal Reserve Bank of Dallas' market value of gross marketable federal debt held by the public as a share of GDP, and g is federal government consumption plus investment expenditures as a share of GDP. All variables are converted to quarterly values.

Parameter estimates are reported in tables 4.1 and 4.2 (standard errors in parentheses) and estimated transition matrices are in table 4.3.[10]

Associated with each set of monetary policy parameters is a high- and a low-variance state.[11] Monetary policy behavior breaks into periods when it responds strongly to inflation (active policy) and periods when it does not (passive policy). In the active, volatile periods, the standard deviation is 3.7 times higher than in the active, docile periods; in passive periods, the standard deviations differ by a factor of seven. Passive regimes respond twice as strongly to the output gap, which is consistent with the Fed paying relatively less attention to inflation stabilization. There are also important differences in duration of regime. Active regimes last about 15 quarters each, on average, while the duration of the docile passive regime is over 22 quarters; the volatile passive regime is most transient, with a duration of 11.6 quarters.

Tax policies fluctuate between responding by more than the quarterly real interest rate to debt (passive) and responding negatively to debt (active). The active policy is what one would expect over the business cycle, with revenues and debt covarying negatively. Active policy reacts strongly to government spending, though by less than one-to-one, while passive policy reacts more weakly. In both regimes taxes rise systematically and strongly with the output gap, as one would expect from built-in stabilizers in the tax system. A stronger response to output

Table 4.1
Monetary Policy Estimates. Log Likelihood Value = −1014.737

	Active		Passive	
State	$S_t^M = 1$	$S_t^M = 2$	$S_t^M = 3$	$S_t^M = 4$
α_0	.0069 (.00039)	.0069 (.00039)	.0064 (.00017)	.0064 (.00017)
α_π	1.3079 (.0527)	1.3079 (.0527)	.5220 (.0175)	.5220 (.0175)
α_y	.0232 (.0116)	.0232 (.0116)	.0462 (.0043)	.0462 (.0043)
σ_r^2	1.266e-5 (8.670e-6)	9.184e-7 (1.960e-6)	2.713e-5 (5.423e-6)	5.434e-7 (1.512e-6)

Table 4.2
Tax Policy Estimates. Log Likelihood Value = −765.279

State	$S_t^F = 1$	$S_t^F = 2$
γ_0	.0497 (.0021)	.0385 (.0032)
γ_b	.0136 (.0012)	−.0094 (.0013)
γ_y	.4596 (.0326)	.2754 (.0330)
γ_g	.2671 (.0174)	.6563 (.0230)
σ_τ^2	4.049e-5 (6.909e-6)	5.752e-5 (8.472e-6)

Table 4.3
Monetary and Fiscal Policy Transition Matrices

$$P^M = \begin{bmatrix} .9349 & .0651 & .0000 & .0000 \\ .0000 & .9324 & .0444 & .0232 \\ .0093 & .0000 & .9552 & .0355 \\ .0000 & .0332 & .0529 & .9139 \end{bmatrix}, \quad P^F = \begin{bmatrix} .9372 & .0628 \\ .0520 & .9480 \end{bmatrix}$$

under passive policy is consistent with active policy pursuing countercyclical objectives more vigorously.

2.3 *Plausibility of Estimates*

We consider several checks on the plausibility of the estimated rules. First, are the estimates reasonable on *a priori* grounds? We think they are, as the rules fluctuate between theoretically interpretable regimes. Monetary policy fluctuates between periods when it is active, satisfying the Taylor principle ($\alpha_\pi > 1$), and periods when it is passive ($\alpha_\pi < 1$). Passive tax policy responds to debt by a coefficient that exceeds most estimates of the quarterly real interest rate (and by more than the calibrated real rate in the DSGE model below), while active tax policy lowers taxes when debt is high.

Second, how well do the estimated equations track the actual paths of the interest rate and taxes? We use the estimates of equations (1) and (2), weighted by the estimated regime probabilities, to predict the time paths of the short-term nominal interest rate, r, and the ratio of tax revenues to output, τ, treating all explanatory variables as evolving exogenously. The predicted—using smoothed and filtered probabilities—and actual paths of r and τ appear in figures 4.1 and 4.2. These fits are easily comparable to those reported by, for example, Taylor (1999a) for monetary policy.[12] The interest-rate equation goes off track in the 1950s, suggesting that period might constitute a third distinct regime, but in three-regime specifications the response of policy to output was negative. The tax rule tracks the revenue-output ratio extremely well, except in the last year or so when revenues dropped precipitously.

2.4 *Corroborating Evidence: Individual Policy Processes*

A third check on the plausibility of the estimates, which is a critical step in identifying policy behavior, asks whether the periods estimated to be active and passive correspond with narrative accounts of policy history.[13] The estimated marginal probabilities of the monetary and fiscal states are plotted in figures 4.3 and 4.4. All probabilities reported are at time t, conditional on information available at $t - 1$.

Figure 4.3 reports that, except for a brief active period in 1959–60, monetary policy was passive from 1948 until the Fed changed operating procedures in October 1979 and policy became active. Monetary policy was consistently active except immediately after the two

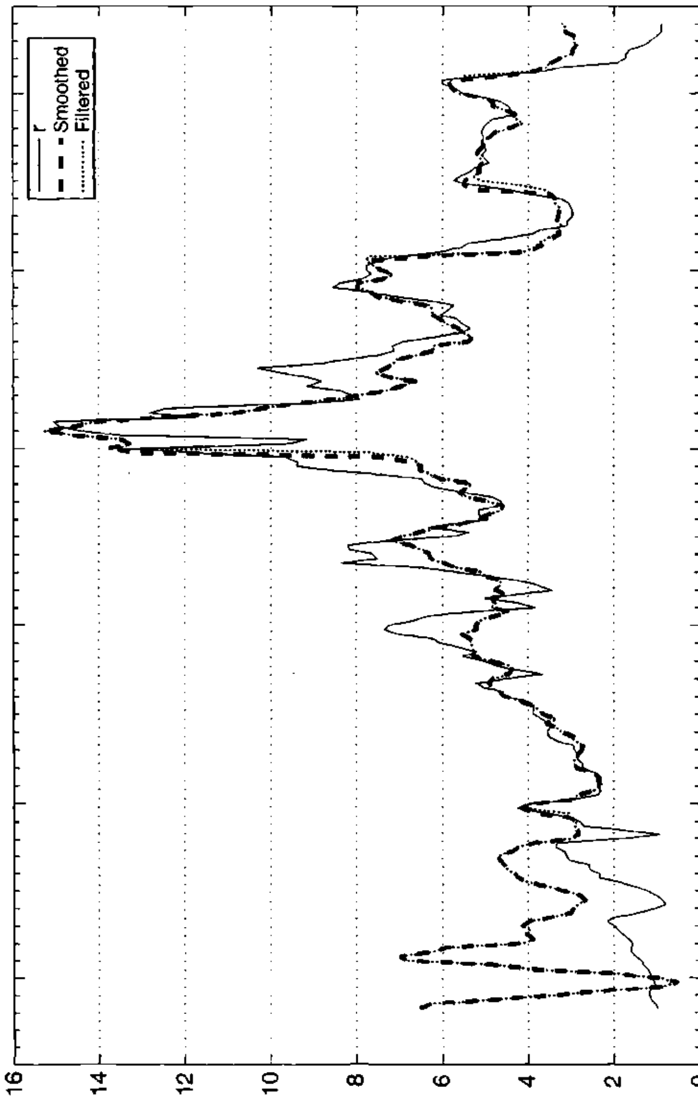

Figure 4.1
Actual and Predicted Paths of the Nominal Interest Rate from Estimates of the Monetary Policy Rule, Equation (1) Using Smoothed and Filtered Probabilities

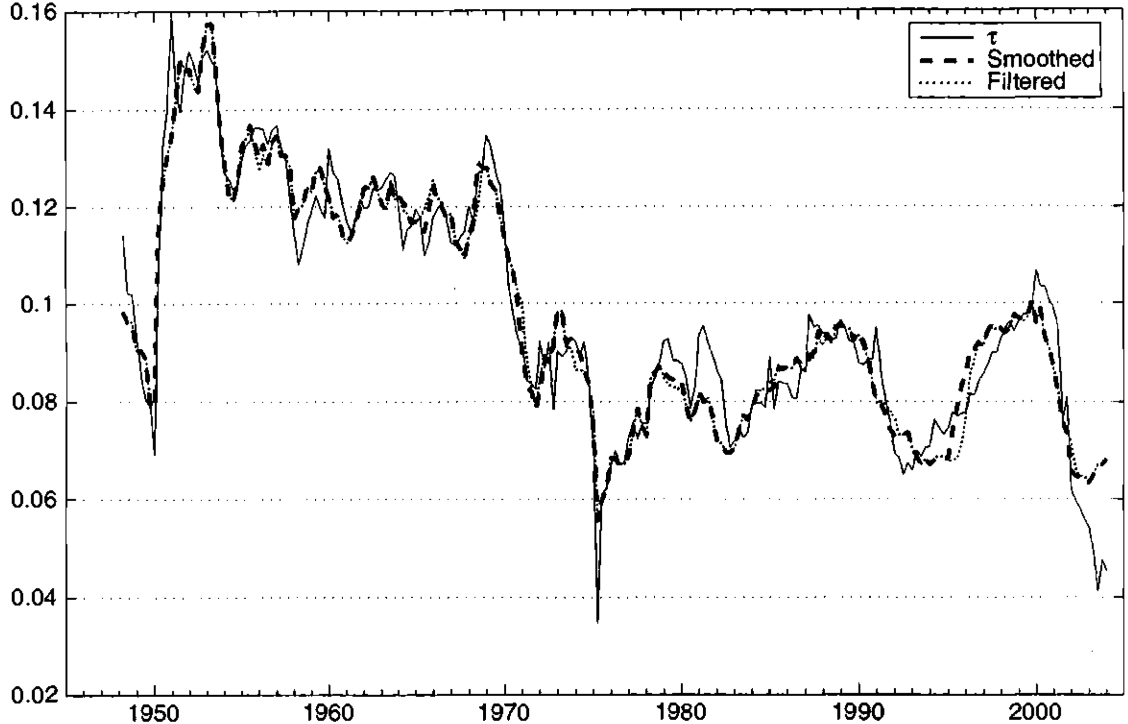

Figure 4.2
Actual and Predicted Paths of the Tax-Output Ratio from Estimates of the Monetary Policy Rule, Equation (2) Using Smoothed and Filtered Probabilities

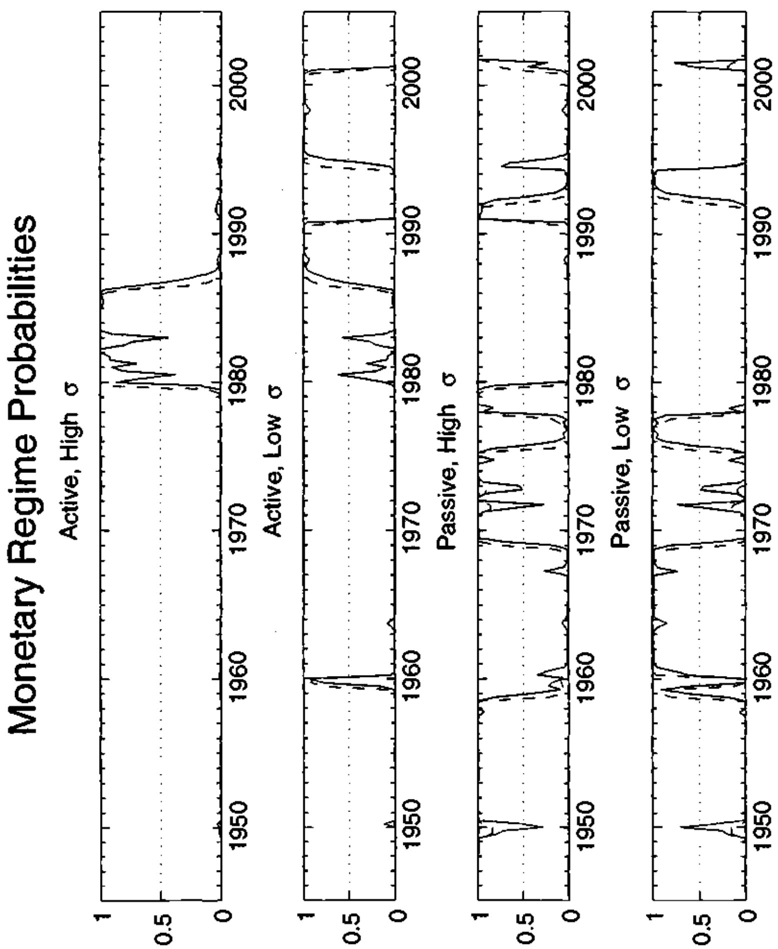

Figure 4.3
Smoothed (Solid Line) and Filtered (Dashed Line) Estimated Probabilities

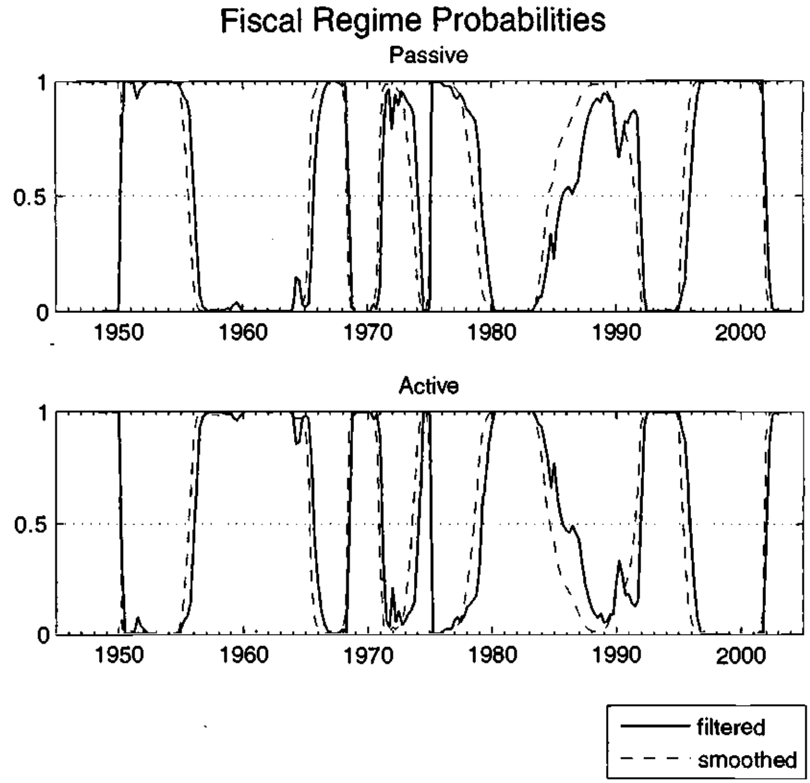

Figure 4.4
Smoothed (Solid Line) and Filtered (Dashed Line) Estimated Probabilities

recessions in 1991 and 2001. For extended periods during the so-called "jobless recoveries," monetary policy continued to be less responsive to inflation for two or more years after the official troughs of the downturns. The passive episode in 1991 became active when the Fed launched its preemptive strike against inflation in 1994.

These results are broadly consistent with previous findings. From the beginning of the sample until the Treasury Accord of March 1951, Federal Reserve policy supported high bond prices to the exclusion of targeting inflation, an extreme form of passive monetary policy (Woodford 2001). Through the Korean War, monetary policy largely accommodated the financing needs of fiscal policy (Ohanian 1997). Romer and Romer (2002) offer narrative evidence that Fed objectives and views about the economy in the 1950s were very much like those in the 1990s, particularly in its overarching concern about inflation. But

Romer and Romer (2002, p. 123) quote Chairman William McChesney Martin's congressional testimony, in which he explained that "the 1957–58 recession was a direct result of letting inflation get substantially ahead of us." The Romers also mention that FOMC "members felt they had not reacted soon enough in 1955 [to offset the burst of inflation]" (p. 122). To buttress their narrative case, the Romers estimate a forward-looking Taylor rule from 1952:1–1958:4. They conclude that policy was active: The response of the interest rate to inflation was 1.178 with a standard error of 0.876. Our estimate of this response coefficient in passive regimes is 0.522, which is less than one standard error below the Romers' point estimate. The Fed might well have intended to be vigilant against inflation, but it appears not to have acted to prevent the 1955 inflation. The brief burst of active monetary policy late in 1959 and early in 1960 is consistent with the Romers' (2002) finding that the Fed raised the real interest rate in this period to combat inflation. From 1960–1979, monetary policy responded weakly to inflation, while since the mid-1980s the Fed has reacted strongly to inflation, a pattern found in many studies (Taylor 1999a, Clarida, Galí, and Gertler 2000, Romer and Romer 2002, and Lubik and Schorfheide 2004).

The estimates of passive monetary policy behavior following the 1991 and 2001 recessions are likely to conflict with some readers' priors. Other evidence, however, corroborates the estimates. As early as March 1993, after the federal funds rate had been at 3 percent for several months, during policy deliberations Governors Angell, LaWare, and Mullins expressed concern that the Fed was keeping the rate low for too long. Angell warned that "our progress to get inflation down low enough so it [isn't a factor affecting] any business decision is now in jeopardy" (p. 30) (Board of Governors of the Federal Reserve System 1993a). At that March FOMC meeting, Governors Angell and Lindsey dissented on the vote to maintain the funds rate at 3 percent. Six months later, Mullins analogized 1993 to the 1970s as another "period in which perhaps short rates weren't appropriately set to track inflation" (p. 11) (Board of Governors of the Federal Reserve System 1993b).

More recently, close observers of the Fed have expressed similar concerns, citing the rapid growth in liquidity in 2003 and 2004 and the exceptionally low real interest rates since 2001 (Unsigned 2005a, b). Financial economists list unusually low interest rates as an important factor behind the spectacular growth in household and corporate debt in recent years (Unsigned 2002 and Roach 2004). These sentiments about monetary policy behavior in the early 1990s and 2000s are consistent with our estimates that the Fed responded only weakly to inflation in those periods.

Estimates of the tax rule in (2) reveal substantially more regime instability than for monetary policy. Over the post-war period, there were 12 fiscal regime changes, with tax policy spending 55 percent of the time in the active regime. Figure 4.4 shows that the model associates tax policy with regimes that accord well with narrative histories. Fiscal policy was active in the beginning of the sample. Despite an extremely high level of debt from World War Two expenditures, Congress overrode President Truman's veto in early 1948 and cut taxes. Although, as Stein (1996) recounts the history, legislators argued that cutting taxes would reduce the debt, the debt-GDP ratio rose while revenues as a share of GDP fell. In 1950 and 1951 policy became passive, as taxes were increased and excess profits taxes were extended into 1953 to finance the Korean War, consistent with the budget-balancing goals of both the Truman and the Eisenhower Administrations. From the mid-50s, through the Kennedy tax cut of 1964, and into the second half of the 1960s, fiscal policy was active, paying little attention to debt. There followed a period of about 15 years when fiscal policy fluctuated in its degree of concern about debt relative to economic conditions.

President Carter cut taxes to stimulate the economy in early 1979, initiating a period of active fiscal policy that extended through the Reagan Administration's Economic Recovery Plan of 1981. By the mid-1980s, the probability of passive tax policy increased as legislation was passed in 1982 and 1984 to raise revenues in response to the rapidly increasing debt-output ratio. Following President Clinton's tax hike in 1993, fiscal policy switched to being passive through the 2001 tax cut. President Bush's tax reductions in 2002 and 2003 made fiscal policy active again.[14]

Favero and Monacelli (2005) estimate switching regressions similar to (1) and (2) and also find that monetary policy was passive from 1961 to 1979. In contrast to our results, they do not detect any tendency to return to passive policy following the 1991 and 2001 recessions, though they estimate one regime, which occurs in 1985:2–2000:4 and 2002:2–2002:4, in which the monetary policy response to inflation is exactly unity. Their estimates of fiscal policy are not directly comparable to ours because Favero and Monacelli use the net-of-interest deficit as the policy variable, which confounds spending and tax policies. Like us, they find that fiscal policy is more unstable than monetary policy.[15] Our findings are also consistent with the time-varying monetary policy rule estimates of Kim and Nelson (2006). They find that the response of monetary policy to inflation is not different from unity in the 1970s and the 1990s.

2.5 *Corroborating Evidence: Joint Policy Process*

It is convenient, and does no violence to the qualitative predictions of the theory in the next sections, to aggregate the four monetary states to two states. We aggregate the high- and low-variance states for both the active and the passive regimes, weighted by the regimes' ergodic probabilities. An analogous transformation is applied to the estimated variances. The resulting transition matrix is

$$P^M = \begin{bmatrix} .9505 & .0495 \\ .0175 & .9825 \end{bmatrix} \tag{3}$$

and variances are $\sigma_r^2(S_t = Active) = 4.0576e - 6$ and $\sigma_r^2\ (S_t = Passive) = 1.8002e - 5$. Combining this transition matrix with the one estimated for fiscal policy yields the joint transition matrix

$$P = P^M \otimes P^F = \begin{bmatrix} .8908 & .0597 & .0464 & .0031 \\ .0494 & .9011 & .0026 & .0469 \\ .0164 & .0011 & .9208 & .0617 \\ .0009 & .0166 & .0511 & .9314 \end{bmatrix} \tag{4}$$

Probabilities on the main diagonal are $P[AM/PF \mid AM/PF]$, $P[AM/AF \mid AM/AF]$, $P[PM/PF \mid PM/PF]$, and $P[PM/AF \mid PM/AF]$. The transition matrix implies that all states communicate and each state is recurring, so the economy visits each one infinitely often.

Figure 4.5 shows that the joint probabilities computed using (4) also correspond to periods that have been noted in the literature. Both policies were passive in the early 1950s, when the Fed supported bond prices (and gradually phased out that support) and fiscal policy was financing the Korean War. From the late 1960s through most of the 1970s, both policies were again passive. Arguing this, Clarida, Galí, and Gertler (2000) claim the policy mix left the equilibrium undetermined, allowing for bursts of inflation and output from self-fulfilling expectations. Using data only from 1960–1979, it is easy to see how one might reach this conclusion. The early-to-mid-1980s, when monetary policy was aggressively fighting inflation and fiscal policy was financing interest payments with new debt issuances, gets labeled as doubly

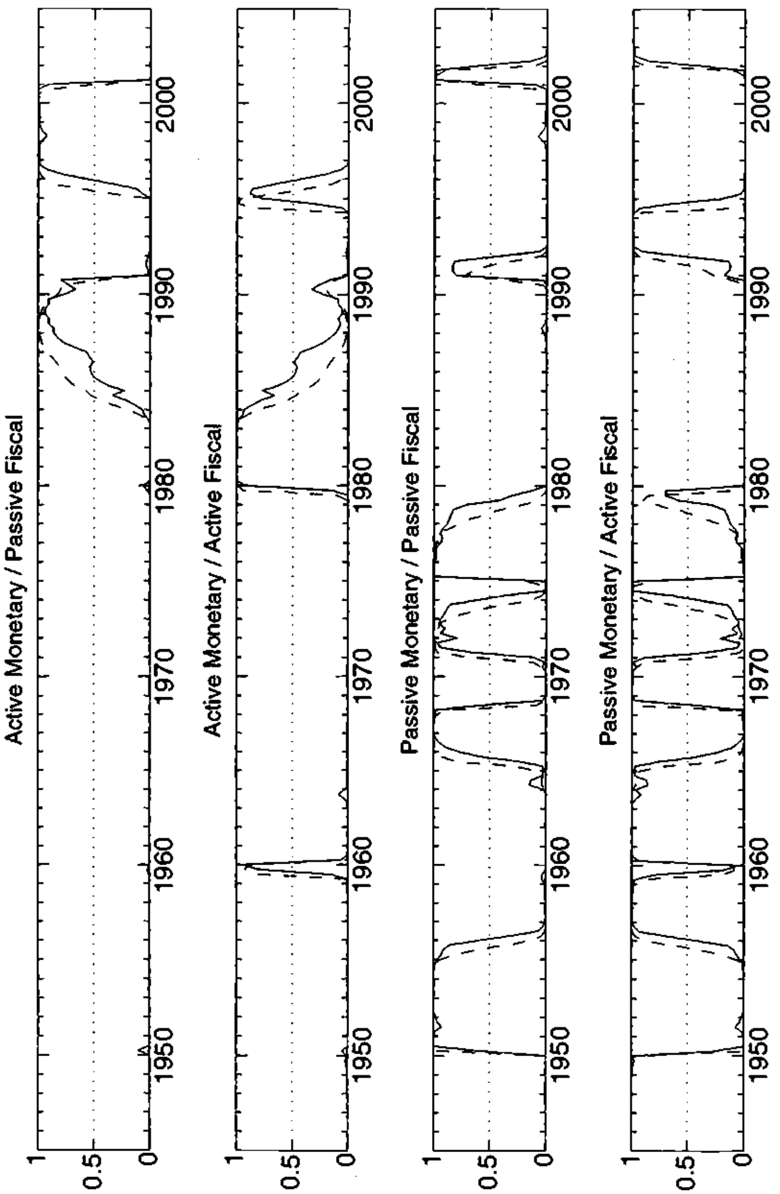

Figure 4.5
Smoothed (Solid Line) and Filtered (Dashed Line) Estimated Probabilities

active policies. Finally, the mid-1980s on is largely a period of active monetary and passive fiscal policies, as most models of monetary policy assume (for example, the papers in Bryant, Hooper, and Mann 1993 and Taylor 1999b).

Taken together, the marginal and joint probabilities paint a picture of post-war monetary and fiscal policies that is broadly consistent with both narrative accounts and fixed-regime policy rule estimates.

A final check on the plausibility of the estimates asks if the policies make economic sense when they are embedded in a conventional DSGE model. Sections 6 and 7 answer this question in detail.

3 A Model with Nominal Rigidities

We employ a conventional model with monopolistic competition and sticky prices in goods markets, extended to include lump-sum taxes and nominal government debt.[16] Although the model is standard, because we intend to solve it in its full nonlinear form, it is worthwhile briefly reviewing the specification.

3.1 *Households*

The representative household chooses $\{C_t, N_t, M_t, B_t\}$ to maximize

$$E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{C_{t+i}^{1-\sigma}}{1-\sigma} - \chi \frac{N_{t+i}^{1+\eta}}{1+\eta} + \delta \frac{(M_{t+i} / P_{t+i})^{1-\kappa}}{1-\kappa} \right] \tag{5}$$

with $0 < \beta < 1$, $\sigma > 0$, $\eta > 0$, $\kappa > 0$, $\chi > 0$, and $\delta > 0$.[17] C_t is a composite consumption good that combines the demand for the differentiated goods, c_{jt}, using a Dixit and Stiglitz (1977) aggregator:

$$C_t = \left[\int_0^1 c_{jt}^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}}, \quad \theta > 1. \tag{6}$$

The household chooses c_{jt} to minimize expenditure on the continuum of goods indexed by the unit interval, leading to the demand functions for each good j

$$c_{jt} = \left(\frac{p_{jt}}{P_t} \right)^{-\theta} C_t, \tag{7}$$

where $P_t \equiv [\int_0^1 p_{jt}^{1-\theta} dj]^{1/1-\theta}$ is the aggregate price level at t.

The household's budget constraint is

$$C_t + \frac{M_t}{P_t} + E_t\left(Q_{t,t+1}\frac{B_t}{P_t}\right) + \tau_t \leq \left(\frac{W_t}{P_t}\right)N_t + \frac{M_{t-1}}{P_t} + \frac{B_{t-1}}{P_t} + \Pi_t, \tag{8}$$

where τ_t is lump-sum taxes/transfers from the government to the household, B_t is one-period nominal bonds, $Q_{t,t+1}$ is the stochastic discount factor for the price at t of one dollar at $t + 1$, and Π_t is profits from the firm, which the household owns. The household maximizes (5) subject to (8) to yield the first-order conditions

$$\chi\frac{N_t^{\eta}}{C_t^{-\sigma}} = \frac{W_t}{P_t} \tag{9}$$

$$Q_{t,t+1} = \beta\left(\frac{C_t}{C_{t+1}}\right)^{\sigma}\frac{P_t}{P_{t+1}}. \tag{10}$$

If $1 + r_t$ denotes the risk-free gross nominal interest rate between t and $t + 1$, then absence of arbitrage implies the equilibrium condition

$$[E_t(Q_{t,t+1})]^{-1} = 1 + r_t, \tag{11}$$

so the first-order conditions imply that real money balances may be written as

$$\frac{M_t}{P_t} = \delta^{\kappa}\left(\frac{r_t}{1+r_t}\right)^{-1/\kappa} C_t^{\sigma/\kappa}. \tag{12}$$

The government demands goods in the same proportion that households do, so the government's demand is $g_{jt} = (p_{jt}/P_t)^{-\theta}G_t$, where $G_t = [\int_0^1 g_{jt}^{\theta-1/\theta}dj]^{\theta/\theta-1}$.

Necessary and sufficient conditions for household optimization are that (9)–(12) hold at all dates and that households exhaust their intertemporal budget constraints. The latter condition is equivalent to requiring that the present value of households' planned expenditure is finite and that wealth accumulation satisfies the transversality condition (Woodford 2001):

$$\lim_{T\to\infty} E_t\left[q_{t,T}\frac{A_T}{P_T}\right] = 0, \tag{13}$$

where $A_t = B_t + M_t$ and $q_{t,t+1} = Q_{t,t+1}P_{t+1}/P_t$.

3.2 *Firms*

A continuum of monopolistically competitive firms produce goods using labor. Production of good j is

$$y_{jt} = ZN_{jt}, \tag{14}$$

where Z is aggregate technology, common across firms and taken to be constant.

Aggregating consumers' and government's demand, firm j faces the demand curve

$$y_{jt} = \left(\frac{p_{jt}}{P_t}\right)^{-\theta} Y_t, \tag{15}$$

where Y_t is defined by

$$C_t + G_t = Y_t. \tag{16}$$

Equating supply and demand for individual goods,

$$ZN_{jt} = \left(\frac{p_{jt}}{P_t}\right)^{-\theta} Y_t. \tag{17}$$

Following Calvo (1983), a fraction $1 - \varphi$ firms are permitted to adjust their prices each period, while the fraction φ are not permitted to adjust. If firms are permitted to adjust at t, they choose a new optimal price, p_t^*, to maximize the expected discounted sum of profits given by

$$E_t \sum_{i=0}^{\infty} \varphi^i q_{t,t+i} \left[\left(\frac{p_t^*}{P_{t+i}}\right)^{1-\theta} - \Psi_{t+i} \left(\frac{p_t^*}{P_{t+i}}\right)^{-\theta} \right] Y_{t+i}, \tag{18}$$

where the real profit flow of firm j at period t, $\Pi_{jt} = (p_{jt}/P_t)^{1-\theta} Y_t - (W_t/P_t) N_{jt}$, has been rewritten using (17). Ψ_t is real marginal cost, defined as

$$\Psi_t = \frac{W_t}{ZP_t}. \tag{19}$$

The first-order condition that determines p_t^* can be written as

$$\frac{p_t^*}{P_t} = \left(\frac{\theta}{\theta - 1}\right) \frac{E_t \sum_{i=0}^{\infty} (\varphi\beta)^i (Y_{t+i} - G_{t+i})^{-\sigma} \left(\frac{P_{t+i}}{P_t}\right)^{\theta} \Psi_{t+i} Y_{t+i}}{E_t \sum_{i=0}^{\infty} (\varphi\beta)^i (Y_{t+i} - G_{t+i})^{-\sigma} \left(\frac{P_{t+i}}{P_t}\right)^{\theta-1} Y_{t+i}}, \tag{20}$$

which we denote by

$$\frac{p_t^*}{P_t} = \left(\frac{\theta}{\theta-1}\right)\frac{K_{1t}}{K_{2t}}, \tag{21}$$

where the numerator and the denominator have recursive representations:

$$K_{1t} = (Y_t - G_t)^{-\sigma}\Psi_t Y_t + \varphi\beta E_t K_{1t+1}\left(\frac{P_{t+1}}{P_t}\right)^{\theta} \tag{22}$$

and

$$K_{2t} = (Y_t - G_t)^{-\sigma} Y_t + \varphi\beta E_t K_{2t+1}\left(\frac{P_{t+1}}{P_t}\right)^{\theta-1}. \tag{23}$$

Solving (21) for p_t^* and using the result in the aggregate price index, $P_t^{1-\theta} = (1-\varphi)(p_t^*)^{1-\theta} + \varphi P_{t-1}^{1-\theta}$, yields

$$\pi_t^{\theta-1} = \frac{1}{\varphi} - \frac{1-\varphi}{\varphi}\left(\mu\frac{K_{1t}}{K_{2t}}\right)^{1-\theta}, \tag{24}$$

where $\mu \equiv \theta/(\theta-1)$ is the markup.

We assume that individual labor services may be aggregated linearly to produce aggregate labor, $N_t = \int_0^1 N_{jt}dj$. Linear aggregation of individual market clearing conditions implies $ZN_t = \Delta_t Y_t$, where Δ_t is a measure of relative price dispersion defined by

$$\Delta_t = \int_0^1 \left(\frac{p_{jt}}{P_t}\right)^{-\theta} dj. \tag{25}$$

Now the aggregate production function is given by

$$Y_t = \frac{Z}{\Delta_t} N_t. \tag{26}$$

It is natural to define aggregate profits as the sum of individual firm profits, $\Pi_t = \int_0^1 \Pi_{jt}dj$. Integrating over firms' profits and combining the household's and the government's budget constraints yields the aggregate resource constraint

$$\frac{Z}{\Delta_t} N_t = C_t + G_t. \tag{27}$$

From the definitions of price dispersion and the aggregate price index, relative price dispersion evolves according to

$$\Delta_t = (1-\varphi)\left(\frac{p_t^*}{P_t}\right)^{-\theta} + \varphi\pi_t^{\theta}\Delta_{t-1}, \tag{28}$$

where $\pi_t = P_t / P_{t-1}$.

Following Woodford (2003), we define potential output, Y_t^p, to be the equilibrium level of output that would be realized if prices were perfectly flexible. Potential output, then, emerges from the model when $\varphi = 0$, so all firms can adjust prices every period. The output gap, y_t, is defined as $y_t = Y_t - Y_t^p$. In this model, with disturbances only to monetary policy and to lump-sum taxes, $Y_t^p \equiv 1$.

3.3 *Policy Specification*

Monetary and tax policies follow (1) and (2), with error terms that are standard normal and *i.i.d.* The processes for $\{G_t, \tau_t, M_t, B_t\}$ must satisfy the government budget identity

$$G_t = \tau_t + \frac{M_t - M_{t-1}}{P_t} + E_t\left(Q_{t,t+1}\frac{B_t}{P_t}\right) - \frac{B_{t-1}}{P_t}. \tag{29}$$

given $M_{-1} > 0$ and $(1 + r_{-1})B_{-1}$. Government spending is assumed to be a constant share of output.

3.4 *Information Assumptions*

Although in the empirical estimates in section 2 regime is a state variable hidden from the econometrician, we do not confront agents in the model with an inference problem. Instead, we assume agents observe at least current and past policy shocks and regimes. Under conventional information assumptions, the model is solved assuming that private agents base their decisions at date t on the information set $\Omega_t = \{\varepsilon^r_{t-j}, \varepsilon^\tau_{t-j}, S^M_{t-j}, S^F_{t-j}, j \geq 0\}$ plus the initial conditions $(M_{-1}, (1 + r_{-1})B_{-1})$. This conventional information structure enables us to quantify the impacts of unanticipated changes in taxes. We also seek to quantify the effects of anticipated changes in taxes. Those effects are computed by endowing agents with foreknowledge of tax disturbances, so the model is solved using the expanded information set $\Omega^*_t = \Omega_t \cup \{\varepsilon^\tau_{t+1}\}$.[18]

4 The Fiscal Theory Mechanism

The economics underlying the fiscal theory mechanism potentially present in the model of section 3 relies on the existence of nominal government debt and particular combinations of monetary and fiscal policies. An equilibrium condition that is useful for heuristic purposes is derived by imposing the transversality condition, (13), on the present value form of the government's budget constraint to obtain:

$$\frac{A_{t-1}}{P_t} = \sum_{T=t}^{\infty} E_t \left[q_{t,T} \left(\tau_T - G_T + \frac{r_T}{1+r_T} \frac{M_T}{P_T} \right) \right]. \tag{30}$$

The expression states that in equilibrium the real value of nominal government liabilities must equal the expected present value of primary surpluses plus seigniorage. When this expression imposes restrictions on the stochastic process for the price level, it does so through the fiscal theory mechanism. In that case, Cochrane (1999, 2001) refers to (30) as a "debt valuation" equation because fluctuations in surpluses or seigniorage can induce jumps in P_t, which alter the real value of debt to keep it consistent with expected policies.[19] Conventional monetary analysis, in contrast, assumes that monetary policy is active and fiscal policy is passive, so (30) holds via adjustments in future surpluses, without imposing any restrictions on the $\{P_t\}$ process (for example, Woodford 2003).

Consider the simple case of an exogenous process for the net-of-interest surplus (active fiscal policy) and a pegged nominal interest rate (passive monetary policy).[20] A debt-financed cut in taxes does not raise the present value of future taxes, so it is perceived by households as raising their wealth. Unlike when productivity or government purchases change, wealth effects from the fiscal theory do not necessarily stem from a change in the resources available to the economy.[21] Instead, a tax cut raises the present value of consumption the households believe they can afford at initial prices and interest rates. This wealth-induced increase in demand for goods raises output relative to potential, when nominal rigidities are present. But it must also cause inflation and/or real interest rates to adjust in order to satisfy (30). With a pegged nominal interest rate, the increase in inflation lowers the ex-ante real interest rate, ensuring that the demand for goods expands. Condition (30) emphasizes that it is changes in the *present value* of primary surpluses and seigniorage that can trigger fluctuations in aggregate demand, suggesting that anticipated and unanticipated taxes have symmetric effects.

Equality between the value of government liabilities and the present value of surpluses plus seigniorage is achieved through three channels, as Woodford (1998a) explains. First, passive monetary policy endogenously expands the money stock to clear the money market at the targeted nominal interest rate, creating seigniorage revenue. Second, unexpectedly higher inflation revalues outstanding nominal debt. Third, lower real interest rates—arising from the pegged nominal rate and higher expected inflation—make it possible to service a higher level of debt with a given stream of primary surpluses.

If condition (30) imposes restrictions on the equilibrium price level, as it does in the fiscal theory, then higher expected seigniorage tends to lower the current price level, an association that seems perverse relative to conventional monetary theory. Of course, (30) is one of several conditions for equilibrium. But this informal analysis offers a preview of the possibility that monetary disturbances may have unconventional impacts in a fiscal theory equilibrium.

The logic of the fiscal theory mechanism carries over directly to a regime-switching environment. Davig, Leeper, and Chung (2004) show that in that environment the fiscal theory is always at work, regardless of the prevailing regime. As long as there is a positive probability of moving to a regime with active fiscal policy, agents' decision rules will reflect that probability and disturbances to current or expected future taxes will generate wealth effects that affect aggregate demand. This occurs even if in the current regime fiscal policy is passive and monetary policy is active. Whether this logic is practically relevant depends on whether the fiscal theory mechanism is quantitatively important. We now turn to this issue.

5 Calibration

Parameters describing preferences, technology and price adjustment for the model in section 3 are specified to be consistent with Rotemberg and Woodford (1997) and Woodford (2003). The model's frequency is quarterly. The markup of price over marginal cost is set to 15 percent, implying $\mu = \theta(1-\theta)^{-1} = 1.15$, and 66 percent of firms are unable to reset their price each period ($\varphi = .66$). The quarterly real interest rate is set to 1 percent ($\beta = .99$). Preferences over consumption and leisure are logarithmic ($\sigma = 1$, $\eta = -1$) and χ is chosen to make deterministic steady state employment 0.2. Each intermediate goods producing firm has access to a production function with constant returns to labor. The technology parameter, Z, is chosen to normalize the deterministic steady state level of output to be 1.

The preference parameter on real balances, δ, is set to ensure that velocity in the deterministic steady state, defined as cP/M, matches average U.S. monetary base velocity at 2.4. This value comes from the period 1959–2004 and uses the average real expenditure on non-durable consumption plus services. The parameter governing the interest elasticity of real money balances, κ, is set to 2.6 (Mankiw and Summers 1986, Lucas 1988, Chari, Kehoe, and McGrattan 2000).

Reaction coefficients in the policy rules are taken from the estimates in tables 4.1 and 4.2 and the four-state joint transition matrix (4). The intercepts in the policy rules govern the deterministic steady state values of inflation and debt-output in the computational model. Intercepts are set so the deterministic steady state values of variables are common across regimes and match their sample means from 1948:2–2004:1. Those values, annualized, are $\pi = 3.43$ percent and $b = .3525$. Government purchases as a share of output are fixed in the model at their mean value of .115.

6 Solution Method and General Characteristics of Equilibrium

This section discusses the qualitative features of the computed equilibrium. In particular, we argue that the solution is locally unique and satisfies the necessary and sufficient conditions for an equilibrium in the DSGE model. An analytical demonstration of these features is not available, so we rely on numerical arguments.

6.1 Numerical Algorithm

We compute the solution using the monotone map method, based on Coleman (1991). The algorithm uses a discretized state space and requires a set of initial decision rules that reduce the system to a set of non-linear expectational first-order difference equations. The complete model consists of the first-order necessary conditions from the households' and firms' optimization problems, constraints, specifications of policy, the price adjustment process, and the transversality condition. The solution is a set of functions that map the minimum set of state variables, $\Theta_t = \{b_{t-1}, w_{t-1}, \Delta_{t-1}, \theta_t, \psi_t, S_t\}$, into values for the endogenous variables, where w is a wealth measure, defined as $w_t \equiv R_t b_t + M_t/P_t$.[22]

6.2 *Uniqueness*

Because monetary and fiscal regimes are free to change independently of one another, the model temporarily permits policy combinations with passive monetary and passive fiscal policies, as well as active monetary and active fiscal policies. A passive-passive policy combination leaves the equilibrium undetermined in fixed-regime versions of the model, admitting the possibility that sunspot shocks affect equilibrium allocations. An active-active policy combination implies either no equilibrium exists or, if it does exist, the equilibrium is non-stationary. But when regimes obey a Markov process, an active-active mix does not necessarily violate the transversality condition because agents correctly impute positive probability to returning to a regime that prevents debt from growing too rapidly. Similarly, temporarily passive-passive policies do not necessary leave the equilibrium indeterminate.[23]

To establish local uniqueness of the equilibrium, we perturb the converged decision rules by a truncated normal random variable at every point in the state space and check that the algorithm converges back to the initial set of rules. We repeated this many times and the algorithm always converged to the initial converged decision rules, which we take to indicate the decision rules are locally unique.

Establishing uniqueness must also address channels through which additional state variables may influence equilibrium outcomes. Additional solutions may exist on an expanded set of state variables, perhaps including lagged endogenous variables and sunpots. This is a possibility, but because we use the full nonlinear model derived from explicit microfoundations, there is limited latitude to intervene in the state space. The only way in which states outside of the minimum set can matter is through expectations formation. Allowing additional states to affect expectations requires moving from the monotone map to some other algorithm, such as parameterized expectations, which can allow expectations to be a function of the expanded set of state variables. Parameterization of expectations requires that one take a stand on exactly what the additional state variables are and how they affect expectation formation—for example, sunspots could enter multiplicatively or additively. Given that there is no theory to guide such decisions, the discipline imposed by the monotone map algorithm is appealing.[24]

We also checked how the monotone map algorithm behaves when it is known there are multiple equilibria or no equilibrium exists. Using the fixed-regime model with PM/PF policies, the algorithm diverges; under AM/AF policies, the algorithm converges, but implies a non-stationary path for debt. The regime-switching DSGE model converges and produces a stationary path for debt, providing further evidence that the equilibrium is locally unique and stationary.

Zero expected present value of debt, which the transversality condition implies, is equivalent to the intertemporal equilibrium condition

$$b_t = x_t + z_t, \tag{31}$$

where x and z are the expected discounted present values of future primary surpluses and seigniorage. We check whether (31) holds following an exogenous shock, conditioning on remaining in each of the three stationary regimes—AM/PF, PM/PF, PM/AF. We repeat this calculation with random realizations of regimes. The condition is always satisfied, confirming that the numerical solution is an equilibrium of the model.

To assess the long-run properties of the model, we compute distributions using a simulation of 250,000 periods (figure 4.6). The top four panels are unconditional distributions and the bottom four panels sort the sample by regime. The simulation randomly draws policy shocks and policy regimes from their estimated distributions. Three of the distributions condition on regime—AM/PF, PM/PF, and PM/AF—are well-behaved, with finite means and variances, as is apparent by inspection of the bottom four panels.[25] The estimated policy rules imply that debt diverges very slowly under AM/AF policies. Although debt temporarily follows a non-stationary path, the duration of the AM/AF regime is not sufficiently long nor is the growth rate of debt high enough to preclude stationary unconditional distributions for debt and other variables.

7 Quantifying the Fiscal Theory Mechanism

To quantify the effects of policy shocks, we report results based on two kinds of impulse response functions. The first conditions on regime to mimic responses functions usually reported from identified VARs. The second reflects the "typical" effect of a policy shock by computing the distribution of equilibrium time paths after a policy disturbance.

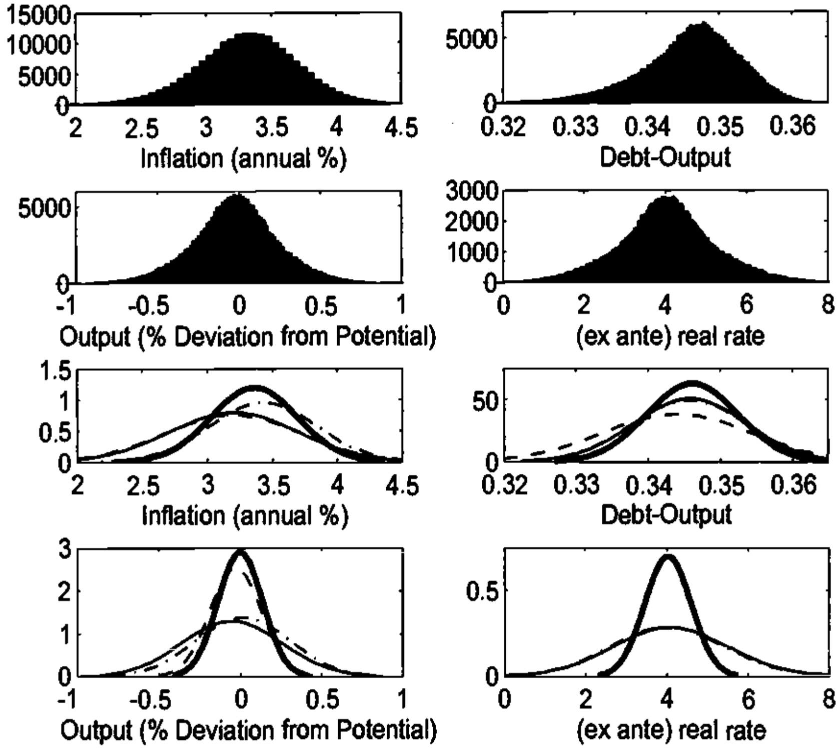

Figure 4.6
Distributions: Unconditional and Conditional. Top Four Panels Are Unconditional Distributions, Taking Draws from Policy Shocks and Regimes; Bottom Four Panels Are Conditional on Regime, Sorting Observations by Regime. AM/PF (Thick Solid), AM/AF (Dashed), PM/PF (Dotted-Dashed), PM/AF (Thin Solid)

7.1 Nonlinear Impulse Response Analysis

When conditioning on regime, we assume the initial state of the economy equals the regime-dependent mean. After perturbing the error term in a policy rule, we solve for equilibrium time paths, holding the prevailing regime fixed, and report paths of variables relative to the baseline of their regime-dependent means. For a policy shock at time t, the initial response of variable k is

$$\phi_t^k(\varepsilon_t^r, \varepsilon_t^\tau) = h^k(\overline{b}^J, \overline{w}^J, \overline{\Delta}^J, \varepsilon_t^r, \varepsilon_t^\tau, J) - h^k(\overline{b}^J, \overline{w}^J, \overline{\Delta}^J, 0, 0, J), \tag{32}$$

where h^k is the decision rule for variable k as a function of the state variables for regime J and the realizations of *i.i.d.* policy disturbances, ε_t^r and ε_t^τ. $\overline{x}^J$ denotes the mean of x in regime J. Following initial impact, policy shocks equal their means of zero and the value of variable k in period $n > t$ is

$$\phi_n^k(\varepsilon_t^r, \varepsilon_t^\tau) = h^k(b_{n-1}, w_{n-1}, \Delta_{n-1}, 0, 0, J) - h^k(\overline{b^J}, \overline{w}^J, \overline{\Delta}^J, 0, 0, J), \tag{33}$$

ϕ_n^k is a function of the initial shocks because the impulse responses are history dependent.

Also of interest is the average ("typical") response of a variable, where the mean is computed over future realizations of regimes. In this case, the impact period is computed as above, but the generalized impulse response of variable k in period $n > t$ is given by

$$\hat{\phi}_n^k(\varepsilon_t^r, \varepsilon_t^\tau) = h^k(b_{n-1}, w_{n-1}, \Delta_{n-1}, 0, 0, S_n) - h^k(\overline{b^J}, \overline{w}^J, \overline{\Delta}^J, 0, 0, J), \tag{34}$$

where the realization of the decision rule depends on the current realization of regime, S_n. We report various summary measures of the random variable $\hat{\phi}_n^k$.

7.2 A Fiscal Expansion

In every regime, a cut in taxes is financed by new sales of nominal government debt and generates wealth effects that increase aggregate demand, inflation, and output.

Figure 4.7 reports paths following a surprise tax reduction of two percent of output in period 5, conditional on starting out and staying in each of the three stationary regimes—AM/PF, PM/AF, and PM/PF. Regardless of the prevailing regime, the fiscal theory mechanism is evident. A surprise tax cut raises current and expected inflation. Monetary policy prevents the nominal interest rate from rising as much as expected inflation, reducing the ex-ante real interest rate and raising output above potential. In all regimes, the one-period tax cut has persistent effects, lasting over five years when monetary policy is passive (thin solid and dashed lines) and for many more years when monetary policy is active (thick solid lines). Figure 4.7 illustrates the three sources of fiscal financing: inflation jumps unexpectedly on impact, revaluing debt; the real interest rate falls, raising the expected discounted present values of surpluses and seigniorage; future inflation and, therefore, seigniorage increases.

Active monetary policy appears to dramatically dampen the tax effects on output and inflation. In fact, a strong response of the nominal interest rate to inflation spreads the responses to taxes over many periods and actually results in larger long-run effects from fiscal disturbances.

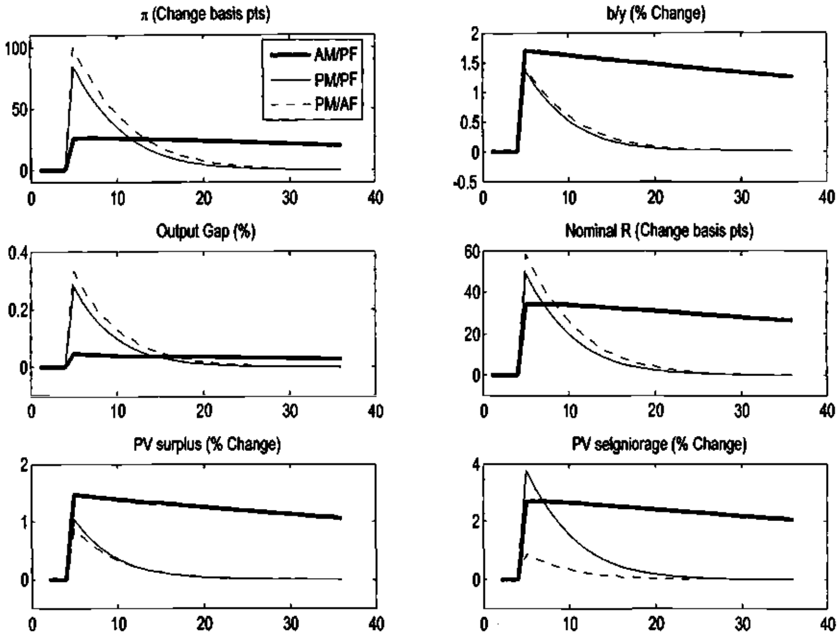

Figure 4.7
Responses to an *i.i.d.* Tax Cut of 2 Percent of Output, Conditional on Remaining in the Prevailing Regime

In a fixed-regime model, the Taylor principle creates explosive inflation dynamics following an *i.i.d.* shock, so it may seem anomalous that the inflation process is stationary in the AM/PF regime. Davig, Leeper, and Chung (2004) show, in an endowment version of this model, that an AM/PF regime creates wealth effects that make the forecast error in inflation serially correlated, depending negatively on past inflation and positively on past real debt. These surprises in inflation are a key feature of the fiscal theory mechanism, as they serve to revalue debt. Through the Taylor principle, higher π_t raises r_t, which increases future debt service. Because regimes can switch, agents expect some debt service to be met with future seigniorage. But the paths in figure 4.7 condition on remaining in the AM/PF regime, so taxes are unexpectedly high, which reduces aggregate demand and stabilizes inflation.

Generalized impulse response functions bring out the role that the evolution of regime plays in affecting economic agents' expectations and choices. Dynamic impacts of policy disturbances display important differences from their counterparts in figure 4.7. For the three stationary regimes, figure 4.8 plots the mean and one standard deviation bands of the generalized impulse responses following a fiscal expansion. The first four periods condition on the stationary mean in a given regime, period 5 imposes the shock and holds regime fixed, and draws of regimes are taken from period 6 on.

Factoring in future regime changes alters the predictions one makes about the dynamic path of the economy following a tax cut. An *i.i.d.* tax cut initially raises inflation and output more when monetary policy is passive than when it is active, but under passive monetary policy the responses also die out more quickly. When the initial regime is AM/PF, the responses of inflation and output are hump-shaped, resembling those in identified VAR studies of fiscal policy. The hump arises from realizations of passive monetary policy regimes, which generate temporary bursts of inflation that are averaged into the responses plotted in the figure.

7.3 *Tax Multipliers*

We compute several summary measures of tax effects, both conditional on the economy remaining in the current regime and unconditional,

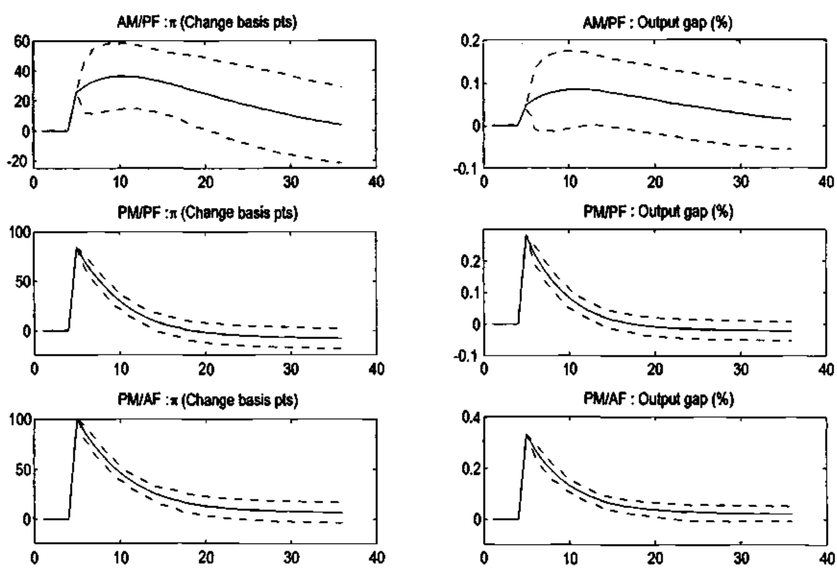

Figure 4.8
Responses to an *i.i.d.* Tax Cut, Given the Regime at the Date of the Shock and Drawing from Regime over the Forecast Horizon

averaging across future realizations of regime. The measures quantify the impacts of a one-time exogenous change in taxes, either unanticipated or anticipated.

Table 4.4 reports tax multipliers, computed as the discounted present value of additional output generated by a tax cut. The multiplier is defined as $PV_n(\Delta y)/\Delta\tau_0 = (1/\Delta\tau_0)\Sigma^n_{s=0}q_{0,s}(y_s - \bar{y})$, where $q_{0,s}$ is the stochastic discount factor. We compute the multipliers for horizons n = 5, 10, 25, and for the long run (∞) conditional on regime and all but the long run when future regimes are random.

A one-time $1 surprise tax cut raises the discounted present value of future output in the long run by $1.02 in the AM/PF regime, by 76 cents in the PM/PF regime, and by 98 cents in the PM/AF regime. The table highlights the stronger persistence of output under active monetary policy, where after 25 quarters the discounted present value of additional output is only 42 cents. Under passive monetary policy, the additional effects of the tax cut have largely dissipated after 25 quarters.

The fiscal theory does not sharply delineate between the impacts of unanticipated and anticipated changes in taxes. As expression (30) emphasizes, the fiscal theory focuses on how fluctuations in the expected discounted present value of taxes impact current aggregate demand. The lower panel of table 4.4 reports output multipliers when households anticipate a tax cut next period; multipliers are computed using the expanded information set Ω^*_t, defined in section 3.4. The multipliers under fore-knowledge of taxes are similar to the multipliers from a tax surprise, confirming that it is the change in the expected

Table 4.4
Output Multipliers for Taxes Conditional on Regime

Regime	Fraction of New Debt Backed by PV of Taxes	$\frac{PV(\Delta y)}{\Delta\tau}$ after 5 Quarters	10 Quarters	25 Quarters	∞
Conventional Information Set Ω_t					
AM/PF	.673	–.108	–.199	–.417	–1.019
PM/PF	.586	–.515	–.686	–.759	–.761
PM/AF	.488	–.623	–.855	–.976	–.981
Foreknowledge Information Set Ω^*_t					
AM/PF	-	–.106	–.195	–.410	–.997
PM/PF	-	–.460	–.612	–679	–.681
PM/AF	-	–.556	–.762	–.873	–.877

discounted present value of primary surpluses that is central to the fiscal theory mechanism.

Table 4.4 shows the proportion of the marginal addition to debt arising from a tax cut that is backed by an increase in discounted primary surpluses. Under an AM/PF policy, two-thirds of new debt is backed by discounted primary surpluses, in contrast to fixed-regime models, where the proportion is 100 percent. The proportions under PM/PF and PM/AF are 59 percent and 49 percent. Consequently, the PM/AF regime experiences the strongest wealth effect on impact from a tax cut, as figure 4.7 makes apparent. Much of this adjustment arises from the lower real interest rates that are used to discount future surpluses and seigniorage.

In the model, it is highly unusual for policy regime to remain unchanged, as the calculations in table 4.4 assume. Typically, after a policy disturbance, regimes evolve according to their estimated transition matrices. Table 4.5 reports 80th percentile ranges for the tax multipliers, computed from 10,000 draws of regimes, using the generalized impulse response function defined in (34). At the 80th percentile, a \$1 tax cut raises the discounted present value of output from 76 cents to \$1.36 after six years, depending on the initial regime.

Table 4.6 reports the price level effects of a one-period tax shock, conditional on regime. In the long run, a transitory tax cut of 2 percent of output raises the price level by 6.7 percent under AM/PF policies. At a little over 1 percent, the long-run price effects are substantially smaller when monetary policy is passive. At shorter horizons, taxes have larger price effects when monetary policy is passive than when it is active. Table 4.7 records typical price level impacts, accounting for possible future regimes. These impacts can be substantial, with the price level more than 2 percent higher six years after the tax cut. Uncertainty about realizations of future regimes creates a wide range of possible output and price level impacts from tax changes, as tables 4.5 and 4.7 attest.[26]

7.4 Quantitative Sensitivity to Policy Process

In this model, tax shocks matter as long as fiscal policy can be active some of the time and agents' expectations incorporate this belief. Figure 4.9 shows the immediate impact of a tax shock (positive or negative) on output and inflation as the percentage of time policy spends in the AM/PF regime varies from 0 percent to 100 percent. This impact effect

Table 4.5
Output Multipliers for Taxes, Unconditional: 80th Percentile Bands Based on 10,000 Draws

	$\frac{PV(\Delta y)}{\Delta \tau}$ after		
Initial Regime	5 Quarters	10 Quarters	25 Quarters
AM/PF	[–.126, –.400]	[–.213, –.754]	[–.430, –.922]
PM/PF	[–.215, –.401]	[–.271, –.623]	[–.414, –.764]
PM/AF	[–.365, –.568]	[–.537, –.928]	[–.993, –1.363]

Table 4.6
Cumulative Effect on Price Level of an *i.i.d.* Unanticipated Tax Cut of 2 Percent of Output

	$\%\Delta P$ after			
Regime	5 Quarters	10 Quarters	25 Quarters	∞
AM/PF	0.324	0.641	1.513	6.704
PM/PF	0.770	1.077	1.232	1.237
PM/AF	0.949	1.369	1.620	1.633

Table 4.7
Cumulative Effect on the Price Level of an *i.i.d.* Tax Cut of 2 Percent of Output, Unconditional: 80th Percentile Bands Based on 10,000 Draws

	$\%\Delta P$ after		
Initial Regime	5 Quarters	10 Quarters	25 Quarters
AM/PF	[.324, .687]	[.641, 1.306]	[1.158, 2.160]
PM/PF	[.678, .770]	[.840, 1.077]	[.533, 1.232]
PM/AF	[.949, 1.008]	[1.325, 1.551]	[1.610, 2.269]

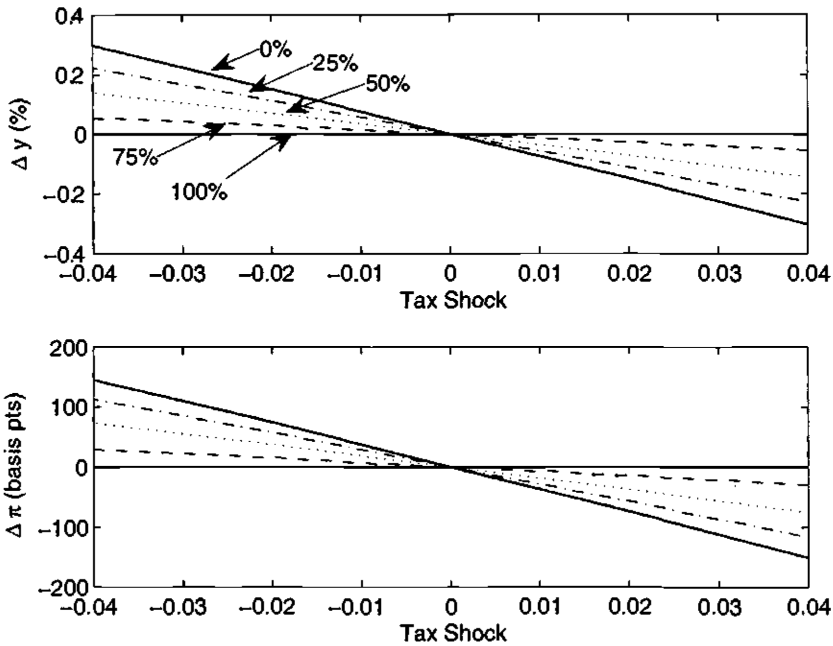

Figure 4.9
Impact Effect of Tax Change on Output and Inflation, Allowing Percentage of Time Policy Spends in AM/PF Regime to Vary from 0 Percent to 100 Percent

declines monotonically as the ergodic probability of the AM/PF regime increases.

7.5 *A Monetary Expansion*

In the model's fiscal theory equilibrium, an expansionary monetary policy disturbance generates conventional short-run responses—lower real interest rate and higher output and inflation—but unconventional longer run impacts—higher real interest rate and lower output and inflation (figure 4.10). Underlying the transitory monetary expansion is an open-market purchase of debt that leaves households holding less government debt. This negative wealth effect is not neutralized in the model, as it is with a fixed AM/PF regime, because the estimated policy process implies that future taxes do not fall in the long run by enough to counteract the decline in wealth from lower debt.

Although the longer run impacts of a monetary disturbance are unconventional by most criteria, the positive correlation between the

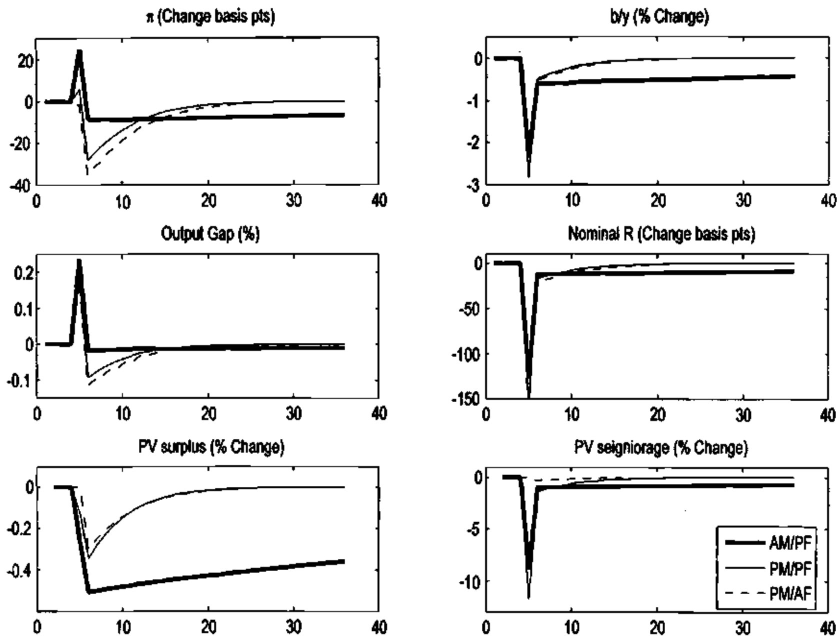

Figure 4.10
Responses to an *i.i.d.* Monetary Expansion, Conditional on Remaining in the Prevailing Regime

nominal interest rate and future inflation that appears in figure 4.10 is a feature of many monetary VARs (Sims 1992). This "price puzzle," which is discussed in more detail in the next section, is a feature of the equilibrium generated by the fiscal theory mechanism.

8 Some Empirical Implications

Many studies of monetary policy condition on policy regime and then estimate policy rules. The estimates are interpreted by embedding them in a fixed-regime variant of the model in section 3. This section illustrates some pitfalls of this approach when data are generated by an environment with recurring changes in policy regimes.

We imagine that the calibrated model with the estimated switching process generated observed time series. Three sources of stochastic variation and the model's nonlinearity are sufficient to ensure that a five-variable VAR fit to taxes, the nominal interest rate, the output gap, inflation, and the real value of debt is stochastically non-singular. In the identified VAR, only the policy rules are restricted. Output, inflation, and debt are treated as a triangular block which, as in the DSGE model, is permitted to respond contemporaneously to monetary and tax disturbances. The policy rules are specified as

$$r_t = \alpha_0 + \alpha_\pi \pi_t + \alpha_y y_t + \varepsilon_t^r \tag{35}$$

$$\tau_t = \gamma_0 + \gamma_y y_t + \gamma_b b_{t-1} + \varepsilon_t^\tau. \tag{36}$$

Following Blanchard and Perotti (2002), we impose the response of taxes to output, but freely estimate the response to debt. Counting only contemporaneous restrictions, the model is just identified if we estimate the response of monetary policy to inflation, but impose its response to output.

The econometrician estimates fixed-regime identified VARs with data generated by the DSGE model under two different assumptions about the econometrician's *a priori* information. In one case, the econometrician believes the full sample comes from a single policy regime; in other cases, the econometrician believes regime changes have occurred and has extra-sample information that identifies which regimes prevailed over various sub-samples. Simulated data in the first case draws both policy shocks and regime, while in the other cases the simulation conditions on regime and draws only policy shocks.[27] After estimating the VARs, the econometrician seeks to interpret the findings in the context of a fixed-regime DSGE model.

The identified VARs obtain accurate quantitative estimates of policy parameters and the impacts of policy shocks. Table 4.8 reports four sets of estimates of the feedback parameters α_π and γ_b. The "All Regimes" estimates come from the full sample and the other columns condition on the indicated regime. All the estimates that condition on regime recover the correct policy parameters and the associated regimes. The "All Regimes" estimates suggest that a researcher using a long sample of data would infer that, on average, monetary policy is passive and fiscal policy is active.

Figure 4.11 shows estimates of the dynamic impacts of policy shocks from the identified VARs. Tax disturbances have important impacts on output and inflation, both conditional on regime and in the full sample. Active monetary policy diminishes the size of the period-by-period impacts, but induces such extreme serial correlation that the

Table 4.8
Policy Parameters from Identified VAR Estimated on Simulated Data. "All Regimes" from Stochastic Simulation Drawing from Regime; Others Are Conditional on Regime. Estimated Equations Are $\tau_t = \gamma_0 + \gamma_y y_t + \gamma_b b_{t-1} + \varepsilon^{\tau}_t$, $r_t = \alpha_0 + \alpha_\pi \pi_t + \alpha_y y_t + \varepsilon^{R}_t$, with γ_y and α_y Restricted to Values Used to Simulate Model. Samples of Length 10,000

	All Regimes	AM/PF	PM/PF	PM/AF
α_π	0.723	1.308	0.595	0.528
γ_b	0.002	0.016	0.018	−0.003

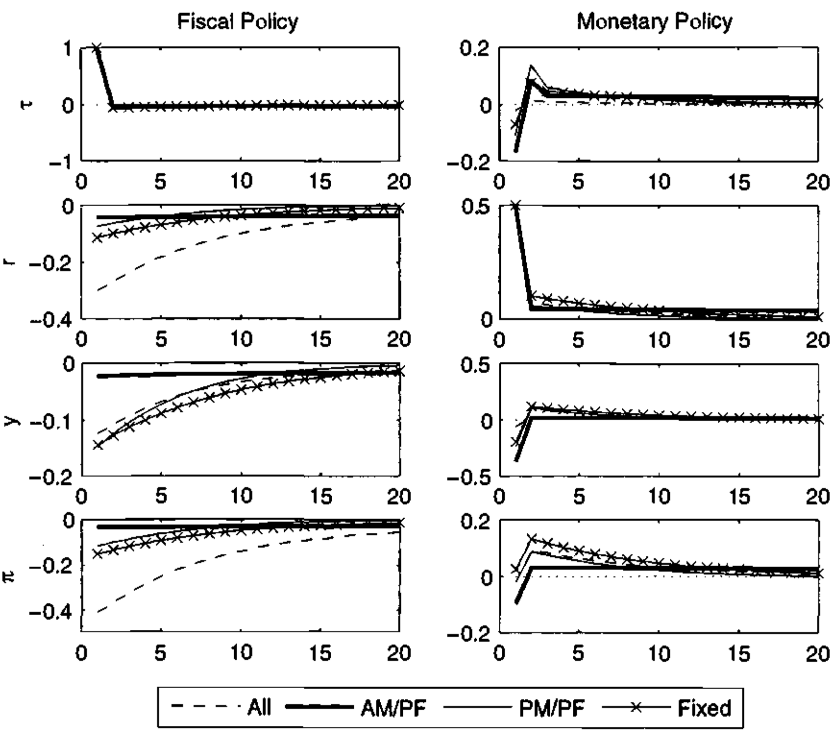

Figure 4.11
Impact of Policy Shocks. Estimated from Simulated Data and Produced by Fixed-Regime DSGE Model

total impacts are substantial. Monetary contractions have conventional short-run effects (lower output and inflation), but unconventional longer run effects (higher output and inflation), owing to the resulting wealth effects engendered by the fiscal theory mechanism. The rise in future inflation resembles the price puzzle Sims (1992) discovered in monetary VARs. That puzzle is more pronounced when monetary policy is passive, consistent with Hanson's (2004) findings that in U.S. data the puzzle is more severe in samples that include data before 1979, a period that section 2 labels passive monetary policy. Both the parameter estimates and the impulse response functions the econometrician obtains are quantitatively consistent with those in the switching model underlying the simulated data (given that the econometrician knows α_y and γ_y *a priori*).

Connecting these quantitative results to fixed-regime theories can lead to qualitatively misleading inferences. Clarida, Galí, and Gertler (2000) and Lubik and Schorfheide (2004) use different econometric methods, but both condition on monetary policy regime and both conclude that since the early 1980s, U.S. monetary policy has been active, while from 1960–1979, monetary policy was passive. Both sets of authors maintain the assumption that fiscal policy was passive throughout, leading in their fixed-regime DSGE models to Ricardian equivalence in the recent sub-sample and indeterminacy in the earlier sub-sample. The results for AM/PF (thick solid lines) in figure 4.11 are difficult to reconcile with Ricardian equivalence. Similarly, in the sub-sample where the estimated rules imply PM/PF (thin solid lines), the econometrician would infer the equilibrium is indeterminate and be compelled to interpret the policy impacts as arising from correlations between sunspot shocks and policy shocks. But the simulated data were generated by locally unique decision rules.

Employing the full sample, the econometrician estimates the policy impacts shown by dashed lines in figure 4.11. Moreover, using the "All Regimes" parameter estimates in a fixed-regime version of the model in section 3, produces the policy impacts represented by lines in the figure punctuated with x's. In contrast to the estimates that condition on regime, the full sample estimates deliver qualitatively correct inferences about policy effects. Correct qualitative inferences require nailing down the correct long-run behavior of policy. That long-run behavior is better gleaned from a long sample that includes the possible realizations of regimes than from sub-samples that condition on regime.[28]

9 Concluding Remarks

Existing work on policy rules is based on a logical inconsistency: It assumes regime cannot change and then proceeds to analyze the implications of alternative regimes. This paper takes a step toward resolving this inconsistency. A simple and plausible empirical specification of regime change finds that U.S. monetary and fiscal policies have fluctuated among active and passive rules. Treating that evidence of regime change in an internally consistent manner can significantly alter interpretations of the historical period and of monetary and fiscal policies more generally. Both the empirical specification and the economic model are very simple, leaving much room for improving fit to data. This is an important area for continued research.

This paper has not addressed why policy regimes change. This is a hard question, but it is the same hard question that can be asked of any model with a stochastic component to policy behavior. Although Sims (1987) offers a rationale for why optimal policy might include a component that is random to private agents, there is certainly no consensus on this issue. Lack of consensus, however, does not undermine the utility of simply postulating the existence of policy shocks and then tracing out their influence in data and in models. In this paper, we have followed the convention of assuming some part of policy behavior is random.

Under the working hypothesis of recurring regime change, this paper shows that when estimated Markov-switching rules for monetary and tax policies are embedded in a DSGE model calibrated to U.S. data, lump-sum taxes have quantitatively important effects on aggregate demand, output, and inflation. In the model, tax non-neutralities arise because the estimates imply that agents always place positive probability mass on an active fiscal regime in the future, a belief that makes the fiscal theory of the price level operative.

Of course, the fiscal theory is not the only source of tax non-neutralities in actual data. A full accounting of tax effects requires introducing some of the panoply of reasons offered for why taxes might be non-neutral—distortions, life-cycle considerations, and so forth. In any case, the quantitative predictions of this paper strongly suggest that the fiscal theory mechanism should be added to the list of usual suspects for the breakdown of Ricardian equivalence.

Acknowledgments

We thank Daron Acemoglu, Hess Chung, Jon Faust, Jordi Galí, Dave Gordon, Ross Levine, Jim Nason, Jürgen von Hagen, Chris Sims, Mike Woodford, Tack Yun, Tao Zha, and seminar participants at the Federal Reserve Board, the ECB, and the NBER Macro Annual meeting for comments. Leeper acknowledges support from NSF Grant SES-0452599. The views expressed herein are solely those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Kansas City or the Federal Reserve System.

Endnotes

1. Some work considers recurring regime switching in exogenous processes, including exogenously evolving policy variables (Andolfatto and Gomme 2003, Davig 2003, 2004, Leeper and Zha 2003, and Schorfheide 2005). There have also been efforts to incorporate one-time regime changes into general equilibrium models of the fiscal theory (Sims 1997, Woodford 1998b, Loyo 1999, Mackowiak 2006, Daniel 2003, and Weil 2003).

2. We apply the terminology in Leeper (1991). *Active monetary policy* arises when the response of the nominal interest rate is more than one-for-one to inflation and *passive monetary policy* occurs when that response is less than one-for-one. Analogously, *passive fiscal policy* occurs when the response of taxes to debt exceeds the real interest rate and *active fiscal policy* occurs when taxes do not respond sufficiently to debt to cover real interest payments. In many models, a unique bounded equilibrium requires one active and one passive policy.

3. See Leeper (1991), Woodford (1994, 1995), Sims (1994), and Cochrane (1999, 2001).

4. Cochrane (1999) interprets U.S. inflation in light of the fiscal theory and Woodford (2001) points to particular historical episodes when the fiscal theory might have been relevant.

5. The table is pretty full. Included among purely monetary interpretations are narratives (DeLong 1997, Mayer 1998, and Romer and Romer 2004), fixed regime (Orphanides 2003a), permanent regime change (Clarida, Galí, and Gertler 2000, and Lubik and Schorfheide 2004), adaptive learning (Cogley and Sargent 2005b, 2002, Primiceri 2006, and Sargent, Williams, and Zha 2006), model uncertainty (Cogley and Sargent 2005a), and regime-switching identified VARs (Sims and Zha 2006). Work that integrates monetary and fiscal policy includes Leeper and Sims (1994), Romer and Romer (1994), and Sala (2004).

6. Davig and Leeper (2006a) examine the implications of making monetary policy regime change endogenous, maintaining the assumption that fiscal policy is perpetually passive.

7. See Beyer and Farmer (2005) for a related discussion.

8. Ireland (2004), Leeper and Zha (2001), Leeper and Roush (2003), and Sims and Zha (2006) argue that allowing money growth to enter the monetary policy rule is important for identifying policy behavior. To keep to a specification that is comparable to the Taylor rule literature, we exclude money growth.

9. Examples of estimated fiscal rules include Bohn (1998), Taylor (2000), Fatas and Mihov (2001), Auerbach (2003), Cohen and Follette (2003), Ballabriga and Martinez-Mongay (2005), and Claeys (2004).

10. To follow existing empirical work on simple policy rules, the paper does not estimate the rules as parts of a fully specified model. We are reassured in doing this by the model-based estimates of Ireland (2004) and Lubik and Schorfheide (2004), which are very close to single-equation estimates of Taylor rules. It is noteworthy, though, that in an identified switching VAR, Sims and Zha (2006) conclude that monetary policy was consistently active since 1960; they do not consider fiscal behavior and their switching specification is more restricted than ours along some dimensions, but less restricted along others (see endnote 8).

11. We include a dummy variable to absorb the variability in interest rates induced by credit controls in the second and third quarters of 1980. See Schreft (1990) for a detailed account of those controls.

12. Orphanides (2003b) argues that the poor U.S. inflation performance from 1965–1979 was due to a strong policy response to poor estimates of the output gap available at the time, rather than a weak response to inflation. Using real-time data on the gap and inflation, he claims the fit of a conventional Taylor rule specification is much improved when real-time data are used rather recent vintage data. Orphanides (2003a) extends this argument to the 1950s. The fit of our switching regression for monetary policy is far superior to Orphanides's over the 1960:2–1966:4 period, yet our results label this as a period of passive monetary policy.

13. This draws on Pechman (1987), Poterba (1994), Stein (1996), Steuerle (2002), Romer and Romer (2004), and Yang (2006).

14. The negative response of taxes to debt in the active fiscal regime might be regarded as perverse. A negative correlation arises naturally over the business cycle, as recessions automatically lower revenues and raise debt. Two active fiscal regimes, the late 1940s and 1973:4–1975:1, almost exactly coincide with the cycle. But there are extended periods of active behavior, which include but do not coincide with recessions (1955:4–1965:2 and 1978:4–1984:3). There are also instances in which recessions occur during periods of passive fiscal policy (1990:3-1991:1 and 2001:1-2001:4). Taken together these results suggest that the tax rule does more than simply identify active regimes with economic downturns.

15. Favero and Monacelli (2005) estimate that through 2002, fiscal policy was active in 1961:1–1974:3, 1975:3–1995:1, and 2001:3–2002:4 and passive otherwise. Our estimates find more periods of passive behavior.

16. Detailed expositions appear in Yun (1996, 2005), Woodford (2003), and Schmitt-Grohé and Uribe (2006).

17. The constant relative risk aversion preferences over real money balances rule out Obstfeld and Rogoff's (1983) speculative hyperinflations.

18. See Leeper (1989) and Yang (2005) for further discussion of the implications of fiscal foresight.

19. In the model all debt matures in one period. Cochrane (2001) emphasizes that with long-maturity debt, the inflation consequences of a fiscal expansion can be pushed into the future.

20. This policy mix does not impose a boundary condition on the inflation process, but it does impose a boundary condition on the *real* debt process. With nominal liabilities predetermined, the price level is uniquely determined. This is the canonical fiscal theory specification (see Woodford 2001 or Gordon and Leeper 2006).

21. Taking a price-theoretic view of the fiscal theory with tax distortions, Leeper and Yun (2006) refer to this as the "asset revaluation effect," as distinct from conventional "wealth" and "substitution" effects.

22. Details appear in Appendix A.

23. Davig and Leeper (2006b) provide a detailed analytical proof of determinacy for bounded solutions under doubly passive monetary and fiscal policies in a linear model with regime switching in monetary policy.

24. In the monotone map algorithm, it is possible to allow additional state variables to enter expectations. However, allowing expectations formation to depend on an expanded state vector does not produce a solution that differs from the locally unique solution.

25. Francq and Zakoian (2001) show that Markov-switching processes can have explosive regimes, yet the entire stochastic process can be stable. Davig (2005) shows that a properly restricted Markov-switching process for discounted debt can have an explosive regime, yet satisfy the transversality condition for debt.

26. Appendix B considers an alternative specification of the policy process that increases the duration of the active monetary policy regime by labeling as active the periods after the recessions in 1991 and 2001, which section 2 estimated as passive monetary policy. This reduces the quantitative impacts of tax shocks, though the fiscal theory mechanism remains important.

27. But the data are generated by decision rules based on the "true" regime-switching process.

28. Unless there is compelling evidence that agents believe the prevailing regime is permanent.

References

Andolfatto, D., and P. Gomme. 2003. "Monetary Policy Regimes and Beliefs." *International Economic Review* 44(1): 1–30.

Auerbach, A. J. 2002. "Is There a Role for Discretionary Fiscal Policy?" In *Rethinking Stabilization Policy: Proceedings of a Symposium Sponsored by the Federal Reserve Bank of Kansas City*, pp. 109–150.

Auerbach, A. J. 2003. "Fiscal Policy, Past and Present." *Brookings Papers on Economic Activity* (1): 75–122.

Ballabriga, F. C., and C. Martinez-Mongay. 2005. "Sustainability of EU Public Finances." European Commission Economic Papers no. 225.

Benhabib, J., and R. E. A. Farmer. 2000. "The Monetary Transmission Mechanism." *Review of Economic Dynamics* 3(2): 523–550.

Benhabib, J., S. Schmitt-Grohé, and M. Uribe. 2001a. "Monetary Policy and Multiple Equilibria." *American Economic Review* 91(1): 167–186.

Benhabib, J., S. Schmitt-Grohé, and M. Uribe. 2001b. "The Perils of Taylor Rules." *Journal of Economic Theory* 96(1-2): 40–69.

Benhabib, J., S. Schmitt-Grohé, and M. Uribe. 2002. "Avoiding Liquidity Traps." *Journal of Political Economy* 110(3): 535–563.

Beyer, A., and R. E. A. Farmer. 2005. "Identifying the Monetary Transmission Mechanism using Structural Breaks." Manuscript, UCLA.

Blanchard, O. J., and R. Perotti. 2002. "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output." *Quarterly Journal of Economics* 117(4): 1329–1368.

Board of Governors of the Federal Reserve System. 1993a. "Transcript of Federal Open Market Committee." March 23.

Board of Governors of the Federal Reserve System. 1993b. "Transcript of Federal Open Market Committee." September 23.

Bohn, H. 1998. "The Behavior of U.S. Public Debt and Deficits." *Quarterly Journal of Economics* 113(3): 949–963.

Brooks, D. 2005. "In the Midst of Budget Decadence, a Leader Will Arise." *The New York Times*, February 19.

Bryant, R. C., P. Hooper, and C. L. Mann, eds. 1993. *Evaluating Policy Regimes: New Research in Empirical Macroeconomics.* Washington, D.C.: The Brookings Institution.

Calvo, G. A. 1983. "Staggered Prices in a Utility Maxmimizing Model." *Journal of Monetary Economics* 12(3): 383–398.

Chari, V. V., P. J. Kehoe, and E. R. McGrattan. 2000. "Sticky Price Models of the Business Cycle: Can the Contract Multiplier Solve the Persistence Problem?" *Econometrica* 68(5): 1151–1179.

Claeys, P. 2004. "Monetary and Budget Policy Interaction: An Empirical Analysis of Fiscal Policy Rules, Stabilisation Policies and Policy Interaction in Monetary Union." Manuscript, European University Institute.

Clarida, R., J. Galí, and M. Gertler. 2000. "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory." *Quarterly Journal of Economics* 115(1): 147–180.

Cochrane, J. H. 1999. "A Frictionless View of U.S. Inflation." In B. S. Bernanke, and J. J. Rotemberg, eds., *NBER Macroeconomics Annual 1998*, 323–384. Cambridge, MA: MIT Press.

Cochrane, J. H. 2001. "Long Term Debt and Optimal Policy in the Fiscal Theory of the Price Level." *Econometrica* 69(1): 69–116.

Cogley, T., and T. J. Sargent. 2002. "Evolving Post-World War II U.S. Inflation Dynamics." In B. S. Bernanke, and J. J. Rotemberg, eds., *NBER Macroeconomics Annual 2001*. Cambridge, MA: MIT Press.

Cogley, T., and T. J. Sargent. 2005a. "The Conquest of U.S. Inflation: Learning and Robustness to Model Uncertainty." *Review of Economic Dynamics* 8(2): 528–563.

Cogley, T., and T. J. Sargent. 2005b. "Drifts and Volatilities: Monetary Policies and Outcomes in the Post WWII U.S." *Review of Economic Dynamics* 8(2): 262–302.

Cohen, D., and G. Follette. 2003. "Forecasting Exogenous Fiscal Variables in the United States." Finance and Economics Discussion Series, 2003–59, Federal Reserve Board.

Coleman, II, W. J. 1991. "Equilibrium in a Production Economy with an Income Tax." *Econometrica* 59(4): 1091–1104.

Cooley, T. F., S. F. LeRoy, and N. Raymon. 1984. "Econometric Policy Evaluation: Note." *American Economic Review* 74(3): 467–470.

Daniel, B. C. 2003 "Fiscal Policy, Price Surprises, and Inflation." Manuscript, SUNY Albany.

Davig, T. 2003. "Regime-Switching Fiscal Policy in General Equilibrium." Manuscript, The College of William and Mary.

Davig, T. 2004. "Regime-Switching Debt and Taxation." *Journal of Monetary Economics* 51(4): 837–859.

Davig, T. 2005. "Periodically Expanding Discounted Debt: A Threat to Fiscal Policy Sustainability?" *Journal of Applied Econometrics* 20(7): 829–840.

Davig, T., and E. M. Leeper. 2006a. "Endogenous Monetary Policy Regime Change." In L. Reichlin and K. D. West, eds., *NBER International Seminar on Macroeconomics 2006*, forthcoming. Cambridge, MA: MIT Press.

Davig, T., and E. M. Leeper. 2006b. "Generalizing the Taylor Principle." *American Economic Review,* forthcoming. NBER Working Paper no. 11874. Cambridge, MA: National Bureau of Economic Research.

Davig, T., E. M. Leeper, and H. Chung. 2004. "Monetary and Fiscal Policy Switching." *Journal of Money, Credit and Banking,* forthcoming. NBER Working Paper no. 10362. Cambridge, MA: National Bureau of Economic Research.

DeLong, B. J. 1997. "America's Peacetime Inflation: The 1970s." In C. D. Romer, and D. H. Romer, eds., *Reducing Inflation: Motivation and Strategy,* 247–276. Chicago, IL: University of Chicago Press.

Dixit, A. K., and J. E. Stiglitz. 1977. "Monopolistic Competition and Optimum Product Diversity." *American Economic Review* 67(3): 297–308.

Fatas, A., and I. Mihov. 2001. "Politica Fiscal y Ciclos Economicos: Una Investigacion Empirica. (Fiscal Policy and the Business Cycle: An Empirical Analysis.)" *Moneda y Credito* (212): 167–205.

Favero, C. A., and T. Monacelli. 2005. "Fiscal Policy Rules and Regime (In)Stability: Evidence from the U.S." IGIER Working Paper no. 282, January.

Francq, C., and J.-M. Zakoian. 2001. "Stationarity of Multivariate Markov-Switching ARMA Models." *Journal of Econometrics.* 102: 339–364.

Gordon, D. B., and E. M. Leeper. 2006. "The Price Level, The Quantity Theory of Money, and the Fiscal Theory of the Price Level." *Scottish Journal of Political Economy* 53(1): 4–27.

Hamilton, J. D. 1989. "A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle." *Econometrica* 57(2): 357–384.

Hanson, M. S. 2004. "The 'Price Puzzle' Reconsidered." *Journal of Monetary Economics* 51(7): 1385–1413.

Ireland, P. N. 2004. "Money's Role in the Monetary Business Cycle." *Journal of Money, Credit and Banking* 36(6): 969–983.

Kim, C-J, and C. R. Nelson. 1999 *State-Space Models with Regime Switching.* Cambridge, MA: MIT Press.

Kim, C-J, and C. R. Nelson. 2006. "Estimation of a Forward-Looking Monetary Policy Rule: A Time-Varying Parameter Model using Ex-Post Data." *Journal of Monetary Economics* 53(8): 1949–1966.

Leeper, E. M. 1989. "Policy Rules, Information, and Fiscal Effects in a 'Ricardian' Model." Federal Reserve Board, International Finance Discussion Paper no. 360.

Leeper, E. M. 1991. "Equilibria Under 'Active' and 'Passive' Monetary and Fiscal Policies." *Journal of Monetary Economics* 27(1): 129–147.

Leeper, E. M., and J. E. Roush. 2003. "Putting 'M' Back in Monetary Policy." *Journal of Money, Credit, and Banking* 35(6, Part 2): 1217–1256.

Leeper, E. M., and C. A. Sims. 1994. "Toward a Modern Macroeconomic Model Usable for Policy Analysis." In S. Fischer, and J. J. Rotemberg, eds., *NBER Macroeconomics Annual 1994*, 81–118. Cambridge, MA: MIT Press.

Leeper, E. M., and T. Yun. 2006. "The Fiscal Theory of the Price Level: Background and Beyond." *International Tax and Public Finance* 13(4): 373–409.

Leeper, E. M., and T. Zha. 2001. "Assessing Simple Policy Rules: A View from a Complete Macro Model." *Federal Reserve Bank of St. Louis Review* 83(July/August), 83–110.

Leeper, E. M., and T. Zha. 2003. "Modest Policy Interventions." *Journal of Monetary Economics* 50(8): 1673–1700.

Loyo, E. 1999. "Tight Money Paradox on the Loose: A Fiscalist Hyperinflation." Manuscript, Harvard University.

Lubik, T. A., and F. Schorfheide. 2004. "Testing for Indeterminacy: An Application to U.S. Monetary Policy." *American Economic Review* 94(1): 190–217.

Lucas, Jr., R. E. 1988. "Money Demand in the United States: A Quantitative Review." *Carnegie-Rochester Conference Series on Public Policy* 29: 137–168.

Mackowiak, B. 2006. "Macroeconomic Regime Switching and Speculative Attacks." *Journal of Economic Dynamics and Control*, forthcoming.

Mankiw, N. G., and L. H. Summers. 1986. "Money Demand and the Effects of Fiscal Policies." *Journal of Money, Credit, and Banking* 18(4): 415–429.

Mayer, T. 1998. *Monetary Policy and the Great Inflation in the United States.* Cheltenham, U.K.: Edward Elgar.

Mountford, A., and H. Uhlig. 2005. "What Are the Effects of Fiscal Policy Shocks?" SFB 649 Discussion Paper no. 2005-039, Humbolt University.

Obstfeld, M., and K. Rogoff. 1983. "Speculative Hyperinflations in Maximizing Models: Can We Rule Them Out?" *Journal of Political Economy* 91(August): 675–687.

Ohanian, L. E. 1997. "The Macroeconomic Effects of War Finance in the United States: World War II and the Korean War." *American Economic Review* 87(1): 23–40.

Orphanides, A. 2003a. "Historical Monetary Policy Analysis and the Taylor Rule." *Journal of Monetary Economics* 50(5): 983–1022.

Orphanides, A. 2003b. "The Quest for Prosperity without Inflation." *Journal of Monetary Economics* 50(3): 633–663.

Pechman, J. A. 1987. *Federal Tax Policy*. Washington, D.C.: The Brookings Institution, fifth edn.

Perotti, R. 2004. "Estimating the Effects of Fiscal Policy in OECD Countries." IGIER Working Paper no. 276.

Poterba, J. M. 1994. "Federal Budget Policy in the 1980s." In M. Feldstein, ed., *American Economic Policy in the 1980s*, 235–270. Chicago, IL: University of Chicago Press.

Primiceri, G. 2006. "Why Inflation Rose and Fell: Policymakers' Beliefs and US Postwar Stabilization Policy." *Quarterly Journal of Economics* 121(3): 867–901.

Roach, S. 2004. "The Asset Economy." Morgan Stanley Online.

Romer, C. D., and D. Romer. 1994. "What Ends Recessions?" In S. Fischer, and J. J. Rotemberg, eds., *NBER Macroeconomics Annual 1994*, 13–57. Cambridge, MA: MIT Press.

Romer, C. D., and D. H. Romer. 2002. "A Rehabilitation of Monetary Policy in the 1950s." *American Economic Review* 92(2): 121–127.

Romer, C. D., and D. H. Romer. 2004. "Choosing the Federal Reserve Chair: Lessons from History." *Journal of Economic Perspectives* 18(1): 129–162.

Rotemberg, J. J., and M. Woodford. 1997. "An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy." In B. S. Bernanke, and J. J. Rotemberg, eds., *NBER Macroeconomics Annual 1997*, 297–346. Cambridge, MA: MIT Press.

Rotemberg, J. J., and M. Woodford. 1999. "Interest Rate Rules in an Estimated Sticky Price Model." In J. B. Taylor, ed., *Monetary Policy Rules*, 57–119. Chicago, IL: University of Chicago Press.

Sala, L. 2004. "The Fiscal Theory of the Price Level: Identifying Restrictions and Empirical Evidence." IGIER Working Paper no. 257.

Sargent, T. J., N. Williams, and T. Zha. 2006. "Shocks and Government Beliefs: The Rise and Fall of American Inflation." *American Economic Review* 96(4): 1193–1224.

Schmitt-Grohé, S., and M. Uribe. 2006. "Optimal Simple and Implementable Monetary and Fiscal Rules." *Journal of Monetary Economics*, forthcoming.

Schorfheide, F. 2005. "Learning and Monetary Policy Shifts." *Review of Economic Dynamics* 8(2): 392–419.

Schreft, S. L. 1990. "Credit Controls: 1990." *Federal Reserve Bank of Richmond Economic Review* 76(6): 25–55.

Sims, C. A. 1987. "A Rational Expectations Framework for Short-Run Policy Analysis." In W. A. Barnett, and K. J. Singleton, eds., *New Approaches to Monetary Economics*, 293–308. Cambridge, UK: Cambridge University Press.

Sims, C. A. 1992. "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy." *European Economic Review* 36: 975–1000.

Sims, C. A. 1994. "A Simple Model for Study of the Determination of the Price Level and the Interaction of Monetary and Fiscal Policy." *Economic Theory* 4(3): 381–399.

Sims, C. A. 1997. "Fiscal Foundations of Price Stability in Open Economies." Manuscript, Yale University.

Sims, C. A., and T. Zha. 2006. "Were There Regime Switches in US Monetary Policy?" *American Economic Review* 96(1): 54–81.

Stein, H. 1996. *The Fiscal Revolution in America.* Washington, D.C.: AEI Press, second revised edn.

Steuerle, C. E. 2002. "Tax Policy from 1990 to 2001." In J. Frankel, and P. Orszag, eds., *American Economic Policy in the 1990s*, 139–169. Cambridge, MA: MIT Press.

Steuerle, C. E. 2006. "Fiscal Policy from Kennedy to Reagan to G. W. Bush." In R. W. Kopcke, G. M. B. Tootell, and R. K. Triest, eds., *The Macroeconomics of Fiscal Policy*, 119–142. Cambridge, MA: MIT Press.

Taylor, J. B. 1993. "Discretion versus Policy Rules in Practice." *Carnegie-Rochester Conference Series on Public Policy* 39: 195–214.

Taylor, J. B. 1999a. "An Historical Analysis of Monetary Policy Rules." In J. B. Taylor, ed., *Monetary Policy Rules*, 319–341. Chicago, IL: University of Chicago Press.

Taylor, J. B., ed. 1999b. *Monetary Policy Rules*. Chicago, IL: University of Chicago Press.

Taylor, J. B. 2000. "Reassessing Discretionary Fiscal Policy." *Journal of Economic Perspectives* 14(3): 21–36.

Unsigned. 2002. "Dicing with Debt." *The Economist*, (January 24).

Unsigned. 2005a. "Saturated." *The Economist*, (February 26).

Unsigned. 2005b. "Still Gushing Forth." *The Economist*, (February 3).

Weil, P. 2003. "Reflections on the Fiscal Theory of the Price Level." Manuscript, ECARES.

Woodford, M. 1994. "Monetary Policy and Price Level Determinacy in a Cash-in-Advance Economy." *Economic Theory* 4(3): 345–380.

Woodford, M. 1995. "Price-Level Determinacy Without Control of a Monetary Aggregate." *Carnegie-Rochester Conference Series on Public Policy* 43: 1–46.

Woodford, M. 1998a. "Control of the Public Debt: A Requirement for Price Stability?" In G. Calvo, and M. King, eds., *The Debt Burden and Its Consequences for Monetary Policy*, 117–154. New York: St. Martin's Press.

Woodford, M. 1998b. "Public Debt and the Price Level." Manuscript, Princeton University.

Woodford, M. 2001. "Fiscal Requirements for Price Stability." *Journal of Money, Credit, and Banking* 33(3): 669–728.

Woodford, M. 2003. *Interest and Prices: Foundations of a Theory of Monetary Policy.* Princeton, NJ: Princeton University Press.

Yang, S-C. S. 2005. "Quantifying Tax Effects Under Policy Foresight." *Journal of Monetary Economics* 52(8): 1557–1568.

Yang, S-C. S. 2006. "Tentative Evidence of Tax Foresight." *Economic Letters*, forthcoming.

Yun, T. 1996. "Nominal Price Rigidity, Money Supply Endogeneity, and Business Cycles." *Journal of Monetary Economics* 37(April): 345–370.

Yun, T. 2005. "Optimal Monetary Policy with Relative Price Distortions." *American Economic Review* 95(1): 89–108.

Zanna, L. F. 2003. "Interest Rate Rules and Multiple Equilibria in the Small Open Economy." Federal Reserve Board IFDP No. 785.

Appendix A Solution Method

Implementation of the algorithm begins by conjecturing an initial set of rules, which we take to be the solution from the model's fixed-regime counterpart. Specifically, we take the solutions from the fixed-regime model with AM/PF and PM/AF policies as the initial rules for the corresponding regimes in the non-synchronous switching model. For the AM/AF and PM/PF regimes there are no stationary, unique fixed-regime counterparts, so we use the solution from the PM/AF fixed-regime model to initialize the algorithm. To ensure the solution is not sensitive to initial conditions, we also use the solution from the AM/PF regime and weighted averages of the two.

Taking the initial rules for labor, $\hat{h}^N(\Theta_t) = N_t$, and the functions determining the firm's optimal pricing decision, $\hat{h}^{K_1}(\Theta_t) = K_{1,t}$ and $\hat{h}^{K_2}(\Theta_t) = K_{2,t}$, we find values using a nonlinear equation solver for N_t, $K_{1,t}$, $K_{2,t}$ such that

$$C_t^{-\sigma} = \beta R_t E_t[\pi_{t+1}(h^C(\Theta_{t+1}))^{-\sigma}], \tag{37}$$

$$K_{1,t} = C_t^{1-\sigma}\Psi_t + \varphi\beta E_t \hat{h}^{K_1}(\Theta_{t+1}), \tag{38}$$

$$K_{2,t} = C_t^{1-\sigma} + \varphi\beta E_t \hat{h}^{K_2}(\Theta_{t+1}), \tag{39}$$

where $h^C(\Theta_t) = (A/\Delta_t)\hat{h}^N(\Theta_t) - g$. Given N_t, $K_{1,t}$, $K_{2,t}$, we compute the endogenous variables. Note that Δ_t, b_t and $w_t = R_t b_t + M_t/P_t$ are states at $t+1$. Gauss-Hermite integration is used over possible values for ε^r_{t+1}, ε^τ_{t+1}, and S_{t+1}, yielding values for $E_t[\pi_{t+1}C^{-\sigma}_{t+1}]$, $E_t K_{1,t+1}$, $E_t K_{2,t+1}$, which reduces the above system to three equations in three unknowns. The (net) nominal interest rate is restricted to always be positive.

When solving the above system, the state vector and the decision rules are taken as given. The system is solved for every set of state variables defined over a discrete partition of the state space. This procedure is repeated until the iteration improves the current decision rules at any given state vector by less than some $\varepsilon = 1e - 8$.

Appendix B An Alternative Policy Process

Many authors have argued that monetary policy has been active since around 1979. Since our empirical estimates indicate two brief episodes of passive monetary policy after 1979, this section conducts a sensitivity analysis that adjusts the transition matrix to be consistent with an active monetary regime for the entire post 1979 sample. This exercise highlights that the general message of the paper, namely that fiscal shocks have important real effects even under AM/PF policy, carries into an environment with a more persistent active monetary policy.

Our empirical estimates indicate that there are a total of 28 quarters of passive monetary policy after 1979. Relabeling these periods as active monetary policy results in 44.2 percent of all periods having active monetary policy. There is no unique way of adjusting the transition matrix so that 44.2 percent of periods are active. However, increasing the persistence of the active monetary regime, instead of decreasing the persistence of the passive regime, is more consistent with the priors of many researchers that the U.S. has had active monetary policy since 1979. So, we adjust the transition matrix by increasing the transition probability of staying in the active regime, conditioning on being in the active regime, from .9505 to .9779.

To summarize the effects of a more persistent active monetary regime, tables analogous to those reported in the paper are computed (tables 4.9–4.12). The proportion of new debt backed by discounted surpluses increase in all regimes as the persistence of the active monetary regime increases. However, the primary differences that arise relative to the baseline specification occur under AM/PF policy. Across all time horizons, a more persistent active monetary regime diminishes the impacts fiscal shocks have on output and inflation. For example, the increase in all additional discounted output under AM/PF policy arising from a $1 tax reduction is 61 cents, compared to $1.02 under the baseline specification.

Table 4.9
Output Multipliers for Taxes Conditional on Regime. Uses the Alternative Policy Process That Makes Monetary Policy Active after the 1991 and 2001 Recessions

Regime	Fraction of New Debt Backed by PV of Taxes	$\frac{PV(\Delta y)}{\Delta \tau}$ after 5 Quarters	10 Quarters	25 Quarters	∞
AM/PF	.801	−.053	−.099	−.213	−.607
PM/PF	.588	−.512	−.683	−.758	−.760
PM/AF	.490	−.619	−.853	−.976	−.981

Table 4.10
Output Multipliers for Taxes, Unconditional. 80th Percentile Bands Based on 10,000 Draws. Uses the Alternative Policy Process That Makes Monetary Policy Active after the 1991 and 2001 Recessions

	$\frac{PV(\Delta y)}{\Delta\tau}$ after		
Initial Regime	5 Quarters	10 Quarters	25 Quarters
AM/PF	[–.062, –.066]	[–.107, –.667]	[–.218, –.959]
PM/PF	[–.172, –.174]	[–.192, –.512]	[–.249, –.655]
PM/AF	[–.314, –.317]	[–.447, –.799]	[–.802, –1.252]

Table 4.11
Cumulative Effect on Price Level of an *i.i.d.* Unanticipated Tax Cut of 2 Percent of Output. Uses the Alternative Policy Process That Makes Monetary Policy Active after the 1991 and 2001 Recessions

	$\%\Delta P$ after			
Regime	5 Quarters	10 Quarters	25 Quarters	∞
AM/PF	.166	.331	.798	5.128
PM/PF	.765	1.073	1.231	1.236
PM/AF	.942	1.364	1.620	1.633

Table 4.12
Cumulative Effect on the Price Level of an *i.i.d.* Tax Cut of 2 Percent of Output, Unconditional: 80th Percentile Bands Based on 10,000 Draws. Uses the Alternative Policy Process That Makes Monetary Policy Active after the 1991 and 2001 Recessions

	$\%\Delta P$ after		
Initial Regime	5 Quarters	10 Quarters	25 Quarters
AM/PF	[.166, .180]	[.331, 1.206]	[.798, 1.906]
PM/PF	[.673, .765]	[.837, 1.073]	[.542, 1.231]
PM/AF	[.943, 1.001]	[1.292, 1.546]	[1.621, 2.233]

Comment

Jordi Galí, Centre de Recerca en Economia Internacional (CREI) and NBER

1 Introduction

In their contribution to the present volume, Davig and Leeper (henceforth, DL) study the implications of variations over time in policy rules. More specifically, they analyze the equilibrium effects of exogenous random switches in the coefficients of monetary and fiscal policy rules, embedded in an otherwise conventional dynamic optimizing model with staggered price setting. Their motivation for the exercise is an empirical one: They estimate a Markov switching model for the two policy rules and find evidence of recurring changes in those coefficients. Most interestingly, the estimated changes in the policy rules involve "qualitative" changes in the nature of the regime in place, i.e., they imply a shift from an "active" to a "passive" monetary policy (or vice versa), as well as analogous (but not necessarily synchronous) shifts in the fiscal policy rule. When DL embed their estimated monetary and fiscal Markov switching processes in a calibrated new Keynesian model and analyze the implied equilibrium properties, they uncover a number of interesting results, some of which are summarized below.

Before we turn to some specifics of their analysis, I think it is important to stress the central, more general message of the DL exercise: Once we accept the possibility of a change in the policy regime (and the recognition of that possibility by agents in the model as a logical implication of the rational expectations assumption), a conventional fixed-regime equilibrium analysis, i.e., one that treats the regime in place *as if* it were to persist forever, may be highly misleading. The fact that the fixed-regime assumption is common-place in the macroeconomics literature is somewhat paradoxical, since one of the main stated objectives for the development of current generation of microfounded DSGE models was *precisely* to analyze the implications of policy regime changes.

That general message of the DL paper is illustrated by some of their results. Here are, in my opinion, the most significant ones:

- An equilibrium may exist and be unique even under a "doubly passive" or a "doubly active" policy regime, i.e., regimes which would imply, respectively, an indeterminate equilibrium or the non-existence of a stationary equilibrium, when modeled "as if" they were permanent. Thus, for instance, the empirical violation of the Taylor principle in the pre-Volcker era detected by several authors (including DL in the present paper) does *not* necessarily imply that the equilibrium in that period was indeterminate or subject to potential sunspot fluctuations, even if fiscal policy was simultaneously passive.
- Fiscal deficits resulting from changes in lump-sum taxes may be nonneutral, *even under a passive fiscal policy regime*. In other words, and using the authors' language, the mechanisms underlying the fiscal theory of the price level may be effective (to a lesser or greater degree) at all times. Equivalently, Ricardian equivalence may not hold even if the conditions under which it has been shown to hold (in a fixed-regime world) are operating in any given period.
- The dynamic effects of any shock that occurs when a given regime is in place are *not* invariant to the characteristics (or the likelihood) of other possible future regimes. It follows that the use of estimated impulse responses for the purposes of calibration of "fixed regime models" may be unwarranted, even if those impulse responses are estimated using data from a "stable regime" period.

All of those findings share a common feature, which DL refer to as *cross-regime spillovers:* The equilibrium properties of an economy under any given regime are "contaminated" by the characteristics of the other possible regimes and by the probability distribution describing the shifts in regime. In other words, once we admit that policy regimes are subject to change, a description of the current policy regime is not sufficient to characterize the equilibrium dynamics of the economy under that regime. One needs to know all possible regimes and the probability distribution describing the shifts among regimes over time.

Given the forward-looking nature of the models involved, combined with the assumption of rational expectations, that result may not be that surprising after all. But the fact that such a result is not surprising does not mean that it is not important or useful. In some sense it takes the logic of the Lucas' critique to a higher level: The properties of the equilibrium are shown to be a function of the "meta-regime" in place. As far as I know, DL are the first to analyze this phenomenon explicitly in the context of a modern, quantitative macro model.

The rest of this comment raises two caveats on DL's paper. The first has to do with the approach followed in analyzing the uniqueness of the equilibrium. The second deals with the empirical relevance of the assumption of recurring regimes.

2 Determinacy Analysis

One of the most striking findings in DL's paper is the claimed coexistence of a unique stationary equilibrium with periods characterized by "doubly passive" and "doubly active" policies. Unfortunately, as the authors themselves acknowledge, no formal proof of that claim is provided in the paper. Instead, it is based on the convergence of a numerical algorithm that searches for decision rules consistent with equilibrium conditions. The postulated rules contain a minimum set of state variables as arguments, but that set does not allow for "redundant" state variables, including sunspots. It is thus not obvious that the mere convergence of the algorithm to a set of decision rules guarantees that those rules are the only ones consistent with equilibrium. The authors' finding of algorithm divergence when solving for the equilibrium under a *fixed* PM/PM regime known to imply indeterminacy offers some comfort, but is no definitive proof.

An alternative approach, pursued by the authors in a companion paper in the context of a simpler model (Davig and Leeper 2005), involves log-linearizing the equilibrium conditions and determining whether the resulting Markov-switching model satisfies the analytical conditions for stationarity established in the relevant literature (see, e.g., Francq and Zaqoïan 2001). Let me illustrate that analytical approach (as well as a potential caveat) using a simple univariate example.

Suppose that the condition describing the equilibrium behavior of variable x_t is given by the expectational difference equation

$$E_t\{x_{t+1}\} = \phi_t x_t \tag{1}$$

where coefficient ϕ_t is possibly time-varying and where, for simplicity, we ignore the presence of a fundamental driving force. A stationary solution to the above equation always exists, and is given by $x_t = 0$ for all t. The condition for uniqueness of that stationary solution for the case of a constant AR coefficient ($\phi_t = \phi$ for all t) is well known:

The above solution is the only one that remains in an arbitrarily small neighborhood of the steady state whenever $|\phi| \geq 1$. If instead we have $|\phi| < 1$ we have an additional set of stationary solutions of the form

$$x_{t+1} = \phi x_t + \xi_{t+1}$$

where $\{\xi_t\}$ is an arbitrary random process (a "sunspot") satisfying the martingale-difference property $E_t\{\xi_{t+1}\} = 0$ for all t.

If we assume instead a Markov process for the AR coefficient ϕ_t things change considerably. For the sake of concreteness, let us assume a two-state process $\phi_t \in \{\phi_L, \phi_H\}$ where $0 < \phi_L < 1 < \phi_H$ and where the transition matrix is given by

$$P \equiv \begin{bmatrix} p_L & 1-p_L \\ 1-p_H & p_H \end{bmatrix}.$$

Any potential sunspot solution to (1) takes the form

$$x_{t+1} = \phi_t x_t + \xi_{t+1} \tag{2}$$

where $E_t\{\xi_{t+1}\} = 0$. Furthermore, and under our assumptions, that solution is generally taken to be an admissible equilibrium if it is stationary. Francq and Zaqoïan (2001) derive necessary and sufficient conditions for stationarity of Markov-switching ARMA processes of which (2) is a particularly simple case. Their condition implies that (2) may be nonstationary even if $\phi_L < 1$ (i.e., even if solution (2) would be stationary in the case of a fixed regime with $\phi_t = \phi_L$ for all t). Roughly speaking, this will be the case whenever ϕ_H is sufficiently larger than one and when the system spends enough time under the ϕ_H regime. In that case, solution $x_t = 0$ for all t will be the only stationary solution even if ϕ_t recurrently takes a value less than one.

The previous result corresponds to DL's claim that their model's equilibrium may be locally unique even if, recurrently, a regime characterized by passive monetary policy and passive fiscal policy becomes effective. Their finding thus seems consistent with analytical results from the literature on Markov-switching processes. One would feel more confident about DL's uniqueness result if the latter was cross-checked using the analytical conditions derived in that literature.

That confidence may, however, be unwarranted in light of the findings of a recent paper by Farmer, Waggoner, and Zha (2006; FWZ, henceforth). FWZ show that a regime-switching expectational difference equation may have a multiplicity of solutions as long as one of the recurrent regimes implies such a multiplicity when considered in isolation, and as long as the economy operates under that regime a sufficiently large fraction of time. That result holds independently of the value taken by ϕ_H. For the particular case of the simple univariate model (1) above, the FWZ solution takes the form

$$x_t = 0 \qquad \text{if} \qquad \phi_t = \phi_H > 1 \tag{3}$$

$$x_t = \frac{\phi_L}{p_L}\, x_{t-1} + \gamma_t \quad \text{if} \qquad \phi_t = \phi_L < 1$$

where $\{\gamma_t\}$ is an arbitrary *exogenous* martingale-difference process. Notice that $\{x_t\}$ reverts back to the steady state recurrently, with probability one as long as $p_H < 1$. Furthermore, as shown by FWZ the assumption $|\phi_L| < \sqrt{p_L}$ is sufficient to guarantee stationarity of the global solution. Hence multiplicity of stationary equilibria appears to arise for a broad range of parameter values, as long as a regime with $\phi_L < 1$ emerges recurrently. Whether a version of the FMZ result carries over (at least locally) to a non-linear model, like the one considered by DL in the present paper is not clear. If it did, one of the key findings of the DL paper, which currently relies exclusively on the convergence of a numerical algorithm, would unfortunately turn out to be wrong.

How can one reconcile the FMZ finding with the *possibility*, under certain conditions, of a unique equilibrium, as implied by the Francq and Zaqoïan (2001) result discussed above? My conjecture is that the analysis in the latter paper (and in the related literature) requires that the error term in the regime-switching process (2) is truly exogenous (as assumed in conventional ARMA models). By contrast, the FMZ solution (3) implies

$$\xi_t = -\phi_{t-1} x_{t-1} \quad \text{if} \quad \phi_t = \phi_H > 1$$

$$\xi_t = \left(\frac{\phi_L}{p_L} - \phi_{t-1} \right) x_{t-1} + \gamma_t \quad \text{if} \quad \phi_t = \phi_L < 1$$

Notice that the previous $\{\xi_t\}$ process satisfies the martingale difference property $E_t\{\xi_{t+1}\} = 0$, but it is *not* exogenous, depending instead on lagged values of ϕ_t and x_t, as well as on the exogenous sunspot shock γ_t. Note that this kind of solution is not allowed for by DL's solution method, and it is also inconsistent with regime-switching models driven by exogenous shocks.

3 Empirical Relevance

In the introduction to their paper, DL point to the assumption of a fixed policy regime commonly made in modern analyses of fiscal and monetary policy as possibly being the least plausible among the many assumptions underlying that literature. In spite of that, there are many reasons for the prevalence of that assumption: It is convenient, it has a long tradition in economic theory (e.g., in the literature on the effects of capital income taxation), it allows for comparative dynamics exercises, and it facilitates the evaluation of a model's predictions. DL's analysis, however, emphasizes an important shortcoming of the fixed-regime fiction: The fact that it assumes away the possibility of cross-regime spillovers.

Of course, one may find DL's case for an explicit modeling of the possibility of regime changes fully persuasive without necessarily sympathizing with the specific model of regime changes postulated in the paper. i.e., one characterized by exogenous, *recurrent* switches between a finite number of policy regimes. Given that any two different policy regimes are likely to be rankable in terms of their desirability, it is hard to understand why policymakers would periodically switch to the least desirable of those regimes. Furthermore, the exogenous nature of those switches represents a renewed emphasis on *policy randomization*, away from the emphasis on the endogenous component of policy found in the recent literature.

While few economists would question the empirical relevance of regime change, I conjecture that most would view non-recurrent changes as more likely. Two examples of relevant non-recurrent regime changes come to mind:

- Anticipated "permanent" regime changes: including a stabilization program aimed at ending high inflation, or the abandonment of an unsustainable exchange rate peg
- A gradual variation in the policy regime, resulting either from learning (in an unchanged environment) or from adjustment of optimal responses to changes in the environment.

Any rational expectations model that incorporates the possibility of regime changes of that kind is likely to display the central property of DL's model, namely, the presence of cross-regime spillovers, without having to rely on the less plausible notion of recurrence.

4 Concluding Comments

DL's paper is ambitious and important. Taking it seriously leads to questioning some results previously thought of as well established (e.g., the need to satisfy the Taylor principle in order to guarantee a unique equilibrium). Unfortunately, one key result in the paper (the global uniqueness of the equilibrium in DL's calibrated model) has not yet been established in a rigorous way. That notwithstanding, the importance of cross-regime spillovers emphasized by the authors is somewhat orthogonal to the issue of indeterminacy and is likely to be relevant even in the context of switches among regimes which, when considered in isolation, are associated with a unique equilibrium. Similarly, the significance of those cross-regime spillovers does not hinge on the questionable Markov switching formalism adopted to characterize regime change in the present paper. In my opinion, much of the value added in DL's paper and the significance of their contribution lies in providing a useful illustrative model of the potential importance of cross-regime spillovers, rather than a model that one should take seriously as a description of post-war U.S. fluctuations and its sources.

Acknowledgments

I am grateful to Roger Farmer and Tao Zha for their comments.

References

Davig, T., and E. Leeper. 2005. "Generalizing the Taylor Principle." NBER Working Paper no. 11874. Cambridge, MA: National Bureau of Economic Research.

Farmer, R., D. Waggoner, and T. Zha. 2006. "Indeterminacy in a Forward-Looking Regime Switching Model." Unpublished manuscript.

Francq, C., and J-M Zaqoïan. 2001. "Stationarity of Multivariate Markov-Switching Models." *Journal of Econometrics* 102: 339–364.

Comment

***Christopher Sims**, Princeton University and NBER*

1 Introduction

This is an important and thought-provoking paper. Its basic idea, that long-run fiscal considerations are central to understanding price and, in a sticky-price world, output fluctuations, is surely correct. In fact it is the ability of fiscal policy to create a temporary imbalance between the value of government liabilities at current prices and their backing by future tax commitments that is the fundamental source of any impact of fiscal policy on demand. We see in political rhetoric and popular discussion that the extent to which current tax and spending policies are thought appropriately to respond to the amount of outstanding debt or deficits changes over time, and we need to account for this in our thinking about monetary and fiscal policy. The paper estimates a model of time-varying fiscal and monetary policy and embeds it in a calibrated equilibrium model to demonstrate that the estimated effects are important.

The paper makes some dubious assumptions, though, and leaves some important questions open.

2 Money, Simultaneity

In a recent paper (2006) Tao Zha and I find no evidence of passive monetary policy over the same period studied here by Davig and Leeper. As Davig and Leeper point out, we allow monetary policy change along dimensions that are in some ways more restrictive than the Davig and Leeper setup. However in one important way we are less restrictive: We allow the policy reaction function to include a monetary aggregate. Why is this important? The general form of the "Taylor principle" is that the sum of coefficients on percentage changes in *all nominal* variables, not just inflation, on the right-hand side of the reaction function must exceed one. If the true reaction function has an important role for M, but we omit it, other nominal variables are drafted to serve as error-ridden proxies for it. That their coefficients then sum to less than one is unsurprising. Also, as Davig and Leeper point out, reaction function estimation is rife with simultaneity issues. Distinguishing between reaction functions and the Fisher equation can be difficult. Money in the reaction function can help make the distinction from the Fisher relation, but it leaves us still with a simultaneity issue because we need to avoid contamination with the money demand equation. This paper follows much of the literature in assuming away simultaneity bias in a specification without money. Despite the interesting story-telling this allows, I am not convinced.

A similar issue arises with fiscal policy. Davig and Leeper separate government's revenue net of transfers from its purchases, but only in the sense that they enter purchases on the right hand side of a revenue equation, treating it as exogenous. Political rhetoric in the 1980s and again this century has emphasized controlling debt and deficits by controlling expenditures. Not all of the effort to control expenditures has focused on transfer payments. The estimates show the coefficient on purchases in the fiscal equation increasing sharply when the coefficient on debt drops. We really can't be sure what is going on here without more careful treatment of dynamics and recognition that purchases are themselves likely to be responsive to debt and deficits.

The paper argues that regime switches can help with identification. This is true in principle, but it depends on the maintained assumption that we know something about when regimes switched, or in which equations switches were likely to have occurred. The paper simply assumes that what coefficient changes have occurred have been in the policy behavior equations and that there are no simultaneity problems that would lead to parameter change in the private sector being confounded with instability in the policy rule. The inflation of the 1970s and high interest rates of the 1980s led to rapid financial innovation and deregulation of the mortgage market. That these developments changed the private sector's reaction to monetary policy actions seems at least as likely as that the Federal Reserve realized only in 1980 that it was responsible for controlling inflation.

The paper is a technical accomplishment that should provide a basis for further research, but the complexity of the task it sets itself forces a very ascetic specification for the policy rules. This is quarterly data, yet the policy rules are entirely contemporaneous, except for a one-quarter lag on real debt in the fiscal equation and the use of four-quarter averages for debt and inflation. It is well documented that variances of disturbances changed over this period. If the model specification has overly restrictive dynamics or lists of variables, the shifting disturbance variances will result in shifting specification error magnitudes and an illusion of parameter change.

3 Fit

It ought to be standard in empirical work to check the fit of the estimated model. There is only one way to do this—construct an alternative model, usually taken to be a less restricted model, and compare the two models' abilities to explain the data. This amounts to calculating Bayesian posterior odds on the models, or some approximation thereto. In many recent papers in the literature this has been done by using reduced form BVARs as standards of fit. We do not see any such check of fit in this paper. It is likely, because the specification has necessarily been so tightly parameterized, that the model does not fit as well as a BVAR. But we would like to know what the gap is. The paper shows plots of actual data vs. one-step ahead model predictions. While this kind of plot is common in the literature, it is uninformative. Close, in the eyeball sense, tracking of serially correlated data like those in figures 4.1 and 4.2 is easily achieved with naive no-change forecasts. The paper assures us that the plots shown are "easily comparable" to those achieved in an earlier paper by Taylor, but we are given no direct evidence of this, even in the form of root mean squared error. We are not even told how the predictive accuracy of this model compares to that of a naive no-change forecast.

4 Existence and Uniqueness

Farmer, Waggoner, and Zha (2006) discuss existence and uniqueness in linear regime-switching models, pointing out that in such models it is possible for the class of probability-one bounded solutions with bounded inputs and the class of stationary, bounded expectation solutions under bounded inputs to be different. This is not true in purely linear models with no regime-switching. In the paper at hand, Davig and Leeper compute directly a set of nonlinear decision rules that constitute a stationary solution to their model, and argue from numerical results that it is at least locally, and probably globally, unique.

The paper does not claim to have proved that its solutions are unique, however, and this is an important gap. There is no argument based on economic behavior to choose between almost surely bounded and bounded-in-expectation solutions in linear models. In a fully specified general equilibrium model such paths may or may not be ruled out by considering feasibility or transversality conditions.[1] Davig and Leeper show us how conclusions about the effects of monetary and fiscal policy are affected by regime switching in one equilibrium of their model. But if the equilibrium is not unique, these results are not really a prediction of their model. The model would in that case imply that other results are also possible, and it could be these that matter for actual applications.

Often uniqueness problems arise because there are equilibria in which agents pay attention to an expanded state vector, so that elements of this vector matter to the solution, even though there are also equilibria in which they don't matter. In particular, indeterminacy of the time path of prices often involves dependence of current prices or inflation on past prices or inflation, even though there are equilibria in which there is no such dependence. Sometimes such equilbria are pruned off by appeal to McCallum's "minimum state vector" solution. There is no justification within models for this way of eliminating solutions. In some classes of models it can be claimed that the MSV is "learnable," while other solutions are not. But this rests on assuming that learning is by least-squares dynamic regressions. Agents would be quite irrational to use such learning rules if they believed that the explosive solutions the MSV solution rules out in these cases were in fact possible. In an economy with a history of high inflation episodes, agents may "learn" that once inflation starts rising, one should extrapolate accelerating inflation, rather than projecting future inflation as an average of the past. Such agents will quickly "learn" explosive equilibria. DL solve their model with an hypothesized state vector, which may well be a "minimum" state vector, but have not proved that there are no other equilibria with additional nominal history-dependence.

5 Long Rates

The paper refers to a point that has been emphasized by Cochrane, but has been noted in a number of FTPL papers: If the government has long as well as short debt, it can change the real value of outstanding nominal debt without changing the price level. The idea is that, if expected future primary surpluses rise, the resulting deflationary impact, as agents try to trade real goods for nominal government liabilities, can be offset by a decline in nominal rates, because this increases the market value of long debt. The model in this paper does not include this mechanism, and this could be important.

6 Endogenous Switching

Most people who think that policy changed dramatically and permanently in late 1979 in the United States believe that it did so because inflation appeared to be running out of control, not because an independently evolving switching process happened to call for a change at that date. Davig and Leeper note that this could be important and that they don't allow for it. But for fitting data and estimating regime parameters, this may matter less than you'd think. There are a rather small number of estimated policy regime transitions. If we were to allow endogenous switching, our estimates of how the parameters of the transition probability matrix P depend on the state would necessarily be imprecise, and thus would have little impact on estimates of regimes.

In this paper the assumption of exogenous regime switching may have a big impact not on estimates of regimes but on calculations of impulse responses in the equilibrium model. For example, we may believe (as the paper in fact suggests, informally) that if real debt gets high enough, an active fiscal policy becomes a very high probability, because of political economy bounds on tax rates. It is one of the lessons of the paper that beliefs about what will happen in fairly remote contingencies in the fairly distant future can affect the way the economy behaves today. It would be interesting to see how sensitive this paper's exercises with the equilibrium model might be to modifying the policy rules so that they coincide with those estimated near the model steady state, but tend endogenously to switch toward active fiscal policy at high levels of debt and/or toward active monetary policy at high levels of inflation and low debt. Estimation of such a specification would be very difficult, but solving such an amended model using the methods of this paper appears feasible.

7 Conclusion

This paper has made some by and large well chosen simplifying assumptions in order to take a first step in a difficult area. The results are interesting. While the simplifying assumptions mean we should treat the substantive conclusions cautiously, the possibility of relaxing some of those assumptions opens up research possibilities.

Endnote

1. Simple examples of stable and unstable paths that are and are not equilibria in monetary/fiscal models are worked out in Sims (1994).

References

Farmer, R. E. A., D. F. Waggoner, and T. Zha. 2006. "Indeterminacy in a Forward Looking Regime Switching Model." Discussion paper, Federal Reserve Bank of Atlanta.

Sims, C. A. 1994. "A Simple Model for Study of the Determination of the Price Level and the Interaction of Monetary and Fiscal Policy." *Economic Theory* 4: 381–399.

Sims, C. A., and T. Zha. 2006. "Were There Regime Switches in US Monetary Policy?" *American Economic Review* 96(1): 54–81.

Discussion

Andrew Levin remarked that the results of the paper implied that Alan Greenspan's policy in 2002–2003 was essentially the same as the policy of William G. Miller in 1977–1978. Levin felt that most observers would agree that this was implausible and that this illustrated a pitfall in the recurring regime setup employed by the authors.

Levin remarked that he was sympathetic to the main message of the paper that the possibility of an active fiscal regime matters even during periods when the fiscal regime is passive. Levin noted the parallel between this result and the Peso Problem literature. He took the example of Sweden, New Zealand, and Canada, all of which have been in an inflation targeting regime for about 15 years and anticipate that they will continue to target inflation for the next 15 years. He noted that it is nevertheless possible that one of these countries will experience a war or some other type of crisis that leads it to switch to an active fiscal policy and perhaps even a passive monetary policy. He felt that it was important to study how this type of Peso Problem affects price determination and the real economy today.

Greg Mankiw remarked that while this paper was an exercise in positive economics, he felt that it might point the way towards a new way of doing normative economics. He noted that ever since the Lucas critique, there has been a disconnect between academics who think in terms of policy rules and policy makers who think in terms of discretionary actions. He felt that this type of analysis had the potential to bridge the gap between these two world views. He suggested that policy makers might perhaps be thought of as deciding whether to switch regimes with the knowledge that down the road a subsequent policy maker might switch back.

Michael Woodford remarked on the assumption made by the authors that policy regime switches were exogenous. He said that one type of regime switch where this was perhaps a plausible assumption was the change in regime that often accompanied the switch between peace time and war time. He noted that war time has been associated with policies that might best be characterized by the active fiscal-passive monetary regime while peace time regimes were better described by the passive fiscal-active monetary regime. He then noted that if this description was realistic and a researcher wanted to analyze the behavior of inflation and output during war time, then assuming that the war time regime was permanent would be seriously misleading. The analysis of the paper showed how to avoid making such an assumption.

Martin Eichenbaum followed up on Woodford's comment by citing work by Ramey and Shapiro where they seek to identify exogenous military events that lead to large changes in government purchases. He noted that the response of the U.S. government after 9/11 was very different from the typical response found by Ramey and Shapiro to a large military event. He felt that this suggested that there existed at least two war time fiscal regimes.

Robert Gordon agreed that the fiscal regimes in different wars were different. He noted that during WWI, the price level in all the major combatant countries doubled or tripled, yet no countries had employed price controls. He contrasted this with the experience during WWII when price controls had been put on right away, allowing government debt to become a free variable. He cited John Kenneth Galbraith's argument that the rationale for price controls during a war was that the sole goal in wartime was the maximization of production and that this was made possible by fiscal deficits. He then noted that the experience during the Korean War had been very different from either of the World Wars. Taxes had been raised before the government started spending and the United States never ran big deficits during that war. He suggested that each of these regimes represented learning from the past one with different outcomes.

Daron Acemoglu asked whether the features of the data that led the authors to estimate frequent regime changes could be due to non-linearities. He remarked that if the answer was "yes," then the conclusions of the previous literature about determinacy of equilibria should be questioned much more severely since they would then be an artifact of assuming a linear policy rule rather than more general policy rules. Eric Leeper responded that he felt this issue was a serious one and that the answer was an open issue.

Robert Gordon underlined Christopher Sims' caution about explosive inflation. He remarked that when a country has a history of explosive inflation, like Argentina and Brazil, it is unreasonable to expect expectations to be formed with autoregressions. He suggested that in these countries, agents look to the behavior of the fiscal authorities when they form expectations about inflation. He said that when Argentina tried to peg its currency to the dollar, its state and local governments were spending money without restraint. He felt that astute observers realized that Argentina could not possibly continue to peg to the dollar for long, and indeed that regime collapsed.

Leeper took exception to Jordi Galí's comment that recurrence of regimes was implausible. He emphasized that the argument that tax cuts are the best way to retire debt just keeps coming back. He furthermore felt there was no reason to think that this argument would not continue to come back, suggesting that recurrence was plausible for fiscal regimes. He argued that economists have essentially no understanding of what determines fiscal policy and that this justified to some extent their treatment of regime switches as being exogenous.

Regarding monetary policy, Leeper felt that the notion that the Federal Reserve was in an absorbing state had become an article of faith among economists. He suggested that we had dodged a bullet in Ben Bernanke's appointment as Chairman of the Fed, but that there would be many more bullets to dodge in order to stay in that absorbing state. He thought it was possible that the probability of going back to a passive monetary policy was not as high as their estimates suggested, but that this probability was certainly not zero and it was misleading to assume that it was zero as much work in the recent literature has done.