# Taylor Rules

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**Abstract**

Taylor rules are simple monetary policy rules that prescribe how a central bank should adjust its interest rate policy instrument in a systematic manner in response to developments in inflation and macroeconomic activity. This paper reviews the development and characteristics of Taylor rules in relation to alternative monetary policy guides and discusses their role for positive and normative monetary policy analysis.

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# 1 Introduction

Taylor rules are simple monetary policy rules that prescribe how a central bank should adjust its interest rate policy instrument in a systematic manner in response to developments in inflation and macroeconomic activity. They provide a useful framework for the analysis of historical policy and for the econometric evaluation of specific alternative strategies that a central bank can use as the basis for its interest rate decisions.

A perennial question in monetary economics has been how the monetary authority should formulate and implement its policy decisions so as to best foster ultimate policy objectives such as price stability and full employment over time. It is widely accepted that well designed monetary policy can counteract macroeconomic disturbances and dampen cyclical fluctuations in prices and employment, thereby improving overall economic stability and welfare. In principle, when economic growth unexpectedly weakens below the economy's potential, accommodative monetary policy can stimulate aggregate demand and restore full employment. Likewise, when inflationary pressures develop, monetary restriction can restore the central bank's price stability objective. In practice, however, given the limited knowledge that economists have about the macroeconomy—for example, about macroeconomic dynamics, about the monetary transmission mechanism, and even about the measurement of fundamental concepts such as the natural rates of output, employment and interest—there is substantial disagreement about the scope of stabilization policy and about policy design.

One approach is to decide upon what seems to be the best policy on a period-by-period basis, without appeal to any specific policy guide. A seeming advantage of this approach is that it gives policymakers the discretion to use their judgment period by period. However, a basic tenet of modern research is that systematic policy—that is, policy based on a contingency plan or policy rule—has important advantages over a purely discretionary policy approach. By committing to follow a rule, policymakers can avoid the inefficiency associated with the time-inconsistency problem that arises when policy is formulated in a discretionary manner. Following a rule allows policymakers to communicate and explain their policy actions more effectively. Policy based on a well-understood rule enhances the accountability of the central bank and improves the credibility of future policy actions. Also, by making future policy decisions more predictable, rule-based policy facilitates forecasting by financial market participants, businesses, and households, thereby reducing uncertainty.

Various proposals for monetary policy rules have been made over time, and a vast literature continues to examine the relative advantages and drawbacks of alternatives in abstract theoretical terms, in the context of empirical macroeconometric models, and in terms of the practical experience accumulated from past policy practice. To appreciate the appeal and limitations of Taylor rules, it is useful to relate their development to other proposals for systematic monetary policy.

## 2 Development of Monetary Policy Rules

Some proposals suggest postulating a rule in terms of the main objectives of monetary policy, for example "maintain economic stability" or "maintain a constant aggregate price level." (See Simons, 1936, for early arguments favoring price-level targeting over discretionary policy.) One important practical difficulty with these proposals, however, is that the concepts involved are not under the control of the central bank and thus the proposals are not operational. In essence, these proposals fail to draw a clear distinction between the objectives of monetary policy and the policy instruments that are at least under the approximate control of the central bank. As a result, the suggested rules are only implicit in nature and are difficult to monitor and to distinguish from discretionary policy in a meaningful manner.

To be useful in practice, policy rules must be simple and transparent to communicate, implement, and verify. This requires a clear choice of what should serve as the policy instrument—for example the money supply, $m$, or the short-term interest rate, $i$—and clear guidance as to how any other information necessary to implement the rule—for instance, recent readings or forecasts of inflation and economy activity—should be used to adjust the policy instrument.

Perhaps the simplest example of a policy rule is the proposal that the central bank maintain a constant rate of growth of the money supply—Milton Friedman's k-percent rule (Friedman, 1960). The rule draws on the equation of exchange expressed in growth rates:

$$\Delta m + \Delta v = \pi + \Delta q \tag{1}$$

where $\pi \equiv \Delta p$ is the rate of inflation and $p$, $m$, $v$, and $q$ are (the logarithms of), respectively, the price level, money stock, money velocity and real output. Selecting the constant growth of money, $k$, to correspond to the sum of a desired inflation target, $\pi^*$, and the economy's potential growth rate, $\Delta q^*$, and adjusting for any secular trend in the velocity of money, $\Delta v^*$, suggests a simple rule that can achieve, on average, the desired inflation target, $\pi^*$:

$$\Delta m = \pi^* + \Delta q^* - \Delta v^*. \tag{2}$$

Further, if the velocity of money were fairly stable this simple rule would also yield a high degree of economic stability. An early illustration of this rule appeared in 1935 in the work of Carl Snyder, a statistician at the Federal Reserve Bank of New York. After estimating that the normal rate of growth of trade in the United States was about 4 percent per year at the time and observing that the velocity of money was stable, Snyder argued that "the highest attainable degree of general industrial and economic stability will be gained by an expansion of currency and credit ... at this rate [4 percent]" (Snyder, 1935, p. 198). During the 1960s and early 1970s, Milton Friedman's recommendation that the Federal Reserve control the rate of money growth to equal 4 percent per year was similarly based on the assumption that potential output growth in the Unites States roughly equaled 4 percent—the prevailing estimate at that time.

Another way to interpret this policy rule is in terms of the growth of nominal income, $\Delta x = \pi + \Delta q$. With the economy's natural growth of nominal income defined as the sum of the natural growth rate of output and the central bank's inflation objective, $\Delta x^* = \pi^* + \Delta q^*$, a rule for constant money growth can be seen as targeting this natural growth rate. An advantage of a constant money growth rule is that very little information is required to implement it. If velocity does not exhibit a secular trend, the only required element for calibrating the rule is the economy's natural growth of output. In addition, while the calibration of this rule does not rest on the specification of any particular model, the rule is remarkably stable across alternative models of the economy. In this sense, the policy of maintaining a constant growth rate of money is arguably the ultimate example of a rule that is robust to possible model misspecification.

Simple modifications allowing for some automatic response of money growth to economic developments have also been proposed as simple rules that could deliver improved macroeconomic performance. (See, e.g. Cooper and Fischer, 1972). Among the simplest such alternatives is the rule associated with Bennett McCallum(1988, 1993):

$$\Delta m = \Delta x^* - \Delta v^* - \phi_{\Delta x}(\Delta x - \Delta x^*). \tag{3}$$

McCallum showed that if a rule such as this (for example with $\phi_{\Delta x} = 0.5$) had been followed, the performance of the U.S. economy likely would have been considerably better than actual performance, especially during the 1930s and 1970s—the two periods of the worst monetary policy mistakes in the history of the Federal Reserve.

A factor that complicates the use of the money stock as a policy instrument is the potential for instability in the demand for money either due to temporary disturbances or due to persistent changes resulting from financial innovation. In part for this reason, central banks generally prefer to adjust monetary policy using an interest rate instrument.

A policy rule quite as simple as Friedman's k-percent rule cannot be formulated with an interest rate instrument. As early as Wicksell's (1898) monumental treatise on *Interest and Prices*, it was recognized that attempting to peg the short-term nominal interest rate at a fixed value does not constitute a stable policy rule. (Indeed, this was one reason why Friedman, 1968, and others expressed a preference for rules with money as the policy instrument.) Wicksell argued that the central bank should aim to maintain price stability, which in theory could be achieved if the interest rate were always equal to the economy's natural rate of interest, $r^*$. Recognizing that the natural rate of interest is merely an abstract, unobservable concept, however, he noted: "This does not mean that the bank ought actually to *ascertain* the natural rate before fixing their own rates of interest. That would, of course, be impracticable, and would also be quite unnecessary." Rather, Wicksell pointed out that a simple policy rule that responded systematically to prices would be sufficient to achieve satisfactory, though imperfect, stability: "If prices rise, the rate of interest is to be raised; and if prices fall, the rate of interest is to be lowered; and the rate of interest is henceforth to be maintained at its new level until a further movement in prices calls for a further change in one direction or the other." (Wicksell, 1898 [1936], p. 189, emphasis in the original). In algebraic terms, Wicksell proposed what is arguably the simplest reactive monetary rule with an interest rate instrument:

$$\Delta i = \theta \pi. \tag{4}$$

Wicksell's simple interest rate rule did not attract much attention in policy discussions, perhaps because of its exclusive focus on price stability and lack of explicit reference to developments in real economic activity.

## 3 The Classic Taylor Rule and its Generalizations

The policy rules that are commonly referred to as Taylor rules are simple reactive rules that adjust the interest rate policy instrument in response to developments in both inflation and economic activity. An important advance in the development of these rules can be identified with the policy regime evaluation project reported in a volume published by the Brookings Institution (Bryant, Hooper and Mann, 1993). The objective of the project was to identify simple reactive interest rate rules that would deliver satisfactory economic performance for price stability and economic stability across a range of competing estimated models. The Brookings project examined rules that set deviations of the short-term nominal interest rate, $i$, from some baseline path, $i^*$, in proportion to deviations of target variables $z$, from their targets, $z^*$:

$$i - i^* = \theta(z - z^*). \tag{5}$$

The collective findings pointed to two alternatives as the most promising in delivering satisfactory economic performance across models. One targeted nominal income, while the other targeted inflation and real output:

$$i - i^* = \theta_\pi(\pi - \pi^*) + \theta_q(q - q^*) \tag{6}$$

The potential usefulness of this particular rule as a benchmark for setting monetary policy was further highlighted in the celebrated contribution by John B. Taylor (1993) at the Fall 1992 Carnegie-Rochester Conference on Public Policy. Taylor developed a "hypothetical but representative policy rule" (p. 214) by using the sum of the equilibrium or natural rate of interest, $r^*$, and inflation, $\pi$, for $i^*$ and setting the inflation target and equilibrium real interest equal to two and the response parameters to one half. The result was what became known as the classic Taylor rule:

$$i = 2 + \pi + \frac{1}{2}(\pi - 2) + \frac{1}{2}(q - q^*). \tag{7}$$

Taylor noted that if one used the deviation of real quarterly output from a linear trend to measure the output gap, $(q - q^*)$, and the year-over-year rate of change of the output deflator to measure inflation, $\pi$, this parameterization appeared to describe Federal Reserve behavior well in the late 1980s and early 1990s.

The confluence of the econometric evaluation evidence supporting the stabilization properties of this rule and its usefulness for understanding historical monetary policy in a period generally accepted as having good policy performance generated tremendous interest, and numerous central banks began to monitor this policy rule or related variants to provide guidance in policy decisions. These developments also greatly influenced monetary policy research and teaching. By linking interest rate decisions directly to inflation and economic activity, Taylor rules offered a convenient tool for studying monetary policy while abstracting from a detailed analysis of the demand and supply of money. This allowed the development of simpler models (see the survey in Clarida, Gali, and Gertler, 1999 and papers in Taylor, 1999) and the replacement of the "LM curve" with a Taylor rule in treatments of the Hicksian IS-LM apparatus. (It should be noted, however, that this abstraction is overly simplistic when the short-term interest rate approaches zero. At the zero bound, the stance of monetary policy can no longer be measured or communicated with a short-term interest rate instrument; see, for example, Orphanides and Wieland 2000). Subsequent research (see Orphanides, 2003b, for a survey) suggested that a generalized form of Taylor's classic rule could provide a useful common basis both for econometric policy evaluation across diverse families of models and for historical monetary policy analysis over a broad range of experience:

$$i = (1 - \theta_i)(r^* + \pi^*) + \theta_i i_{-1} + \theta_\pi(\pi - \pi^*) + \theta_q(q - q^*) + \theta_{\Delta q}(\Delta q - \Delta q^*) \qquad (8)$$

The generalized Taylor rule (8) nests rule (6) as a special case but introduces two additional elements. First, it allows for inertial behavior in setting interest rates, $\theta_i > 0$, which proves particularly important for policy analysis in models with strong expectational channels (Woodford, 2003). Second, it allows the policy response to developments in economic activity to take two forms: a response to the level of the output gap, $(q - q^*)$, or its difference, which can also be restated as a response to the difference between output growth and its potential, $(\Delta q - \Delta q^*)$. The generalized Taylor rule also nests another simplification of special interest, $\theta_i = 1$ and $\theta_q = 0$, which yields a family of difference rules similar to Wicksell's original proposal:

$$\Delta i = \theta_\pi(\pi - \pi^*) + \theta_{\Delta q}(\Delta q - \Delta q^*). \tag{9}$$

These difference rules are also of interest because, like money-growth rules, their implementation does not require estimates of the natural rate of interest or the level of potential output (and the output gap) but only of the growth rate of potential output. Indeed, these rules may be viewed as a reformulation of money-growth rules in terms of an interest rate instrument. To see the relationship of (9) to money growth targeting note that by substituting the money growth in rule (3) into the equation of exchange, that rule can be stated in terms of the velocity of money:

$$\Delta v - \Delta v^* = (1 + \phi_{\Delta x})(\Delta x - \Delta x^*). \tag{10}$$

To reformulate this strategy in terms of an interest rate rule, consider the simplest formulation of money demand as a (log-) linear relationship between velocity deviations from its equilibrium and the rate of interest. In difference form this is

$$\Delta v - \Delta v^* = a\Delta i + e, \tag{11}$$

where $a > 0$ and $e$ summarizes short-run money demand dynamics and temporary velocity disturbances. An interest-rate-based strategy that avoids the short-run velocity fluctuations, $e$, may be obtained by substituting the remaining part of (11) into (10). This yields

$$\Delta i = \theta((\pi - \pi^*) + (\Delta q - \Delta q^*)) \tag{12}$$

for some $\theta > 0$, which, as can be readily seen, has the same form as rule (9).

In light of this flexibility in nesting a wide range of alternative monetary policy strategies and the relative simplicity of the form (8), Taylor rules have been used to discuss a variety of policy regimes, from money growth targeting (see, e.g., Clarida and Gertler, 1997) to inflation targeting (see, e.g. Orphanides and Williams, 2007).

# 4 Operational Implementation

A crucial element for the design and operational implementation of a Taylor rule is the detailed description of its inputs. This requires specificity regarding the measures of inflation and economic activity that the policy rule should respond to, whether forecasts or recent outcomes of these variables are to be employed, and the source of these data or forecasts. In addition, the source of information and updating procedures regarding the unobservable concepts required for implementing the rule must be stipulated. Specificity in these dimensions is essential for practical analysis because there is often a multitude of competing alternatives and a lack of consensus about the appropriate concepts and sources of information that ought to be used for policy analysis. This situation is particularly vexing in regard to the treatment of unobservable concepts, such as the output gap. Unfortunately, econometric policy evaluation exercises suggest that inferences regarding the performance of a particular Taylor rule often depend sensitively on assumptions regarding the availability and reliability of these inputs. Differences in underlying assumptions complicate comparisons across studies and often explain differences in reported findings.

An illustrative example of this sensitivity relates to improper treatment of information regarding the current state of the economy. A common pitfall in theoretical policy evaluation exercises is to assume that the current state of the economy, e.g. the current output gap, can be perfectly observed. Under this assumption, a Taylor rule with a vigorous response to the output gap is often recommended as "optimal" in model-based policy evaluations. However, naive adoption of such recommendations would be counterproductive. Available real-time estimates of the output gap are imperfect, and historical experience suggests that the mismeasurement is often substantial. Under these circumstances, better stabilization outcomes would result if policy did not respond to the output gap at all or if it responded to output growth instead (Orphanides, 2003a). If the natural rate of interest is also unknown and its real-time estimates are subject to significant mismeasurement, the difference variant of the Taylor rule, (9), proves considerably more robust than the Brookings variant, (6), reversing the ranking of the two alternatives that is implied under perfect knowledge (Orphanides and Williams, 2002).

Another example of such sensitivity relates to the use of forecasts in the Taylor rule. Because of lags in the monetary policy transmission mechanism, preemptive policy reaction is generally recommended, especially with respect to inflation. But inferences regarding the performance of forecast-based policy are sensitive to the quality of the forecasts. In some models, Taylor rules responding to several-quarters-ahead forecasts of inflation appear more promising for stabilization than rules focusing only on near-term conditions. However, this conclusion is not robust and is overturned once the potential unreliability of longer-term forecasts due to model misspecification is factored into the analysis (Levin, Wieland, and Williams, 2003).

As already noted, Taylor rules have proven valuable for historical policy analysis. Following Taylor (1993), numerous authors have examined historical monetary policy in the United States using either calibrated or estimated versions of Taylor rules (8). Studying the characteristics of policy in periods associated with good or bad economic performance helps identify aspects of policy that may be associated with such differences in performance. A complicating factor is the need for real-time data and forecasts for proper inference (Orphanides, 2001). The pitfall of using ex post revised data and retrospective estimates of unobserved concepts in estimating Taylor rules is not uncommon. However, interpretations of historical policy based on information that was unavailable to policymakers when policy decisions were made is of questionable value. Policy prescriptions from a fixed rule are distorted as the inputs to the rule are revised from those originally available to policymakers, and therefore counterfactual comparisons of alternative policy rules can be misleading when they are based on revised data.

## 5 Concluding Remarks

Despite these challenges, some useful elements of policy design emerge from historical analysis of Taylor rules. First, and arguably most important, good stabilization performance is associated with a strong reaction to inflation. Second, good performance is associated with policy rules that exhibit considerable inertia. Third, a strong reaction to mismeasured output gaps has historically proven counterproductive. Fourth, successful policy could still usefully incorporate information from real economic activity by focusing on the growth rate of the economy. To be sure, such broad principles provide insufficient guidance for identifying the precise policy rule that might be ideal in a specific context. But this is not the objective of policy design with Taylor rules. Rather, the goal is the identification of simple guides that are robust to misspecification and other sources of error experienced over history.

In summary, Taylor rules offer a simple and transparent framework with which to organize the discussion of systematic monetary policy. Their adoption as a tool for policy discussions has facilitated a welcome convergence between monetary policy practice and monetary policy research and proved an important advance for both positive and normative analysis.

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