The Taylor Rule: Is It a Useful Guide to Understanding Monetary Policy?

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More than anyone else in the decade of the 1990s, John Taylor spurred research into the nature of the monetary policy pursued by the Federal Reserve System. Taylor has advanced a simple and intuitive reason for why the Fed has done a better job of controlling inflation since the early 1980s: It has raised the funds rate more aggressively in response to inflation. This article suggests a different perspective. The question should be how the Fed prevents inflation from arising in the first place, not how vigorously it responds to observed inflation.

1. TAYLOR'S RESEARCH AGENDA

Indisputably, the behavior of inflation improved in the 1980s under the leadership of Paul Volcker as chairman of the FOMC (Federal Open Market Committee) of the Federal Reserve System. John Taylor attributes the improved behavior of inflation to the Fed's increased aggressiveness in responding to realized inflation. Specifically, Taylor (1993, 1998, 1999a) argues that the FOMC sets an interest rate target based on the observed behavior of inflation and the amount of excess capacity in the economy. According to Taylor, before 1979, the FOMC raised the funds rate less than one-for-one with increases in inflation. After 1979, it raised the funds rate more than one-for-one with inflation.

Taylor presented his analysis to encourage discussion of how to move from discretion to explicit rules in the formulation of policy. His work advanced the cause of thinking about monetary policy as a systematic strategy by distilling

I received extremely helpful criticism from Michael Dotsey, Andreas Hornstein, Athanasios Orphanides, and Alexander Wolman. The ideas expressed in this paper are those of the author and do not necessarily reflect those of the Federal Reserve Bank of Richmond or the Federal Reserve System.

systematic behavior from actual FOMC behavior. That is, he advanced a rule for monetary policy that was both prescriptive and descriptive. The policymaker could adopt Taylor's proposed rule as a systematization of what had worked in practice rather than as an ideal based solely on an abstract model of the economy.

Taylor deduced his rule from the observed behavior of the FOMC by emphasizing two aspects of that behavior. First, the FOMC uses a short-term interest rate as its policy instrument. Second, it sets its interest rate peg (the funds rate) based on the observed behavior of the economy. In the words of former FOMC chairman William McChesney Martin, the FOMC follows a policy of "leaning against the wind." It raises its interest rate peg when economic activity is "strong" and inflation undesirably "high," and conversely. In a broad sense, any characterization of monetary policy will possess the flavor of a Taylor rule.

For all these reasons, Taylor has stimulated much useful research on monetary policy. Furthermore, more than anyone else, he has conveyed the professional consensus in economics that policymakers should conduct policy with explicit, quantitative objectives and a clear strategy for achieving those objectives.

2. THE TAYLOR RULE AND ITS PRIMARY POLICY IMPLICATION

Taylor (1993) showed that the following formula (now known as the Taylor rule) with g_π and g_x equal to .5 predicts the funds rate reasonably well over the period 1987 through 1992:

$$i_t = 2 + \pi_t + g_\pi(\pi_t - \pi^*) + g_x x_t. \tag{1}$$

The funds rate is i_t. The constant term, 2, is the assumed long-run average of the real rate of interest. The prior four-quarter inflation rate is π_t and the FOMC's inflation target is π^*. The output gap, x_t, is the percentage deviation of real GDP from a trend line measuring potential output. Taylor assumes that the FOMC's inflation target has remained unchanged at 2 percent. Taylor (1999) also contends that over time monetary policy has improved because the FOMC has responded more vigorously to deviations of inflation from this 2 percent value by increasing the magnitude of the coefficient g_π on the inflation term $(\pi_t - \pi^*)$.

Taylor (1999b) illustrates the last point with the following model:

$$x_t = -\varphi(i_t - \pi_t - r) + u_t \tag{2}$$

$$\pi_t = \pi_{t-1} + \lambda x_{t-1} + e_t \tag{3}$$

$$i_t = g_0 + g_\pi \pi_t + g_x x_t \tag{4}$$

The variables are as defined above, except that π_t is current period inflation and r is the long-run average real rate of interest. The parameters φ and λ are positive. The shocks u_t and e_t are serially uncorrelated with zero mean.

Equation (2) is an IS function, which relates the output gap to the real rate of interest. Equation (3) is a Phillips curve, which relates inflation to the output gap. Equation (4) is the reaction function of the central bank, which takes the form of a Taylor rule. The trend inflation rate depends upon the target the central bank sets for inflation, which comes from its joint selection of g_π and g_0 in (4).

Taylor attributes the inflation of the 1960s and '70s to an inadequate response by the Fed to observed inflation. Inflation arose in this period because of dynamic instability caused by $g_\pi < 1$. Specifically, a positive inflation shock ($e_t > 0$) exacerbated inflation by lowering the real rate of interest ($i_t - \pi_t$). Taylor (1999b, p. 664) writes, "This relationship between the stability of inflation and the size of the interest rate coefficient in the policy rule is a basic prediction of monetary models used for policy evaluation research."

3. PUTTING THE TAYLOR RULE IN A MODEL

What problems arise in identifying the systematic part of monetary policy, especially the part that has led to better control of inflation since the early 1980s? To begin, the FOMC does not specify explicit numerical objectives or an explicit strategy for achieving such objectives. Members of the Federal Reserve have typically emphasized the discretionary aspects of monetary policy rather than the systematic aspects. (Gramley [1970] is a prototypical example.) What the economist sees is only the correlations between economic activity and the funds rate that emerge out of the policy process. In order to characterize monetary policy, the economist must infer both the FOMC's objectives and its strategy.

Even if one assumes that a functional form like the Taylor rule successfully predicts the behavior of the funds rate, what has one learned about the behavior of the FOMC? Unfortunately, the answer is "nothing" unless one has solved the identification (simultaneous equations bias) problem. One must determine that the functional form is a structural rather than a reduced form relationship. The former is a behavioral relationship that explains how the FOMC alters its policy instrument in response to the behavior of macroeconomic variables. In contrast, a reduced form is an amalgam of structural relationships embodying both the behavior of the FOMC and the public. To estimate a structural relationship, one needs two kinds of information: knowledge of the proper functional form to estimate and a model that allows for the separation of the response of the FOMC to the behavior of the public from the response of the public to the behavior of the FOMC (see Bernanke and Blinder [1992]).

In practice, this approach is too demanding. As a simpler alternative, economists attempting to characterize actual FOMC behavior posit a plausible policy rule consistent with the observed correlations between the funds rate and economic activity. They then posit a model and ascertain whether the combination of the policy rule and model predicts observed economic activity, especially inflation. That is, they test the rule and the model jointly by observing whether the combination offers a useful analytical framework for understanding monetary policy. As is the case with the more demanding procedure, one must still use a model.

This way of testing the usefulness of the Taylor rule has to date generated useful debate. However, it has not settled any fundamental issues. Economists who use the Taylor rule almost always opt for a particular class of models. The Taylor rule highlights an output gap and observed inflation. Consequently, the rule fits naturally with activist models in which the central bank controls inflation by manipulating an output gap. This article raises questions about whether a combination of the Taylor rule with such models offers a useful explanation for the historical behavior of inflation in the United States.

Real Control Models

Economists use the Taylor rule most commonly in models that embody what I term a "real control" view of inflation. (Below, I also use the term "activist.") In such models, the central bank controls inflation through manipulation of the output gap (the amount of unutilized resources in the economy) in response to exogenous inflation shocks. Because the Taylor rule highlights the response of the central bank to the output gap and realized inflation, the rule fits well with such models. Taylor (1999b) lists papers performing simulations with these models and the Taylor rule.

Ball (1999), Svensson (1999), and Rudebusch and Svensson (1999) are examples of "backward-looking" models of the above sort in that the output gap and inflation depend on their own past values. The model of the economy shown below in equations (5) and (6), from Clarida, Gali, and Gertler (1999), is a "forward-looking" example. Equation (5), an aggregate demand or IS relationship, relates the contemporaneous output gap, x_t, to the expected future output gap, the real rate of interest, $[i_t - E_t\pi_{t+1}]$, and a shock g_t. Equation (6), a Phillips curve, relates inflation to expected future inflation, the output gap, and a shock u_t.

$$x_t = -\varphi[i_t - E_t\pi_{t+1}] + E_t x_{t+1} + g_t \tag{5}$$

$$\pi_t = \lambda x_t + \beta E_t\pi_{t+1} + u_t \tag{6}$$

The Taylor rule and the real control models referred to above will rise or fall together. If together they provide a useful description of U.S. experience, then a Taylor rule embodying an aggressive response to inflation will work well for central banks. How satisfactory are these models? They embody two primary assumptions.

The first assumption is that the price level is a nonmonetary phenomenon.[1] Inflation arises from shocks exogenous to the central bank. The central bank can control inflation if it responds vigorously to these shocks, but it does not create inflation. The assertion that the above models treat the price level as a nonmonetary phenomenon requires fuller explanation. The models allow the central bank to control inflation. They also incorporate a Phillips curve that does not permit the central bank to affect output through sustained changes in the level of the inflation rate. In this sense, they exhibit long-run monetary neutrality.

The statement that the price level is a monetary, as opposed to a nonmonetary, phenomenon is more than an affirmation that the central bank can control inflation and that in the long run money is neutral. It implies that inflation possesses a single cause: excess money creation by the central bank. Control of the price level centers on the central bank's control over the process of creating and destroying money rather than on its manipulation of the amount of unemployed resources in the economy.

Nonmonetary models of inflation treat the price level as an atheoretical phenomenon. There is no single explanation for inflation, but instead a taxonomy of the different varieties of inflation. The primary classes in this taxonomy are demand-pull, cost-push, and expectational inflation. Economists who consider inflation a nonmonetary phenomenon use the empirical correlations of the Phillips curve as a structural relationship in their model simulations. The Phillips curve gives operational content to demand-pull inflation, which becomes the inflation predicted by the output gap (x_t). Additional inflation (the error term u_t in (6)) is either expectational or cost-push.[2]

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[1] The only reference in Clarida, Gali, and Gertler (1999, p. 1685) to money is in the context of whether money is a suitable intermediate target, that is, whether the public's demand for money is stable and interest inelastic. Over the postwar period until 1981, M1 demand was stable and interest inelastic. The authors refer to the introduction of NOW accounts nationwide in 1981 that changed the character of M1 demand. In their words, "the aggregates went haywire." However, they ignore the more fundamental issue of whether inflation is a monetary phenomenon.

The Clarida et al. (1999) paper places monetary policy in an optimal control framework. Based on knowledge of the structure of the economy, the central bank sets an interest rate target to offset exogenous shocks. As long as the central bank sets the interest rate target optimally, money creation and destruction (the central bank itself) is not a source of disturbances. The applicability of the model then is limited to periods when the central bank pursued an optimal monetary policy. For historical investigation of monetary policy, its use would appear to be limited.

[2] Clarida, Gali, and Gertler (1999, p. 1667) state that the output gap measures "movements in marginal costs associated with variation in excess demand. The shock u_{t+i}, which we refer [to] as 'cost push,' captures anything else that might affect expected marginal costs. We allow for the cost push shock to enable the model to generate variation in inflation that arises independently of movement in excess demand, as appears present in the data."

The second assumption is that the central bank can systematically control the real rate of interest in a way that allows it to manipulate fluctuations in excess capacity. That is, the central bank can follow a systematic monetary policy that moves actual output relative to potential output in a predictable way. With the Taylor rule, the central bank responds directly to realized inflation, as one would expect when cost-push shocks drive inflation. The central bank controls inflation by systematically varying the output gap. The key parameter is the sacrifice ratio, the inverse of λ, in the Phillips curve. Rudebusch and Svensson (1999, p. 209) note that both their small model and the Board's larger MPS model possess a sacrifice ratio somewhat above 3. Specifically, a decline in the inflation rate of 1 percentage point requires the output gap to be negative by 1 percentage point for 3.3 years.

In these models, the structural character of the relationship between inflation and excess capacity offers the policymaker a trade-off between the variability of inflation and output. The policymaker can reduce the variability of output by increasing the variability of inflation. In this sense, real control models are activist.[3]

Assessing Real Control Models

Again, most economists who use the Taylor rule to explain U.S. monetary policy use real control models that embody two assumptions. First, inflation is a nonmonetary phenomenon. Second, the central bank can pursue a monetary policy that allows it to manipulate real variables (the real rate of interest and excess capacity) in a systematic fashion. Both assumptions are controversial.

Because policymakers like to see themselves as fighting inflation rather than creating it, they generally find congenial the first assumption. However, a brief overview of the U.S. historical experience suggests that this view of inflation has served policymakers poorly.[4]

William McChesney Martin was FOMC chairman from 1951 through early 1970. He was fiercely antagonistic to inflation and maintained near-price stability until the end of 1965. At that time inflation began to rise and remained high through 1971. Martin and other policymakers blamed the inflation on the rise in the government deficit produced by the Vietnam War and Great Society programs. In terms of equations (5) and (6) above, they attributed inflation to an aggregate demand shock ($g_t > 0$).

[3] Some economists define an activist policy as a rule for which the central bank alters its interest rate peg in response to variations in real economic activity. However, this definition is too general to be useful. An interest rate instrument inevitably requires the central bank to take account of the way fluctuations in real economic activity affect the real rate of interest. The term "activist" most usefully refers to models in which the policymaker can supersede the working of the price system to diminish the variability of real output.

[4] Goodfriend and King (1997), Goodfriend (1997), Hetzel (1998), and Hafer and Wheelock (2000) describe the pre-1980 views held by policymakers.

If the price level is a nonmonetary phenomenon, monetary policy is only one policy instrument available for dealing with demand-pull (aggregate-demand) inflation. Fiscal policy is another. Chairman Martin helped convince Congress to pass an income tax surcharge in June 1968 that turned a deficit equal to 3 percent of GNP into a small surplus. Policymakers chose a restrictive fiscal policy over a restrictive monetary policy to limit the rise in interest rates. However, despite widespread predictions to the contrary, neither the economy nor inflation slowed. Continued high money growth trumped restrictive fiscal policy.

Arthur Burns was FOMC chairman from early 1970 until early 1978. Like Martin, he had a visceral dislike for inflation. Prior to becoming FOMC chairman, Burns (1957) had viewed inflation primarily as an expectational phenomenon made possible by the economic security offered to individuals by the welfare state. Upon becoming chairman, he came to see inflation as driven by cost-push pressures emanating from demands by labor for wage increases ($u_t > 0$ in (6)).

On August 15, 1971, President Nixon announced the price and wage controls desired by Chairman Burns (Hetzel 1998). The controls did in fact restrain the rise in labor costs. Nonetheless, inflation surged in early 1973. This time Burns blamed the inflation on special factors, especially bad agricultural harvests and oil price increases. When those relative price increases ceased, however, inflation still continued. Burns (1979) ended his term as FOMC chairman by returning to his original belief that inflation was primarily an expectational phenomenon (in (6), $E_t\pi_{t+1} > 0$ arises independently of monetary policy). That view dominated policymakers' views until Paul Volcker became FOMC chairman in August 1979.

From the perspective of inflation as a monetary phenomenon, only the central bank can control inflation. If the central bank uses an interest rate as its policy instrument, it must achieve two tasks to ensure the monetary control necessary to control inflation. First, the central bank must stabilize expected inflation at a level equal to its inflation target. Otherwise, movements in its nominal interest rate target translate only unreliably into movements in the real rate. Second, the central bank must move its interest rate target responsively to changes in real output growth to track the economy's equilibrium real interest rate. In that way, the central bank sets its interest rate target to avoid monetary emissions and absorptions that force undesired changes in the price level.[5]

[5] Such a policy approximates a rule for steady, moderate growth in money if the demand by the public for real money balances is stable and relatively interest inelastic. Regardless of whether such a condition holds, from this quantity theory perspective, the control of inflation by the central bank is more aptly characterized in terms of monetary control than in terms of control of the extent of the economy's unemployed resources. The central bank controls inflation by *tracking* (not controlling) the equilibrium real rate of interest, thereby avoiding undesired monetary emissions and absorptions that require changes in the price level.

In contrast, from the perspective of inflation as a nonmonetary phenomenon, monetary policy is not necessarily the socially optimal instrument for controlling inflation. For the control of demand-pull inflation, fiscal policy can work without the side effects produced by high interest rates on interest-sensitive sectors of the economy, like housing. With cost-push or expectational inflation, monetary policy is not the socially optimal instrument. The socially optimal way to deal with such inflation is for the government to intervene directly in the individual markets that are causing the inflation rather than to raise the unemployment rate.

Both monetary and nonmonetary views of inflation allow for central bank control of inflation. If the central bank accepts sole responsibility for the control of inflation, empirical observation will not allow economists to distinguish whether inflation is a monetary or nonmonetary phenomenon. However, the change in the political and intellectual environment in the early 1960s produced an experiment capable of discriminating between these two views. Their differing policy implications become important when society sees the control of inflation as costly, that is, when society sees λ of (6) as low. That happened in the ’60s.

President Eisenhower had made the control of inflation a top priority of his administration. Moreover, he was philosophically opposed to direct intervention by government in private decisionmaking. (See Saulnier [1991], especially Chapter III.) As a result, he had to rely on the indirect control of inflation through monetary policy.

The change of presidential administration in 1961 and the altered social environment of the ’60s made direct intervention by government in the economy to control inflation politically attractive. At the same time, the appearance of the Solow-Samuelson (1960) Phillips curve promised a guide for distinguishing demand-pull from cost-push inflation. When the output gap was negative and, consequently, demand-pull inflation was in check, the central bank could pursue an expansionary monetary policy. Inflation beyond that predicted by excess capacity was of the cost-push or expectational variety. Government should deal with it through direct intervention. In fact, in the ’60s and ’70s, to deal with perceived cost-push inflation, the government made regular use of the moral suasion of public announcements, wage and price guideposts, direct intervention in wage and price decisions, and actual controls.

The attempt to discriminate between demand-pull and cost-push or expectational inflation and to design policies of inflation control accordingly failed. After 1979, the Federal Reserve assumed sole responsibility for inflation. A simple interpretation of this failed experiment is that inflation is a monetary phenomenon. The central bank alone determines and controls inflation.

The assumption that inflation is a monetary phenomenon also provides an explanation of the temporal relationship between money growth and inflation. Friedman (1989, p. 31) estimated that two years typically elapse between a monetary acceleration and the ensuing initial rise in inflation. The issue is not, as Taylor phrased it, whether the Fed responded vigorously enough to realized inflation, but why the Fed created the inflation in the first place.[6]

Furthermore, direct evidence for cost-push shocks is weak. By a cost-push shock, economists mean a change in a relative price that affects the absolute price level. Economists frequently cite as examples increases in the price of oil, real wages, and commodity prices, especially of food. However, unless the central bank makes money creation depend upon relative prices, there is no theoretical basis for such an explanation of inflation. If a central bank were to follow such a policy for money creation, the problem would be with its procedures for monetary control rather than its weak response to inflation when it did appear.[7]

Although some economists cite the two oil price shocks of the ’70s as cost-push shocks, the evidence that these events caused the inflation of the period is problematic. For the United States, monetary policy had been expansionary well before the oil price shocks. The fact that inflation already had risen significantly before the shocks implies that monetary policy created the inflation (Hutchison 1991). Hetzel (1998) disentangles the effect of an expansionary monetary policy and the oil price increases on inflation by looking at Japan, which did not pursue an expansionary monetary policy before the second oil price shock. Although Japan imported all of its energy, it did not experience significant inflation after the second oil price rise.

Also, direct evidence for expectational inflation is lacking. Clarida, Gali, and Gertler (2000) argue that a low response coefficient on the inflation term in the Taylor rule can explain the high, variable inflation of the pre-1980 period. Specifically, a response coefficient of less than one will “lead to indeterminacy of the equilibrium and raise the possibility of fluctuations in output and inflation around their steady state values that result from self-fulfilling revisions in expectations” (Clarida, Gali, and Gertler 2000, Sec. IV B). Chari and Christiano (1998) also argue that the pre-1980 inflation was expectational. In their words, the economy fell into “expectation traps.”

According to this latter view, the Fed ratified the high rate of inflation expected by the public to avoid depressing economic activity. However, an

[6] Keynes (1923, p. 148) in *A Tract on Monetary Reform* cites Hawtrey (*Monetary Reconstruction*) approvingly: “If we wait until a price movement is actually afoot before applying remedial measures, we may be too late. ‘It is not the *past* rise in prices but the *future* rise that has to be counteracted.’ ” (italics in original)

[7] Ball and Mankiw (1995, p. 161) argue that “[A]ggregate inflation depends upon the distribution of relative-price changes.” They dismiss Milton Friedman’s criticism of relative-price (cost-push) theories of inflation with the contention that the latter’s “analysis implicitly assumes that nominal prices are perfectly flexible” (p. 162). The argument is a red herring. Certainly, the relative price changes produced by events particular to individual markets can show through to the price level. However, if the central bank does not accommodate such changes in the price level with money creation, in time they must disappear.

explanation that makes the public's expectations the driving force behind inflation conflicts with a wide variety of evidence that the public was slow to raise its expectations in response to higher inflation. Survey data on expected inflation show that expectations lagged actual inflation throughout the '70s. (See the discussion below in Section 4a.)

The second assumption of real control models is that the central bank exercises predictable control over real variables. Because the central bank controls only a nominal variable (monetary base creation), it must be able to exploit the nominal-real correlations of the Phillips curve to control real variables in a systematic fashion. Friedman (1968) and Phelps (1970) challenged this assumption in their formulation of the natural rate hypothesis, where they assumed that the correlations between excess capacity (the unemployment rate) and inflation summarized in Phillips curves arise from unanticipated monetary shocks. Lucas (1973) and Sargent and Wallace (1975) in their natural rate-rational expectations extension of the natural rate hypothesis argued the policy ineffectiveness proposition. According to this proposition, the predictable part of any monetary policy rule would not affect real variables. Consistently implemented, a Taylor rule would disappoint in its ability to control the variability of real output.[8]

Can the FOMC Make the Concept of an Output Gap Operational?

An additional assumption of the Taylor rule and the activist models that give the rule content is that the concept of an output gap is operational. That is, the central bank possesses a reliable estimate of the amount of unutilized resources in the economy. However, that assumption is problematic. There are references to the output gap in FOMC discussions before 1980. Much later, during the Clinton administration, many policymakers referred to the concept. The members of the Council of Economic Advisors and the Clinton appointees to the Board of Governors used the Taylor rule as a cross-check and relied on the idea of an output gap. However, based on my knowledge of the historical record, I believe that the FOMC from late 1979 through 1992 did not take actions based on an estimate of the output gap.

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[8] Rudebusch and Svensson (1999, p. 208) argue that the empirical correlations of the Phillips curve represent a structural relationship that the central bank can exploit systematically (the Lucas critique does not apply) because of their stability over time.

The Samuelson-Solow (1960) Phillips curve used in models in the '60s and '70s related inflation to excess capacity. Its inverse correlations disappeared with the sustained high inflation of the '70s. The correlations that remained were between changes in inflation and excess capacity (or the difference between the unemployment rate and the NAIRU: the nonaccelerating inflation rate of unemployment).

Lucas (1973) and Friedman (1976, Chapter 12, "Wage Determination and Unemployment") employed the logic of the rational expectations-natural rate hypothesis to argue that these latter correlations would also disappear if the Fed ever pursued a policy of lowering excess capacity (unemployment) by regularly raising the rate of inflation.

Because economists disagree on a theoretical construct for the output gap, there is no accepted guide for making the concept operational. In practice, economists have estimated the output gap as the percentage difference between contemporaneous output and a trend line fitted to past output. Unfortunately, due to data revisions, the estimate for contemporaneous output changes, often considerably, as time passes. Furthermore, not until many years have passed are economists likely to agree on how to fit a trend line measuring potential output. Together, these factors create enormous uncertainty about the true value of the output gap.

Croushore and Stark (1999), Orphanides (1998-03, 1999), and Runkle (1998) point out the resulting problems for making a Taylor rule operational. Orphanides and van Norden (1999, p. 24) concluded:

> [T]he reliability of output gap estimates in real time tends to be quite low. Different methods give widely different estimates of the output gap in real time and often do not even agree on the sign of the gap. The standard error of the revisions is of the same order of magnitude as the standard error of the output gap.

Kozicki (1999) calculated the funds rate targets implied by Taylor rules using alternative plausible real-time measures of the output gap and inflation. She found the range of implied values for the funds rate target to be extremely wide. Kozicki (1999, p. 25) concluded, "Taylor-type rules are likely to be of limited use to policymakers facing real-time decisions." Orphanides (1998-03, p.3) found that one-quarter-ahead forecasts of the funds rate based naively on a continuation of the existing funds rate were more accurate than the forecasts from a Taylor rule implemented with contemporaneously available data.

It is instructive to look at the reliability of estimates of the output gap over the period when an activist policy focused attention on that variable. Over the period 1966Q1 to 1979Q4, real-time estimates of the output gap (measured by the Council of Economic Advisers) averaged −4.5 percent. However, using the data available as of 1994Q4 yields an estimate of the output gap over this period of 1.6 percent.[9] That is, the average difference in the contemporaneous estimates of the output gap and the estimate made later is 6.1 percentage points.

One can interpret monetary policy under Chairman Volcker as the abandonment of a policy rule incorporating the spirit of the Taylor rule. In the earlier period, the FOMC formulated monetary policy based on control of the output gap and on a direct response to inflation. That policy earned the appellation "stop-go," although "go-stop" would have been more apt. In the go phase, monetary policymakers attempted to *eliminate* a perceived negative output gap with expansionary monetary policy. In the stop phase, they had to *create* a negative output gap to eliminate the inflation they had created in the go phase.

[9] Athanasios Orphanides kindly supplied these figures.

Activist stabilization policy promised to mitigate cyclical fluctuations by controlling the variability of the output gap. Furthermore, based on empirical estimates of the Phillips curve, such policy promised that the resulting output gaps would yield only modest inflation. In its actual implementation, however, activist policy foundered on the difficulty of making the concept of an output gap operational and on the long lags in the effects of actions undertaken to control the perceived level of idle resources. As Milton Friedman (1960, p. 88) argued, responding directly to realized inflation destabilized the economy.

Under Chairman Volcker, the FOMC stopped trying to identify the amount of unemployed resources in the economy. Instead of trying to maintain output at an estimated potential level (or maintain the unemployment rate at its full-employment level), the FOMC began to move the funds rate whenever real output appeared to grow faster than its sustainable rate (Mehra 2000b). That is, the FOMC retained a sense of the slope of the trend line measuring potential output, but stopped trying to estimate its level.

Orphanides' Critique of the Taylor Rule

Athanasios Orphanides (1999, p. 41) has attacked the Taylor rule for its unrealistic demand that policymakers possess reliable information on the output gap:

> The recent resurrection of interest in policy activism through rules that rely on accurate knowledge of the economy's 'full employment potential' must be recognized for the danger it embodies. Much like during the 1970s, insufficient attention appears to have been paid to the informational limitations inherent in such activist policies.

Orphanides simulates a model that would permit an activist monetary policy if the policymaker had reliable information on potential output. In particular, the model is in the spirit of the activist model of Rudebusch and Svensson (1999). In such a model, the policymaker can take advantage of the backward-looking expectations of the public to vary systematically the real rate of interest. Changes in the real rate of interest affect the output gap with a lag. In turn, changes in the output gap affect inflation with a lag. Using this model and characterizing monetary policy with a Taylor rule, Orphanides explains the inflation of the '60s and '70s as resulting from overly pessimistic contemporaneous estimates of the output gap. Because Orphanides accepts the empirical correlations of Phillips curves as structural, his criticism of activist stabilization policy stops short of the more sweeping criticisms contained in the natural rate-rational expectations critique summarized above.

Economists who accept Orphanides' demonstration that real-time estimates of the output gap are unreliable but favor Taylor rules conclude that the central bank should respond primarily to observed misses of inflation from target (Orphanides et al. 1999). However, if the central bank is credible, unintentional expansionary monetary policy actions would appear initially as increases in output and only belatedly as increases in inflation. The long lag in the impact of expansionary monetary policy on inflation would then cause this monetary policy to destabilize the economy.

Monetary policy has been a success since the early 1980s. There is then much at stake in the debate over how to characterize it. If one can characterize it with a Taylor rule embedded in an activist model, then monetary policy should be used actively to stabilize the economy. The Fed could have avoided the inflation of the ’70s while still pursuing an activist policy if it had adjusted the parameters of its rule and implemented it more cautiously. The alternative is that the inflation of the ’70s derived from a fundamental misunderstanding of the nature of inflation and the inevitable failure of activist policy. The improvement in monetary policy came from the abandonment of activist monetary policy.

4. PITFALLS IN ESTIMATING AN OPTIMAL TAYLOR RULE

John Taylor laid out a normative research agenda: the formulation of a monetary policy rule that will stabilize the economy. This section criticizes the Taylor rule literature that has attempted to derive an optimal rule from empirical estimation.

Choosing the Estimation Period

To begin, because the FOMC uses an interest rate as its instrument, an optimal rule describes how the interest rate responds in a way that offsets the effects of real shocks that push output away from its potential value. An optimal rule then characterizes the optimal behavior of the price system. Empirical estimation of such a rule requires estimation over a period when the central bank responded optimally to real shocks and did not itself create nominal demand shocks. In this spirit, Taylor compares policy rules estimated over periods of relative instability and stability of inflation.

This procedure raises difficult issues, however. Economists use 1980 as a dividing line between policies that failed to stabilize inflation and policies that stabilized inflation. They then typically use that year as a dividing line for estimating “bad” and “good” reaction functions. Even so, the Fed gained credibility much later than 1980. A rule implemented over a period like the ’80s when the Fed did not possess credibility will not necessarily constitute an optimal rule. Such a rule may differ from the optimal rule implemented when the Fed possesses credibility. From this perspective, 1980 is not a good dividing line.

To see this point, note the undesirability of estimating an optimal rule over a period when the central bank had to suppress inflation. From a quantity theory perspective, the central bank created the inflation, not the private sector. That is, one should look for an optimal rule over a period when the central bank did not have to correct its own past mistakes.[10] Similarly, one should not estimate over a period when the central bank had to "correct" the expectational behavior of the public. It is true that the FOMC largely stabilized the inflation rate starting in 1983; however, it only gradually gained credibility for an objective of price stability. As Goodfriend (1993) documents, because the Fed lacked credibility, it had to respond to "inflation scares."

Interpreting the Estimated Coefficient on Inflation

The key result that emerged in the empirical estimation of Taylor rules is the rise over time in the coefficient estimating the Fed's reaction to inflation. Taylor attributes the improved control of inflation to this rise. However, such an inference is questionable. If the central bank is credible and stabilizes inflation, then the correlation between realized inflation and expected future inflation will be zero. Fluctuations in inflation will occur randomly around the central bank's target, but those fluctuations will not alter the public's expectation of future inflation. The latter is the relevant variable for the behavior of interest rates.

Consider again Taylor's (1999b) model expressed in equations (2), (3), and (4). A more realistic model will determine the real rate of interest as the difference between the interest rate and expected inflation, not realized inflation, π_t. Assume a positive inflation shock, $e_t > 0$. If, as Taylor assumes, such shocks are serially uncorrelated, expected future inflation will remain unchanged and so will the equilibrium rate of interest. The transitory rise in inflation will redistribute income between parties who had entered into nominal contracts, but that is water under the bridge. The market and the central bank should not respond to realized inflation. The policy parameter g_π should be zero.

How then can one explain the increase over time in Taylor-rule regressions of the estimated value of g_π, the parameter that is supposed to capture the response of the central bank to inflation? Does the rise over time in the coefficient estimated on the inflation term reflect an independent change in the FOMC's behavior deriving from a more aggressive response to inflation? Alternatively, does the rise reflect a response of the FOMC to a change in the public's behavior that derives from a loss of Fed credibility? A historical review will clarify the issues.

The monetary history of the United States is one of moving from a commodity standard to that of pure fiat money. One would then expect that over time, as the public adapted to the change in regime, the value of the correlation between the interest rate and inflation would rise. Imagine a commodity

[10] Taylor (1993) originally estimated his rule over the period 1987 to 1992. However, during that period FOMC actions produced a reduction in inflation. The FOMC had brought the inflation rate down to 4 percent in 1983. Faced with the strains of a worldwide banking crisis and recession, it stabilized inflation at that level. By the end of the decade, the FOMC moved to a soft-landing strategy to continue the process of restoring price stability.

standard in which the price level is stationary. In this case, a positive inflation rate will imply a subsequent negative inflation rate. The correlation between inflation and the interest rate will be negative.

In contrast, imagine a fiat money standard where changes in the inflation rate are a random walk. Now, the contemporaneous inflation rate is the best predictor of future inflation. The inflation premium in the interest rate will be equal to observed inflation. The emergence of a positive correlation between inflation and the interest rate will reflect the change in the way the public forecasts inflation based on past inflation. The increase in the correlation over time reflects a loss of credibility, not a more aggressive policy of controlling inflation.

Until the mid-1960s, the public could retain the way it had formed its expectation of future inflation under a commodity standard. Until then, a pure fiat money regime with no institutional constraints on the level of inflation was still a historical novelty (Friedman 1986). At this time, the Fed's rejection of the constraints imposed by the Bretton Woods system and its attempt to make the economy grow along an unrealistically high path for potential output caused the inflation rate to begin to wander.[11]

As McCallum (1994, Figure 1) shows, over the period from mid-1955 to 1980, inflation went from being a low-order autoregressive process to being nearly a random walk. The public did adapt to this change in the behavior of inflation. Friedman and Schwartz (1970, p. 631) found that interest rates began to incorporate a Fisher effect (inflation premium) starting in the mid-1960s. However, the public learned only slowly.

The fact that bondholders continued to suffer losses throughout the 1970s is evidence that learning proceeded slowly. Until the beginning of the 1980s, inflation regularly exceeded the forecasts of inflation made by the public and by economists (see Darin and Hetzel [1994], Sec. 4 and Croushore and Stark [1996]). One reason the public adapted slowly to the change in the monetary regime was the association of the large increases in inflation in the '60s and '70s with the unusual events of the Vietnam War and oil price shocks. By 1979, however, the public came to see inflation as a nonstationary process. Indeed, the resulting turmoil that belief caused for bond markets provided one impetus to the change in Fed procedures in 1979 (Hetzel 1986). Paul Volcker and later Alan Greenspan made Fed credibility into the nominal anchor lost in going off the gold standard.

[11] The last time the FOMC raised the level of short-term interest rates to offset a balance of payments deficit and gold outflows was in November 1964.

Estimation Bias

Consider a specific example of how the change over time in the way the public has forecast inflation can raise empirical estimates of the response of the funds rate to inflation. Clarida, Gali, and Gertler (2000) estimate a forward-looking Taylor rule:

$$i_t^* = a + g_\pi(E[\pi_{t+1} \mid \Omega_t] - \pi^*) + g_x E[x_{t+1} \mid \Omega_t] \tag{7}$$

$$i_t = (1-\rho)i_t^* + \rho i_{t-1} + \nu_t \tag{8}$$

The variable i_t^* is an implied funds rate target. According to (7), the FOMC determines i_t^* as the sum of a constant term a and responses to the miss of forecast inflation from its targeted value and to a forecast of the output gap. The FOMC forms these forecasts based on available information Ω_t. E is the expectations operator. According to (8), the FOMC smoothes the actual funds rate, i_t, by setting it equal to a weighted average of the implied target and last period's actual target. (ν_t is a random policy shock.)

Clarida, Gali, and Gertler (2000) estimate (7) and (8) through an instrumental variables procedure. Specifically, they use as a proxy for $E[\pi_{t+1} \mid \Omega_t]$ predicted values derived from a regression of future quarterly inflation, π_{t+1}, on four quarterly lags of past inflation as well as other lagged variables. (The time subscript one on inflation indicates one year or four quarters in the future.) Empirical estimation shows a rise in the value of g_π over time. However, this result may derive from a change in the way the public formed its expectation of inflation in response to a change in the monetary regime.

The central bank cannot set its interest rate target in a way that ignores the public's expectation of inflation. Therefore, the dependent variable of (7), the interest rate target, will on average contain an inflation premium that reflects the public's true measure of expected inflation. A problem arises if the right-hand variable used to proxy for the central bank's forecast of inflation, $E[\pi_{t+1} \mid \Omega_t]$, is a biased measure of the public's expected inflation. If that case, the coefficient estimated for g_π will also be biased.[12]

Consider first use of observed inflation as a proxy for $E[\pi_{t+1} \mid \Omega_t]$. In a world of incomplete credibility, the public will form its measure of expected inflation based in part on the observed value of inflation, not exclusively on

[12] Presumably, the central bank varies its policy instrument so that at some appropriate future horizon its inflation forecast always equals π^*. That is, the term $(E[\pi_{t+1} \mid \Omega_t] - \pi^*)$ in (7) will always equal zero. What one wants is the central bank's inflation forecast conditional on no change in its instrument. In the absence of such forecasts, one must use some proxy. The proxy that economists use typically depends upon the observed behavior of inflation. The problem comes because the public's expectation of inflation was not completely determined by π^*. Then the proxy used for expected inflation will be related to the inflation premium the public puts into the interest rate, which affects the behavior of i_t and i_t^*. However, that relationship can change over time in a way that biases empirical estimates of g_π.

the central bank's objective π^*. As explained above, in the pre-1980 period, the public's expectation of future inflation rose with observed inflation, but less than one for one. In the post-1980 period, it rose one for one. In a regression of (7) and (8), that fact will bias downward the coefficient estimated for g_π in the earlier period.[13]

Consider next a two-stage estimation procedure that uses as an instrument for expected inflation the forecasted value from a regression of inflation on its own past values. Again, as explained above, the sum of the weights in such a regression rose over time and approached one in 1980 with the change in the character of the monetary regime. This rise in the sum of estimated coefficients captures the change in the inflation rate from a stationary to a nonstationary series. However, the public only gradually accepted this change as the normal state of affairs. Consequently, the problem identified above arose. In the pre-1980 period, the public's expectation of inflation and the interest rate rose in line with rises in this proxy for $E[\pi_{t+1} \mid \Omega_t]$, but less than one for one. That fact biases downward the coefficient estimated for g_π. However, by the 1980s, that bias disappears.[14]

A different kind of estimation bias arises because of the difficulty in finding instruments that are orthogonal to the shocks in a Taylor rule regression. Clarida, Gali, and Gertler (2000) conduct their estimation subject to the following orthogonality condition, which comes from combining (7) and (8) and some algebra involving adding and subtracting actual inflation in period $t + k$, $\pi_{t,k}$, and the actual output gap in period $t + q$, $x_{t,q}$:

$$E\{[i_t - (1 - \rho)a - (1 - \rho)g_\pi \pi_{t,k} - (1 - \rho)g_x x_{t,q} - \rho i_{t-1}]z_t\} = 0. \qquad (9)$$

The term in brackets measures the difference between the actual interest rate target and an estimate of it from (7) and (8). The authors assume that this term is orthogonal to the instruments, which include lagged inflation and the lagged output gap.

Evaluating the plausibility of this last assumption requires some knowledge of monetary history. After 1980, periodic "inflation scares" caused the FOMC to raise sharply its interest rate peg (see Hetzel [1986], Goodfriend [1993], and

[13] The problem is analogous to the one identified by Sargent (1971) in tests of the natural rate hypothesis using regressions with lagged inflation rates as a proxy for expected inflation. (See also Woodford 1999, p. 43.)

[14] My reading of the pre-1980 historical record is that the FOMC did increase its funds rate target in line with increases in the inflation rate that it and the public expected. The problem was that both the FOMC and the public underpredicted inflation because of the novelty of an activist monetary regime. Both the FOMC and the public knew when monetary policy was expansionary. However, they underestimated the inflationary consequences. The FOMC believed that an expansionary policy would primarily affect output growth rather than inflation when the output gap was negative. Because most policymakers believed inflation was a nonmonetary phenomenon, they ignored the warning signs coming from high rates of money growth.

Mehra [1999, 2000a]). It follows that the policy rule (7) omits a variable—the FOMC's assessment of its credibility. Specifically, when the rate of growth of real output rose, financial markets became concerned that inflation would revive. Bond rates rose and the FOMC raised the funds rate to demonstrate its determination to prevent a rise in inflation. To capture this effect, (10) adds a credibility variable, $INFSC_t$, to (7). That variable is correlated with output growth and the output gap, x_t:

$$i_t^* = a + g_\pi(E[\pi_{t+1} \mid \Omega_t] - \pi^*) + g_x E[x_{t+1} \mid \Omega_t] + INFSC_t. \qquad (10)$$

The aggressive response of the FOMC in raising the funds rate during an inflation scare would generate a positive error in a regression using (7), but not (10). Persistence of the initial shock causing the high output growth would then produce a correlation between the contemporaneous error and the instrumental variables z_t, which include lagged real output. This correlation biases the estimation results. In sum, an instrumental variables procedure does not solve the omitted variables problem.

Are the Long-run Real Rate and Inflation Target Constant?

Problems arise in the estimation of a Taylor rule if the long-run real rate of interest is not constant. The Taylor rule attributes the historically high value of the real funds rate starting in 1980 to the excess of inflation over a 2 percent inflation target. (From 1980 through 1990, the real commercial paper rate shown in Figure 2 is 4.7 percent, well above the assumed 2 percent long-run average.[15]) That is, the FOMC supposedly kept the real funds rate higher than its long-run average because inflation was above target. However, the 2 percent figure for the FOMC's inflation target does not derive from internal FOMC documents. It could simply be an ad hoc way of getting a higher prediction for the funds rate by artificially creating a positive miss of an inflation target. A low inflation target compensates for an unrealistically low estimate of the long-run average real rate of interest.

In addition, the assumption that the FOMC's objective for inflation remained unchanged during the period from 1965 through 1981 when inflation rose is implausible. In the pre-1980 period, the FOMC tried to determine whether inflation was demand-pull, cost-push, or expectational in origin. It tended to accommodate changes in inflation perceived as cost-push or expectational rather than demand-pull. The inflation rate acceptable to the FOMC then rose as actual inflation rose.

[15] The Appendix explains the measure of the real rate of interest. It is the difference between the interest rate on commercial paper observed at the time of FOMC meetings and the inflation forecast made at the same time by the staff of the Board of Governors. (This series is available only through 1994 because of the five-year lag in the release of Board staff inflation forecasts.)

5. HOW WELL DOES THE TAYLOR RULE PREDICT?

Regression equation (11) embodies the Taylor rule. Equation (12) collects the actual inflation terms π_t, and (13) rewrites (12) with $k_1 + k_2 = 1$. Equation (14) combines the constant term and the inflation target term under the assumption that the inflation target and the weight the central bank assigns to it do not change ($k_4 = k_0 + k_2\pi_t^*$).

$$i_t^* = c_0 + \pi_t + c_1(\pi_t - \pi_t^*) + c_2 x_t + \mu_t \tag{11}$$

$$i_t^* = c_0 + (1 + c_1)\pi_t - c_1\pi_t^* + c_2 x_t + \mu_t \tag{12}$$

$$i_t^* = k_0 + k_1\pi_t + k_2\pi_t^* + k_3 x_t + \mu_t \tag{13}$$

$$i_t^* = k_4 + k_1\pi_t + k_3 x_t + \mu_t \tag{14}$$

The wide popularity of the Taylor rule derives from its presumed ability to predict the actual behavior of the funds rate. This section extends the work of Croushore and Stark (1999), Kozicki (1999), Orphanides (1998-03), and Runkle (1998) by examining how well a Taylor rule predicts the funds rate using data available to the FOMC at the time of its meetings. (The Empirical Appendix explains the data.) Figure 1 shows the value of the funds rate benchmark that came out of FOMC meetings and the value predicted by regression equations possessing the functional form (14).[16] The regressions used to generate the predictions shown in Figure 1 are estimated separately for the periods November 1965 through July 1979, August 1979 through July 1987, and August 1987 through May 1999. The last two periods correspond, respectively, to the tenures of Paul Volcker and Alan Greenspan as FOMC chairman.[17]

The fit shown in Figure 1 is not particularly close. For the period November 1965 through July 1979, the standard error of estimate of the appendix

[16] See the discussion in Section A of the Empirical Appendix for an explanation of the construction of the series label "funds rate benchmark."

[17] I do not compare the funds rate with predictions from a Taylor rule assumed to be different from what the FOMC actually used. Taylor (1999, section 7.4) performs this exercise as a test of the superiority of a hypothetical Taylor rule. However, predictions derived from inserting historical data into a hypothetical rule make no sense. If the hypothetical rule had been implemented, it would have produced different macroeconomic outcomes, and one should use those outcomes to test the rule. That exercise requires a model. (See McCallum [1987, 1988] for an example.)

The logic of the Taylor (1999a) experiment appears to be as follows. One can look at a period when inflation was undesirably high. Then, one FOMC meeting at a time, one can construct the funds rate implied by the hypothetical rule and historical data. If the implied funds rate is uniformly higher than the actual, one can argue that the hypothetical rule would have produced a more restrictive monetary policy and, therefore, would have been better. However, a similar exercise would be to take the following as a rule: Keep the funds rate 5 percentage points above its historically observed maximum value. That hypothetical rule would also be unambiguously more restrictive. But one has no way of knowing whether it would have been better than actual policy without model simulations.

regression (1) predicting the funds rate is 1.6. For the period August 1979 through July 1987, the value is 2.1 (appendix regression (2)). For August 1987 through May 1999, it is .76 (appendix regression (3)).

Judd and Rudebusch (1998) estimate the Taylor rule with a lagged value of the funds rate. They argue that such a term reflects interest rate smoothing by the FOMC. The appendix estimates Taylor rule regressions that include a lagged value of the funds rate. The output gap and inflation terms add little predictive power beyond that offered by the lagged value of the funds. In the pre-Volcker period, the regression basically implies that the FOMC sets the funds rate equal to its prior value. For the Volcker period, the standard error of estimate is 1.44 and for the Greenspan period, .24. Even in the Greenspan period, the prediction error seems rather large as the .24 value is basically the same magnitude as the 25-basis-point change the FOMC generally uses when it changes the funds rate.[18]

Can the Taylor Rule Explain Inflation?

This section finds that the actual real rate of interest has generally been high when evaluated in the context of a Taylor rule. It is then puzzling that inflation persisted above the FOMC's presumed 2-percent target for so long.

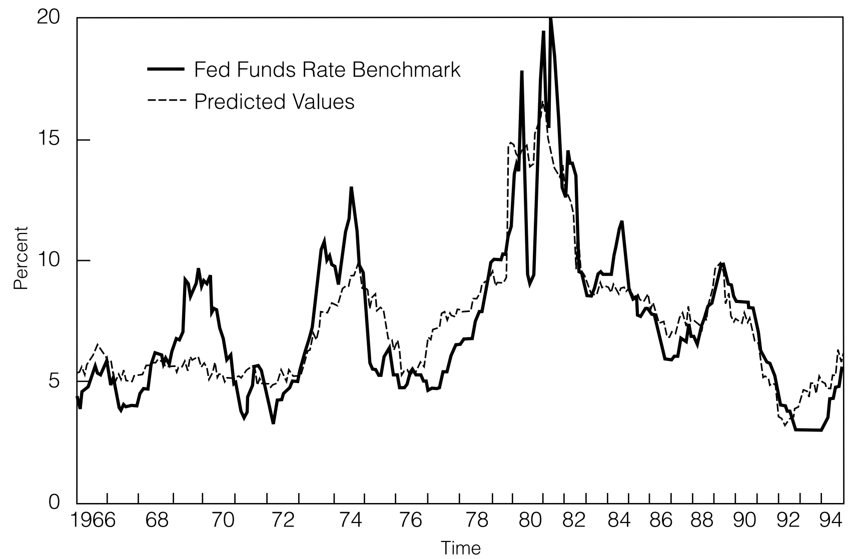
Below, I construct a measure of disinflationary pressure. It is the difference between the real rate of interest and a Taylor-rule benchmark value that should maintain inflation at its prevailing level. I construct this benchmark measure under the assumption that the FOMC actually used the Taylor rule in implementing monetary policy. Furthermore, I construct it using the data contemporaneously available to the FOMC at the time of its meetings. Observations correspond to FOMC meetings.

The solid line of Figure 2 plots the short-term real rate of interest. The dashed line is the benchmark value measuring neutral monetary policy.[19] I make use of the following intuitive interpretation of how the Taylor rule specifies how the FOMC sets the real funds rate implicit in its funds rate benchmark. It sets

[18] For the Volcker and Greenspan periods, the standard deviations of the first differences of the funds rate benchmarks are, respectively, 1.6 and .29, only slightly higher than the standard errors of estimate from the regressions that include the lagged interest rate targets as regressors. One can think of these standard deviations as measuring the predictive ability of a naive forecast that assumes the contemporaneous value equals the prior value. The Taylor rule part of the regression then adds very little information beyond what the lagged interest rate target adds.

[19] The output gap proxy used to generate this benchmark is only partially satisfactory, especially for the pre-1979 period. As Orphanides (1999) has emphasized, in the '60s and '70s, policymakers typically used a measure of the output gap derived from a trend line for potential output that was unrealistically high. The effect on Figure 2 of using a more realistic contemporaneous (pessimistic) estimate of the output gap would be to make the FOMC appear more hawkish on inflation by showing the real rate of interest to be significantly higher relative to the neutral benchmark level.

Figure 1 The Funds Rate Benchmark and Its Taylor Rule Predictions



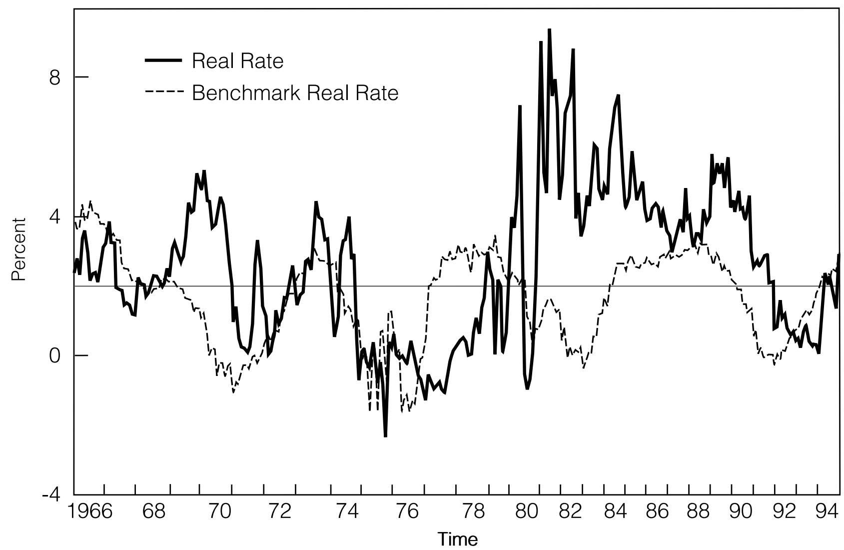
Notes: The dashed line is the within-sample predicted values of regressions (1), (2), and (3) in the Appendix. Observations correspond to FOMC meetings, whose number per year has declined. See Appendix for discussion of the series "Fed Funds Rate Benchmark." Tick marks indicate last observation of the year.

this implicit real rate as the sum of three components: 1) the long-run average real rate, assumed constant at 2 percent; 2) a cyclical component, assumed equal to half the output gap, $.5x_t$; and 3) an amount to correct for misses of the inflation target, $.5(\pi_t - \pi^*)$. The benchmark value measuring neutral monetary policy is the sum of the first two components: the long-run average real rate and the cyclical component of the real rate. In periods when the real rate exceeds the benchmark, inflation should fall, and conversely.

Over the entire period shown in Figure 2, the real rate of interest usually exceeded or equaled the neutral benchmark level. That is, the FOMC was setting the real rate implicit in the funds rate at a level designed to lower inflation. The major exception was the period from 1977 through 1979. Since 1980, the real rate has also generally exceeded the presumed long-run average real rate of 2 percent. Given the willingness of the FOMC to maintain disinflationary real rates of interest on average, it is hard to explain why inflation fell to its targeted value of 2 percent only in 1997.[20]

[20] From 1983 through 1991, CPI inflation generally exceeded its assumed target by 2 to 3 percentage points. From 1992 until early 1997, the excess was about 1 percentage point.

Figure 2 The Real Rate of Interest and Its Neutral Benchmark Value

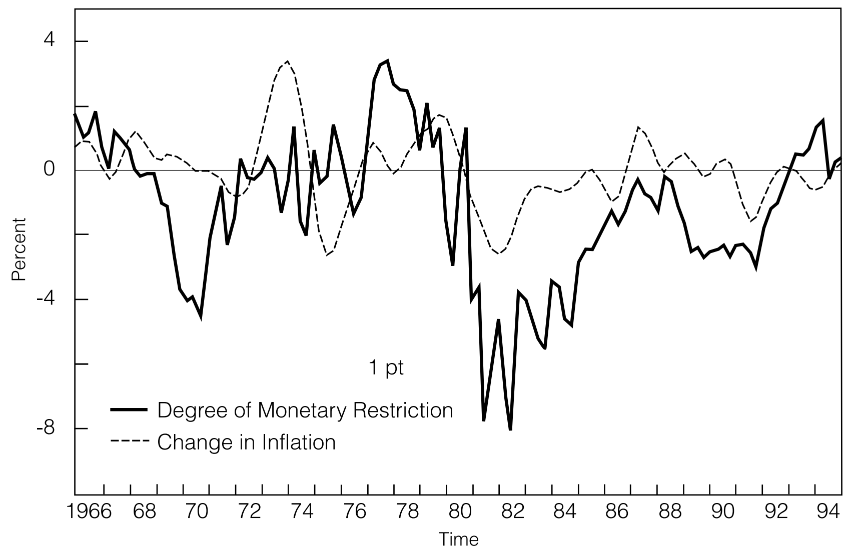


Notes: The real rate of interest is the real commercial paper rate calculated as described in the Appendix. The neutral benchmark values are the sum of the Taylor rule components: $2 + .5x_t$, with x_t an output gap. Observations correspond to FOMC meetings. Tick marks indicate last observation of the year.

Figure 3 plots quarterly averages of the difference between the dashed and solid lines of Figure 2, that is, the neutral benchmark minus the real rate of interest. A rise in the real rate relative to the benchmark produces a fall in this measure of the stance of monetary policy. Figure 3 also plots quarterly observations of the difference between subsequently realized four-quarter (personal consumption expenditures) inflation and the prior four-quarter inflation rate. Negative values indicate that the inflation rate is falling. Falls in the solid line (an increase in the degree of monetary restriction) below zero should produce negative values of the dashed line (falls in inflation). Over the entire period shown, as measured here, monetary policy is generally disinflationary (the solid line is generally negative). However, inflation remained above 2 percent until early 1997.

Over the period 1965Q4 through 1979Q4, the correlation between the two lines is almost zero (.06). Inflation does fall starting in 1971 after a prolonged monetary tightening. However, that fall may have occurred chiefly because of the price controls instituted in August 1971. The Taylor rule fails to predict the disinflation starting in 1975. Although there is a professional consensus that

Figure 3 Monetary Restrictiveness and Changes in the Inflation Rate



Notes: The solid line is quarterly averages of the observations of the dashed line minus the solid line of Figure 2. The dashed line is the change in (personal consumption expenditure) inflation measured as the average of the contemporaneous and future 3 quarters values minus the average of the contemporaneous and past 3 quarter values. Tick marks indicate fourth quarter.

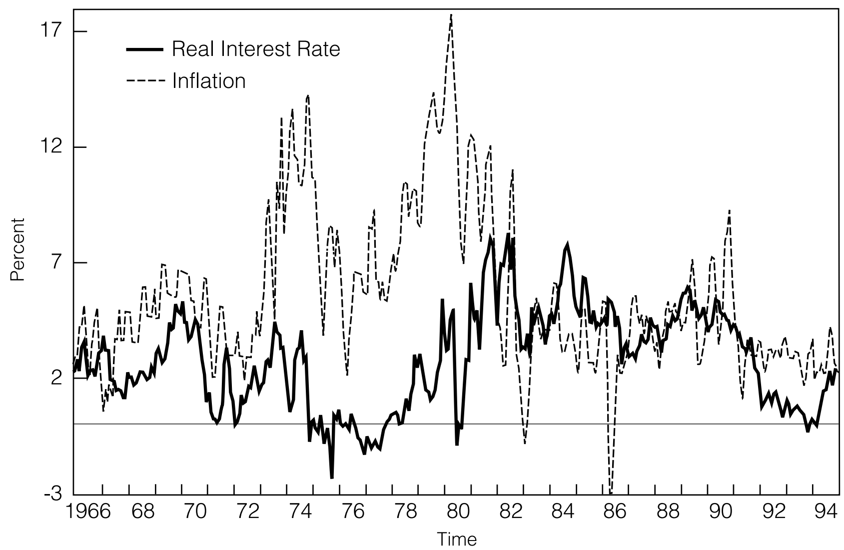
monetary policy was highly contractionary after summer 1974, the Taylor rule does not unambiguously identify that tightness.

The correlation between the two lines of Figure 3 rises to .62 over the period 1980Q1 to 1999Q1. However, the correlation derives primarily from a single episode of monetary stringency—the Volcker disinflation. The message is little more than that the FOMC can reduce inflation through a sharp rise in the funds rate. Inflation rises after 1986 even though the Taylor rule indicates that monetary policy is disinflationary.

Cost-push shocks could explain the failure of "high" interest rates to produce falling inflation. A high real rate of interest relative to the Taylor rule neutral benchmark could then be associated with rising rather than falling inflation. However, if this assumption is correct, one would expect to see the level of inflation positively correlated with the real rate of interest. That is, causation goes from inflation to the real rate rather than vice versa.

Figure 4 shows the real rate of interest and the inflation rate. It fails to reveal a consistent positive relationship. For example, contrary to the Taylor rule, the real rate of interest is somewhat higher in 1969–1970 than in 1973–1974, yet

Figure 4 Real Interest Rate and Inflation



Notes: The real interest rate is the monthly observation of the short-term real commercial paper rate. The series after 1978 differs from that of Figure 2 in that a monthly series is constructed using inflation forecasts from DRI. Inflation is the monthly annualized growth rate of the CPI. Tick marks indicate December.

the inflation rate is considerably higher in the latter period. In 1984–1985 the real rate is higher than in 1988–1989, yet the inflation rate is somewhat lower.

6. SUMMARY COMMENT

This article criticizes two assumptions of the Taylor rule literature. First, the use of the Taylor rule in activist models with cost-push shocks is a good guide for the monetary policymaker. Second, the FOMC has done a better job since 1980 of controlling inflation because it became more aggressive in responding to realized inflation.

EMPIRICAL APPENDIX

The Appendix summarizes the estimation of Taylor rules for three periods: the pre-Volcker period (November 1965–July 1979), the Volcker period (August 1979–July 1987), and the Greenspan period through to the near present (August 1987–May 1999). Section A explains the use of contemporaneously available data. Section B presents the regressions. Section C explains the construction of the series on the real rate of interest.

A. Data Used to Estimate the Taylor Rule

The observations correspond to FOMC meetings, which are monthly through 1978 and 8 per year thereafter (11 in 1980). If there were two meetings in a month, I have used the first one. For the December 1965 through October 1970 meetings, the funds rate benchmark is the actual average value in the first full statement week following the FOMC meeting. For the November 1970 through September 1979 meetings, the funds rate benchmark is the initial value set by the FOMC. It comes from the Board of Governors staff document called the Bluebook ("Monetary Policy Alternatives") and FOMC *Memoranda of Discussion.*

For the February 1980 through October 1981 meetings, the funds rate benchmark is the actual average value in the first full statement week following the FOMC meeting with the following exceptions: November 1979, January 1980, May 1980, May 1981, and July 1981. For these meetings and for the meetings from November 1981 through December 1993, the funds rate benchmark is the value the Desk "anticipated" would prevail subsequent to the FOMC meeting as reported in the New York Fed memorandum "Open Market Operations and Securities Market Developments." From 1994 on, the funds rate benchmark is the figure publicly announced after the FOMC meeting.

One should keep in mind that the FOMC did not use the funds rate as its policy instrument consistently over this period. In the '60s, it used a complex of money market conditions, chiefly the short-term Treasury bill rate. In the '70s it did set a funds rate target. From October 1979 until fall 1982, it set a target for nonborrowed reserves. Thereafter, until February 1994, it set a "reserve-position" target for banks approximated by borrowed reserves. Along with the level of the discount rate, the value of borrowed reserves determined the level of the short-term interest rate.

The important point to keep in mind is that there are two distinct kinds of policy instruments: reserve aggregates and money market conditions. With the former, the Fed sets a reserve aggregate like the monetary base or total bank reserves and the marketplace determines the level of short-term interest rates. With the latter, the Fed sets a short-term money market rate of interest and supplies whatever reserves are necessary to defend that rate of interest. In practice, the Fed has at times implemented this latter procedure directly by setting an interest rate peg. At other times, it has controlled the short-term interest rate indirectly. For example, it has set the discount rate and a value for reserves that banks borrow through the discount window (see Cook [1989] and Hetzel [1982]). The Fed has always operated using money market conditions as its policy instrument. The funds rate benchmark series described above is a general measure of the money market conditions intended by the FOMC.

Data for calculating values of inflation π_t and the output gap x_t come from the Board of Governors staff document called the Greenbook ("Current Economic and Financial Conditions, Part 1") and from the Federal Reserve Bank of Philadelphia Real Time Data Set (Croushore and Stark 1999). The contemporaneously available data series for each FOMC meeting derives from splicing Greenbook data with the contemporaneously available longer data set from the appropriate Philadelphia Fed Real Time Data series. π_t is a four-quarter average of annualized quarterly percentage changes in the implicit nominal output deflator (GNP before 1992 and GDP thereafter).

I call the values of inflation and the output gap calculated as described below "actual" values because they rely primarily on actually available data rather than on forecasts of the future made by the Board staff. If the FOMC meeting was in the first or second month of the quarter, the four lagged inflation values averaged to calculate π_t begin with the quarter prior to the quarter of the FOMC meeting. If the FOMC meeting was in the last month of the quarter, the four lagged values begin with the contemporaneous quarter.

The output gap x_t is the percentage difference between current real output and trend real output (real GNP before 1992 and real GDP thereafter). Trend real output is the value of a trend line fitted through the past 40 quarters of data available at the time of the FOMC meeting. If the meeting was in the first or second month of the quarter, the value used for current real output is for the quarter prior to the quarter in which the FOMC meeting occurred. If the FOMC meeting was in the last month of the quarter, current real output is for the contemporaneous quarter.

I also experimented with "predicted" values of inflation and the output gap that relied more heavily on forecasts of the future made by the Board staff. If the FOMC meeting was in the first or second month of the quarter, the four lagged inflation values used to calculate average inflation begin with the contemporaneous quarter's predicted value. If the FOMC meeting was in the last month of the quarter, the four lagged values begin with the succeeding quarter's predicted value. If the FOMC meeting was in the first or second month of the quarter, the value of current real output used in calculating the output gap is quarterly real output predicted for the contemporaneous quarter. If the FOMC meeting was in the last month of the quarter, current real output is the succeeding quarter's predicted value.

The inflation target is π^*. Taylor arbitrarily assumes it is constant at 2 percent. However, if that is the case, the Taylor rule predicts that the real rate should move in line with the level of the inflation rate. Figure 4, which shows the real rate of interest and the inflation rate, fails to reveal such a consistent relationship. I therefore attempted to infer a target from FOMC documents and statements.

As a proxy, I use the inflation forecast from the Greenbook made for the quarter that was most distant in the future (usually three to four quarters into the future in the '70s and eight quarters thereafter). After November 1979, I use as an additional proxy the midpoint of the central tendency range of fourth quarter to fourth quarter inflation predicted by FOMC members and presented by the FOMC chairman at the most recent February or July Humphrey Hawkins Hearings preceding the pertinent FOMC meeting.

Although these latter figures are forecasts, forecasting inflation is not like forecasting the weather. The FOMC controls inflation over some appropriately long forecast horizon. Both the Board staff and FOMC members make their forecasts contingent on the monetary policy they consider desirable. The forecasts then reflect the outcomes the Board staff and the FOMC members consider acceptable. In that sense, these "forecasts" are acceptable benchmark values. That is, the participants in the formulation of monetary policy assumed they would behave in a way that brought their forecast of inflation into agreement with these benchmarks for inflation.

Inclusion of such a term, however, did not yield satisfactory results. For example, it often entered with the wrong sign. The results reported below drop this term. The regressions adopt the assumption of the empirical Taylor rule literature that the FOMC's inflation target is constant and is captured by the constant term of the regression equation.

B. Estimated Taylor Rules

Regression (1) fits a Taylor rule from December 1965 to July 1979. It uses the "predicted" series for inflation and the output gap described above. The standard error of estimate of the regression fitted with the "actual" series was slightly higher.

$$i_t^* = \underset{(8.6)}{3.0} + \underset{(11.0)}{.69}\pi_t + \underset{(5.1)}{.21}x_t + \hat{\mu}_t \qquad (1)$$

Date: 11/65 to 7/79 $\bar{\text{R}}$ = .43 SEE = 1.6 DW = .11 DoF = 157

(The absolute value of the t-statistic is in parentheses. $\bar{\text{R}}$ is the corrected R-squared statistic. SEE is the standard error of estimate. DW is the Durbin-Watson statistic. DoF is degrees of freedom.)

Below, I report regression equations for the Volcker and Greenspan periods. For the Volcker period, the fit of the regressions using actual and predicted data is basically the same. For this period, I report the regression estimated with predicted data. For the Greenspan period, I use the actual inflation and output gap data as they yield a somewhat lower standard error of estimate.

Regression equation (2) is for the Volcker period.

$$i_t^* = 4.1 + 1.16\pi_t + .14x_t + \hat{\mu}_t \tag{2}$$

(6.0) (9.4) (.95)

Date: 8/79 to 7/87 $\bar{R}$ = .66 SEE = 2.1 DW = .59 DoF = 63

Regression equation (3) is for the Greenspan period.

$$i_t^* = 1.5 + 1.56\pi_t + .62x_t + \hat{\mu}_t \tag{3}$$

(6.2) (18.9) (15.4)

Date: 8/87 to 5/99 $\bar{R}$ = .82 SEE = .76 DW = .42 DoF = 92

As emphasized by Taylor, the estimated coefficients on the inflation terms rise over time.

Regressions (4) and (5) add a lagged value of the funds rate for the Volcker and Greenspan periods, respectively. The regression for the pre-Volcker period is uninformative in that it implies that the FOMC sets the funds rate equal to its prior value.

$$i_t^* = .87 + .43\pi_t + .12x_t + .69i_{t-1}^* + \hat{\mu}_t \tag{4}$$

(1.5) (3.7) (1.1) (8.7)

Date: 8/79 to 7/87 $\bar{R}$ = .85 SEE = 1.44 DW = 1.6 DoF = 62

$$i_t^* = .20 + .22\pi_t + .13x_t + .86i_{t-1}^* + \hat{\mu}_t \tag{5}$$

(2.3) (4.1) (6.3) (28.4)

Date: 8/87 to 5/99 $\bar{R}$ = .98 SEE = .24 DW = 1.8 DoF = 91

C. The Real Rate of Interest

The following explains the real rate of interest used in Figure 2. It is the commercial paper rate minus predicted inflation. The commercial paper rate more closely approximates the funds rate than the Treasury bill rate. Over the period November 1965 through July 1979, the pre-Volcker period, the commercial paper rate used to construct the real rate averaged 6.6 percent, while the actual value of the funds rate averaged 6.5 percent. Reflecting its riskless and liquid character, the short-term Treasury bill rate averaged only 5.9 percent.

The commercial paper rate used to construct the real rate is recorded on the date of the Greenbook publication. Until 1970, the paper rate is the 4–6 month rate. Thereafter, it is either the 3-month or 6-month rate depending upon whether the interval from the Greenbook date to the end of the succeeding quarter is closer to 3 or 6 months. Predicted inflation is for the implicit price deflator through July 1992, the fixed-weight deflator through March 1996, and the GDP chain-weighted price index thereafter. Predicted inflation is a weighted average for the quarter in which the Greenbook was published and the succeeding quarter with the weights varying with the number of days remaining in the contemporaneous quarter after the Greenbook date and the number of days in the succeeding quarter. For a full discussion of this series, see Darin and Hetzel (1995).

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