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Discretion versus policy rules in practice

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Abstract

This paper examines how recent econometric policy evaluation research on monetary policy rules can be applied in a practical policymaking environment. According to this research, good policy rules typically call for changes in the federal funds rate in response to changes in the price level or changes in real income. An objective of the paper is to preserve the concept of such a policy rule in a policy environment where it is practically impossible to follow mechanically any particular algebraic formula that describes the policy rule. The discussion centers around a hypothetical but representative policy rule much like that advocated in recent research. This rule closely approximates Federal Reserve policy during the past several years. Two case studies—German unification and the 1990 oil-price shock—that had a bearing on the operation of monetary policy in recent years are used to illustrate how such a policy rule might work in practice.

The econometric evaluation of monetary and fiscal policy rules using new methods of "rational expectations" macroeconomics has been the subject of substantially increased research in recent years.[1] A number of factors

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[1]The forthcoming volume by Bryant, Hooper, and Mann (1993) summarizes much of the empirical research with large multicountry models. A recent Federal Reserve System conference summarized in Taylor (1992) was largely devoted to the analysis of policy rules. A prototype empirical analysis was provided by Taylor (1979) with a full multicountry analysis described in Taylor (1993). Research by McCallum (1988) has also generated considerable interest in econometric evaluation of policy rules. Much of the material in this paper is drawn from Taylor (1993).

have motivated this research: the Lucas critique showing that traditional econometric policy evaluation was flawed, the recognition that rational expectations does not imply monetary policy ineffectiveness, the finding that credibility has empirically significant benefits, and the time inconsistency demonstration that policy rules are superior to discretion. Although one can find precursors of the new research on policy rules, the recent analysis has been made possible by new solution and estimation techniques for economy-wide equilibrium models, the development of empirical models of expectations-consistent wage and price dynamics, and the ability of multi-country empirical frameworks to handle international capital flows in efficient world markets.

The preferred policy rules that have emerged from this research have not generally involved fixed settings for the instruments of monetary policy, such as a constant growth rate for the money supply. The rules are responsive, calling for changes in the money supply, the monetary base, or the short-term interest rate in response to changes of the price level or real income. Some of the research has been quite precise about this response; the coefficients in the algebraic formulas for the policy rules provide exact instructions about how much the Fed should adjust its instruments each quarter in response to an increase in the price level or an increase in real GDP. While the exact coefficients differ from study to study, recently there has been some indication of a consensus about the functional forms and the signs of the coefficients in the policy rules.

Despite the emphasis on policy rules in recent macroeconomic research, the notion of a policy rule has not yet become a common way to think about policy in practice. Policymakers do not, and are not evidently about to, follow policy rules mechanically. Some of the reasons are purely technical. For example, the quarterly time period that has been used to evaluate policy in most econometric models is probably too short to average out blips in the price level due to factors such as temporary changes in commodity prices. On the other hand, a quarter is too long to hold the federal funds rate fixed between adjustments. For example, when the economy starts into recession, sharp and rapid interest-rate declines are appropriate. Many of these technical problems could be corrected, in principle, by modifications of these policy rules. A moving average of the price level over a number of quarters, for example, would be a way to smooth out temporary price fluctuations. Averaging real output—or nominal output—could also be considered. Going to a monthly model—and taking even longer-moving averages—would be a way to make the interest rate more responsive in the very short term. Such generalizations are an important task for future research.

However, these modifications would make the policy rule more complex and more difficult to understand. Even with many such modifications, it is difficult to see how such algebraic policy rules could be sufficiently encompassing. For example, interpreting whether a rise in the price level is temporary or permanent is likely to require looking at several measures of prices (such as the consumer price index, the producer price index, or the employment cost index). Looking at expectations of inflation as measured by futures markets, the term structure of interest rates, surveys, or forecasts from other analysts is also likely to be helpful. Interpreting the level and the growth rate of the economy's potential output—which frequently is a factor in policy rules—involves predictions about productivity, labor-force participation, and changes in the natural rate of unemployment. While the analysis of these issues can be aided by quantitative methods, it is difficult to formulate them into a precise algebraic formula. Moreover, there will be episodes where monetary policy will need to be adjusted to deal with special factors. For example, the Federal Reserve provided additional reserves to the banking system after the stock-market break of October 19, 1987 and helped to prevent a contraction of liquidity and to restore confidence. The Fed would need more than a simple policy rule as a guide in such cases.

Does all this mean that we must give up on policy rules and return to discretion? In fact, arguments like the one in the previous paragraphs sound much like those used by advocates of discretion rather than rules. Even some of those who have advocated the use of rules in the past seem to have concluded that discretion is the only answer. For example, David Laidler (1991) argues, "We are left, then, with relying on discretionary policy in order to maintain price stability."

If there is anything about which modern macroeconomics is clear however—and on which there is substantial consensus—it is that policy rules have major advantages over discretion in improving economic performance. Hence, it is important to preserve the concept of a policy rule even in an environment where it is practically impossible to follow mechanically the algebraic formulas economists write down to describe their preferred policy rules.

The purpose of this paper is to begin to consider how the recent research on policy rules might apply in such an environment. Section 1 starts with some important semantic issues. Section 2 describes recent results on the design of policy rules that form the basis for this research. Sections 3 and 4 consider the use of such policy rules in practice. For concreteness, I center the discussion around a hypothetical but representative policy rule that is much like that advocated in recent research. This policy rule also describes recent Fed policy surprisingly accurately. I also discuss two case studies—German unification and the 1990 oil-price shock—that had bearing on the operation of monetary policy in recent years.

1. Semantic issues

There is considerable agreement among economists that a policy rule need not be interpreted narrowly as entailing fixed settings for the policy instruments. Although the classic rules versus discretion debate was usually carried on as if the only policy rule were the constant growth rate rule for the money supply, feedback rules in which the money supply responds to changes in unemployment or inflation are also policy rules. In the area of fiscal policy, the automatic stabilizers—transfer payments that automatically rise and tax revenues that automatically grow more slowly with a rise in the unemployment rate—can be interpreted as a "policy." In the area of exchange-rate policy, a fixed exchange-rate system is clearly a policy rule, but so are adjustable or crawling pegs.

Moreover, in my view, a policy rule need not be a mechanical formula, but here there is more disagreement among economists. A policy rule can be implemented and operated more informally by policymakers who recognize the general instrument responses that underlie the policy rule, but who also recognize that operating the rule requires judgment and cannot be done by computer. This broadens the definition of a policy rule significantly and permits the consideration of issues that would be excluded under the narrower definition. By this definition, a policy rule would include a nominal income rule in which the central bank takes actions to keep nominal income on target, but it would not include pure discretionary policy.

In broadening the definition beyond mechanical formulas, I do not mean to lose the concept of a policy rule entirely. Under pure discretion, the settings for the instruments of policy are determined from scratch each period with no attempt to follow a reasonably well-defined contingency plan for the future. A precise analytical distinction between policy rules and discretion can be drawn from the time-consistency literature. In three of the major contributions—Kydland and Prescott (1977), Barro and Gordon (1983), or Blanchard and Fischer (1989)—a policy rule is referred to as the "optimal," the "rules," or the "precommitted" solution, respectively, to a dynamic optimization problem. Discretionary policy is referred to as the "inconsistent," the "cheating," or the "shortsighted" solution, respectively. That literature demonstrates that the advantage of rules over discretion is like the advantage of a cooperative over a noncooperative solution in game theory. This is one of the reasons that researchers have focused on policy rules in recent normative policy research.

As argued above, the term "policy rule" need not necessarily mean either a fixed setting for the policy instruments or a mechanical formula. Saying so, however, does not change common usage. Among most policymakers, the term "policy rule" connotes either a fixed setting for the policy instruments or a simplistic mechanical procedure. An alternative terminology would help focus attenion on the concept of a policy rule as defined here. For example, one alternative terminology was adopted in the 1990 *Economic Report of the President*. "Policy *rule*" was replaced by "*systematic* policy" or sometimes by "policy *system*" when a noun seemed more appropriate. For example, the 1990 *Economic Report of the President* said, "My Administration will...support a credible, *systematic* monetary policy program that sustains maximum economic growth while controlling and reducing inflation." (p. 4, italics added). The adjective "systematic" is defined in the *Oxford American Dictionary* as "methodical, according to a plan, and not casually or at random." Hence, this word connotes the important properties of a policy rule without bringing along the baggage of fixed settings or mechanical formulas.

With this broader definition of policy rules, comparing the performance of different rules becomes more challenging. Technically speaking, a policy rule is a contingency plan that lasts forever unless there is an explicit cancellation clause. While no policy rule will literally last forever, if a policy rule is to have any meaning, it must be in place for a reasonably long period of time. For a macroeconomic policy rule, several business cycles would certainly be sufficient, but for many purposes several years would do just as well. Policymakers need to make a commitment to stay with the rule if they are to gain the advantages of credibility associated with a rule. If economic analysis is to predict how the economy will perform with a policy rule, some durability of the rule is obviously required. In addition, econometric evaluation of policy rules is of little use if the policy rule is constantly changing.

A final semantic point relates to how different types of policy questions can be described using the language of policy rules. I find it useful to distinguish among three types of policy issues related to policy rules: (1) the design of a policy rule, (2) the transition to a new policy rule once it is designed, and (3) the day-to-day operation of a policy rule once it is in place. As I will describe below, certain policy actions that appear to be discretionary can be interpreted as transitions from one policy rule to another or even as part of the operation of an existing policy rule.

2. Policy design: the search for a good monetary policy rule

The policy design issues I consider in this paper focus entirely on monetary policy. The study of fiscal policy rules—automatic stabilizers or budget-balancing strategies—could be considered using the same approach. The design of fiscal policy rules is an important element of macroeconomic policy analysis despite problems with discretionary fiscal policy. Automatic stabilizers remain an important part of macroeconomic policy and help mitigate recessions. However, automatic stabilizers are affected by goals that go well beyond macroeconomic policy. For example, changes in the progressivity of the tax system affect the responsiveness of the automatic stabilizers to economic fluctuations but are not made with stabilization policy in mind.

The forthcoming volume by Bryant, Hooper, and Mann (1993) compares what nine different multicountry econometric models say about the performance of different monetary policy rules. Seven of the nine models are estimated rational expectations models. The models were developed by the International Monetary Fund, the Federal Reserve Board, the Department of Finance in Canada, and several individual researchers.

All the policy rules evaluated in the Bryant comparison are interest-rate rules. The monetary authorities are assumed to adjust their interest rate in response either to (1) deviations of the money supply from some target, (2) deviations of the exchange rate from some target, or (3) weighted deviations of the inflation rate (or the price level) and real output from some target.

There are substantial differences from model to model, and there is no agreement on a particular policy rule with particular parameters. Yet there is some consensus. The policy rules that focus on the exchange rate or policies that focus on the money supply do not deliver as good a performance (measured in output and price variability) as policies that focus on the price level and real output directly. In other words, monetary policy rules in which the short-term interest rate instrument is raised by the monetary authorities if the price level and real income are above a target and is lowered if the price level and real income are below target, seem to work well. By how much the interest rate should change is still uncertain, but that a consensus is emerging about a functional form is very promising.

My own research on policy rules reported in Taylor (1993) is generally consistent with these results. Using my multicountry rational expectations model, I simulated economic performance of the G-7 countries under several different monetary policy rules. Economic performance was then examined under the different policy rules. The policy rules were ranked according to how successful they were in achieving price stability and output stability. The approach deals explicitly with several issues raised by the Lucas critique of traditional econometric policy evaluation methods. In fact, the three examples used in the original critique paper of Lucas—consumption demand, price determination, and investment demand—are part of this multicountry model. Endogenizing expectations using the rational expectations assumption, as Lucas did in his original paper, is precisely what automatically happens in this model. To be sure, the equations of the model could benefit from more theoretical research, but the approach does seem appropriate for estimating the long-term effects of different policy regimes.

The approach uses an empirically estimated distribution of shocks. Theoretical studies are useful for highlighting key parameters that affect the

answers. For example, in a standard nonrational expectations model, a fixed exchange-rate system will work better if country-specific shocks to the liquidity preference equations have a relatively large variance. In that case, a fixed exchange-rate system has the same advantages as interest-rate targeting. On the other hand, a flexible exchange-rate system will work better if country-specific shocks to the consumption or investment equations have a relatively large variance. To get any farther than this requires estimates of the size of the shocks.

For the flexible exchange-rate regime, I assumed that each central bank adjusts its short-term interest-rate target in response to changes in the price level and real output from a target. However, for the fixed exchange-rate system, the interest rates in the individual countries cannot be set independently of one other. For example, if the Fed raised the Federal funds rate above the Japanese call money rate, funds would flow quickly into the United States putting upward pressure on the dollar and threatening the fixed rate unless the Bank of Japan likewise raised the call money rate. In order to keep exchange rates from fluctuating, therefore, a common target for the "world" short-term interest rate must be chosen. Analogously with the flexible exchange-rate case, it was assumed that the world short-term interest rate rises if the world price level rises above the target.

My comparison of the flexible exchange-rate system with the fixed exchange-rate system shows that the fluctuations in real output are much larger in the United States, France, Germany, Italy, Japan, and the United Kingdom when exchange rates are fixed, compared with when they are flexible. The standard deviation of output nearly doubles in Germany and Japan under fixed exchange rates in comparison with flexible exchange rates. The fluctuations in real output in Canada are slightly less under fixed rates than under flexible rates, but there is a deterioration of price stability in Canada under fixed exchange rates. A change in the Canadian domestic policy rule under flexible exchange rates could easily match the output stability of the fixed exchange-rate case with more price stability. In this sense the flexible exchange-rate system dominates for all the countries I considered.

Inflation performance is also better with the flexible exchange-rate system than with the fixed-rate system. Price volatility—as measured by the standard deviation of the output deflator around its target—is greater in all countries under fixed exchange rates. Japan and Germany have more than twice as much price volatility under the system that fixes their exchange rate with the dollar.

In addition to finding that it is preferable for the central banks to set interest rates based on economic conditions in their own country (paying little attention to exchange rates), the results show that placing a positive weight on <u>both</u> the price level and real output in the interest-rate rule is preferable in most countries. Placing some weight on real output works better than a simple price rule, but it is not clear whether the weight on output should be greater than or less than the weight on the price level. A general conclusion from these results is that placing some weight on real output in the interest-rate reaction function is likely to be better than a pure price rule.

Although there is not a consensus about the size of the coefficients of policy rules, it is useful to consider what a representative policy rule might look like. One policy rule that captures the spirit of the recent research and which is quite straightforward is:

$$r = p + .5y + .5(p - 2) + 2 \quad (1)$$

where

- r is the federal funds rate,
- p is the rate of inflation over the previous four quarters
- y is the percent deviation of real GDP from a target.

That is,

- $y = 100(Y - Y^*)/Y^*$ where
- Y is real GDP, and
- Y^* is trend real GDP (equals 2.2 percent per year from 1984.1 through 1992.3).

The policy rule in equation (1) has the feature that the federal funds rate rises if inflation increases above a target of 2 percent or if real GDP rises above trend GDP. If both the inflation rate and real GDP are on target, then the federal funds rate would equal 4 percent, or 2 percent in real terms. (Using the inflation rate over the previous four quarters on the right-hand side of equation (1) indicates that the interest-rate policy rule is written in "real" terms with the lagged inflation rate serving as a proxy for expected inflation.) The 2-percent "equilibrium" real rate is close to the assumed steady-state growth rate of 2.2 percent. This policy rule has the same coefficient on the deviation of real GDP from trend and the inflation rate.

The policy rule in equation 1 has the general properties of the rules that have emerged from recent research, and the coefficients are round numbers that make for easy discussion. What is perhaps surprising is that this rule fits the actual policy performance during the last few years remarkably well. Figure 1 shows the actual path for the federal funds rate and the path implied by the example policy rule during the 1987–1992 period. There is a significant deviation in 1987 when the Fed reacted to the crash in the stock market by easing interest rates. In this sense the Fed policy has been conducted as if the Fed had been following a policy rule much like the one called for by recent research on policy rules.

For completeness, the paths of the two factors in the policy rule are illustrated in Figures 2 and 3. Note that according to this policy rule, the economy was above trend in the late 1980s and fell below trend during the 1990–91 recession. The gap between actual GDP and trend GDP has narrowed only slightly since the end of the 1990–91 recession. The inflation rate is shown in Figure 3. It certainly appears that the changes in inflation and real GDP influenced the path of the federal funds rate.

3. Discretion versus transitions between policy rules

Most macroeconomic research on policy rules has focused on the design of such rules, as summarized in the previous section. Questions about making a transition from one policy rule to a new policy rule have been given relatively little attention. This situation is not unique to macroeconomics. In general, economists have been better at determining what type of system works best than at determining how to make a transition to that system. In international trade theory, not much is known about the appropriate speed at which one should move to free trade. Also, economists have shown the benefits of a market economy, but there is relatively little research on the transition from one system to another. Because there has been relatively little research in this area and because the problems are harder, there is less formal framework than there is for the design of policy rules.

Examples of transitions

Suppose that it becomes clear that a policy in operation is not performing well and that a new policy system would work better. Suppose, for example, that the target inflation rate in the policy rule in the previous section is shown to be too high. Rather than aim for a 5-percent per year inflation rate, it is recognized that a target of 2-percent per year would be better for long-run economic performance. In this example, only the "intercept" term in the policy rule must be changed. This transition problem is, of course, none other than the problem of disinflation.

Similar examples can be given for fiscal policy rules. Analogous to a change in the intercept in the monetary policy rule would be a recognition that the budget deficit should be balanced at full employment. Analogous to a change in the response coefficient would be a recognition that an increase in the response of the automatic stabilizers to economic conditions would be desirable. The latter might entail a change in the unemployment

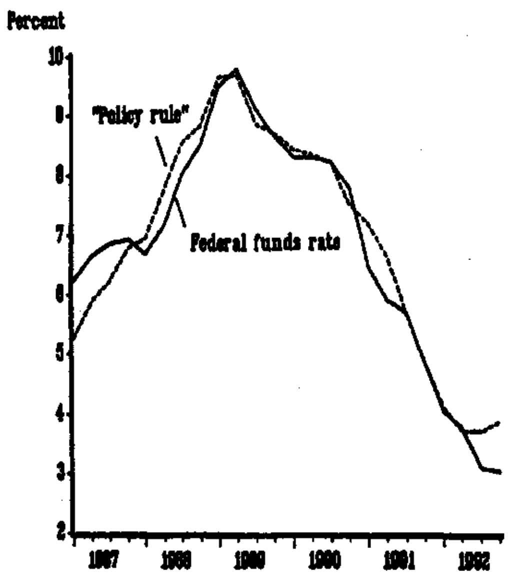

Figure 1. Federal funds rate and example policy rule.

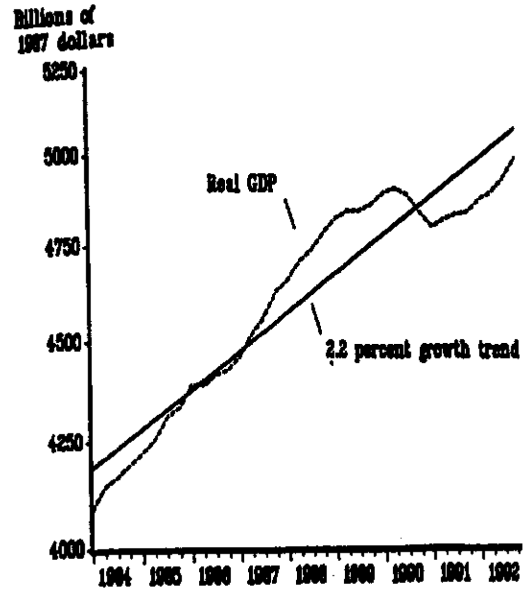

Figure 2. Real GDP and 2.2 percent growth trend.

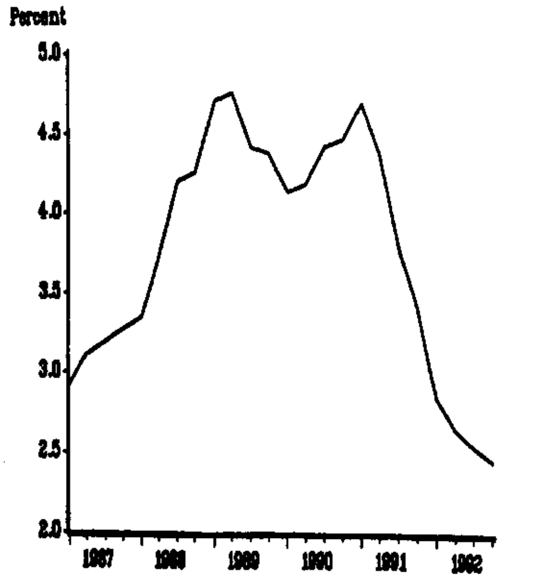

Figure 3. Inflation during previous 4 quarters (GDP deflator).

compensation system that determines at what unemployment rate long-term unemployment benefits are automatically paid.

Why do we need any special treatment of these transitions? First, the research that underlies the design of policy rules assumes that expectations are rational. This makes sense when a policy is in operation for a long time. People will have adjusted their behavior to the policy in place, and expectations of policy and other variables are most likely to be unbiased. However, in the period immediately after a new policy rule has been put in place, people are unlikely either to know about or understand the new policy or to believe that policymakers are serious about maintaining it. Simply assuming that people have rational expectations and know the policy rule is probably stretching things during this transition period. Instead, people may base their expectations partly on studying past policy in a Bayesian way, or by tring to anticipate the credibility of the new policy by studying the past records of policymakers, or by assessing whether the policy will work.

Because expectations only gradually converge during this transition period, the impact of the policy rule on the economy may be quite different than projected by an analysis that assumes rational expectations. This problem of learning about a new policy during a transition was worked out in the case of a change in the price level or inflation target in a very simple model in Taylor (1975). If the initial inflation rate is above the long-run inflation rate, as in the disinflation examples given above, then it is optimal to make the new policy as credible as possible. Announcing the policy and starting to use it is optimal. However, in the case where initial conditions have an inflation rate lower than is optimal, a welfare function that includes both inflation and unemployment can be increased only by gradually informing the public about the plans to move to a new policy. In this unusual case, the precise amount of information to release each period can be computed using optimal control theory.

A second reason for worrying about transitions is that there are natural rigidities in the economy that prevent people from changing their behavior instantly. People may have committed to projects, plans, or contracts under the assumption that the old policy was in place. Moreover, they may have assumed that other people they deal with have similar commitments. Long-term wage-setting commitments are primary examples, but there are many others, including long-term investment projects and loan contracts. Such rigidities suggest that the transition to a new policy rule should be gradual and announced publicly. This gives people a chance to unravel previous commitments without significant losses.

In my view there are many other examples of policy issues that can be usefully interpreted as transitions from one policy rule to another. In practice, however, there is little distinction between such transition issues and what appears to be pure discretion. To highlight the distinction, I examined two transition problems more explicitly in Taylor (1993): (1) the transition to a monetary policy rule with a zero-inflation target, and (2) the transition toward a fiscal policy rule with a balanced full-employment government budget.

4. Discretion in the operation of policy rules

As stated in the introduction of this paper, operating monetary policy by mechanically following a policy rule like equation 1 is not practical. But how can the constructive results of research as summarized by such a policy rule be made operational? Using equation 1 as an example, I consider two possibilities. One is to try to make use of the specific form of the policy rule as one of the inputs to central bank decision-making. A second is to list the general principles that underlie the policy rule and to leave it up to the policymakers to decide the policy-setting without the guidance of the algebraic formula. Some combination of these two options could also be tried. After describing these two alternative approaches, I consider several case studies to illustrate how they might be used in practice.

Making use of a specific rule

Policymakers, such as the members of the FOMC, currently base their decisions on many factors: leading indicators, the shape of the yield curve, the forecasts of the Fed staff models, etc. There is no reason why a policy rule such as in equation 1 could not be added to the list, at least on an experimental basis. Each time the FOMC meets, the Fed staff could be asked to include in the briefing books information about how recent FOMC decisions compare with the policy rule. Forecasts for the next few quarters—a regular part of the staff briefing—could contain forecasts of the federal funds rate implied by the policy rule. There are many variants on this idea. For instance, there could be a range of entries corresponding to policy rules with different coefficients, or perhaps a policy rule where the growth rate of real GDP rather than its level appears. Bands for the federal funds rate path could span these variants.

At a minimum, experimenting with such a format would bring attention to the concept of a policy rule. "Learning by doing" with the rule, however, would likely bring changes and improvements in the rule and in the format for presenting and using the rule. If the policy rule comes so close to describing actual Federal Reserve behavior in recent years and if FOMC members believe that such performance was good and should be replicated in the future even under a different set of circumstances, then a policy rule could provide some guide to future decisions. This may be particularly relevant when the

membership of the FOMC changes. Such a policy rule could become a guide for future FOMCs.

Making use of general characteristics of policy rules

A second possible approach to making a policy rule operational does not try to use the details of any particular algebraic formulation. Instead, it requires a characterization of the fundamental properties of the rule. Patent laws provide a useful analogy. Patent laws establish the principle that inventors who obtain a patent have the rights to market their invention for a given number of years. The details are left to patent office officials and the court system. Where one draws the line between the fundamentals and the details will depend on many factors.

For example, some of the fundamental features of a monetary policy rule like equation 1 were summarized in the 1990 *Economic Report of the President* as,

> The Federal Reserve generally increases interest rates when inflationary pressures appear to be rising and lowers interest rates when inflationary pressures are abating and recession appears to be more of a threat.... Assessing just how much the policy instrument needs to be changed as circumstances evolve requires judgement. Thus, a policy approach that relies on the expertise of the FOMC members is appropriate and should be preserved. If the operating stance of policy is...measured by interest rates, appropriate settings vary with the interest sensitivity of aggregate demand. (p. 85)

Note that this characterization gives only the signs of the response coefficients of the policy rule. Rather than specifying the magnitudes of the coefficients, it states that the magnitudes should depend on the sensitivity of aggregate demand to interest rates. That is an implication of the design analysis, but it is considerably less specific than stating the magnitudes of the responses.

This characterization is not specific about the target for inflation or for real output. It states only that the federal funds rate should be adjusted when infation rises or falls and when output rises or falls. Certainly, more is needed if the characterization is to effectively convey the fundamental properties of a policy rule like equation 1.

Since the mid-1970s monetary targets have been used in many countries to state targets for inflation. If money velocity were stable, then, given an estimate of potential output growth, money targets would imply a target for the price level; given velocity and a real output target, the target price level would obviously fall out algebraically from the money supply target.

Even though the 1980s have shown that money velocity is not stable in the short run, the long-run stability of the velocity of some monetary measures allows one to state targets for the price level. For example, with an estimated secular growth of real output of $2\frac{1}{2}$ percent and a steady velocity, a money growth range of $2\frac{1}{2}$ percent to $6\frac{1}{2}$ percent—the Fed's targets for 1992—would imply that the price level target grows at 0 to 4 percent per year. Given biases such as index number problems in measuring prices, the 2-percent per year implicit target inflation rate is probably very close to price stability or "zero" inflation.

Case study one: the oil-price shock of 1990

Operating a monetary policy rule in the face of an oil-price shock is difficult and deserves particular study. It is even more difficult if the shock occurs during a transition to a new policy rule with lower inflation as perhaps was occurring in the early 1990s. I focus here on the events that followed the Iraqi invasion of Kuwait on August 2, 1990.

The oil-price shock occurred as the U.S. economy was growing slowly following the 1988-89 monetary tightening—increases in the federal funds rate that had been aimed at containing and reducing the rate of inflation (see Figure 1). If one characterizes Fed actions in terms of the policy rule described above, then the increase in the federal funds rate can be interpreted as occurring for two reasons. First, economic growth in 1987 and 1988 was very strong and inflation was rising; both factors would call for an increase in the federal funds rate according to a policy rule like that in equation 1. Moreover, the Fed had indicated that its intention was to move the economy toward price stability. In other words, the Fed had been attempting to gradually disinflate—to make a transition to greater price stability. In fact, the mean of the target growth rate ranges for the M2 money supply had been reduced from 7 percent in 1987 to 5 percent in 1990, and was reduced to $4\frac{1}{2}$ percent in 1991. The explicit intention of reducing the growth rate targets was to reduce the rate of inflation by an equivalent amount.

Iraq invaded Kuwait on August 2, 1990. Iraq and Kuwait had together been producing 4.3 million barrels of oil a day, and there was a threat to the supply of oil from Saudi Arabia. Not surprisingly the price of oil rose sharply from $21 per barrel at the end of July to $28 on August 6 and eventually to a peak of $46 in mid-October. The monthly average price rose from $17 in July to $36 in October. The effect that this increase in oil prices might have on the economy was of great concern, and major efforts were put in place to estimate the economic impacts. Task forces were assembled and many models—both traditional and forward-looking—were simulated to obtain estimates. The Council of Economic Advisers published a consensus estimate that a one-year temporary increase in oil prices of 50 percent could

temporarily raise the overall price level (GDP deflator) by about 1 percent and with a longer lag, cause real output to fall by about the same amount.

What should be the monetary and fiscal policy reaction to these changes? Suppose that a monetary policy rule like the one described above were in place. Taken literally, equation 1 would say that an increase in the central bank's interest-rate target—relative to what it otherwise would be—was in order; in the short run the price level would rise more than real output would fall. However, such an interest-rate increase would be inappropriate if the price level rise was temporary and would soon disappear. A more complex rule with a longer moving average of inflation or a two-sided moving average including expected inflation might be more appropriate, but the point here is to keep the rule simple.

In fact, analysis at the time suggested that the increase would be temporary. The futures market for oil was helpful in making this assessment. Although the spot price for oil doubled by mid-October, the one-year-ahead futures price changed very little. The December 1991 futures price rose only about $4 per barrel while the spot price rose by $25. Moreover, oil supply analyses suggested that increased oil production elsewhere could eventually make up most of the lost production in Iraq and Kuwait if the embargo continued. The main uncertainty was whether additional oil production facilities would be destroyed before the conflict ended. This uncertainty was dramatically resolved with the successful start of Desert Storm in mid-January 1991.

For these reasons an increase in interest rates to counteract the increase in the price level brought about by the oil shock would be inappropriate-despite the literal interpretation of equation 1. However, not adjusting interest rates in the face of a rising price level would require deviation from the policy rule.

In most countries, the oil-price rise was not viewed as requiring short-term changes in monetary policies. With central banks following monetary strategies that focused on adjustment of interest rates, this position is best interpreted as a policy response like the one discussed above for the United States: interest rates should follow the path that would have occurred without the oil-price shock. There was also a broad consensus that the credibility of economic policies that had been built up in the 1980s should be maintained, and that a clear message be sent that this was the intention of policymakers.

Fiscal policy was also a factor. The automatic stabilizers of fiscal policy provide some built-in response to any negative effects on real output and employment that an oil shock might have, and it was certainly the intention in the Untied States in the summer of 1990 to allow this response to work to mitigate the impact of the oil-price shock on the economy. Some international policy officials raised the possibility of over-riding the automatic stabilizers—offsetting them by increasing taxes or reducing expenditures elsewhere—but others raised strong opposition to such over-rides. Surprisingly, therefore, there was less consensus about continuing to keep "systematic" fiscal policies in place than there was about monetary policy.

The Gramm-Rudman-Hollings budget law that was still in force in the United States in the summer of 1990 did not allow for the automatic stabilizers. Increases in the budget deficit whether caused by new programs or by the automatic stabilisers were against this law, and would result in across-the-board cuts in spending. The deficit targets would not change even if an oil-price shock worsened economic conditions. Hence, changes in this law were needed if the automatic stabilizers were to be allowed to help stabilize the economy. The revisions in the budget law worked out in the weeks following the oil-price shock required that the budget targets be adjusted for changes in the economy.

Case study two: the bond market, inflation and German unification

Assessing whether an increase in long-term interest rates is due to an increase in expected inflation or to an increase in the real interest rate is part of the task of operating a systematic monetary policy rule. For example, if the policy is to raise interest rates when inflation picks up, then a rise in long-term interest rates might suggest an incipient rise in inflation and might make policymakers less willing to keep the short-term interest rate steady, even if actual inflation does not change. Even so, that increase in long-term interest rates could be due to other factors, such as a shift in the demand for investment or saving.

Such a situation arose in early 1990 before the oil shock discussed above. After declining in the latter part of 1989, long-term interest rates rose sharply in early 1990. Ten-year Treasury bond yields rose by 75 basis points. Concern about a rise in inflation could have caused this increase, and if so could have called for a postponement of declines in interest rates that the monetary policy rule would have called for. However, considerable evidence suggested that other factors were responsible for the increase in long-term rates.

The United States was not the only country to experience an increase in long-term interest rates. Germany had even larger increases, suggesting the possibility that real factors were behind the increase in interest rates. In an integrated world capital market, an increase in interest rates in Germany could be transmitted to U.S. interest rates.

In fact, there was a major change in Germany at this time that could have had such an impact on German long-term rates—anticipations that East Germany and West Germany would be unified and that the unification would increase the demand for capital in Germany and lead to an increase in the government budget deficit in Germany. Greater investment demand would be expected to raise real interest rates in Germany later in 1990 and in 1991, and with forward-looking expectations raise long-term interest rates immediately. In fact, the anticipated increase in demand for investment and reduction in national saving occurred in 1990 as the unification took place. In 1989, the West German budget was essentially in balance, with a surplus of .2 percent of GDP. That surplus turned dramatically into a deficit of 3-percent of GDP in 1990. Hence, the timing turned out to be correct and consistent with this explanation.

Monetary policy decisions in early 1990, however, could not wait until 1991 when evidence was available about unification and its impact. In early 1990, the analysis had to rely on forecasts and model simulations to see if the magnitudes were plausible. In other words, would an increase in the demand for capital in Germany of plausible magnitudes cause an increase in interest rates of the magnitudes observed? Was it a quantitatively sufficient explanation? Calculations were made with forward-looking empirical models.

Model simulations suggested that increases in interest rates of about one percentage point were consistent with plausible increases in the demand for capital. Hence, an increase in expected inflation was not needed to explain the increase in long-term interest rates. This gave some guidance that interest-rate policy need not be adjusted.

Concluding remarks

This paper has endeavored to study the role of policy rules in a world where simple, algebraic formulations of such rules cannot and should not be mechanically followed by policymakers. Starting with the assumption that systematic and credible features of rule-like behavior improve policy performance, I considered several ways to incorporate rule-like behavior into actual policymaking. Clarification of terms, distinguishing between the design, the transition, and the operation of policy rules, and actually using specific rules or their general features in policy decisions are some of the ideas considered. Two case studies and a hypothetical policy rule illustrated how the ideas could work in practice.

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Introduction

John B. Taylor

This book has two broad goals. The first goal is to present econometric evidence on which type of monetary policy rule is likely to be both efficient and robust when used as a guideline for the conduct of monetary policy in the United States. The second goal is to settle several current monetary policy issues—such as the effects of uncertainty about potential GDP growth or the role of the exchange rate in the setting of interest rates—that are most naturally addressed within a framework of monetary policy rules.

To achieve these two goals, a number of economists who are actively engaged in research on monetary policy put their econometric policy evaluation methods to use in order to investigate various monetary policy rules. The economists then came together at a conference in the Florida Keys to discuss their results with policymakers and other economists. This volume—including nine papers, comments on the papers, and discussions from the conference—is the outcome of that effort. Many researchers at universities, central banks, and private financial institutions around the world are now using modern econometric policy evaluation methods to analyze monetary policy rules. We are fortunate that many of them—over 30 individuals are represented in the volume—were able to participate in the project.

A Variety of Models and a Uniform Methodology

The research reported in this volume represents a wide variety of models. The models differ in size: from 3 equations to 98 equations. They differ in degree of openness; some are closed economy models, some are small open econ-

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omy models, and some are large open economy models. The models also differ in degree of forward looking assumed, in the method of establishing a good microeconomic foundation for the equations, and in the goodness of fit to the data. Some models are estimated with formal econometric methods and fit the historical data tightly. Others are calibrated using rules of thumb or information from other studies, and they give rough approximations to historical data.

To get a feel for the differences between the models, consider some key features of the nine papers. The models developed by Bennett McCallum and Edward Nelson, by Julio Rotemberg and Michael Woodford, and by Robert King and Alex Wolman have a microfoundation built around a *representative agent framework* in which a household maximizes utility over time. The representative agent approach is attractive because it automatically builds in people's responses to policy and because it allows policy to be evaluated using the utility function of the representative agent. These models tend to be smaller than many of the other models in the volume, and they give rough approximations of the quarterly time series in the United States.

Like the models using a representative agent framework, the model used by Nicoletta Batini and Andrew Haldane and the four models used by Andrew Levin, Volker Wieland, and John Williams assume that agents have *rational expectations*. However, the microeconomic foundations for these models are separate decision rules for a household's consumption or for a firm's investment and production, rather than explicit dynamic optimization of a representative agent. These decision rules are motivated by rational behavior and frequently have the same variables as the equations in the explicitly derived models. These rational expectations models are generally more detailed, and they fit the data better than the representative agent models.

The models used by Laurence Ball, by Glenn Rudebusch and Lars Svensson, and by Arturo Estrella and Frederic Mishkin are *non–rational expectations models*. In order to achieve better empirical accuracy (Rudebusch and Svensson) or to focus on other issues such as exchange rates (Ball) or measurement error (Estrella and Mishkin), these models do not build in agents' responses to future policy decisions as the rational expectations models do—whether representative agent models or not. These non–rational expectations models make the simplifying assumption that the parameters will not change when policy changes.

In contrast to these model-based policy evaluation models, my own paper in the volume uses a historical methodology to evaluate policy rules. This approach is similar to that used by Milton Friedman and Anna Schwartz in their monetary history of the United States or to that of Christina Romer and David Romer in their analysis of Federal Open Market Committee decision making. Rather than testing policy rules in a structural model, this paper looks at different historical periods to see if different policy rules result in different

macroeconomic outcomes. Moreover, the paper uses a general monetary theory rather than a tightly specified model to interpret the historical data.

Despite these differences, the papers in the volume share an important common methodology that defines the state of the art in monetary policy evaluation research. First, each of the models is a dynamic, stochastic, general equilibrium model. The relevance of expectations of the future and events of the past to current decisions gives the models a dynamic feature. Shocks to preferences, to technology, or simply to decision rules make the models stochastic. The term "general equilibrium" applies because the models pertain to the whole economy, not to an individual sector of the economy.

Second, each of the models incorporates some form of temporary nominal rigidity, usually a variant of staggered wage or price setting, which results in a short-run trade-off between inflation and output or unemployment. With stochastic shocks, the short-run inflation-output relationship can be characterized as a trade-off between the variance of inflation and the variance of output, but none of the models has a long-run trade-off between the level of inflation and unemployment. Several of the papers in the volume break new ground in modeling price rigidities. For example, the paper by King and Wolman derives a firm's pricing rule by analyzing how the firm would maximize its present discounted value in a setting where there are monopolistic competition and infrequent price adjustment opportunities. It is interesting to note that the optimal decision rules resemble the staggered price-setting equations studied by Levin, Wieland, and Williams. King and Wolman show that staggered price setting increases the costs of inflation, an issue that has not been raised in earlier calculations of the welfare costs of inflation. Because of their explicit derivation one can calculate the welfare costs of steady inflation with their model.

Third, for each model the variances can be computed directly or through stochastic simulation, and the measure of economic performance depends on the variance of inflation around the target inflation rate, the variance of real output around a measure of potential or full-employment output, and, in some cases, the variance of unanticipated inflation or the variance of the interest rate. It is possible to feed these variances into an objective function that is a weighted average of the variances, and in some of the papers (Rotemberg-Woodford and King-Wolman), the objective function is the same as the utility function of the representative household.

These common features can be illustrated by noting that all the models can be written in the following general form:

$$y_t = A(L,g)y_t + B(L,g)i_t + u_t. \quad (1)$$

This equation is the reduced-form solution to the model. The vector y_t contains the endogenous variables. The scalar i_t is the short-term nominal interest rate. The vector u_t is a serially uncorrelated random variable with covariance matrix Σ. The matrices $A(L,g)$ and $B(L,g)$ are polynomials in the lag operator L. These matrix polynomials depend on the parameter vector g, which consists of all the parameters in the policy rule. The policy rule itself can be written as

$$i_t = G(L)y_t, \quad (2)$$

where $G(L)$ is a vector polynomial in the lag operator L. Making the parameter vector g explicit in this notation emphasizes that reduced-form parameters in A and B depend on the parameters of the policy rule, an important common feature of these models. For the Ball model, the Rudebusch-Svensson model, and the Estrella-Mishkin model, none of which are rational expectations models, the above equation for y_t is the model itself. For the Rotemberg-Woodford, McCallum-Nelson, and King-Wolman models, there are forward-looking expectations variables that enter through the Euler equations of the representative agent's optimizing problem; these have been solved out using a rational expectations solution method to get the reduced-form equation for y_t. For the Batini-Haldane model and the four models considered by Levin, Wieland, and Williams (Federal Reserve, Fuhrer-Moore, MSR, and linearized Taylor multicountry), there are also forward-looking variables that have been solved out to get the reduced-form equation.

Substitution of the policy rule for i_t into the reduced-form equation for y_t above results in a vector autoregression in y_t. The steady state stochastic distribution of y_t is a function of the parameter vector g of the policy rule. Hence, for any choice of parameters in g one can evaluate an objective function that depends on the steady state distribution of y_t. For example, if the loss function is a weighted average of the variance of inflation and the variance of real output, then the two diagonal elements of the covariance matrix corresponding to inflation and real output are used. Using this approach, the papers in the volume present simulation evidence that helps determine the optimal policy rule.

I believe that there is much to be learned from these simulations, not only from the tables and charts presented in the nine papers, but also from the comments on the papers (many of which also contain new results) and the discussions about the papers. Here I can only summarize some key results. Rather than reviewing each paper and comment separately I will try to organize the summary around the following key issues: (1) robustness of policy rules, (2) usefulness of simple policy rules compared with complex rules, (3) role of the exchange rate, (4) role of inflation forecasts, (5) importance of information lags, (6) uncertainty about potential GDP or the natural rate of unemployment, and (7) implications of the historical evidence.

Robustness of Policy Rules

A number of the papers in this volume propose specific monetary policy rules. Some of these rules are modifications of policy rules that have been proposed in earlier research. Others would involve more substantial changes. Regardless of the specific form, each rule is proposed because, according to

the model used in the research, the rule results in good macroeconomic performance. But how robust are the proposed rules? How would the rule proposed by one researcher stand up to scrutiny by other researchers using different models and methods? To answer these questions we asked researchers who participated in the conference to investigate the other researchers' proposals for policy rules using their own models. We did not specify what model (whether large or small, rational or nonrational) should be used. That decision was left up to the researchers. In the end, nine models were used in this robustness exercise. The models, all described in the conference papers published in this volume, are

1. Ball model
2. Batini-Haldane model
3. McCallum-Nelson model
4. Rudebusch-Svensson model
5. Rotemberg-Woodford model
6. Fuhrer-Moore model
7. MSR (small Federal Reserve model)
8. FRB/US (large Federal Reserve model)
9. TMCM (Taylor multicountry model)

The last four of these models (6 through 9) are used in the paper by Levin, Wieland, and Williams, which is a robustness study itself as the title indicates.

Of course, these nine models do not include all possible models that could be used for a robustness study. For example, as part of their comment on the Levin, Wieland, and Williams paper, Lawrence Christiano and Christopher Gust analyze several monetary policy rules using a type of model much different from those used in the other papers. The short-run monetary nonneutralities in the Christiano-Gust model are based on limited participation in financial markets rather than on temporary price and wage rigidities. Christiano and Gust report deterministic simulations and a stability analysis that tend to favor money supply rules over interest rate rules. Note also that the King and Wolman paper was not included in the robustness analysis because the authors believe that their type of model is in an early stage of development, and they are hence not ready to make an empirical identification of business cycle determinants in the way that the robustness analysis requires.

Five different policy rules were selected for the robustness exercise. These rules are of the form

$$i_t = g_\pi \pi_t + g_y y_t + \rho i_{t-1}, \quad (3)$$

where i is the nominal interest rate, π is the inflation rate, and y is real GDP measured as a deviation from potential GDP. (The intercept term is ignored here.) The coefficients defining the five policy rules are shown in table 1.

Rules I and II have the interest rate reacting to the lagged interest rate with a response coefficient of one. Rule I has a high weight on inflation compared

Table 1 **Five Conference Rules**

Rule	g_π	g_y	ρ
I	3.0	0.8	1.0
II	1.2	1.0	1.0
III	1.5	0.5	0.0
IV	1.5	1.0	0.0
V	1.2	0.06	1.3

to the weight on output, and rule II has a smaller weight on inflation compared to output. These two rules are referred to as interest-rate-smoothing rules and are the type of rule favored in the simulations in the Levin, Wieland, and Williams paper, though not necessarily with these coefficient values on inflation and output. As I show below these rules sometimes result in more interest rate volatility than rules that do not involve a reaction to the lagged interest rate. Rule III is the simple rule that I proposed in 1992 after considering the policy evaluation results from a number of multicountry models. Rule IV is much like rule III except there is a coefficient of 1.0 rather than 0.5 on real output. The simulation results of several researchers, including Laurence Ball and John Williams, indicate that the interest rate should respond about twice as aggressively to output than the 0.5 response coefficient in the simple rule that I proposed. Rule V is the rule favored in the paper by Rotemberg and Woodford in this volume. This rule is distinctive in that it places a very small weight on real output and a very high weight on the lagged interest rate.

Of course, the policy rules in table 1 do not exhaust all possible policy rules. Table 1 omits rules for the money supply, such as constant growth rate rules. Moreover, two policy rules for the interest rate proposed in this volume—the rule that reacts to exchange rates examined by Ball and the inflation-forecast rules examined by Batini and Haldane and by Rudebusch and Svensson—could also be subjected to robustness analysis. They were not part of this robustness exercise because many of the models do not have exchange rates and because the inflation-forecast rules are themselves model specific, making robustness tests more difficult, as explained in the comment by James Stock in this volume. Although it is quite possible that another policy rule would do better than any of the five policy rules listed in table 1, these rules represent the degree of disagreement that currently exists about the most appropriate form for policy rules.

Assessing the robustness across models is difficult because different models have different absolute measures of performance. One model might show that all the rules work much better—have smaller fluctuations in inflation or real output—than another model shows. In fact, this is the case for the models in this robustness study. For example, the Batini-Haldane model and the Fed's small model (MSR) imply that much better economic performance can be achieved by following an optimal rule than the Fuhrer-Moore model implies.

Moreover, these performance differences across models are fairly arbitrary, because the size of the variances of the shocks in u_t (or more generally the magnitude of each element in the covariance matrix Σ) is assumed in some models. Even in the models where the covariance matrix of the shocks is estimated using formal econometric methods, the estimates depend on arbitrary choices about specification—such as how many lagged endogenous variables or exogenous variables are placed in the model. This lack of uniformity in absolute performance measures means that one must focus on *rankings* of rules across different models. An analogy with expert evaluation in other areas is useful. Consider wine tasting (an analogy pointed out to me by Orley Ashenfelter). A panel of experts is asked to evaluate different wines. But some tasters tend to give high ratings and some tasters tend to give low ratings. Looking at the average rating across tasters will be a mistake because the tasters who give high scores will have greater influence on the average than tasters with low scores. However, by first converting the scores of each taster into a simple ranking of each taster and then adding up ranks, one can eliminate this scale effect. Similarly, one can consider pairwise rankings between two wines that differ in a key characteristic. Of course, in this book we have policy rules rather than wine and models rather than tasters, but the principle is the same.

Consider using this approach to determine the robustness of policy rules that are more responsive to output in comparison to rules that are less responsive. In other words, is the finding that one policy rule is better than another policy rule a robust finding that stands up against the different models in this book? Consider rule III and rule IV, for example. As stated earlier, several researchers have suggested that rule IV is better than rule III in the sense that the variability of inflation and real output is less with rule IV than with rule III. Is this finding robust? Table 2 shows the standard deviations of inflation rate, real output, and interest rate for rule III and rule IV. These standard deviations are obtained from the covariance matrix of the endogenous variables. Several conclusions can be drawn from table 2. First, it is clear that a finding that rule IV dominates rule III is not robust across models. For all models, rule IV gives a lower variance of output than rule III does, which is not surprising with the higher weight on output in rule IV. But for six of the nine models rule IV gives a higher variance of inflation. Raising the coefficient on real output from 0.5 to 1.0 represents a trade-off between inflation variance and output variance. The change in average standard deviations across all the models shown in table 2 indicates such a trade-off, but rule IV's increase in average inflation variability is small compared with the decrease in average output variability. (To be sure, this average change may be influenced by the lack of uniformity in absolute performance levels discussed above.) If we also consider the variability of the interest rate, then the finding that rule IV is better than rule III is even less robust: rule III is higher than rule IV in seven of the eight models that reported interest rate variances. (The average interest rate variance across models is higher with rule IV, though that result is also affected by the arbitrariness of a cardinal

Table 2 **Comparative Performance of Two Conference Policy Rules**

Model	Standard Deviation: Inflation	Output	Interest Rate
		Rule III	
Ball	1.85	1.62	–
Batini-Haldane	1.38	1.05	0.55
McCallum-Nelson	1.96	1.12	3.94
Rudebusch-Svensson	3.46	2.25	4.94
Rotemberg-Woodford	2.71	1.97	4.14
Fuhrer-Moore	2.63	2.68	3.57
MSR	0.70	0.99	1.01
FRB	1.86	2.92	2.51
TMCM	2.58	2.89	4.00
Average	2.13	1.94	2.82
		Rule IV	
Ball	2.01	1.36	–
Batini-Haldane	1.46	0.92	0.72
McCallum-Nelson	1.93	1.10	3.98
Rudebusch-Svensson	3.52	1.98	4.97
Rotemberg-Woodford	2.60	1.34	4.03
Fuhrer-Moore	2.84	2.32	3.83
MSR	0.73	0.87	1.19
FRB/US	2.02	2.21	3.16
TMCM	2.36	2.55	4.35
Average	2.16	1.63	3.03

scale.) One could formalize these ranking calculations by putting weights on the three standard deviations and then ranking the rules in terms of the values of the objective function in each model. Rule III would rank above rule IV for relatively high weights on inflation and interest rate variability, while rule IV would rank better for high weights on output variability.

Now consider the relative robustness of the three rules that respond to the lagged interest rate (rules I, II, and V) as shown in table 3. Each of these three rules has exactly the same functional form as the others. Hence, this robustness analysis considers the appropriate size of the response coefficients for rules having this functional form. The sum of the ranks of the three rules shows that rule I is most robust if inflation fluctuations are the sole measure of performance; it ranks first in terms of inflation variability for all but one model for which there is a clear ordering. For output, rule II has the lowest (best) sum of the ranks, which reflects its relatively high response to output. However, regardless of the objective function weights, rule V has the highest (worst) sum of the ranks for these three policy rules, ranking first for only one model (the Rotemberg-Woodford model) in the case of output. Comparing these three rules with the rules that do not respond to the lagged interest rate (rules III and

Table 3 **Three Conference Rules That React to Lagged Interest Rates**

Model	Standard Deviation: Inflation	Output	Interest Rate
		Rule I	
Ball	2.27	23.06	–
Batini-Haldane	0.94	1.84	1.79
McCallum-Nelson	1.09	1.03	5.14
Rudebusch-Svensson	∞	∞	∞
Rotemberg-Woodford	0.81	2.69	2.50
Fuhrer-Moore	1.60	5.15	15.39
MSR	0.29	1.07	1.40
FRB/US	1.37	2.77	7.11
TMCM	1.68	2.70	6.72
		Rule II	
Ball	2.56	2.10	–
Batini-Haldane	1.56	0.86	0.99
McCallum-Nelson	1.19	1.08	4.41
Rudebusch-Svensson	∞	∞	∞
Rotemberg-Woodford	1.35	1.65	2.53
Fuhrer-Moore	2.17	2.85	8.61
MSR	0.44	0.64	1.35
FRB/US	1.56	1.62	4.84
TMCM	1.79	1.95	5.03
		Rule V	
Ball	∞	∞	∞
Batini-Haldane	∞	∞	∞
McCallum-Nelson	1.31	1.12	2.10
Rudebusch-Svensson	∞	∞	∞
Rotemberg-Woodford	0.62	3.67	1.37
Fuhrer-Moore	7.13	21.2	27.2
MSR	0.41	1.95	1.31
FRB	1.55	6.32	4.67
TMCM	2.06	4.31	4.24

IV, in table 2) shows that the lagged interest rate rules do not dominate rules without a lagged interest rate. Note that the variance of the interest rate is highest for the rules that react to the lagged interest rate according to many of the models. Table 3 also indicates a key reason why rules that react to lagged interest rates work well in some models and poorly in others in comparison with the rules without lagged interest rates. For a number of models the rules with lagged interest rates are unstable or have extraordinarily large variances. Observe that the models that give very poor performance for the lagged interest rate rules are the non–rational expectations models. These rules rely on people's forward-looking behavior: if a small increase in the interest rate does not bring inflation down, then people expect the central bank to raise interest rates by a larger amount in the future. But in a model without forward looking, it is obviously impossible to capture this forward-looking behavior. Because rule V has a lagged interest rate coefficient greater than one, it greatly exploits these expectations effects and is less robust than the other rules when evaluated with non–rational expectations models. These results illustrate the importance of forward-looking behavior. In his comment on the McCallum and Nelson paper, Mark Gertler reports on some preliminary estimation results that may help determine whether models are too forward looking or not forward looking enough.

Many more robustness findings can be found in the individual papers. Although this robustness analysis is very informative, I think it just touches the surface of what can now be done. It would be useful to do this type of robustness analysis for many more policy rules, including rules with the exchange rate, the forecast of inflation, or even more complex rules. There are also important statistical issues, such as measures of significant differences across models arising from the use of rank orders in robustness analysis. In fact, the subject of robustness arose in many of the comments and the discussions at the conference.

For example, in his comment on Ball's paper, Thomas Sargent calculates an alternative policy rule that is robust to changes in the serial correlation structure of the model. In effect, Sargent looks for rules that are robust if the u_t in the notation of equation (1) were serially correlated rather than uncorrelated. Sargent finds that in his robust version of Ball's policy rule, the interest rate responds even more aggressively than the relatively aggressive rule IV above.

Stock's comment on the paper by Rudebusch and Svensson also calculates a robust policy rule. In contrast to Sargent's focus on robustness to different serial correlation assumptions, Stock's policy rule is meant to be robust to different values of the parameters in the IS equation and the price adjustment equation in the Rudebusch-Svensson model. Stock's robust rule is a minimax policy with respect to this parameter uncertainty. Like Sargent, Stock finds that the optimal policy should be more aggressive in responding to inflation and output than the simple rules III and IV. Sargent's and Stock's findings that robust policy rules are more aggressive generated much discussion at the conference.

The Usefulness of Simple Rules Compared with Complex Rules

All five conference rules have a simple functional form, so the results in tables 2 and 3 are not helpful in determining how useful simple rules are compared to complex rules. But several of the papers in the volume address this question. Rudebusch and Svensson find that simple rules perform nearly as well as the optimal rule in their model. Levin, Wieland, and Williams show that simple rules are more robust across models than more complex optimal rules. Their paper reports on a robustness analysis of simple rules versus optimal rules in four models. They find that optimal rules from one model perform much worse than the simple rules when simulated in other models. Evidently, the optimal rule exploits properties of a model that are specific to that model, and when the optimal rule is then simulated in another model those properties are likely to be different and the optimal rule works poorly.

Role of the Exchange Rate

What is the appropriate role for the exchange rate in a monetary policy rule? This question is obviously very important for small open economies that operate under a flexible exchange rate system, but it may be an important issue for larger areas such as the European Central Bank.

The paper by Laurence Ball uses a small open economy model to assess the role of the exchange rate in a monetary policy rule. Ball shows that adding the exchange rate to simple policy rules, such as rule III and rule IV, can improve macroeconomic performance in his model. He adds the exchange rate to the simple policy rules in two places: (1) the monetary conditions index—a weighted average of the interest rate and the exchange rate—replaces the interest rate as the policy instrument, and (2) the lagged exchange rate is added to the right-hand side of the policy rule along with the inflation rate and real output. Alternatively stated, Ball adds both the current and lagged exchange rate to the right-hand side of the policy rule for i_t. Holding inflation variability constant, Ball finds that the standard deviations of output can be reduced by about 17 percentage points by giving the exchange rate a role in the simple policy rule. It would be interesting to see whether this result is robust. Because many of the models in this book are closed economy models, a robustness study will have to be the subject of future research.

Role of Inflation Forecasts

The papers by Batini and Haldane and by Rudebusch and Svensson focus on another key policy issue. They examine whether policy rules in which the interest rate adjusts to forecasts of future inflation perform better than simple rules, such as rule III and rule IV, that respond to current inflation and real output. Rules that respond to the forecast of inflation rather than actual inflation are frequently referred to as "forward-looking" rules, but since forecasts are based on current and lagged data, these rules are no more forward looking than "backward-looking" rules. Inflation-forecast rules implicitly respond to other variables in addition to output and inflation if such variables are useful predictors of future inflation; hence, these rules could in principle work better than rules such as rule III and rule IV.

The papers by Rudebusch and Svensson and by Batini and Haldane examine a number of inflation-forecasting rules with different forecast horizons and parameters. Both papers report that for the appropriate forecast horizon (usually greater than one year) and for the appropriate response coefficient, inflation-forecast rules can improve performance slightly compared with other simple rules. Batini and Haldane report that an inflation-forecast rule with a six-quarter forecast horizon reduces the standard deviation of inflation by 0.1 percentage points (from 1.4 to 1.3 percent) and the standard deviation of output by 0.2 percentage points (from 1.1 to 0.9 percent) compared with rule III.

Importance of Information Lags

Another policy question addressed by the models in this book is the effect of information lags on monetary policy rules. For example, Bennett McCallum has argued that it is not realistic to assume, as in equation (3), that policy can respond to current-quarter values, and that estimated performance would deteriorate if policymakers could only react to the most recently available data. To investigate this problem the researchers were asked to evaluate the performance of the following lagged version of the policy rule in equation (3):

$$i_t = g_\pi \pi_{t-1} + g_y y_{t-1} + \rho i_{t-1}. \qquad (4)$$

To be sure, it is not clear that equation (4) is any more realistic than equation (3) because policymakers have some current-period information available when they make interest rate decisions. In any case, there is virtually unanimous agreement among the models in the book that this one-quarter lag has little effect on economic performance. The variances of inflation and output increase by only a small amount when equation (3) is replaced by equation (4). Hence, it appears that this kind of information lag does not have major implications for policy rules.

Uncertainty about Potential GDP and the Natural Unemployment Rate

In his comments on the Batini and Haldane paper, Donald Kohn emphasizes that economic uncertainty—especially about potential GDP—poses a serious problem for monetary policy rules. Of course, assessing the effects of general model uncertainty, and the robustness of different policy rules to this uncertainty, is a major aim of this book. Two papers in the book specifically address the issue of uncertainty about potential GDP or the natural rate of unemployment. McCallum and Nelson examine the impact of making gross errors in estimating the trend in real GDP. They find that big errors lead to a big deterioration in performance. Similarly, Estrella and Mishkin show that errors in measuring the natural rate of unemployment lead to a worsening of performance. However, Estrella and Mishkin also show that uncertainty about the natural rate of unemployment or potential GDP is additive uncertainty; therefore, the form of the policy rule should not be affected by such uncertainty. Only in the case of multiplicative uncertainty would the policy rule itself be different.

Historical Evidence

Historical analysis of policy rules complements the evidence about the interest rate response to inflation and output found in the simulations. As I show in my paper the estimated response coefficients of monetary policy were much larger in the 1980s and 1990s in the United States than they were during the late 1960s and 1970s. Moreover, the response coefficients appear to have been even lower during the international gold standard period from 1880 to 1914 when inflation and real output were less stable. For example, the estimated inflation response coefficient is about 0.8 for the 1960s and 1970s compared to about 1.5 for the 1980s and 1990s, nearly twice as large. Since the inflation rate and real output were much more stable in the 1980s and 1990s than in the late 1960s and 1970s, or than in the international gold standard period, the result supports the model simulations that predict that such a change would take place. Similar results for the later two periods are reported in recent papers by Judd and Rudebusch (1998) and by Clarida, Galí, and Gertler (1998) as discussed in the comment on my paper by Richard Clarida.

Conclusion

Of the many important findings in this volume several seem particularly important to me. First, the model simulations show that simple policy rules work well; their performance is surprisingly close to that of fully optimal policies. Second, the simulations show that the gains reported in earlier research from using rules with high response coefficients are not robust to the variety of models considered in this volume; however, new approaches to robustness discussed in the volume suggest that rules that are robust to certain kinds of uncertainty may be more aggressive. Third, simulation results show that simple policy rules are more robust than complex rules across a variety of models. Fourth, introducing information lags as long as a quarter does not affect the performance of the policy rules by very much. Fifth, the historical analysis finds a significant correlation between policy rules and economic performance.

The areas of disagreement are also important. First, there is disagreement about whether central banks should react to the exchange rate when setting interest rates, or whether they should use a monetary conditions index. Second, there is disagreement about whether policy should respond to the *lagged* interest rate. Third, there is disagreement about whether the interest rate should respond solely to a measure of *expected future* inflation, rather than actual observed values. In these cases of disagreement, the papers are useful in determining what features of the models lead to the differences. This will be helpful in future research.

These remaining uncertainties and disagreements indicate that there is more work to do in this area. There is much to be learned from studying the many simulations already performed for this volume. The robustness analysis in this book, which is the focus of so many of the papers, comments, and discussions, makes a good start, but it has only scratched the surface. Improving the models, considering additional models, expanding the analysis to other countries, and examining more rules are all essential.

In the meantime, it is wise for policymakers to work with a collection or portfolio of policy rules as mentioned by Martin Feldstein in his comment on the Rotemberg and Woodford paper. Such a portfolio might include the rules of the type examined in table 1. When I proposed a specific simple policy rule in 1992 I suggested that the rule be used as a guideline along with several other policy rules. In his comment on the King and Wolman paper, Benjamin Friedman mentions the distinction between using a monetary policy rule as a guideline and using the rule mechanically. Although all the rules in this book can be written down algebraically—indeed that is one of their main advantages—at least for the near future they will probably be more useful as guidelines than as mechanical formulas for policymakers to follow exactly. By carefully studying the results in this volume, I hope that researchers and policymakers can make monetary policy rules even more useful in the future.

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7 A Historical Analysis of Monetary Policy Rules

John B. Taylor

This paper examines several eras and episodes of U.S. monetary history from the perspective of recent research on monetary policy rules.[1] It explores the timing and the political economic reasons for changes in monetary policy from one policy rule to another, and it examines the effects of different monetary policy rules on the economy. The paper also defines—using current information and the vantage point of history—a quantitative measure of the size of past mistakes in monetary policy. And it examines the effects that these mistakes may have had on the economy. The history of these changes and mistakes is relevant for monetary policy today because it provides evidence about the effectiveness of different monetary policy rules.

The Rationale for a Historical Approach

Studying monetary history is, of course, not the only way to evaluate monetary policy. Another approach is to build structural models of the economy and then simulate the models stochastically with different monetary policy rules.

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1. In this paper a monetary policy *rule* is defined as a description—expressed algebraically, numerically, graphically—of how the *instruments* of policy, such as the monetary base or the federal funds rate, change in response to economic variables. Thus a constant growth rate rule for the *monetary base* is an example of a policy rule, as is a contingency plan for the monetary base. A description of how the *federal funds rate* is adjusted in response to inflation or real GDP is another example of a policy rule. A policy rule can be normative or descriptive. According to this definition, a policy rule can be the outcome of many different institutional arrangements for monetary policy, including gold standard arrangements in which there is no central bank. The term *regime* is usually used more broadly than the specific definition of a policy rule used in this paper. E.g., the term "policy regime" is used by Bordo and Schwartz (1999) to mean people's expectations as well as the institutional arrangements.

A model economy provides information about how the actual economy would operate with different policies. One monetary policy rule is better than another monetary policy rule if it results in better economic performance according to some criterion such as inflation or the variability of inflation and output.[2] This model-based approach has led to practical proposals for monetary policy rules (see Taylor 1993a), and the same approach is now leading to new or refined proposals. The model-based approach has benefited greatly from advances in computers, solution algorithms, and economic theories of how people forecast the future and how market prices and wages adjust to changing circumstances over time.

Despite these advances, the model-based approach cannot be the sole grounds for making policy decisions. No monetary theory is a completely reliable guide to the future, and certain aspects of the current models are novel, especially the incorporation of rational expectations with wage and price rigidities. Hence, the historical approach to monetary policy evaluation is a necessary complement to the model-based approach. By focusing on particular episodes or case studies one may get a better sense about how a policy rule might work in practice. Big historical changes in policy rules—even if they evolve slowly—allow one to separate policy effects from other influences on the economy. Because models, even simple ones, are viewed as black boxes, the historical approach may be more convincing to policymakers.[3] Moreover, case studies are useful for judging how much discretion is appropriate when a policy rule is being used as a guideline for central bank decisions.

Overview

I begin the analysis with a description of the framework I use to examine the history of monetary policy rules. I focus entirely on interest rate rules in which the short-term interest rate instrument of the central bank is adjusted in response to the state of the economy. When analyzing monetary policy using the concept of a policy rule, one must be careful to distinguish between instrument changes due to "shifts" in the policy rule and instrument changes due to "movements along" the policy rule. To make this distinction, I assume a particular functional form for the policy rule. The functional form is the one I suggested several years ago as a normative recommendation for the Federal Reserve (Taylor 1993a). According to this policy rule, the federal funds rate is adjusted by specific numerical amounts in response to changes in inflation and

2. Examples of this approach include the econometric policy evaluation research in Taylor (1979, 1993b), McCallum (1988), Bryant, Hooper, and Mann (1993), Sims and Zha (1995), Bernanke, Gertler, and Watson (1997), Brayton et al. (1997), and many of the papers in this conference volume.

3. In fact, the historical approach is frequently used in practice by policymakers, although the time periods are so short that it may seem like real-time learning. If policymakers were using a particular type of policy and found that it led to an increase in inflation, or a recession, or a slowdown in growth, then they probably would, at the next opportunity, change the policy, learning from the unfavorable experience.

real GDP. This functional form with these numerical responses describes the actual policy actions of the Federal Reserve fairly accurately in recent years, but in this paper I look at earlier periods when the numerical responses were different and examine whether economic performance of the economy was any different.

I examine several long time periods in U.S. monetary history, one around the end of the nineteenth century and the others closer to the end of the twentieth century. The earlier period from 1879 to 1914 is the classical international gold standard era; it includes 11 business cycles, a long deflation, and a long inflation. The later period from 1955 to 1997 encompasses the fixed exchange rate era of Bretton Woods and the modern flexible exchange rate era, including 7 business cycles, an inflation, a sharp disinflation, and the recent 15-year stretch of relatively low inflation and macroeconomic stability. The change in the policy rule over these periods has been dramatic. The type of policy rule that describes Federal Reserve policy actions in the past 10 or 15 years is far different from the ones implied by the gold standard, by Bretton Woods, or by the early part of the flexible exchange rate era.

It turns out that macroeconomic performance—in particular, the volatility of inflation and real output—was also quite different with the different policy rules. Moreover, the historical comparison gives a clear ranking of the policy rules in terms of economic performance. To ensure that this ranking is not spurious—reflecting reverse causation, for example—I try to examine the reasons for the policy changes. I think these changes are best understood as the result of an evolutionary learning process in which the Federal Reserve—from the day it began operations in 1914 to today—has searched for policy rules to guide monetary policy decisions and has changed policy rules as it has learned.

I then consider three specific episodes when "policy mistakes" were made. I define policy mistakes as big departures from two *baseline* monetary policy rules that both this historical analysis and earlier models-based analysis suggest would have been good policy rules. According to this definition, policy mistakes include (1) excessive monetary tightness in the early 1960s, (2) excessive monetary ease and the resulting inflation of the late 1960s and 1970s, and (3) excessive monetary tightness of the early 1980s. I contrast these three episodes with the more recent period of low inflation and macroeconomic stability during which monetary policy has followed the baseline policy rule more closely. I think the analysis of these three episodes and the study of the gradual evolution of the parameters of monetary policy rules from one monetary era to the next gives evidence in favor of the view that a monetary policy that stays close to the baseline policy rules would be a good policy.[4]

4. Judd and Trehan (1995) first brought attention to the difference between the interest rates implied by the policy rule I suggested in Taylor (1993a) and actual interest rates in the late 1960s and 1970s during the Great Inflation.

7.1 From the Quantity Equation of Money to a Monetary Policy Rule

The quantity equation of money ($MV = PY$) provided the analytical framework with which Friedman and Schwartz (1963) studied monetary history in their comprehensive study of the United States from the Civil War to 1960. As they state in the first sentence of their study, "This book is about the stock of money in the United States." A higher stock of money (M) would lead to a higher price level (P) other things—namely, real output (Y) and velocity (V)—equal, as they showed by careful study of episode after episode. In each episode they demonstrated why the money stock increased (gold discoveries in the nineteenth century, for example) or decreased (policy mistakes by the Federal Reserve in the twentieth century, for example), and they focused on the roles of particular individuals such as William Jennings Bryan and Benjamin Strong. But the quantity equation of money transcended any individual or institution: with the right interpretation it was useful both for the gold standard and the greenback period and whether a central bank existed or not.

The idea in this paper is to try to step back from the debates about current policy, as Friedman and Schwartz (1963) did, and examine the history of monetary policy via an analytical framework. However, I want to focus on the short-term interest rate side of monetary policy rather than on the money stock side. Hence, I need a different equation. Instead of the quantity equation I use an equation—called a monetary policy rule—in which the short-term interest rate is a function of the inflation rate and real GDP.[5] The policy rule is, of course, quite different from the quantity equation of money, but it is closely connected to the quantity equation. In fact, it can be easily derived from the quantity equation. To a person thinking about current policy, the quantity equation might seem like an indirect route to a interest rate rule for monetary policy, but it is a useful route for the study of monetary history.

7.1.1 Deriving a Monetary Policy Rule from the Quantity Equation

First imagine that the money supply is either fixed or growing at a constant rate. We know that velocity depends on the interest rate (r) and on real output or income (Y). Substituting for V in the quantity equation one thus gets a relationship between the interest rate (r), the price level (P), and real output (Y). If we isolate the interest rate (r) on the left-hand side of this relationship, we see a function of two variables: the interest rate as a function of the price level

5. Two useful recent studies have looked at monetary history from the vantage point of a monetary policy rule stated in terms of the interest rate instrument rather than a money instrument. These are Clarida, Galí, and Gertler (1998), who look at several other countries in addition to the United States, and Judd and Rudebusch (1998), who contrast U.S. monetary policies under Greenspan, Volker, and Burns. Clarida et al. (1998) show that British participation in the European Monetary System while Germany was tightening monetary policy led to a suboptimal shift of the baseline policy rule for the United Kingdom. Two earlier influential studies using the Friedman and Schwartz (1963) approach to monetary history and policy evaluation are Sargent (1986) and Romer and Romer (1989).

and real output. Shifts in this function would occur when either velocity growth or money growth shifts. Note also that such a function relating the interest rate to the price level and real output will still emerge if the money stock is not growing at a fixed rate, but rather responds in a systematic way to the interest rate or to real output; the response of money will simply change the parameters of the relationship.

The functional form of the relationship depends on many factors including the functional form of the relationship between velocity and the interest rate and the adjustment time between changes in the interest rate and changes in velocity. The functional form I use is linear in the interest rate and in the logarithms of the price level and real output. I make the latter two variables stationary by considering the deviation of real output from a possibly stochastic trend and by considering the first difference of the log of the price level—or the inflation rate. I also abstract from lags in the response of velocity to interest rates or income. These assumptions result in the following linear equation:

$$r = \pi + gy + h(\pi - \pi^*) + r^f, \qquad (1)$$

where the variables are r = the short-term interest rate, π = the inflation rate (percentage change in P), and y = the percentage deviation of real output (Y) from trend and the constants are g, h, π^*, and r^f. Note that the slope coefficient on inflation in equation (1) is $1 + h$; thus the two key response coefficients are g and $1 + h$. Note also that the intercept term is $r^f - h\pi^*$. An interpretation of the parameters and a rationale for this notation is given below.

7.1.2 Interpreting the Monetary Policy Rule

Focusing now on the functional form for the policy rule in equation (1), our objective is to determine whether the parameters in the policy rule vary across time periods and to look for differences in economic performance that might be related to any such variations across time periods. Note how this historical policy evaluation method is analogous to model-based policy evaluation research in which policy rules (like eq. [1]) with various parameter values are placed in a model and simulations of the model are examined to see if the variations in the parameter values make any difference for economic performance. Equation (1) is useful for this historical analogue of the model-based approach because it can describe monetary policy in different historical time periods when there were many different policy regimes. In each regime the response parameters g and $1 + h$ would be expected to differ, though in most regimes they would be positive. To see this, consider several types of regimes.

Constant Money Growth. We have already seen that the quantity equation with fixed money growth implies a relationship like equation (1). To see that the parameters g and $1 + h$ are positive with fixed money growth consider the demand for money in which real balances depend negatively on the interest rate and positively on real output. Then, in the case of fixed money growth, an increase in inflation would lower *real* money balances and cause the interest rate to rise: thus higher inflation leads to a higher interest rate.[6] Or suppose that real income rises thus increasing the demand for money; then, with no adjustment in the supply of money, the interest rate must rise. In other words, the monetary policy rule with positive values for g and $1 + h$ provides a good description of monetary policy in a fixed money growth regime. However, the monetary policy rule also provides a useful framework in many other situations.

International Gold Standard. Important for our historical purposes is that such a relationship also exists in the case of an international gold standard. The short-run response $(1 + h)$ of the interest rate to the inflation rate in the case of a gold standard is most easily explained by the specie flow mechanism of David Hume. If inflation began to rise in the United States compared with other countries, then a balance-of-payments deficit would occur because U.S. goods would become less competitive. Gold would flow out of the United States to finance the trade deficit; high-powered money growth would decline and the reduction in the supply of money compared with the demand for money would put upward pressure on U.S. interest rates. The higher interest rates and the reduction in demand for U.S. exports would put downward pressure on inflation in the United States.[7] Similarly, a reduction in inflation in the United States would lead to a trade surplus, a gold inflow, an increase in the money supply, and downward pressure on U.S. interest rates.

Fluctuations in real output would also cause interest rates to adjust. Suppose that there were an increase in real output. The increased demand for money would put upward pressure on interest rates if the money supply were unchanged. Amplifying this effect under a gold standard would be an increase in the trade deficit, which would lead to a gold outflow and a decline in the money supply.

These interest rate responses would occur with or without a central bank. If there were a central bank, it could increase the size of the response coefficients if it played by the gold standard's "rules of the game." Interest rates would be even more responsive, because a higher price level at home would then bring about an increase in the "bank rate" as the central bank acted to help alleviate the price discrepancies. The U.S. Treasury did perform some of the functions of a central bank during the gold standard period; it even provided liquidity during some periods of financial panic, though not with much regularity or predictability. However, there is little evidence that the U.S. Treasury performed "rules of the game" functions as the Bank of England did during the gold standard era.

6. Note that this effect of inflation on the interest rate is a short-term "liquidity effect" rather than a longer term "Fisherian" or "expected inflation" effect. The expected inflation effect would occur if the growth rate of the money supply increased or if π^* (the target inflation rate in the policy rule) increased.

7. Short-term capital flows would of course limit the size of such interest rate changes. One reason why U.S. short-term interest rates did not move by very much in response to U.S. inflation fluctuations (as shown below) may have been the mobility of capital.

Leaning against the Wind. The most straightforward application of equation (1) is to situations where the Fed sets short-term interest rates in response to events in the economy. Then equation (1) is a central bank interest rate reaction function describing how the Federal Reserve takes actions in the money market that cause the interest rate to change in response to changes in inflation and real GDP. For example, if the Fed "leaned against the wind," easing money market conditions in response to lower inflation or declines in production and tightening money market conditions in response to higher inflation or increases in production, then one would expect g and $1 + h$ in equation (1) to be positive. However, "leaning against the wind" policies have not usually been stated quantitatively; thus the size of the parameters could be very small or very large and would not necessarily lead to good economic performance.

Monetary Policy Rule as a Guideline or Explicit Formula. Finally, equation (1) could represent a guideline, or even a strict formula, for the central bank to follow when making monetary policy decisions. As in the previous paragraph, decisions would be cast in terms of whether the Fed would raise or lower the short-term interest rate. But equation (1) would serve as a normative guide to these decisions, not simply a description of them after the fact. If the policy rule called for increasing the interest rate, for example, then the Federal Open Market Committee (FOMC) would instruct the trading desk to make open market sales and thereby adjust the money supply appropriately to bring about this increase. In this case, the parameters of equation (1) have a natural interpretation: π^* is the central bank's target inflation rate, r^f is the central bank's estimate of the equilibrium real rate of interest, and h is the amount by which the Fed raises the ex post real interest rate $(r - \pi)$ in response to an increase in inflation. In the case that $g = 0.5$, $h = 0.5$, $\pi^* = 2$, and $r^f = 2$, equation (1) is precisely the form of the policy rule I suggested in Taylor (1993a). Others have suggested that g should be larger, perhaps closer to one (see Brayton et al. 1997). Thus an alternative baseline rule considered below sets $g = 1$. These are the parameter values that define the baseline policy rules for historical comparisons in this paper.

7.1.3 The Importance of the Size of the Coefficients

To summarize, a constant growth rate of the money stock, an international gold standard, an informal policy of leaning against the wind, and an explicit quantitative policy of interest rate setting all will tend to generate positive responses of the interest rate to changes in inflation or real output, as described by equation (1). And we expect that g and $1 + h$ in equation (1) would be greater than zero in all these situations. However, the magnitude of these coefficients will differ depending on how monetary policy is run.

In the case of the gold standard or a fixed money growth policy, the size of the coefficients depends on many features of the economy. Under a gold standard, the size of the response of the interest rate to an increase in inflation will depend on the sensitivity of trade flows to international price differences. It will also depend on the size of the money multiplier, which translates a change in high-powered money due to a gold outflow into a change in the money supply. The interest rate elasticity of the demand for money is also a factor.

With a policy that keeps the growth rate of the money stock constant, the response of the interest rate to an increase in real output will depend on both the income elasticity of money demand and the interest rate elasticity of money demand. The higher the interest rate elasticity of money demand (or velocity), the smaller would be the response of interest rates to an increase in output or inflation.

The size of these coefficients makes a big difference for the effects of policy. Simulations of economic models indicate, for example, that the coefficient h should not be negative; otherwise $1 + h$ will be less than one and the real interest rate would fall rather than rise when inflation rose. As a result inflation could be highly volatile. As I show below there is evidence that h was negative during the late 1960s and 1970s when inflation rose in the United States. Hence, policymakers need to be concerned about the size of these coefficients.

A recent example of this concern demonstrates the usefulness of thinking about monetary history from the perspective of equation (1). Consider Alan Greenspan's (1997) recent analysis of the size of the interest rate response to real output with a constant money growth rate. In commenting on a money growth strategy, Greenspan reasoned: "Because the velocity of such an aggregate [M1] varies substantially in response to small changes in interest rates, target ranges for M1 growth in [the FOMC's] judgement no longer were reliable guides for outcomes in nominal spending and inflation. In response to an unanticipated movement in spending and hence the quantity of money demanded, a small variation in interest rates would be sufficient to bring money back to path but not to correct the deviation in spending" (1997, 4–5). In other words, in Greenspan's view the interest rate elasticity of velocity is so large that the interest rate would respond by too small an amount to an increase in output. In terms of equation (1) the parameter g is too small, according to Greenspan's analysis, under a policy that targets the growth rate of M1.

7.2 The Evolution of Monetary Policy Rules in the United States: From the International Gold Standard to the 1990s

Figures 7.1 and 7.2 illustrate the historical relation between the variables in equation (1). They show the interest rate (r), the inflation rate (π), and real GDP deviations (y) during two different time periods: 1880–1914 versus 1955–97. The upper part of each figure shows real output, an estimate of the trend in real output, and the percentage deviation of real output from this trend. Our focus is on the deviations of real output from trend rather than on the

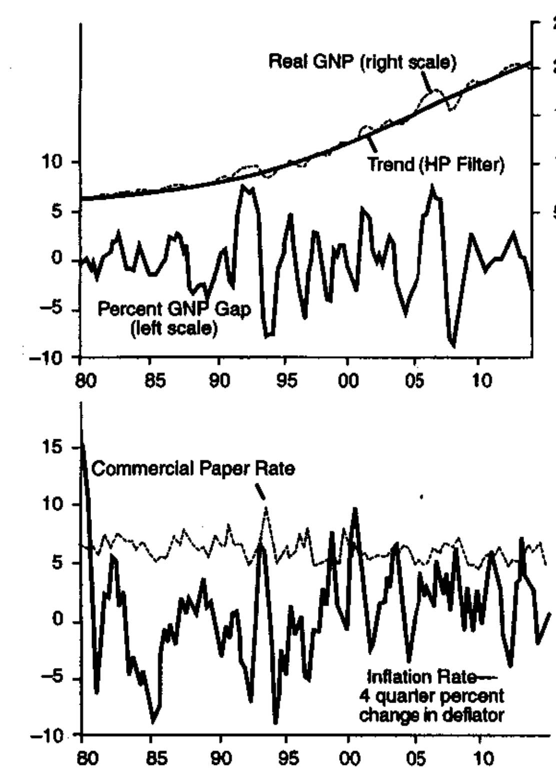

Fig. 7.1 The 1880–1914 period: short-term interest rate, inflation, and real output

Source: Quarterly data on real GNP, the GNP deflator, and the commercial paper rate are from Balke and Gordon (1986). Real output data are measured in billions of 1972 dollars and the trend is created with the Hodrick-Prescott filter.

average output growth rate in the two periods. The lower part of each figure shows a short-term interest rate (the commercial paper rate in the earlier period and the federal funds rate in the later period) and the inflation rate (a four-quarter average of the percentage change in the GDP deflator). Recall that the earlier period coincides with the classical international gold standard, starting with the end of the greenback era when the United States restored gold convertibility and ending with the suspension of convertibility by many countries at the start of World War I.

7.2.1 Changes in Cyclical Stability

The contrast between the display of the data in figure 7.1 and figure 7.2 is striking. First, note that business cycles occur much more frequently in the earlier period (fig. 7.1) than in the later period (fig. 7.2), and the size of the

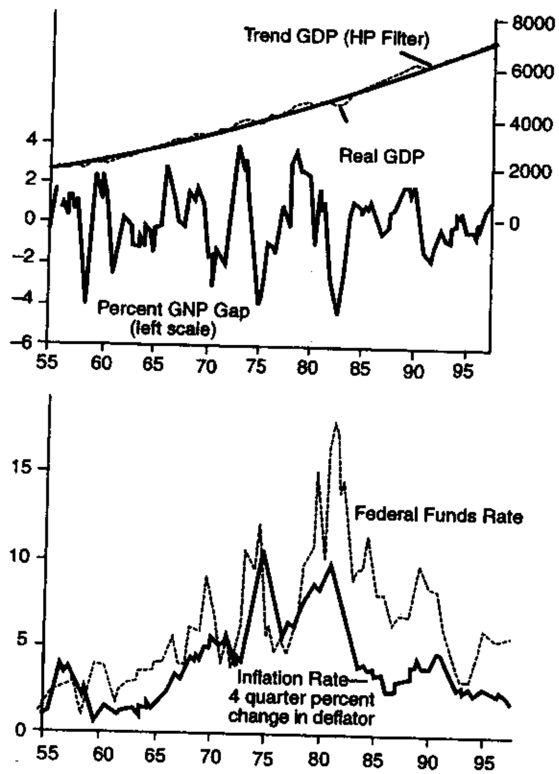

Fig. 7.2 The 1955–97 period: short-term interest rate, inflation, and real output
Source: Quarterly data are from the DRI data bank. Real output is measured in billions of 1992 dollars and the trend is created with the Hodrick-Prescott filter.

fluctuations of inflation and real output is much greater. From 1880 to 1897 there was deflation on average. From 1897 to 1914 prices rose on average. But throughout the whole period there were large fluctuations around these averages. The later period is not of course uniform in its macroeconomic performance. The late 1960s and 1970s saw a large and persistent swing in inflation, while the years since the mid-1980s have seen much greater macroeconomic stability.

One way to highlight the greater macroeconomic turbulence in the earlier years is to consider the period from 1890 to 1897, which saw three recessions. These years were so bad that they were called the "Disturbed Years" by Friedman and Schwartz (1963). One cannot avoid the temptation to contrast 1890–97 with 1990–97. If we had the same business cycle experience in the later years, we would have had a recession in 1990–91 slightly longer than the one we actually had. But we would have also had another recession starting in January 1993 just as President Clinton started in office and yet another recession starting in 1995. The trough of that third recession of the 1990s would have occured in June of 1997. Even allowing for measurement error due to overemphasis of goods versus services in the earlier period, it appears that the earlier period was less stable.[8] To be sure, if one ignores the long swing of average deflation and then inflation, the fluctuations in inflation were much less persistent during the gold standard period, as emphasized in a comparison by McKinnon and Ohno (1997, 164–71). But this long-term deflation and inflation should count as part of the sub-par inflation performance during this period.

7.2.2 Changes in Interest Rate Responses

A second, and even more striking, contrast between the two periods is the response of the short-term interest rate to inflation and output. While the short-term interest rate is procyclical during both the earlier period and the later period, the elasticity of its response to output is clearly much less in the earlier period than in the later period. Cagan (1971) first pointed out the increased cyclical sensitivity of the interest rate to real output fluctuations, and it is more evident now than ever. The short-term interest rate is also much less responsive to fluctuations in the inflation rate in the earlier period. It appears that the gold standard did lead to a positive response of interest rates to real output and inflation, but this response is much less than for the monetary policy in the post–World War II period.

The huge size of these differences is readily visible in figures 7.1 and 7.2. But to see how the responses changed during the post–World War II period it is necessary to go beyond these time-series charts. Some numerical information about the size of these differences is provided in table 7.1. The table shows least squares estimates of the coefficients on real output (the parameter g in eq. [1]) and the inflation rate (the parameter $1 + h$ in eq. [1]) for different time periods.[9]

The far right-hand column shows the results for each of the two full periods. Observe that the estimated values of g and $1 + h$ are about 10 times larger in the Bretton Woods and post–Bretton Woods eras than in the international gold standard era. It is clear that the gold standard implied much smaller response coefficients for the interest rate than Federal Reserve policy has implied in later periods.

8. Romer (1986) demonstrated that biases in the pre–World War I data tend to overestimate the volatility in comparison with later periods.

9. As explained above this equation is actually a reduced form of several structural equations, especially in the gold standard and Bretton Woods periods. I have purposely tried to keep the statistical equations as simple as the theoretical policy rule in eq. (1). No attempt has been made to correct the estimates for serial correlation of the errors in the equation. I want to allow for the possibility that monetary policy mistakes are serially correlated in ways not necessarily described by simple time-series models. In fact, this serial correlation is very large, especially in the gold standard period when the equations fit very poorly. Hence, the "t-statistics" in parentheses are not useful for hypothesis testing. See Christiano, Eichenbaum, and Evans (1997) for a comprehensive analysis of estimation and identification issues in the case of reaction functions.

Table 7.1 Monetary Policy Rules: Descriptive Statistics

	International Gold Standard Era		
Variable	1879:1–91:4 Coefficient	1897:1–1914:4 Coefficient	1879:1–1914:4 Coefficient
Constant	6.458 (70.5)	5.519 (47.3)	5.984 (75.0)
π	0.019 (1.01)	0.034 (1.03)	0.006 (0.32)
y	0.059 (2.28)	0.038 (1.89)	0.034 (1.52)
R^2	0.15	0.07	0.02
	Bretton Woods and Post–Bretton Woods Eras		
	1960:1–79:4 Coefficient	1987:1–97:3 Coefficient	1954:1–97:3 Coefficient
Constant	2.045 (6.34)	1.174 (2.35)	1.721 (5.15)
π	0.813 (12.9)	1.533 (9.71)	1.101 (15.1)
y	0.252 (4.93)	0.765 (8.22)	0.329 (3.16)
R^2	0.70	0.83	0.58

Note: These are ordinary least squares estimates of the coefficients of the variables in eq. (1). The left-hand-side variable (r) is measured by the commercial paper rate for the years 1879–1914 and by the federal funds rate for the years 1954–97. The variable π is measured by the average inflation rate over four quarters, and the variable y is measured by the percentage deviation of real output from a trend. Numbers in parentheses are ratios of coefficients to standard errors. See figs. 7.1 and 7.2 for data sources.

Note also that the size of these coefficients has increased gradually over time. Compared with the 1960s and 1970s the coefficients on real output tripled in size by the 1987–97 period while the coefficient on inflation doubled in size. They are now close to the values of the rule I suggested in Taylor (1993a). Hence, when viewed over the past century we have seen an evolution of the monetary policy rule as I have defined and characterized it empirically here. The monetary policy rule had very low interest rate responses during the gold standard era. It had higher responses during the 1960s and the 1970s, and it had still higher responses in the late 1980s and 1990s.

7.2.3 A Graphical Illustration of the Importance of the Size of the Inflation Response

Figure 7.3 shows how dramatically the monetary policy rule has changed from the 1960–70s to the 1980–90s. The two solid lines show two monetary policy rules corresponding to the two periods. The slopes of the solid lines measure the size of the interest rate responses to inflation in the policy rule. I abstract from output fluctuations in figure 7.3, by assuming that the economy is operating at full employment with real GDP equal to potential GDP ($y = 0$). The dashed line in figure 7.3 has a slope of one and shows a constant real interest rate of 2 percent. If the actual long-run real interest rate is 2 percent,

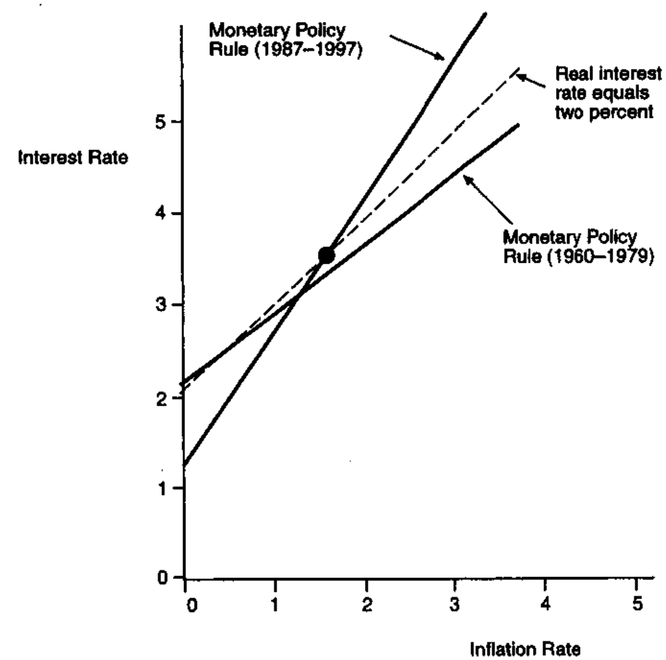

Fig. 7.3 Two estimated monetary policy rules: 1960–79 versus 1987–97

then the intersection of the dashed line and the policy rule line gives the long-run average inflation rate.

Observe that the slope of the policy rule has gone from below one to above one. A slope below one would lead to poor economic performance according to variety of models. With the slope less than one, an increase in inflation would bring about a *decrease* in the real interest rate. This would increase demand and add to upward pressures on inflation. This is exactly the wrong policy response to an increase in inflation because it would lead to ever increasing inflation. In contrast, if the slope of the policy rule were greater than one, an increase in inflation would bring about an *increase* in the real interest rate, which would be stabilizing.

These theoretical arguments are illustrated in figure 7.3. For a long-run equilibrium, we must be at the intersection of the policy rule line and the dashed line representing the long-run equilibrium real interest rate. If the slope of the policy rule line is greater than one, higher inflation leads to higher real interest rates and the inflation rate converges to an equilibrium at the intersection of the policy rule line and the dashed real interest rate line. For example, if the equilibrium real interest rate is 2 percent as in figure 7.3, the equilibrium inflation rate is about 1.5 percent for the recent, more steeply sloped, monetary policy rule in figure 7.3. However, if the slope of the policy rule line is less than one, higher inflation leads to a lower real interest rate, which leads to even higher inflation; the inflation rate is unstable and would not converge to an equilibrium. In sum, figure 7.3 shows why the inflation rate would be more stable in the 1987–97 period than in the 1960–79 period.

7.3 Effects of the Different Policy Rules on Macroeconomic Stability

Can one draw a connection between the different policy rules and the economic performance with those policy rules? In particular, within the range of policy rules we have seen, is it true that more responsive policy rules lead to greater economic stability? Making such a connection is complicated by other factors, such as oil shocks and fiscal shocks, but it is at least instructive to try.

7.3.1 Three Monetary Eras

As the analysis summarized in table 7.1 indicates, three eras of U.S. monetary history can be clearly distinguished by big differences in the degree of responsiveness of short-term interest rates in the monetary policy rule.

First, during the period from about 1879 to about 1914 short-term interest rates were very unresponsive to fluctuations in inflation and real output. Second, during the period from about 1960 to 1979 short-term interest rates were more responsive, but still small in the sense that the response of the nominal interest rate to changes in inflation was less than one. Third, during the period from about 1986 to 1997 the nominal interest rate was much more responsive to both inflation and real output fluctuations.

These three eras can also be distinguished in terms of overall economic stability. Of the three, there is no question that the third had the greatest degree of economic stability. Figure 7.1 shows that both inflation and real output had smaller fluctuations during this period. The period contains both the first and second longest peacetime expansions in U.S. history. Moreover, inflation was low and stable. And, of course, this is the period in which the monetary policy rule had the largest reaction coefficients, giving support to model-based research that this was a better policy rule than those implied by the two earlier periods.

The relative ranking of the first and second periods is more ambiguous. Real output and inflation fluctuations were larger in the earlier period. But while inflation was more variable, there was much less persistence of inflation during the gold standard than in the late 1960s and 1970s. However, the different exchange rate regimes are another monetary factor that must be taken into account. It was the gold standard that kept the long-run inflation rate so stable in the earlier period. Bretton Woods may have provided a similar constraint on inflation during the early 1960s, but as U.S. monetary policy mistakenly became too easy, it was not inflation that collapsed, it was the Bretton Woods system. And after the end of Bretton Woods this external constraint on inflation was removed. With the double whammy of the loss of an external constraint and an inadequately responsive monetary policy rule in place, the inevitable result was the Great Inflation.

If one properly controls for the beneficial external influences of the gold standard on long-run inflation during the 1879–1914 period, one obtains an unambiguous correlation between monetary policy rule and macroeconomic stability. The most economically stable period was the one with the most responsive policy rule. The least economically stable (again adjusting for the gold standard effects) was the one with the least responsive policy rule. The late 1960s and 1970s also rank lower than the most recent period in terms of economic stability and had a less responsive monetary policy rule.

7.3.2 Explaining the Changes in the Policy Rules

In any correlation analysis between economic policy and economic outcomes there is the possibility of reverse causation. Could the lower responsiveness of interest rates in the two earlier periods compared with the later period have been caused by the greater volatility of inflation and real output? If one examines the history of changes in the monetary policy rule I think it becomes clear that the answer is no. The evolution of the monetary policy rule is best understood as a gradual process of the Federal Reserve learning how to conduct monetary policy. This learning occurred through research by the staff at the Fed, through the criticism of monetary economists outside the Fed, through observation of central bank behavior in other countries, and through direct personal experience of members of the FOMC. And, of course, there were steps backward as well as forward.[10]

This learning process occurred as the United States moved further and further away from the classical international gold standard. Under the gold standard, increases and decreases in short-term interest rates were explained by the interaction of the quantity of money supplied (determined by high-powered money through the inflow and outflow of gold) and the quantity of money demanded (which rose and fell as inflation and output rose and fell). A greater response of the short-term interest rate to rising or falling price levels and to rising or falling output would probably have reduced the shorter run variability of inflation and output. For example, lower interest rates during the start of the deflation period may have prevented the deflation. But because of the fixed exchange rate feature of the gold standard, the U.S. inflation rate was constrained to be close to the inflation rates of other gold standard countries; the degree of closeness depended on the size and the duration of deviations from purchasing power parity.

The Federal Reserve started operations at the same time as the classical gold standard ended: 1914. From the start there was therefore uncertainty and dis-

10. If economists' research on the existence of a long-run trade-off between inflation and unemployment helped lead to the Great Inflation in the 1970s, then this research should be counted as a step backward. The effect of economic research and other factors that may have led to the Great Inflation are discussed in De Long (1997) and in my comment on De Long's paper.

agreement about how monetary policy should be conducted without the constraints of the gold standard and fixed exchange rates. The Federal Reserve Act indicated that currency—best interpreted now as the monetary base or high-powered money—was to be elastically provided. But how was the Fed to determine the degree of this elasticity?

The original idea was that two factors—each pulling in an opposite direction—were to be balanced out. One was the gold standard itself; with a gold reserve requirement limiting the amount of Federal Reserve liabilities, the supply of money was limited. This was a long-run constraint on the supply of money; it worked through gold inflows and gold outflows and the gradual adjustment of the U.S. price level compared with foreign price levels. The other factor, which worked more quickly, was "real bills" or "needs of trade" doctrine under which the supply of money was to be created in sufficient amounts to meet the demand for money. Clearly, the needs-of-trade criterion was not effective on its own because it did not put a limit on the amount of money creation. Therefore, with the suspension of the gold standard and with the real bills criterion ineffective in determining the supply of money, the Federal Reserve began operations with no criteria for determining the appropriate amount of money to supply. Hence, ever since this uncertain beginning, the Fed has been searching for such criteria. From the perspective of this paper, we can think of the Fed as searching for a good monetary policy rule.

This search is evident in many Federal Reserve reports. Early on, the idea of "leaning against the wind" was discussed as a counterbalance to the needs-of-trade criterion. For example, the Fed's annual report for 1923 stated that "it is the business of the [Federal] Reserve system to work against extremes either of deflation or inflation and not merely to adapt itself passively to the ups and downs of business" (quoted in Friedman and Schwartz 1963, 253). But there was no agreement about how much leaning against the wind there should be. As discussed above, leaning against the wind would result in a policy rule of the type in equation (1), but the parameters of the policy rule could be far from optimal. That the Fed was unable throughout the interwar period to find an effective policy rule for conducting monetary policy is evidenced by the disastrous economic performance during the Great Depression when money growth fell dramatically.

The search for a monetary policy rule was postponed during World War II and in the postwar period by the overriding objective of keeping Treasury borrowing costs down. (Effectively the Fed set $g = 0$ and $h = -1$ so that r was a constant stipulated by the U.S. Treasury.) However, after the 1951 Treasury–Federal Reserve Accord, the Fed once again needed a policy rule for conducting monetary policy. Leaning against the wind—now articulated by William McChesney Martin—again became a guideline for short-run decisions about changes in the money stock. But the idea was still very vague. As stated by Friedman and Schwartz (1963) in discussing the mid-1950s when William McChesney Martin was chairman, "There was essentially no discussion of how to determine which way the relevant wind was blowing. . . . Neither was there any discussion of when to start leaning against the wind. . . . There was more comment, but hardly any of it specific about how hard to lean against the wind" (631–32).

The experience of new board member Sherman Maisel indicates that the search was still going on 10 years later in the mid-1960s. According to Maisel in his candid memoirs, "After being on the Board for eight months and attending twelve open market meetings, I began to realize how far I was from understanding the theory the Fed used to make monetary policy. . . . Nowhere did I find an account of how monetary policy was made or how it operated" (1973, 77). Maisel was particularly concerned about various money market conditions indexes such as free reserves that came up in Fed deliberations, because of the difficulty of measuring the impact of these changes on the economy. He states, "Money market conditions cannot measure the degree to which markets should be tightened or for how long restraint should be retained" (82). And when referring to a decision to raise the short-term interest rate in 1965, he states, "It became increasingly clear that an inflationary boom was getting underway and that monetary policy should have been working to curb it" (81). However, he argued that the actions taken to raise interest rates were insufficient to curb the inflation. In retrospect he was correct. Interest rates did not go high enough. With no quantitative measure of how high interest rates should go, the chance of not raising them high enough was great.

The increased emphasis on money growth in the 1970s played a very useful role in clarifying the serious problems of interest rate setting without any quantitative guidelines. And money growth targets had a very useful role in the disinflation of the 1979–81 period because it was clear that interest rates would have to rise by large amounts as the Fed lowered the growth rate of the money supply. But after the disinflation was over, money growth targets again receded to being a longer run consideration in Federal Reserve operations as the demand for money appeared to be less stable. Moreover, as noted earlier, according to Greenspan's (1997) analysis, keeping money growth constant does not give sufficient response of interest rates to inflation or real output when the aim is to keep inflation low and steady.

The importance of having a policy rule to guide policy became even more important when the Bretton Woods system fell apart in the early 1970s. Until then the long-run constraints on monetary policy were similar to those of the international gold standard. If the Fed did not lean hard enough against the wind, the higher inflation rate would start to put pressure on the exchange rate and the Fed would have to raise interest rates to defend the dollar. But without the dollar to defend, this constraint on monetary policy was lost. After Bretton Woods ended there was an even greater need for the Fed to develop a monetary policy rule that was sufficient to contain inflation without the external constraint. This need was one of the catalysts for the rational expectations econometric policy evaluation research in the 1970s and 1980s.

This brief review of the evolution of policy indicates that macroeconomic events, economic research, and policymakers at the Fed have gradually brought forth changes in the monetary policy rule in the United States. I think this gradual evolution makes it clear that the causation underlying the negative correlation between the size of the policy response of interest rates to output or inflation and the volatility of output or inflation goes from policy to outcome, not the other way around.

If we apply this learning hypothesis to the changes in the estimated policy rule described above, it suggests that the Federal Reserve learned over time to have higher response coefficients in a policy rule like equation (1). What led the Fed to change its policy in such a way that the parameter h changed from a negative number to a positive number? Experience with the Great Inflation of the 1970s that resulted from a negative value for h may be one explanation. Academic research on the Phillips curve trade-off and the effects of different policy rules resulting from the rational expectations revolution may be another.[11]

7.4 "Policy Mistakes": Big Deviations from Baseline Policy Rules

The historical analysis thus far in this paper has not assumed that any particular policy rule was better than the others. However, that was the conclusion of the analysis: a comparison of policy rules and economic outcomes points to the rule the Fed has been using in recent years as a better way to run monetary policy than the way it was run in earlier years. That conclusion of the historical analysis bolsters the very similar conclusion of the model-based research summarized in the introduction to this paper.

Once one has focused on a particular policy rule, however, there is another way to use history to check whether the policy rule would work well. With a preferred policy rule in hand, one can look at episodes in the past when the instrument of policy—the federal funds rate in this case—deviated from the settings given by the preferred policy rule. We can characterize such deviations as "policy mistakes" and see if the economy was adversely affected as a result of these mistakes.[12]

Figures 7.4, 7.5, and 7.6 summarize the results of this historical "policy mistake" analysis. They show the actual federal funds rate and the value of the federal funds rate implied by two policy rules. The gap between the actual

11. Chari, Christiano, and Eichenbaum (1998) argue that the Fed was too accommodative to inflation (h was too low) in the 1970s because high expectations of inflation raised the costs of disinflation, rather than because the Fed still had something to learn about the Phillips curve trade-off or about the effects of different policy rules. I find the learning argument more plausible in part because it explains the end of the inflation and the change in the policy rule.

12. We are, of course, looking at these past episodes with the benefit of later research and experience. The term "mistake" does not necessarily mean that policymakers of the past had the information to do things differently.

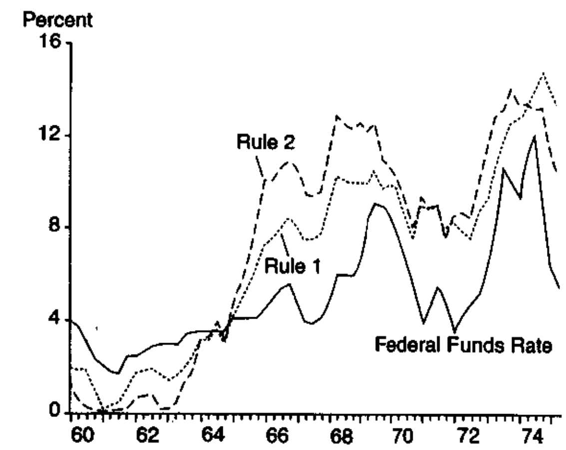

Fig. 7.4 Federal funds rate: too high in the early 1960s; too low in the late 1960s

Note: Rules 1 and 2 are given by the monetary policy rule in eq. (1) with $g = 0.5$ and 1.0, respectively.

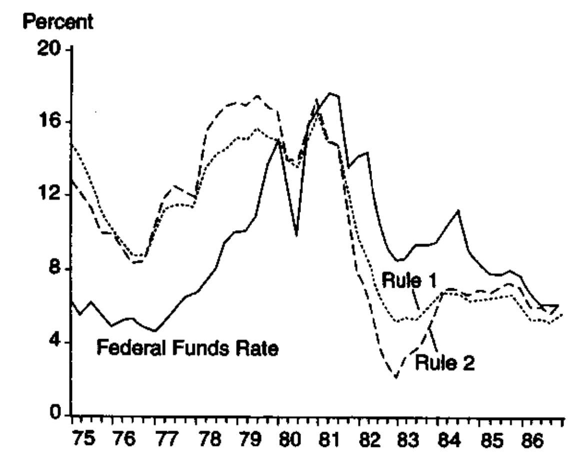

Fig. 7.5 Federal funds rate: too low in the 1970s; on track in 1979–81; too high in 1982–84

Note: See note to fig. 7.4.

federal funds rate and the policy rules is a measure of the policy mistake. One of the monetary policy rules I use is the one I suggested in Taylor (1993a), which is equation (1) with the parameters g and h equal to 0.5. This is rule 1 in figures 7.4, 7.5, and 7.6. As mentioned above, more recent research has suggested that g should be closer to 1.0, giving a more procyclical interest rate. This variant is rule 2 in the figures.

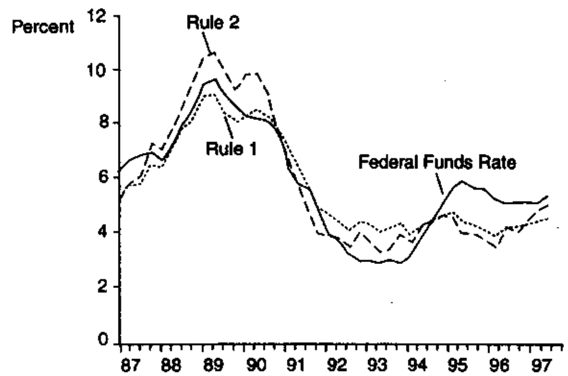

Fig. 7.6 Federal funds rate: on track in the late 1980s and 1990s
Note: See note to fig. 7.4.

The gap between the actual federal funds rate and the policy rule is particularly large in three episodes shown in figures 7.4 and 7.5, especially in comparison with the relatively small gap in the late 1980s and 1990s shown in figure 7.6.

The first episode occurred in the early 1960s when the mistake was making monetary policy too tight. Regardless of whether g is 0.5 or 1.0 the actual federal funds rate is well above the policy rule. The gap between the funds rate and the baseline policy was between 2 and 3 percentage points and this gap lasted for about three and a half years.[13]

It is interesting to note that Friedman and Schwartz (1963, 617) also concluded that monetary policy was overly restrictive during this period. They cite several reasons why policy may have been too tight. First, the Fed was concerned about the balance of payments and an outflow of gold. Second, in looking back at the previous recovery, it appeared to the Fed that policy had eased too soon after the recession. What was the result of this policy mistake? The recovery from the 1960–61 recession was weak and the eventual expansion was slow for several years from about 1962 to 1965. In fact, the economy did not appear to catch up to its potential until 1965. The New Economics introduced by President Kennedy and his economic advisers was addressed at this prolonged period with real output below potential.

The second episode started in the late 1960s and continued throughout the 1970s—a mistake with so much serial correlation it would pass a unit root test! In this case the monetary policy mistake was being way too easy. As shown in figures 7.4 and 7.5, the gap between the funds rate and the baseline policy

13. With its high output response, rule 2 brings the interest rate below zero for several quarters, so the interest rate is set to a small positive number in the chart.

started growing in the late 1960s. It grew as large as 6 percentage points and persisted in the 4 to 6 percentage point range until the late 1970s when Paul Volcker took over as Fed chairman. The excessive ease in policy began well before the oil price shocks of the 1970s, thus raising doubts that these shocks were the cause of the 1970s Great Inflation.

What caused this monetary policy mistake? Economic research of the 1960s suggested that there was a long-run trade-off between inflation and unemployment; this research probably reduced some of the aversion to inflation by the Federal Reserve. At the least the belief by some in a long-run Phillips curve made defending low inflation more difficult at the Fed. Note that the mistake began well before the Friedman-Phelps hypothesis was put forward. Moreover, as the quotes from Maisel's memoirs above make clear, the Fed's use of money market conditions caused them to understate the degree of tightness. De Long (1997) argues that the overly expansionary policy was due to a great fear of unemployment carried over from the Great Depression, though he does not attempt to explain why this mistake occurred when it did. While the causes of this mistake may be uncertain, there is little doubt that it was responsible for bringing on the Great Inflation of the 1970s. In my view this mistake is the second most serious monetary policy mistake in twentieth-century U.S. history, the most serious being the Great Depression. If a policy closer to the baseline were followed, the rise in inflation may have been avoided.

The third episode occurred after the disinflation of the early 1980s. The increase in interest rates in 1979 and 1980 was about the right magnitude according to either of the policy rules. But both rule 1 and rule 2 indicate that the funds rate should have been lowered more than it was in the 1982–84 period. During this period the interest rate was well above the value implied by the two policy rules. However, it should be emphasized that this period occurred right after the end of the 1970s inflation, and interest rates higher than recommended by the policy rules may have been necessary to keep expectations of inflation from rising and to help establish the credibility of the Fed. In effect the Fed was in a transition between policy rules. In my view this period has less claim to being a "policy mistake" than the other two periods.

7.5 Conclusions

The main conclusions of this paper can be summarized as follows. First, a monetary policy rule for the interest rate provides a useful framework with which to examine U.S. monetary history. It complements the framework provided by the quantity equation of money so usefully employed by Friedman and Schwartz (1963). Second, a monetary policy rule in which the interest rate responds to inflation and real output is an implication of many different monetary systems. Third, the monetary policy rule has changed dramatically over time in the United States, and these changes are associated with equally dramatic changes in economic stability. Fourth, an examination of the underlying reasons for the monetary policy changes indicates that they have caused the changes in economic outcomes, rather than the reverse. Fifth, a monetary policy rule in which the interest rate responds to inflation and real output more aggressively than during the 1960s and 1970s or than during the international gold standard—and more like the late 1980s and 1990s—is a good policy rule. Sixth, if one defines policy mistakes as deviations from such a good policy rule, then such mistakes have been associated with either high and prolonged inflation or drawn-out periods of low capacity utilization, much as simple monetary theory would predict.

Overall the results of the historical approach in this paper are quite consistent with the results of the model-based approach to monetary policy evaluation. But in an important sense this paper has only touched the surface; many other issues could be explored with a historical approach. For example, two difficult problems with monetary policy rules such as equation (1) have been mentioned by Alan Greenspan (1997): both potential GDP and the real rate of interest are uncertain. Uncertainty about the level of potential GDP (and the natural rate of unemployment) is a problem faced by monetary policymakers today regardless of whether they use a policy rule for guidance. Looking back at previous episodes and seeing the results of mismeasuring either potential GDP or the real rate of interest might help reduce the probability of making the next monetary policy mistake.

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Comment Richard H. Clarida

It is a pleasure to discuss this paper by John Taylor. In it, he proposes to use the Taylor rule as an analytical framework for the interpretation of monetary history, much as Friedman and Schwartz employed the quantity equation. I agree with the approach that he is trying to promote, I concur in general with the inferences he draws from it, and I believe that this way of interpreting monetary history can be, and in my work with Jordi Galí and Mark Gertler (1998a, 1998b) has already been, applied in fruitful ways that complement the application emphasized in this paper.

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The basic idea is straightforward, and much of the paper is devoted to justifying its application. A baseline, or reference, time path of the short-term (federal funds) interest rate is constructed using a Taylor (1993) rule of the form

$$r_t = r^f + \pi^* + h(\pi_t - \pi^*) + gy_t,$$

where r^f is the long-run equilibrium real interest rate, π^* is the long-run equilibrium rate of inflation, and y_t is the output gap. After the baseline is constructed, the actual time path of the short-term interest rate is compared to the baseline path. Episodes (i.e., sequences of observations) in which the funds rate is persistently higher than the baseline path are interpreted as episodes of excessively "tight" monetary policy, while episodes in which the funds rate is consistently below the baseline are interpreted as episodes in which monetary policy is too "easy." Although Taylor provides some qualification in footnote 12, he is explicit in his interpretation of these episodes of "easy" and "tight" policy as representing policy mistakes.

Now if, as we have learned from the central bankers present at this conference, the Taylor rule can be and is used as a benchmark for assessing the current stance of actual monetary policies, then certainly it can also be used as part of a framework to interpret monetary history. But certainly the caveats that apply to its use as a benchmark for current policy also apply, and perhaps with even greater force, to its use as a framework for interpreting monetary history. Unobservable but essential inputs to the Taylor rule such as the equilibrium real interest rate and the NAIRU fluctuate over time. Data get revised, and with these revisions the amplitudes—and sometimes the signs—of business cycle indicators appear much different with hindsight than they did to contemporaries. Taylor's paper exhibits the appreciation and awareness of these issues that I would expect of him, and subsequent authors that pursue this approach would do well to emulate him.

As applied to U.S. monetary policy since 1960, I believe Taylor's interpretations are largely correct. In fact, my paper with Jordi Galí and Mark Gertler (1998a) makes very similar points using an estimated version of what we call a "forward-looking" Taylor rule. A forward-looking Taylor rule estimated over the post-1979 period—with $h = 1.96$ and $g = 0.07$—captures all the major swings in the funds rate. When we backcast the post-1979 rule on the pre-1979 data, we also infer—as does Taylor—that policy was "too easy" between 1965 and 1979. Indeed, our parameter estimates for the 1960–79 period ($h = 0.80$ and $g = 0.52$) confirm Taylor's interpretation that the source of the 1965–79 policy mistake was that the Fed, when faced with an increase in inflation, raised the funds rate, *but by less than the rise in inflation so that a rise in inflation was countered by a fall in the real interest rate.* This finding is perfectly consistent with, indeed it can be viewed as the explanation for, Mishkin's (1981) famous empirical result that during the 1970s the ex ante real interest rate varied inversely with inflation.

Why is it that before 1979, the Fed appears to have followed a policy that, with hindsight, was clearly inferior to the policy it has followed since? According to Clarida et al.:

> Another way to look at the issue is to ask why it is that the Fed maintained persistently low short term real rates in the face of high or rising inflation. One possibility, emphasized by DeLong (1997), is that the Fed thought the natural rate of unemployment at this time was much lower [and potential output higher] than it really was. . . . Another . . . possibility is that, at the time, neither the Fed nor the economics profession understood the dynamics of inflation very well. Indeed, it was not until the mid-to-late 1970s that . . . textbooks began emphasizing the absence of a long run trade-off between inflation and output. The idea that expectations may matter in generating inflation and that credibility is important in policy-making were simply not well established during that era. What all this suggests is that in understanding historical economic behavior, it is important to take into account the state of policy-maker's knowledge of the economy and how it may have evolved over time. Analyzing policy-making from this perspective, we think, would be a highly useful undertaking. (1998a, 24)

To this, I might add that I believe policymakers and the profession only began, in the late 1960s, to appreciate the distinction between movements in nominal and real interest rates.

As Taylor suggests in his paper, a systematic policy of raising the funds rate by less than inflation "would ultimately imply an unstable inflation rate." In Clarida et al. (1998a), we embed a forward-looking Taylor rule with $h < 1$ in a version of the sticky price models found in King and Wolman (1996), Woodford (1996), and McCallum and Nelson (chap. 1 of this volume). We find that for $h < 1$, there can be bursts of inflation and output fluctuations that result from self-fulfilling changes in expectations. These sunspot fluctuations may arise because under this rule individuals correctly anticipate that the Fed will accommodate a rise in expected inflation by letting real interest rates decline. These sunspot fluctuations do not arise when $h > 1$.

As Taylor mentions in his paper, in Clarida et al. (1998b), we introduce another way to use the Taylor rule baseline to interpret recent monetary history. Specifically, we interpret the collapse in September 1992 of the European Monetary System (EMS) by calculating for France, Italy, and Britain during the several years leading up to and several years following the collapse a stress indicator defined as

$$\text{stress}_{j,t} = r_{j,t} - r_{j,t}^{\text{fltr}}.$$

When $stress_{j,t}$ is positive, short-term interest rates in country j are higher than they would be if they were set according to a Taylor rule based on inflation and output in country j. Does this mean that monetary policy in country j is "too tight"? In this instance no, because with the dismantling of capital controls in the 1990s, these countries' decisions to fix their exchange rates meant they

King then noted that an output gap measured by the Hodrick-Prescott filter implied that the Federal Reserve had to react to output in the future. *Taylor* agreed but reminded him that already with revised data, as mentioned by Donald Kohn before, policy rules look very different than with actual data.

Martin Feldstein remarked that Taylor rightly stresses, and the diagrams in the paper nicely show, that the response coefficient on inflation has to be greater than one, so that when inflation increases, real rates rise. In the 1960s and 1970s, for the reasons given by De Long (1997), the focus was too much on nominal rates. Even though nominal rates were tightened, real rates were going down. However, what really matters are the real net rates as shown in the following equation:

$$R_N = (1 - \theta)i - \pi.$$

If the nominal rate, i, is raised one to one with inflation, π, the real net rate, R_N, falls by the marginal tax rate coefficient θ. If the real net rate should rise when inflation goes up, the derivative of i with respect to π has to be at least equal to $1/(1 - \theta)$. The coefficient θ is equal to 1/3, which means that in the policy rule, the coefficient on inflation should be greater than one. Of course, there are a lot of markets in which taxes do not matter or for some players the marginal tax rate is higher than that, so this makes not too much of a point about a value of exactly 1/3 for θ, but it makes a point that the coefficient on inflation should be greater than one and that 1.5 might not be a bad number at all.

Poole recalled that in the early 1970s, Friedman's natural rate hypothesis did not sweep the profession instantaneously. Year after year, prominent members of the profession came to the academic consultants' meetings reporting that this was a nice theoretical idea, but that in practice there was a long-run tradeoff between unemployment and inflation. The real rate of interest was not yet a variable in the Federal Reserve's macromodel, built in the mid-1960s, until its revision in 1968. The influence of fiscal policy on aggregate demand was vastly overestimated. The potential impact of tight money on housing and fiscal policy—all sorts of excuses were made to delay actions. It was not until 1975, the end of the Burns era, that the Federal Reserve finally decided that the long-run Phillips curve was indeed vertical. *Ben McCallum* noted that Taylor (1996) supports the point just made. A small piece of documentation is a long speech about inflation written by Arthur Burns and published by the Federal Reserve Bank of Richmond during the late 1970s. In that 20-page document, monetary policy is not mentioned in any shape or form.

McCallum liked Taylor's approach of running a policy rule through history and encouraged further research in this direction.

John Lipsky pointed out that market participants have paid increasing attention to the Taylor rule formulation as an indicator of the appropriateness of Fed policy. Its predictive power has been extremely impressive over the past few

years. Lipsky conjectured that the deregulation of financial markets and pervasive securitization is enhancing the linkage between the real economy, policy, and financial markets. Thus the impact of monetary policy has been boosted, underscoring the importance of research on potential policy rules like the Taylor rule.

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gave up autonomy over their national monetary policies. The EMS evolved into a system in which Germany set the level of interest rates for all member countries; any remaining fluctuations in country-specific interest differentials with Germany reflected the changing sentiments of speculators regarding the commitment of that country to the fixed exchange rate. How then do we interpret a positive reading of stress? It is a measure, in basis points, of the cost to country *j* of belonging to a fixed exchange rate system when monetary policy is not being set based on the macroeconomic conditions in country *j*.

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Discussion Summary

Laurence Ball asked Taylor for his conjecture on how much of the economy's better performance under Alan Greenspan than under Arthur Burns was attributable to optimal policy and how much to better luck in the sense of not experiencing the Vietnam War and two oil shocks. This could be addressed formally by decomposing output variance into the variance of shocks and variance caused by deviations from the optimal rule. *Taylor* replied that his view on this issue was influenced by De Long (1997), who indicates that the policy mistake, under this definition, began well before the oil shocks. A more responsive policy rule could have led to a bigger decline in output during the first oil shock, but it is quite likely that inflation would not have risen so much. Thus the economy would have gotten away with a much smaller disinflation in the early 1980s.

Ball then questioned the result that policy was too tight in 1983, whereas there was a rapid recovery going on during that time. *Taylor* responded that the policy mistake had already occurred at the beginning of 1982. While the general raising of interest rates by Volcker during 1979–81 was about right, the funds rate should have been lowered by a greater amount when the economy really sank. *Glenn Rudebusch* expressed doubts as to whether another measure of output gap rather than the one used in the paper would have shown such a deep recession for 1982. *Taylor* replied that the gap obtained with the Hodrick-Prescott filter looked similar to the one in Judd and Trehan (1995). *Martin Feldstein* mentioned that part of the reason for overtight interest rates at that point was that Volcker felt keeping up with the disinflation for much longer was politically unsustainable; hence, the disinflation had to occur in a shorter than optimal length of time. *Edward Gramlich* mentioned that Volcker shifted from the money to the funds standard during that period. This happened at least in part because there was a shift in money demand due to, for example, interest payments on demand deposits. *Donald Kohn* added that money growth was accelerating toward the end of 1982 and inflation expectations were persistently high, much higher than ex post realized inflation. *Frederic Mishkin* added that after a history of bad policy, Volcker wanted to be tough in order to gain credibility. *Ben McCallum* mentioned that the Federal Reserve was below its M1 target in 1981. *William Poole* stressed that the economy sank much more quickly than anybody anticipated in 1982. There was an enormous inventory runoff, and the unemployment rate shot up in literally two months.

Bob Hall noted that during the national bank era, prior to the creation of the Federal Reserve, the control of the price level was through the commodity definition of the dollar. Federal involvement in the portfolio sense of controlling the quantity of money was only indirect, through the national bank notes. Hall expressed concern about the fact that the paper repeats what he sees as the mistake of Friedman and Schwartz in trying to understand the commodity standard as if it were a portfolio-based monetary standard. *Taylor* replied that the gold standard kept the price level stable during that period through the pressure of purchasing power parity, similar to the early time in Bretton Woods.

Michael Woodford remarked that the coefficient on inflation for the nineteenth-century period was even lower than in the 1970s. The Gibson paradox suggests that under the gold standard, interest rates seem to be related to the price level rather than the inflation rate. Even if interest rates rise with the price level but are not associated with the inflation rate, the real rate does not need to fall since the inflation rate and even the price level were mean reverting during that period.

Robert King wondered about the determination of the trend in inflation with an interest rate rule. Under the monetarist, Friedman and Schwartz interpretation the trend in money growth determines the trend in inflation. *Taylor* suggested thinking about the policy rule as an inverted money demand equation. An inflation coefficient greater than one will generate a stable inflation rate. If inflation rises, real interest rates rise in the same way as with a money-based rule. Therefore, this is not inconsistent with the money-based view on the determination of the inflation rate.