Comments on
"Three Lessons for Monetary Policy in a Low Inflation Era"
by David Reifschneider and John Williams

John B. Taylor
Stanford University

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This paper by David Reifschneider and John Williams is a useful and innovative analysis of monetary policy problems caused by the lower bound of zero on the nominal interest rate. The authors provide estimates, with the help of a large econometric model, of the size of the output fluctuations and the probability of instability if the Fed had a target inflation rate that was very low and followed a monetary policy rule. They also illustrate, with the help of a very simple model, how the lower bound of zero on the nominal interest rate could cause economic instability. Finally, they propose an innovative modification of simple policy rules that virtually eliminates any increase in output volatility. The modification entails pledging to keep interest rates low *in the future* in the event that the policy rule would call for nominal rate below zero *in the present*.

The authors use the Federal Reserve Board model (FRB/US) of the United States economy to obtain their quantitative estimates. I think it is a good model for this purpose. It is forward-looking, dynamic, stochastic, and econometrically estimated. It also has a detailed specification of the monetary transmission mechanism, which starts with changes in the federal funds rate and feeds into long-term rates, exchange rates, and other asset prices. The lower the target inflation rate, the lower will be the average nominal interest rate, and thus, the greater will be the likelihood that the nominal interest rate will hit zero when the model economy is hit by shocks. The authors obtain estimates of the impact of this zero bound using a methodology that is becoming increasingly common in monetary policy evaluation, and which might be called the *new normative macroeconomics*. They place a policy rule in the model and then simulate it stochastically. In the stochastic simulations of the FRB/US model the shocks are drawn from distributions that match U.S. history over the sample period for the estimation of the model.

The simulations show that there is indeed an increase in output variability, but the increase is quite small, especially for target inflation rates of between 1 and 3 percent. They also find that there is a positive, but low, probability of getting stuck in a completely unstable situation. These simulation results should be reassuring to policy makers who have chosen to target inflation in the 1 to 3 percent range as many central banks have done, either explicitly or implicitly.

I have no criticisms of these very useful simulation results. In my comments on the paper I focus on the stability analysis and on the proposed policy rule. I discuss the authors' stability arguments using a diagram that shows how the zero bound creates a non-linearity in the monetary policy rule used by the central bank. This diagram shows the connection of their analysis to other expositions of policy rules and provides some additional insights. I then introduce a simple model to explore the general nature of policy rules that pledge to react in the future to current events, and I use that model to discuss the authors' novel policy rule proposal.

A Simple Graphical Analysis of Stable and Unstable Equilibria

Figure 1 shows a typical monetary policy rule with the nominal interest rate on the vertical axis and the inflation rate on the horizontal axis. I have found the part of this graph corresponding to positive interest rates to be helpful in elementary expositions of monetary policy rules (Taylor (1998)) and for explaining the importance of having a policy rule that reacts by a sufficiently large amount to inflation (Taylor (1999)). It is easy to modify the diagram to deal with the complications caused by the zero bound as in Figure 1. Doing so leads to a non-linearity and to the creation of another equilibrium as discussed by Reifschneider and Williams.

The solid line in Figure 1 is the policy rule showing the reaction of the interest rate to inflation. It is two linear sections with different slopes. The slope is greater than one for all positive values of the interest rate. However, the slope is zero for values of the nominal interest rate equal to zero, where the nominal interest rate hits the lower bound of zero.

The dashed line has a slope of one. It corresponds to a constant long-run real interest rate. Equilibrium must occur at an intersection of the dashed line and the solid line. It is only at such an intersection that the nominal interest rate in the policy rule is equal to the long run inflation rate plus the long-run real interest rate. Observe that there are two intersections, and hence two long run equilibria. The intersection at the upper right occurs at a positive interest rate and at the target inflation rate. I call this the *target inflation equilibrium*. The other equilibrium occurs at a point where inflation is negative; I call this the *deflation equilibrium.* Clearly the deflation equilibrium is sub optimal if the target inflation rate is the optimal inflation rate.

By appealing to simple inflation adjustment dynamics, one can easily show that the target inflation equilibrium is stable and deflation equilibrium is not. First consider the intersection at the upper right. Suppose that the inflation rate rises from that point. Then the policy rule raises the nominal interest rate by more than the inflation rate and thus the real interest rate rises. The rise in the real interest rate lowers demand in the economy and puts downward pressure on inflation. Hence, the inflation rate moves back toward the equilibrium as shown by the arrow. A similar argument holds for decreases in the inflation rate. Then the policy rule calls for cutting the interest rate by more than the decrease in inflation and the real interest rate falls, stimulating demand and putting upward pressure on inflation as shown by the upward pointing arrow in Figure 1. Hence, the "target inflation equilibrium" is stable. In fact, the whole reason to have the slope of the policy rule greater than one is that it will generate such stability.

Now consider the other intersection where the nominal interest rate is at zero. Suppose that the inflation rate rises. Then the real interest rate falls, stimulating demand and placing upward pressure on inflation. There is no tendency for the inflation rate to return to the deflation equilibrium; rather it moves away from the deflation equilibrium and toward the target inflation equilibrium. Starting from any inflation rate above the deflation equilibrium, there is convergence to the inflation target equilibrium.

Finally, if the inflation rate falls below the deflation equilibrium, the real interest rate rises and this places downward pressure on inflation, leading to a downward spiral. This is the situation where instability can arise, and it should obviously be avoided. This stability analysis confirms the analysis of Reifschneider and Williams, but has the advantage of looking directly at the non-linearity of the policy rule as the technical source of the instability. It also relates the stability analysis to existing discussions (e.g. Taylor (1999)) that have stressed that an attractive feature of policy rules with a slope greater than one is that "target inflation equilibrium."

Figure 1 also illustrates how overly simple views of the monetary transmission mechanism may exaggerates the stability problem. The dynamics in the above stability analysis focus on the short-term nominal interest rate and assume that the ex ante real interest rate moves with the ex post real interest rate. But other expectations assumptions or positive real balance effects of deflation could offset the downward spiral. So could exchange rate and long term interest rate effects. That is perhaps why the simulations of the FRB/US model—which incorporate such effects—reveal a very low probability of getting into the unstable region. Moreover, one could add the effects of fiscal policy rules, such as the automatic stabilizers. Such rules could provide stimulus to demand when prices and output (nominal income) began go fall, and thereby reduce the chances of the downward spiral continuing.

A Simple Model With Expectation Effects

The Reifschneider -Williams proposal to modify simple policy rules exploits people's expectations of future policy changes in a very innovative way. Such policy rules can lead to big improvements in performance and deserve serious consideration. In fact, there may be similar modifications of existing policy rules that could improve performance in other ways. However, rules that exploit expectations "too much" may have some disadvantages.

To illustrate the advantages and disadvantages of such rules, I have found a simple model to be useful. The model has the essential features of the FRB/US model that figure into the Reifschneider-Williams analysis, but it is very much simpler, with only one target variable, one instrument, and one equation. The single instrument r_t is related to the single target variable y_t through the following equation:

$$y_t = \alpha(r_t + E_t r_{t+1}) + e_t \qquad (1)$$

where e_t is a serially uncorrelated shock with a zero mean and α is a parameter. There are many applications of such a model. For example, the case where the target variable is output and the instrument is the interest rate corresponds most closely to the Reifschneider-Williams paper; then the expectation of next period's interest rate reflects its role in long-term (in this case two period) interest rate determination through the term structure. The target variable y_t could also be the inflation rate, but with only one equation the model cannot deal with both inflation and real output goals.

Consider policy rules of the form:

$$r_t = g e_t + h e_{t-1} \qquad (2)$$

where g and h are policy parameters. Suppose that the optimal policy problem is to chose the policy rule parameters (g and h) to minimize $var(y_t) + \lambda var(r_t)$. It is easy to show that unless the weight λ is zero that neither the parameter g nor the parameter h will be zero. The variances of y_t and r_t in the stochastic steady state are

$$var(y_t) = (\alpha(g + h) + 1)^2 + \alpha^2 h^2 \qquad (3)$$

$$var(r_t) = g^2 + h^2 \qquad (4)$$

Substituting these two expressions into the loss function and minimizing the loss function over g and h then gives the optimal policy rule:

$$r_t = -(\alpha(\alpha^2 + \lambda)\varepsilon_t \ + \ \lambda\alpha\varepsilon_{t-1})((\alpha^2 + \lambda)^2 + \alpha^2\lambda)^{-1} \qquad (5)$$

For $\lambda = 0$, we have $g = -(1/\alpha)$ and $h = 0$. But for $\lambda > 0$ there is a non-zero reaction coefficient on ε_{t-1}.

It may seem counter intuitive that h is not set to zero for all values of λ. Why does the optimal policy react to the lagged shock when the lagged shock is not in the model? Observe that if policy rule (2) is followed, then

$$E_t r_{t+1} \ = he_t \qquad (6)$$

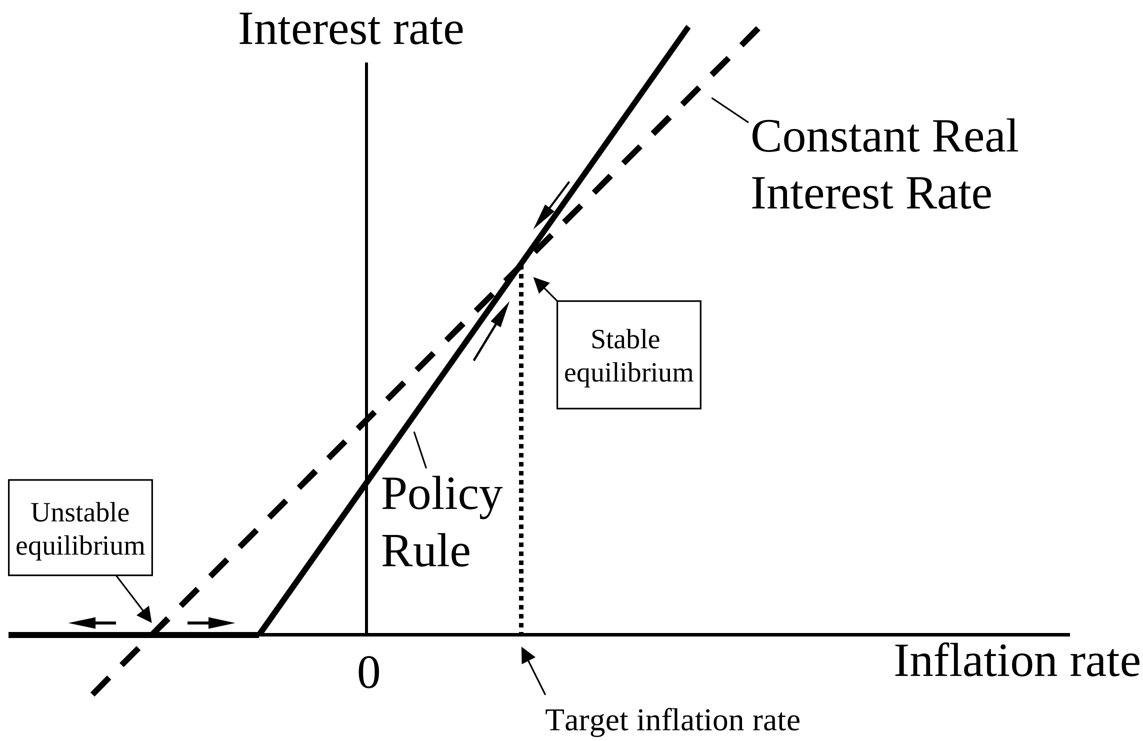
Since this expectation of next period's instrument $E_t r_{t+1}$ appears in the model, reacting in this way ($h \neq 0$) can have a stabilizing effect on y_t while having smaller variations in the instrument. If h were equal to 0, then by raising h and lowering g one could and get the same variance of y_t and a lower variance of r_t. That optimal policy may have to react to *lagged* variables that are not in the model has been pointed out and stressed in recent work by Woodford (1999).

However, to make such a policy work over a number of periods, it is necessary for the policy makers to *actually* react in this way, not just to say they will; that is, in period t+1 the interest rate has to be set to $r_{t+1} = ge_{t+1} + he_t$ even though in that period it will in general be better to ignore e_t. Saying that $h \neq 0$ before period t+1, but then setting h = 0 when t+1 comes around is precisely the time inconsistency problem that Kydland and Prescott warned about. For well-understood problems with frequently recurring situations, time inconsistency may not be much of a problem, but for very rare events it may be more serious. The problem of the interest rate going to zero is a rare event, both in history and in the simulations of Reifschneider and Williams.

The proposal of Reifschneider and Williams is analogous to not setting h to zero. In their case pledging to keep the interest rate low after the economy is recovering helps the performance of the economy now, through the term structure effects. But when the economy is in recovery stage it will be tempting to raise the interest rate, which is the equivalent of setting h to zero. But the application of this idea to events that are very rare, such as the unusual situation in Japan today, may raise credibility problems.

Another related concern about the Reifschneider-Williams proposal can also be illustrated by the model in equation (1). The good properties of the rule depend on people being forward-looking, and, in particular, having rational expectations so that equation (6) holds. Hence, rules that exploit expectations in this way rule relies heavily on the rational expectations assumption. Such rules will not be robust against other models that have more backward looking expectations.

Nonetheless, the fact that the Reifschneider and Williams proposal, or other rules in the spirit of equation (2) with a nonzero parameter h, can improve performance by a great deal is important. Examining ways to deal with the credibility and robustness problems would be well worth the effort. Hence, by quantifying the gains from such policy rules, Reifschneider and Williams have increased the probability that their proposal or similar ones might be effectively used in practice to improve the workings of the economy. More generally, they have added much to our understanding of the monetary problems associated with zero bound on the interest rate, and they have given us much to think about and do.



<u>Figure 1</u>. Illustration of the stable and unstable equilibria with a policy rule subject to the zero lower bound on the interest rate. The solid line is the policy rule. The dashed line has a slope of one and represents a constant real interest rate. Long run equilibrium occurs at an intersection of the two curves. Starting from any inflation rate above that of the unstable deflationary equilibrium, there is convergence is to the inflation target equilibrium. Starting below the unstable equilibrium leads to a downward spiral.

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