Discussion of Andrew Levin, Volker Wieland, and John C. Williams, 'Are Simple Monetary Policy Rules Robust to Model Uncertainty?'*

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1. General Remarks

A key research objective in monetary economics is the identification of monetary policy rules with good operating characteristics. The primary strategy for achieving this objective is to construct quantitative monetary models and use them as laboratories for descriminating between alternative candidate rules.[1] A difficulty with this strategy is that economists have not yet converged on a single model. As a result, to build a case for a particular policy rule, it is not enough to show that it works well in just one model. After all, if the world is better described by some other model, it could still be that the policy rule might not perform well in practice. This is why robustness is an important characteristic for a policy rule to satisfy. That is, it must perform well across a variety of empirically plausible models.

The paper by Levin, Wieland, and Williams represents an outstanding contribution to this research program. It examines the performance of a class of

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[1] An alternative, complementary, strategy is implemented in the paper by John Taylor in this volume. It is based on examining the historical evidence on how well different policy rules have worked in practice.

monetary policy rules in four large-scale models. The performance criteria they focus on include the variance of output and inflation. The class of rules considered have the following representation:

$$r_t = c + \rho r_{t-1} + \alpha \pi_t + \beta y_t, \tag{1.1}$$

where π_t is the annualized rate of inflation, r_t is the annualized Federal Funds rate and y_t is the log deviation of output from trend. This policy rule is often referred to as a Taylor rule. The key conclusions are as follows:

1. There is reason to be optimistic that a suitably parameterized Taylor rule can be found which can serve as a useful guide to the conduct of monetary policy.

2. Complicated rules are less robust across models than simple rules.

3. There are gains to increasing ρ.

4. Adding lags and other variables does not help much.

5. Whether one includes π_t, y_t or π_{t-1}, y_{t-1} in the policy rule makes little difference.

Of these, the first is the most important. This finding is consistent with the outcome of other simulation experiments reported in this volume. Moreover, the conclusion also appears to be consistent with informal observations. For example, John Taylor's contribution to this volume makes a compelling case that the relatively good US inflation experience of the past two decades reflects the Fed's adoption of a version of (1.1) with large values of α and β.

The second result is also of interest. The hunch that a result like 2 is true is an important motivation behind the current widespread interest in simple rules. However, we are not aware that anyone has attempted to formally check out this hunch before. The idea is the more complicated a rule, the more its parameters need to be 'tuned' to the idiosyncracies of a given model to make it perform well in that model. But this very tuning process may render the rule incompatible with the fine details of other models, giving rise to poor performance in those models. Presumably, the notion that complexity is the enemy of robustness cannot be established as a theorem, so it is interesting to see how it fares in quantitative models with solid empirical foundations. The remaining results are interesting at a practical level. Significantly, the third result is also a finding of other papers. The fourth result is consistent with the authors' finding that replacing π_t by $E_t\pi_{t+1}$ does not help much, since including $E_t\pi_{t+1}$ is implicitly a way of adding lags and other variables. The last result is also of importance in view of lags in data collection that pose practical problems for implementing (1.1) in real time.

2. The Taylor Rule in a Limited Participation Model

The Levin, Wieland, and Williams paper is sure to be an important reference for some time to come. The authors have put in an enormous amount of painstaking, scholarly effort, with instructive results. They are to be applauded. In our discussion, we will assess the robustness of the authors' findings to a fifth model, the one developed in Christiano, Eichenbaum and Evans (1998) (CEE).

The reason looking at the CEE model may serve as a useful robustness check is that it is in some respects very different from the four models considered in the Levin, Wieland, and Williams paper and, indeed from all the other models analyzed in this conference. For example, our model does not assume that prices are sticky. Of course, to get monetary policy to matter at all, some kind of rigidity is needed. The rigidity we adopt is a version of the financial market friction suggested by Lucas in his article on limited participation models. Although prices are not sticky by assumption in our model, they do nevertheless turn out to be sticky as an equilibrium phenomenon.[2]

We reassess the authors' conclusions, primarily #1, through the lense of the CEE model. We find it useful in our analysis to posit another rule as a benchmark for comparison. The rule that we use for this purpose is the $k\%$ rule. This rule specifies that money growth proceeds at a constant pace, independent of developments in the economy.

What are the sorts of pitfalls that can interfere with the good performance of a monetary policy rule? There are at least two:

1. The rule could itself be a source of economic instability.

There are two possibilities:

[2] This is a theme emphasized in Christiano, Eichenbaum and Evans (1997,1998).

(i) The nonstochastic steady state equilibrium may be indeterminate. This can give rise to instability of two types:

a. Real quantities may fluctuate in response to extraneous, sunspot shocks.

b. Real quantities may overreact to fundamental shocks.

(ii) The nonstochastic steady state may be unstable. This happens when there exist no equilibrium paths converging into nonstochastic steady state for initial conditions arbitrarily close to steady state.

2. The central bank may not have the commitment technology to actually implement the policy rule in practice.

We show that these two pitfalls are very real possibilities in our model economy. Regarding the first one, we show that there are large regions of the parameter space in which a monetary policy regime characterized by (1.1) makes the economy vulnerable to suboptimal fluctuations in real and nominal variables. After exploring several variants of (1.1), we find that there is none that completely eliminates this risk. Still, we find that the chances are smallest when ρ and α are large and β is small.

Others, including Rotemberg and Woodford in this volume and Clarida, Gali and Gertler (1997), have also encountered indeterminacy and explosiveness working with policy rules like (1.1).[3] However, our results differ from theirs in at least two ways. First, in our model, the region of the parameter space in which indeterminacy or explosiveness occurs when the monetary authority pursues an interest rate rule like (1.1) appears to be larger. Second, the likelihood of indeterminacy or explosiveness is increased, the more aggressively monetary policy reacts to output, i.e., the larger is β. By contrast, Levin, Wieland, and Williams report that they never encounter indeterminacy or explosiveness. Others such as Rotemberg and Woodford in this volume and Clarida, Gali, and Gertler (1997) do encounter these problems, but over a smaller region of the parameter space. Significantly, the likelihood of indeterminacy and explosiveness problems in these models is typically reduced the *larger* is the value of β. Moreover, researchers increasingly are reporting the recommendation that β be set rather large. It is

[3]Benhabib, Schmitt-Grohe and Uribe (1998) have written on this recently too. Unfortunately, we received their paper too late to incorporate it into our comment.

of interest to understand what are the key model features that account for these differences in results.

We conjecture that the key features which differentiate our model from the others lies in the mechanisms by which higher expected inflation impacts on the economy. Other models, following the IS-LM tradition, emphasize that higher anticipated inflation leads to a reduction in the real rate of interest, which in turn results in a rise in output and actual inflation by stimulating the investment component of aggregate demand. It is not surprising that in these models, aggressive increases in interest rates when inflation and/or output rises can prevent higher expected inflation from being self-fulfilling.

In our model, higher anticipated inflation induces households to substitute out of cash deposits in the financial sector and towards the purchase of goods. The resulting shortfall of cash in the financial sector puts upward pressure on the nominal rate of interest. If α in the Fed's policy rule were small, it would have to inject liquidity into financial markets in order to resist the rise in the interest rate. This expansion of liquidity would produce the increase in inflation that people anticipated. It is therefore not surprising that we obtain a result similar to one found for existing models: a large value of α reduces the likelihood that expectations of inflation can be self-fulfilling. However, unlike the existing literature, our model also suggests that a large value of β can actually *increase* the likelihood of indeterminacy. That is because the rise in the interest rate that occurs with a rise in inflation under the Fed's policy rule also produces a reduction in output. With a large β, that fall in output operates to offset the Fed's policy of raising the interest rate when $\alpha > 0$. In effect, raising β cancels out the indeterminacy-fighting properties of a high value of α. Finally, a large value of ρ can be helpful in reducing the likelihood of indeterminacy by amplifying increases in the interest rate.

The second pitfall refers to the fact there may be states of the world in which it is politically infeasible to implement the policy action dictated by (1.1). For example, an interest rate rule which reacts aggressively to inflation could require raising the interest rate after a supply shock which drives up prices and reduces output. Raising rates at a time when output is already low might be viewed as producing unacceptably large social costs. That this possibility may be of more than academic interest is suggested by the US experience in the 1970s, when there was an acceleration in inflation. Statements by Arthur Burns, the Federal Reserve chairman at the time, indicate that it was not out of ignorance about the connection between money and inflation that he failed to raise interest rates in the 1970s. He claimed that, instead, it was his fear of the social consequences of such an action that prevented him from implementing a high interest rate policy.[4] We display a version of our model economy, in which there would be substantial pressure to deviate from a policy rule like (1.1) during a supply shock-induced recession. The increased welfare gains from deviating to a $k\%$ rule at that time are the equivalent of about 0.3% of consumption, forever. To get a sense of the magnitude of this, it corresponds roughly to the amount the federal government spends on the administration of justice, or on general science, space, and technology.[5] This is a substantial amount. These considerations make one wonder whether the Fed would have been able to resist the pressure to deviate from a rule like (1.1), and be accommodative if instead of dropping in 1986, oil prices had risen.

In sum, our analysis provides somewhat less cause for optimism about the authors' conclusion #1. Our less optimistic view reflects differences in the models analyzed. The authors report that in their model, they did not encounter the possibility of indeterminacy or explosiveness. So, a final assessment of the authors' conclusion #1 hinges on which of these models is a better approximation to the data. We don't have an answer to that question yet.

The next two sections present the quantitative exercises which are the basis for the conclusions just summarized.

[4] An excerpt from a speech by Arthur Burns in 1977 summarizes views that he repeated often during his tenure as chairman of the Federal Reserve: 'We well know–as do many others–that if the Federal Reserve stopped creating new money, or if this activity were slowed drastically, inflation would soon either come to an end or be substantially checked. Unfortunately, knowing that truth is not as helpful as one might suppose. The catch is that nowadays there are tremendous nonmonetary pressures in our economy that are tending to drive costs and prices higher....If the Federal Reserve then sought to create a monetary environment that seriously fell short of accommodating the nonmonetary pressures that have become characteristic of our times, severe stresses could be quickly produced in our economy. The inflation rate would probably fall in the process but so, too, would production, jobs, and profits. The tactics and strategy of the Federal Reserve System–as of any central bank–must be attuned to these realities.' For additional discussion of Burns' (1978) speeches, see Chari, Christiano and Eichenbaum (1998).

[5] The preliminary estimate for 1997 of consumption of nondurable goods and services in the 1998 Economic Report of the President is \$4.8 trillion, so that 0.3% of this is \$16 billion. The federal expenditures in fiscal year 1997 on general science, space, and technology was \$17 billion, an on the administration of justice it was \$20 billion.

3. Model

In this section, we describe the model used in our analysis and we present some empirical evidence in its favor.

We examine the operating characteristics in our model of the following three variants on (1.1):

$$r_t = c + \rho r_{t-1} + (1-\rho)\left[\alpha E_t \pi_{t+1} + \beta y_t\right], \text{ (Clarida-Gali-Gertler)}$$

$$r_t = c + \rho r_{t-1} + \alpha \pi_t + \beta y_t, \text{ (Generalized Taylor)}$$

$$r_t = c + \rho r_{t-1} + \alpha \tilde{\pi}_{t-1} + \beta y_{t-1}, \text{ (Lagged Taylor)}$$

As before, r_t is the (annualized) nominal rate of interest that extends from the beginning of quarter t to the end of quarter t. Also, $\pi_t = log(P_t) - log(P_{t-1})$, $\tilde{\pi}_t = log(P_t) - log(P_{t-4})$, and $y_t = log(Y_t)$, after a trend has been removed. We refer to the above as the Clarida, Gali, and Gertler (1997) (CGG), the Generalized Taylor (GT) and Lagged Taylor (LT) policy rules, respectively.

We study the performance of these three rules in the CEE model. A detailed discussion of the model appears in CEE, and so we describe it only very briefly here. Apart from two modifications, it is basically a standard limited participation model. One modification is that, in addition to having a technology shock, it also has a money demand shock. Traditionally, an important rationale for adopting an interest rate targeting rule was to eliminate the effects of money demand shocks from the real economy (see, for example, Poole (1970).) So, if anything, including them should bias things in favor of the interest rate targeting rule. A second difference is that, although there is still a monetary authority on the sidelines transferring cash into and out of the financial system in our model economy, those transfers are endogenous when the monetary authority conducts its operations with the objective of supporting an interest rate targeting rule.

The representative household begins period t with the economy's stock of money, M_t, and then proceeds to divide it between Q_t dollars allocated to the purchase of goods, and $M_t - Q_t$ dollars allocated to the financial intermediary. It faces the following cash constraint in the goods market:

$$Q_t + W_t L_t \geq P_t \left(C_t + I_t\right),$$

where I_t denotes investment, C_t denotes consumption, L_t denotes hours worked, and W_t and P_t denote the wage rate and price level. The household owns the stock of capital, and it has the standard capital accumulation technology:

$$K_{t+1} = I_t + (1 - 0.02)K_t.$$

The household's assets accumulate according to the following expression:

$$M_{t+1} = Q_t + W_t L_t - P_t (C_t + I_t) + R_t(M_t - Q_t + X_t) + D_t + r_t K_t,$$

where X_t is a date t monetary injection by the central bank and R_t denotes the gross rate of return on household deposits with the financial intermediary. Also, D_t denotes household profits, treated as lump sum transfers, and r_t is the rental rate on capital. An implication of this setup is that the household's date t earnings of rent on capital cannot be spent until the following period, while its date t wage earnings can be spent in the same period. As a result, inflation acts like a tax on investment. The household's date t decision about Q_t must be made before the date t realization of the shocks, while all other decisions are made afterward. This assumption is what guarantees that when a surprise monetary injection occurs, the equilibrium rate of interest falls, and output and employment rise. To assure that these effects are persistent, we introduce an adjustment cost in changing Q_t, $H_t = H\left(\frac{Q_t}{Q_{t-1}}\right)$, where H_t is in units of time, and H is an increasing function.[6] The household's problem at time 0 is to choose contingency plans for C_t, I_t, Q_t, M_{t+1}, L_t, K_{t+1}, $t = 0, ..., \infty$ to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t, H_t), \; U(C, L, H) = log\left[C - \psi_0 \frac{(L+H)^{(1+\psi)}}{1+\psi}\right],$$

subject to the information, cash, asset accumulation and other constraints. Here, $\psi = 1/2.5$, $\beta = 1.03^{-.25}$, and ψ_0 is selected so that $L_t = 1$ in nonstochastic steady state.

Firms must finance J_t of the wage bill by borrowing cash in advance from the financial intermediary, and $1 - J_t$ can be financed out of current receipts. The

[6] To assure that the interest rate effect is persistent, we introduce a cost of adjusting Q_t :

$$H\left(\frac{Q_t}{Q_{t-1}}\right) = d\left\{\exp\left[c\left(\frac{Q_t}{Q_{t-1}} - 1 - x\right)\right] + \exp\left[-c\left(\frac{Q_t}{Q_{t-1}} - 1 - x\right)\right] - 2\right\}$$

where x denotes the average rate of money growth. We set $d = c = 2$ and $x = 0.01$.

random variable, J_t, is our money demand shock, and it is assumed to have the following distribution:

$$log(J_t) = 0.95 log(J_{t-1}) + \varepsilon_{J,t},$$

where $\varepsilon_{J,t}$ has mean zero and standard deviation 0.01. All of the rental payments on capital can be financed out of current receipts. This leads to the following first order conditions for labor and capital:

$$\frac{W_t\left[R_t J_t + 1 - J_t\right]}{P_t} = \frac{f_{L,t}}{\mu},\ \frac{r_t}{P_t} = \frac{f_{K,t}}{\mu},$$

where $\mu = 1.4$ is the markup of price over marginal cost, reflecting the existence of market power. Also, $f_{i,t}$ represents the marginal product of factor i, $i = L, K$, and

$$f(K_t, L_t, v_t) = exp(v_t) K_t^{0.36} L_t^{0.64},$$

where

$$v_t = 0.95 v_{t-1} + \varepsilon_{v,t},$$

and $\varepsilon_{v,t}$ has mean zero and standard deviation 0.01.

Finally, we specify monetary policy in four ways. In the first, money growth is purely exogenous, and has the following second order moving average form:

$$x_t = x + 0.08\varepsilon_t + 0.26\varepsilon_{t-1} + 0.11\varepsilon_{t-2},$$

where ε_t is a mean zero, serially uncorrelated shock to monetary policy and $x = 0.01$. This representation is Christiano, Eichenbaum and Evans (1998)'s estimate of the dynamic response of M1 growth to a monetary policy shock, after abstracting from the effects of all other shocks on monetary policy. Other representations of monetary policy analyzed here include the CGG, the GT and the LT rules presented above. In these cases, the response of x_t to nonmonetary shocks is endogenous, although we preserve the assumption throughout that $Ex_t = x$.

Figure 1 presents the dynamic response of the model's variables to an ε_t shock in period 2. The percent deviation of the stock of money from its unshocked growth path is displayed in panel c. The magnitude of the shock was chosen so that the money stock is eventually up by 1 percent. Panels a, b and f indicate that the impact effect on output of the monetary policy shock is so great that the price response is nil. Afterward, the price level rises slowly, and does not reach its steady state position until around one year later. This sluggish response of the price level is what we had in mind in the introduction when we reported that even though we do not assume sticky prices, they nevertheless exhibit stickyness as an equilibrium phenomenon. Next, note the hump-shaped responses of employment, output, consumption and investment. Finally, there is a persistent fall in the interest rate. As emphasized in Christiano, Eichenbaum and Evans (1998), these patterns are all qualitatively consistent with the data. They support the notion that our model represents a useful laboratory for evaluating the operating characteristics of alternative monetary policy rules.

4. Results

This section presents our quantitative results. We first display the regions of the policy parameter space in which indeterminacy, determinacy (i.e, local uniqueness of equilibrium) and explosiveness occurs. We report that the region of indeterminacy and explosiveness is disconcertingly large. In the subsequent two sections we report some calculations to illustrate the economic meaning of the indeterminacy and explosiveness findings. In addition, we discuss the difficulties that may exist in implementing an interest rate rule in practice.

4.1. Indeterminacy, Determinacy and Explosiveness

Figures 2, 3 and 4 report regions of α, β where equilibrium is determinate (light grey), indeterminate (grey) and explosive (black), for $\rho = 0.0, 0.5, 1.5$. The results are for the CGG, GT and LT rules, respectively.

Consider first the results for the CGG rule in Figure 2. When $\beta = 0$ then determinacy requires $\alpha \geq 1$. A result also reported in CGG. Our results resemble those of CGG in supporting the notion that an aggressive response to expected inflation reduces the likelihood of indeterminacy. In contrast with CGG, however, we find that the likelihood of indeterminacy and explosiveness increase with β. The intuition for this was discussed in the introduction.

Now consider the results reported in Figure 3 for the GT rule. The paper by Taylor in this volume suggests that a good parameterization for (1.1) is $\rho = 0$, $\alpha = 1.5$ and $\beta = 1$. Interestingly, Figure 3 indicates that, for our model, this parameterization lies in the explosiveness region. Thus, our model indicates that the economy would perform very poorly with this policy rule. According to the results in Rotemberg and Woodford in this volume, when $\rho = 0$, $\alpha > 0$, then increasing β raises the likelihood of equilibrium determinacy. In our model, this is not the case. Either we enter the explosiveness region for large β, or we enter the region of indeterminacy. Interestingly, as ρ increases, the region of determinacy expands.

The results in Figure 4 for the LT policy rule resemble those in Figure 3. The preferred parameterization of Rotemberg and Woodford, $\alpha = 1.27$, $\beta = 0.08$ and $\rho = 1.13$ lies in the determinacy region for our model, if we extrapolate between the $\rho = 0.5$ and $\rho = 1.5$ graphs in Figure 4. A notable feature of the LT policy rule is that with ρ large, the determinacy region is reasonably large and resembles the determinacy region for the GT rule.

To summarize, an aggressive response to inflation (or, expected inflation) increases the likelihood of determinacy. However, a more aggressive response to output has the opposite effect in our model. In addition, our results support the notion that choosing a high value of ρ increases the likelihood of determinacy. Finally, the CGG rule appears to have the smallest region of determinacy.

4.2. Illustrating Indeterminacy

We report some calculations to illustrate what can happen when there is indeterminacy. To this end, we worked with two versions of the CGG rule. The first is useful for establishing a benchmark, and uses a version of the CGG rule for which there is a locally unique equilibrium, ($\rho = 0.66$, $\beta = 0.48$, $\alpha = 1.8$). The second uses a version, ($\rho = 0.66$, $\beta = 0.48$, $\alpha = 0.95$), of the CGG rule for which there is equilibrium indeterminacy. We refer to the first rule as the stable CGG rule and to the second as the unstable CGG rule. We consider the dynamic response of the variables in our model economy to a one standard deviation innovation in J_t in period 2.

Figure 5 displays the results for economy operating under a $k\%$ money growth rule (dotted line) and under the stable CGG rule. Note that under the $k\%$ rule, the results are what one might expect from a positive shock to money demand: interest rates rise for a while and inflation, output, employment, consumption and investment drop. Now consider the economy's response to the money demand shock under the stable CGG rule. As one might expect, this monetary policy fully insulates the economy from the effects of the money demand shock. Figure 5c indicates that this result is brought about by increasing the money stock. Not surprisingly, the present discounted utility of agents in the economy operating under the stable CGG rule, 74.092, is higher than it is in the economy operating under the $k\%$ rule, 74.036. These present discounted values are computed under the assumption that the money demand shock takes on its mean value in the initial period, and the capital stock is at its nonstochastic steady-state level.

Now consider the results in Figure 6, which displays the response of the model variables to a money demand shock in two equilibria associated with the unstable CGG policy rule. In equilibrium #2 (see the dotted line), the economy responds in essentially the same way that it does under the stable CGG rule. Now consider equilibrium #1 (the solid line). The money demand shock triggers an expectation of higher inflation.[7] Seeing the inflation coming, the central bank raises interest rates immediately by only partially accommodating the increased money demand.[8] In the following period households, anticipating higher inflation, shift funds out of the financial sector and towards consumption (Figure 6b shows that Q_t rises, relative to its steady state path, in period 3). The central bank responds by only partially making up for this shortfall of funds available to the financial sector. This leads to a further rise in the interest rate and in the money supply. In this way, the money stock grows, and actual inflation occurs. Employment and output are reduced because of the high rate of interest. Investment falls a lot because the higher anticipated inflation acts as a tax on the return to investment. In addition, the rental rate on capital drops with the fall in employment.

The utility level associated with equilibrium #1 is 73.825 and the utility level in equilibrium #2 is 74.110. The utility numbers convey an interesting message. On the one hand, if the stable CGG rule is implemented, then agents enjoy higher utility than under the $k\%$ rule. On the other hand, if the unstable CGG policy rule is used, then it is possible that utility might be less than what it would be under the $k\%$ rule. In this sense, if there were any uncertainty over whether a given interest rate rule might produce indeterminacy, it might be viewed as less risky to simply adopt the $k\%$ rule. In a way, this is a dramatic finding, since the assumption that money demand shocks are the only disturbances impacting on the economy would normally guarantee the desirability of an interest rate rule like

[7]This illustrates the possibility mentioned in the introduction that when there is equilibrium indeterminacy, an economy might 'over-react to fundamental shocks'.

[8]This is difficult to see in Figure 6c because of scale. Money growth in period 2 is nearly 6 percent, at an annual rate, in equilibrium 2. According to Figure 6g, this is enough to prevent a rise in the interest rate in that equilibrium. Money growth in period 2 of equilibrium #1 is less, namely 5.5 percent, at an annual rate.

(1.1).

4.3. Illustrating Explosiveness and Implementation Problems

We now consider a version of our model driven only by technology shocks. We consider two versions of the LT policy rule. One adopts the preferred parameterization of Rotemberg and Woodford: $\alpha = 1.27$, $\beta = 0.08$, $\rho = 1.13$. The other adops a version of this parameterization that is very close to the explosive region in which β is assigned a value of unity. Figure 7 reports the response of the economy to a one standard deviation negative shock to technology under two specifications of monetary policy. In one, monetary policy is governed by a $k\%$ rule (see the dotted line), and in the other it is governed by the LT rule just described (see the solid line).

Consider first the $k\%$ rule. The technology shock drives up the price level, which remains high for a long period of time. Employment, investment, consumption and output drop. There is essentially no impact on the rate of interest. The present discounted value of utility in this equilibrium is 74.095. Consider by contrast the LT rule. The rise in inflation in the first period leads the central bank to cut back the money supply in the following period (recall, this policy rule looks back one period). This triggers a substantial rise in the interest rate, which in turn leads to an even greater fall in employment, output, consumption and investment than occurs under the $k\%$ rule. The present discounted value of utility in this equilibrium is 74.036. It is not surprising that in this case, the $k\%$ rule dominates the monetary policy rule in welfare terms, and in terms of the variability of output and inflation.

Now consider the operation of the nearly explosive policy rule, in Figure 8. With this rule, responses are much more persistent than under the previous rule. The response looks very much like a regime switch, with money growth and the interest rate shifting to a higher level for a long period of time. Given all the volatility in this equilibrium, it is not surprising that welfare is lower at 73.549.

These examples illustrate the practical difficulties that can arise in implementing an interest smoothing rule like (1.1). In a recession, when output and employment are already low, the rule may require tightening even further. The social cost of doing that may be such that the pressures to deviate may be irresistible.

5. Conclusion

In this comment we reassessed Levin, Wieland, and Williams' findings concerning the desirability of adopting an interest rate rule of the form, (1.1). We did this using a model that is in several respects quite different from theirs. That model replaces the sticky price assumption used in their paper and in many of the papers in this conference with a particular credit market friction. Our analysis provides several reasons to be cautious in designing an interest rate rule. In this conclusion, we would like to stress two.

First, which parameterized version of (1.1) will work well is sensitive to the nature of the fundamental shocks driving the economy. At the same time, there is little consensus on what the nature of those shocks might be. To illustrate the problem, we showed that when Rotemberg and Woodford's preferred rule is applied in our model, and the disturbances are shocks to technology, then a simple $k\%$ monetary policy rule dominates their policy rule. Second, in our model there are large portions of the parameter space in which application of an interest rate rule implies equilibrium indeterminacy or explosiveness. This suggests an element of risk associated with the adoption of this type of rule. The uncertainty we have in mind here stems from two sources. (i) In advocating the use of a particular rule of the form (1.1), one cannot be sure precisely what parameter values policymakers will use in practice. Even if one were confident that the rule being advocated had attractive properties, a policy maker may implement a version with different parameter values, and which gives rise to indeterminacy. We showed how, under these circumstances, a $k\%$ rule might dominate an interest rate smoothing rule, even in the supposedly ideal case where the only shocks driving the economy are disturbances to money demand. (ii) The region of indeterminacy for the parameters of a policy rule no doubt is partially a function of the underlying model parameters. These parameter values are not known with certainty. So, in principle, one might construct a set of policy rule parameter values that exhibit determinacy under the estimated model parameter values. But, if the actual parameter values were different, say for sampling reasons, it could be that the constructed policy rule might produce indeterminacy. The analysis in this comment suggests to us that these sources of concern deserve further investigation.

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