Real-time Taylor rules and the federal funds futures market

Charles L. Evans

Introduction and summary

The Federal Reserve Act (as amended by the Full Employment and Balanced Growth Act of 1978) specifies that the Board of Governors of the Federal Reserve System and the Federal Open Market Committee should seek to "promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates" (Board of Governors of the Federal Reserve System, 1994). Maximum employment facilitates the creation of national income and wealth. Low and predictable rates of inflation help ensure that financial resources are allocated efficiently to their most productive uses. When long-term interest rates are moderate, the interests of borrowers and savers are balanced to produce sustained high rates of capital accumulation. With these broad objectives in mind, the Federal Open Market Committee (FOMC) assesses the state of the U.S. economy and charts a course for monetary policy.

How are these monetary objectives translated into month-to-month monetary policy decisions? Perhaps the most accurate answer to this question is contained in the minutes of the FOMC meetings, the Federal Reserve Chairman's semi-annual testimony to Congress as mandated by the Humphrey–Hawkins Act, and numerous speeches by members of the FOMC on an almost daily basis. The sheer volume of this material is somewhat daunting, and a more casual observer of economic events would almost surely appreciate a simpler answer to this question.

This article explores two recent developments in attempts to describe by simple means the response of monetary policy to changing economic events. The first development is the introduction in 1988 of a futures market for the federal funds rate. Since 1982, the primary instrument of monetary policy has been the federal funds rate, either directly or indirectly.[1] The futures market data provides a market expectation for the future course of the fed funds rate. In principle, the market participants have digested a large volume of material related to the FOMC's expected future actions, so the futures rate reflects this information. Of course, moving the question from the FOMC's deliberations to the futures market's inference about FOMC actions is simply trading one black box explanation for another.

The second development, however, holds potential for looking into this black box. In 1993, John Taylor suggested a simple formula that he believes describes how the Federal Open Market Committee has set the federal funds rate since 1987.[2] This formula has been dubbed the *Taylor rule*, and its predictions matched the 1987–92 path of the federal funds rate rather well. The Taylor rule states that 1) the federal funds rate should be increased/decreased whenever real gross domestic product (GDP) is above/below its trend level, and inflation has been above/below its desired level; and 2) that equal weight should be given to output and inflation gaps. Taylor finds that his rule's predictions are quite accurate. Consequently, the Taylor rule approximately answers the question posed earlier about month-to-month monetary policy decisions. Further confirmation would follow if the Taylor rule predictions roughly matched the predictions of the federal funds futures market.

An important caveat, however, has been raised by Orphanides's (1997) analysis of the Taylor rule in practice. Taylor used final, revised data that were not available to the FOMC at the time it set the federal funds rate. Orphanides uses the actual data and forecasts from the FOMC's staff forecasts to construct real-time predictions according to the Taylor rule; the results are not as satisfactory as Taylor's findings.

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In comparing the Taylor rule predictions with the futures market implications, it is important to use real-time data since market participants made decisions with the real-time data, not the final, revised data.[3]

Orphanides's analysis of the Taylor rule with real-time data uses only data through 1992. The fact that official Fed staff forecasts are only released with a five-year delay limits his data availability. In my analysis, I modify Taylor's rule so that it can be analyzed through 1997 using data on the unemployment rate and the Consumer Price Index (CPI).[4] It turns out that these data are real-time data. Specifically, while real GDP and the GDP deflator are revised regularly, the unemployment rate and the CPI do not get revised. Of course, additional assumptions must be made in order to make the unemployment/CPI Taylor rule comparable to Taylor's original rule. These assumptions are spelled out below.

The empirical evidence comparing the modified, real-time Taylor rules with the futures market data is mixed. The futures contract data do better than the unemployment/CPI Taylor rules considered here. From 1989–97, the standard deviation of the three-month-ahead futures forecast error is 28 basis points. The Taylor rule forecasts considered in this article have standard deviations that range from 100 basis points to a low of 42 basis points. The unemployment/CPI Taylor rules do not account for the large increases in the funds rate in 1989 and the relatively low funds rates in 1993–94. The futures market participants performed substantially better during these periods.[5] Nevertheless, although the best Taylor rule forecast has a standard deviation 50 percent higher than the futures data, the overall fit appears good enough to justify its use as a *rough description* of monetary policy actions for the purposes of evaluating alternative econometric models of the monetary policy transmission mechanism.

Fed funds futures as forecasts of future monetary policy shifts

Since the federal funds rate has been the primary instrument of monetary policy since 1982, I use the federal funds futures data to produce a market expectation for the future path of the federal funds rate. This futures market allows market participants to hedge their exposure to a certain type of interest rate risk. For example, consider a bank that anticipates the need to borrow $100 million in the interbank market for a number of weeks. Suppose the current federal funds rate is 4 percent and the bank is concerned that the rate may increase to 5 percent during this period. If the bank is fairly certain about the likelihood of this higher funds rate path, it may be willing to lock in a 4.5 percent interest rate over the next month. If other providers of federal funds expect the funds rate to remain unchanged at 4 percent, they may be willing to guarantee a future interest rate of 4.5 percent over the next month. Consequently, there is an opportunity to pool these interest rate risks by using the futures market. Krueger and Kuttner (1996) found that the federal funds futures market is efficient: that is, the futures data provide predictions on the future path of the federal funds rate that cannot be improved upon by considering other financial or macroeconomic data available to market participants at the time.[6]

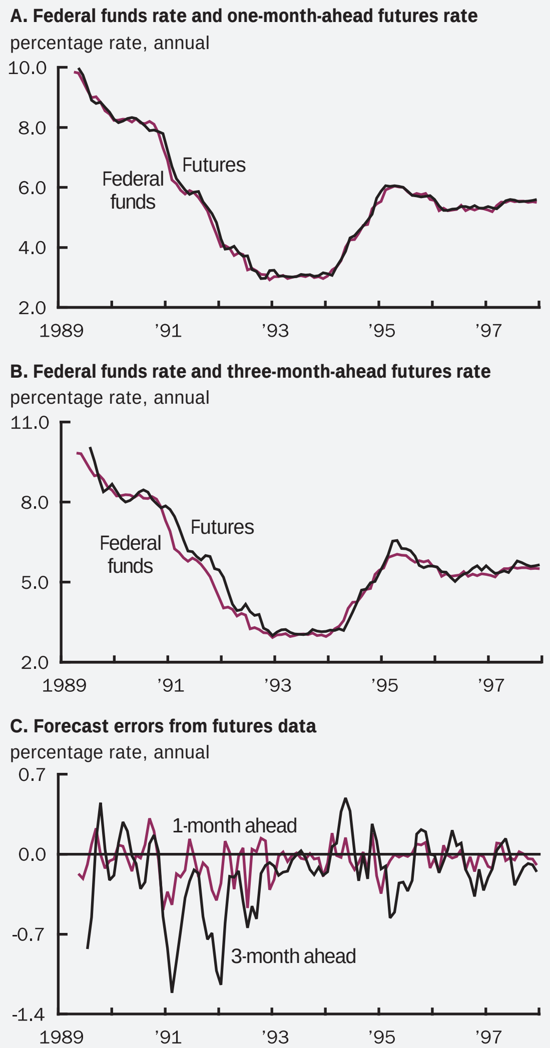
Figure 1 displays the federal funds rate forecast implied by the one-month-ahead and three-month-ahead futures contracts, as well as the actual funds rate. On the whole, the futures data track the funds rate fairly well. However, movements in the actual funds rate often precede the expected movement from the futures rate data. For example, in October 1990, the funds rate was 7.75 percent and in June 1991 it was 5.75 percent. Both the one-month and three-month futures contracts were surprised by this rapid reduction in the funds rate. For each contract, the futures data implied a greater likelihood that the current funds rate (at that time) would be maintained. As the funds rate was reduced during this period, the futures market gradually ratcheted down its own expectation.

Panel C displays the actual forecast error: that is, the difference between the futures rate forecast of the federal funds rate and the actual funds rate. Three observations are noteworthy. First, the forecast errors are larger for the three-month-ahead contract. This is not surprising. Movements in the funds rate are extremely persistent, with the funds rate not changing for long periods of time. Consequently, when economic developments change sufficiently to warrant a movement in the funds rate, the longer forecast horizon implies more uncertainty about how interest rates will move. Second, there are typically large prediction errors around the time that the funds rate path changes its tilt; examples of these large errors occur in late 1990, late 1992, early 1994, and early 1995. A closely related point is that negative forecast errors tend to be associated with a declining federal funds path, and positive errors with a rising federal funds path. Finally, from 1989 through 1997, the standard deviation of the forecast errors was 14 basis points and 32 basis points for the one-month and three-month-ahead contracts, respectively.

Since the federal funds futures market is efficient, market participants are using all available and useful information in forecasting the future path of

FIGURE 1

Futures forecasts of the federal funds rate



Notes: The daily futures rates are averaged over the month to construct the monthly data observations. The one-month-ahead futures rate for January 1990 is the implied federal funds rate composed from the December one-month-ahead futures contract data. Similarly, the three-month-ahead futures rate for January 1990 is computed from October 1989 data.

Source: Board of Governors of the Federal Reserve System and the Chicago Board of Trade.

the federal funds rate. As Rudebusch (1997) has pointed out, these market forecasts are completely flexible in their ability to incorporate new information, unlike more rigid highly parameterized and stylized statistical models. Consequently, to the extent that the futures market is efficient, the standard deviation of 32 basis points for the three-month-ahead forecast error can be thought of as a lower limit on the ability of statistical models to forecast future changes in the federal funds rate for the next quarter.

Taylor's rule for monetary policy

In an influential article, Taylor (1993) summarized recent evidence on how industrialized economies were likely to perform when the monetary authority followed simple rules in setting short-term interest rates. In econometric simulations, the variability of real GDP growth and inflation was relatively low when a monetary authority increased short-term nominal interest rates in response to strong GDP growth or rising inflation. Taylor then asked, could the behavior of the Federal Open Market Committee during Alan Greenspan's tenure as chairman be described in terms of a simple rule? Interestingly, Taylor's answer was *yes*.

Taylor specified the following rule for the setting of the federal funds:

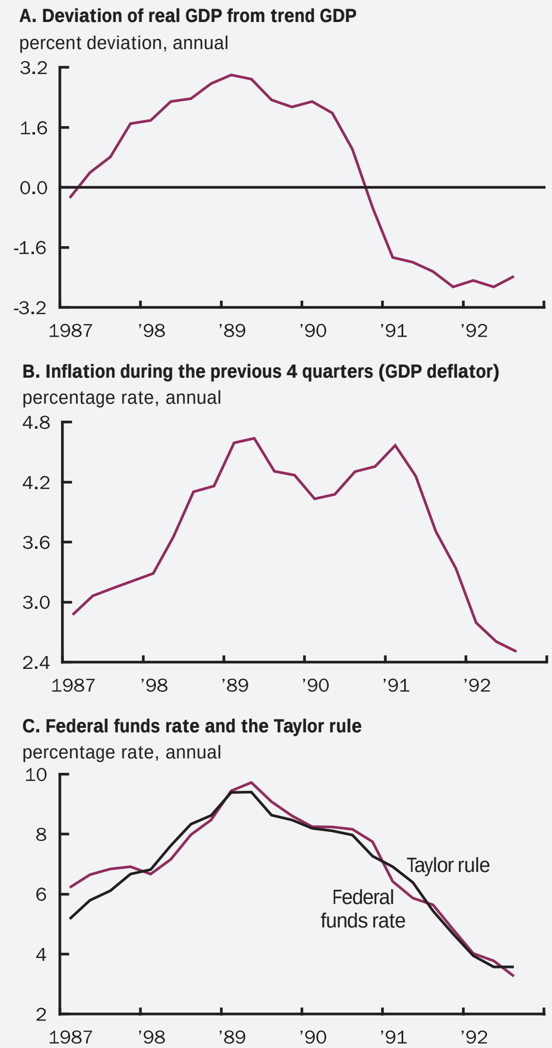
$$1)\quad FF_t = r_t + \pi_t + \frac{1}{2}(y_t - y_t^*) + \frac{1}{2}(\pi_t - \pi^*),$$

where FF is the federal funds rate, r is the real interest rate, π is the average inflation rate over the prior four quarters, π^* is the target inflation rate, y is real GDP, and y^* is trend real GDP. This policy rule instructs the monetary authority to raise the federal funds rate by one-half of the output gap $(y_t - y_t^*)$ and one-half of the inflation gap $(\pi_t - \pi^*)$.

Taylor's discussion indicates that the numerical parameters were selected primarily for illustrative purposes. The real interest rate and inflation target are both assumed to be 2 percent, and the weights on output and inflation are each ½. However, as figure 2 indicates, the implied path for the federal funds rate during the Greenspan era (at the time of Taylor's writing in 1992 and early 1993) matched the actual path quite well.[7] Reconstructing Taylor's analysis is difficult since the data he used have been revised substantially. Nevertheless, the data in figure 2 are from *National Income and Product Account* releases around the time of Taylor's 1992–93 analysis. Panel A displays the deviation of real GDP from Taylor's trend path estimated over the time period 1984–92. Panel B is the four-quarter average growth rate of the implicit GDP deflator. Panel C displays the implied path for the federal funds rate versus the actual funds rate. The Taylor rule picks out the general rise in the interest rate from 1987 through early 1989 and then the reversal through 1992. It is particularly interesting that the Taylor rule includes no references to the past history of the federal funds rate. This path of the funds rate emerges solely from macroeconomic fundamental variables, not simply the past history of the federal funds rate.[8]

FIGURE 2

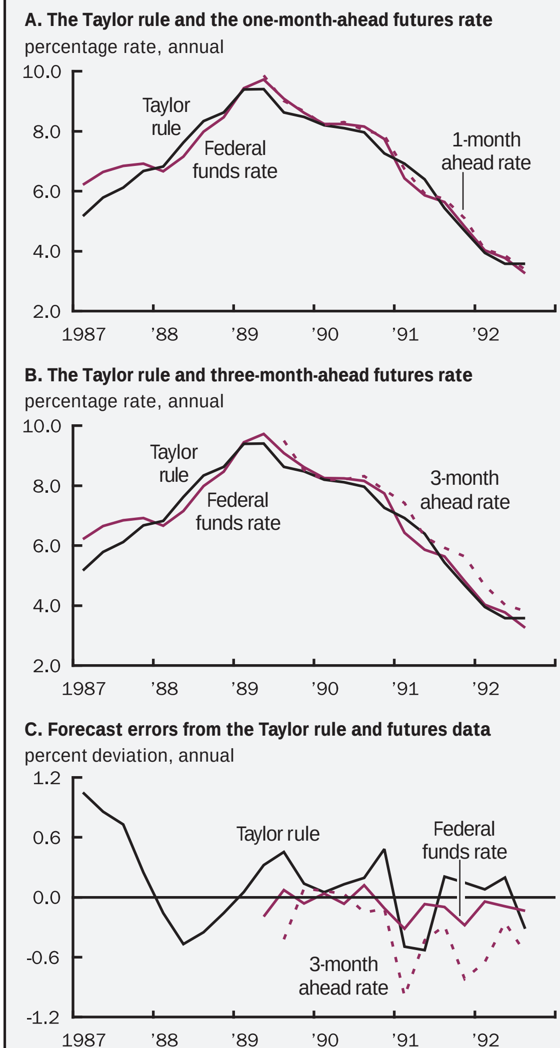
The Taylor rule and its components



Source: Author's calculations based upon data from the U.S. Department of Commerce, Bureau of Economic Analysis, *National Income and Product Accounts*, release, October 1993.

FIGURE 3

The Taylor rule and the futures market



Notes: The daily futures rates are averaged over the month to construct the monthly data observations. The one-month-ahead futures rate for January 1990 is the implied federal funds rate composed from the December one-month-ahead futures contract data. Similarly, the three-month-ahead futures rate for January 1990 is computed from October 1989 data.

Figure 3 displays the differences between the actual federal funds rate and the implied funds rates from my recreation of the original Taylor rule, the one-month and three-month-ahead futures rate data.[9] The Taylor errors cover his original sample period of 1987–92, while the futures errors begin in 1989, soon after the futures market began. Over the common sample period of 1989:Q2 through 1992:Q3, the standard deviations of the Taylor and three-month-ahead futures errors were 31 basis points and 34 basis points, respectively. In other words, the Taylor rule did slightly better than the federal funds futures. The patterns indicate that both forecasts were surprised by the rapidness of the policy easing in early 1991. Other surprises tended to be more idiosyncratic. The Taylor rule overpredicted the funds rate in late 1990 when the futures market did not. The futures market was surprised by the rate reductions in late 1991 when the Taylor rule was not. On balance, for this small number of observations, these two simple methods of predicting monetary policy performed similarly.

At first glance, the excellent performance of the Taylor rule seems amazing. After all, this policy rule does not *peek* at the actual level of the funds rate at any time. Furthermore, the Taylor rule performed better than the futures market. Although the discrepancy is small, it is slightly surprising that the futures market forecast errors tended to be slightly larger over this small number of observations. However, the Taylor rule has at least one advantage over the futures market participants, and possibly two.[10]

First, the Taylor rule uses a measure of the output gap which is computed from a regression of the logarithm of real GDP on a linear trend over the sample period 1984–92. Simply put, this estimate uses information about future movements in real GDP which the futures market and other interested parties did not have. Second, the real GDP data which Taylor used in his study had been revised from the initial data releases that futures market participants and monetary policymakers had access to. It's unclear how or if this later data helps to better identify the policy decisions of the FOMC, but it is a source of difference between the Taylor rule and the information available to futures market participants at the time of the futures contracts. If we implement a Taylor rule but restrict the data inputs to information actually available, would we continue to see the excellent performance of the Taylor approach?

Simple policy rules and real-time data

Orphanides (1997) has investigated the robustness of Taylor's original fed funds projections from 1987 to 1992. Specifically, Orphanides points out that the FOMC and market participants did not have the final revised GDP and implicit GDP deflator data that Taylor used (as displayed in figure 2). Instead, Orphanides uses the actual GDP and deflator data that the Board of Governors' staff presented to the FOMC at the time of their meetings during this period.[11] To compute the output gap, he uses an estimate of potential output, constructed by Board staff, at the time of the meeting. In this way, there is no possibility that data unavailable to the FOMC are contaminating the projected path of the federal funds rate using the simple rule for monetary policy.

Orphanides finds a very different picture than the one contained in figure 2. The real-time data do imply a general increase in interest rates from 1987 through 1988 and then a decline into 1992. But the implied level of the federal funds rate in early 1987 is 200 basis points lower than Taylor's calculation; and often the discrepancy is as large as 100 basis points. There is also a period from mid-1989 through mid-1990 when the real-time data indicate a rising funds rate, but the actual funds rate was falling. As Orphanides discusses, the real-time data from 1987 through 1990 suggested smaller output and inflation gaps than Taylor's data; this implied substantially lower projections of the funds rate using the Taylor rule. This analysis implies that the federal funds futures market projections were in fact much more accurate than a real-time Taylor rule using real GDP and GDP deflator data. Orphanides' analysis highlights an important example in which data revisions play a potentially important role in the monetary policy review process.

There are two other examples from this period that emerge from the U.S. Bureau of Labor Statistics (BLS) employment report. The first example centers on the reduction in the federal funds rate from 3.25 percent to 3 percent on September 4, 1992. Unbeknownst to participants at the time, this was the *final* interest rate cut following the initial reduction from 9.75 percent in 1989. On September 4, the BLS released the August employment report. According to reports in the *New York Times* and *Wall Street Journal*, market analysts expected the August employment report to overstate true employment growth by 100,000 to 150,000 jobs.[12] The explanation involved a seasonal adjustment factor that did not accurately account for an unusual season of summer jobs programs in 1992. The initial data release at 8:30 a.m. EDT indicated *reductions* in total establishment payrolls of 83,000 jobs and 167,000 private jobs. These numbers were interpreted as *overestimates* of true employment changes.[13] At 9:00 a.m. EDT, the target federal funds rate was reduced by 25 basis points to 3 percent.

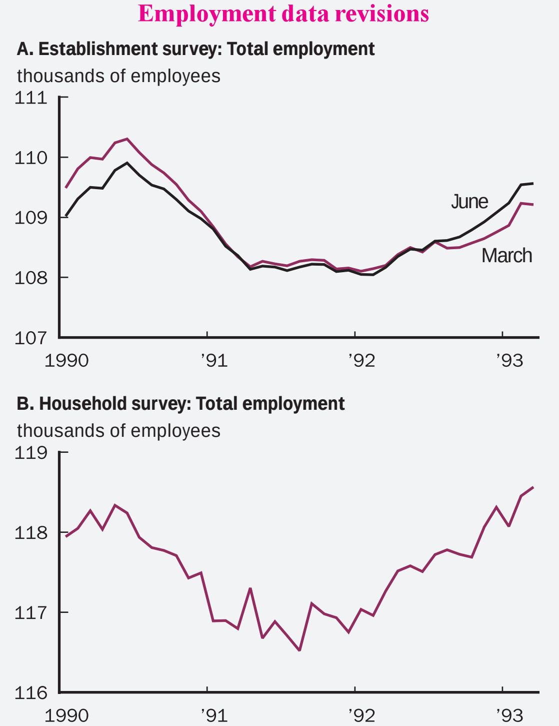
One interpretation of this policy move is that the *normal response* of monetary policy to a sharp, unexpected reduction in employment at this juncture was to ease monetary policy. In other words, analysts at the time probably did not interpret this as an exogenous monetary policy shock to the economy. By the time this article was prepared in 1998, however, the August 1992 employment data had been revised to reflect an *increase* in total establishment payrolls of 129,000 jobs. In other words, the data revisions suggest that the economy was growing more strongly than market analysts and the FOMC anticipated at the time of the 25 basis point cut in the federal funds rate on September 4, 1992. If the prior easing was thought to be a normal response to an employment reduction of 167,000 (less another 100,000), then it most likely looks now to be an exogenous policy easing relative to employment growth of 129,000. This example shows how data revisions can alter everyone's perspective on the state of the economy after the fact, and possibly even the rationale for a change in interest rates.

The second example can be found in the two years following the 1990–91 recession, when employment grew slowly. However, part of this perception has been altered by data revisions. During this period, a common benchmark comparison was to relate the current level of employment to the previous business cycle peak level of employment in July 1990. Panel A of figure 4 shows that as of March 1993, payroll employment had only closed 48 percent of the gap between the peak and trough levels of employment. In June 1993, the BLS announced its annual benchmark revisions. Panel A also displays the revised data as of June 1993. The revisions reduced the peak level of employment in 1990 and increased the growth in payrolls from June 1992 through 1993. Suddenly, with the data revisions, the March 1993 employment gap was 80 percent closed and completely closed with the June 1993 increase in employment.

Panel B of Figure 4 displays an alternative measure of employment, constructed from surveys of households which are used in constructing the unemployment rate. Month-to-month movements in these data are more variable than the corresponding payroll employment data. However, this measure of employment does not get revised. For the 1991–93 period, the household survey more quickly made apparent the fact that employment regained its prior business cycle peak by early 1993. Even though the month-to-month movements in the household survey measure of employment are quite volatile, longer horizon movements seem to provide useful corroborating information about the state of the economy. Consequently, the household survey of employment and the unemployment rate are plausible alternative sources of data on economic activity that are not subject to data revisions.

FIGURE 4

Employment data revisions



Source: U.S. Department of Labor, Bureau of Labor Statistics, "Employment report," March and June 1993 for establishment survey data and June 1993 for household survey data.

Taylor-type rule using unemployment and CPI data

The previous discussion has highlighted the difficulties that real-time data considerations pose for implementing monetary policy. Specifically, any policy that relies on data that are ultimately revised can yield conflicting policy recommendations over time. However, policy rules that are based on data that do not get revised will not suffer from this. Of course, this data must be sufficiently informative about the state of the economy to be used in place of real GDP and the implicit GDP deflator. Another way to compute a Taylor-type monetary policy rule is to use the unemployment rate and the CPI. Clearly these data are relevant to the setting of monetary policy: In their semi-annual report to Congress, the FOMC presents forecasts of the unemployment rate and the CPI inflation rate. These data do not get revised, except for their seasonal factors which presumably do not play a large role in the discussion. Since food and energy inflation rates tend to be more volatile and transitory than other components of the CPI, many business analysts and policymakers exclude food and energy from their CPI analyses as a better indicator of underlying inflationary pressures than the total CPI. Hereafter, this will be referred to as the core CPI.

Just as Taylor's rule required additional assumptions, implementing an unemployment/CPI Taylor rule requires additional judgment. Specifically, I consider the following rule:

$$2)\quad FF_t = r_t + \pi_t + \tfrac{1}{2}{}^{*}\, okun^{*}(u_t^{*} - u_t) + \tfrac{1}{2}{}^{*}(\pi_t - \pi_t^{*}),$$

where u_t is the unemployment rate, u_t^* is the natural rate of unemployment, and *okun* is a parameter that refers to Okun's law. As in equation 1, the target inflation rate and the real interest rate are each assumed to be 2 percent.[14] Two new conceptual issues are introduced in this formulation of a Taylor rule. First, the natural rate is that value of the unemployment rate, which if maintained, would forecast no change in the inflation rate. In Taylor's rule, the strength of economic activity is measured by the percentage points that real GDP is above its trend path. In the rule considered here, it is measured by the percentage points that the unemployment rate is *below* its natural rate of unemployment. Just as trend GDP is not observed or reported by a government agency, neither is the natural rate; some estimate is necessary. The time subscript allows for the possibility that the natural rate varies over time. The second new concept is Okun's law which describes the relationship between output gaps and unemployment gaps. In 1962, Arthur Okun observed that a 1 percent fall in the unemployment rate from its full employment level tended to produce a 3 percent increase in real GDP relative to trend. There is substantial uncertainty as to the precise value for Okun's law. For example, Hall and Taylor (1988) cite 3 percent as the value of Okun's law, while Mankiw (1994) uses 2 percent. In any event, for the remainder of this article, I will assume the Okun's law coefficient to be 3.

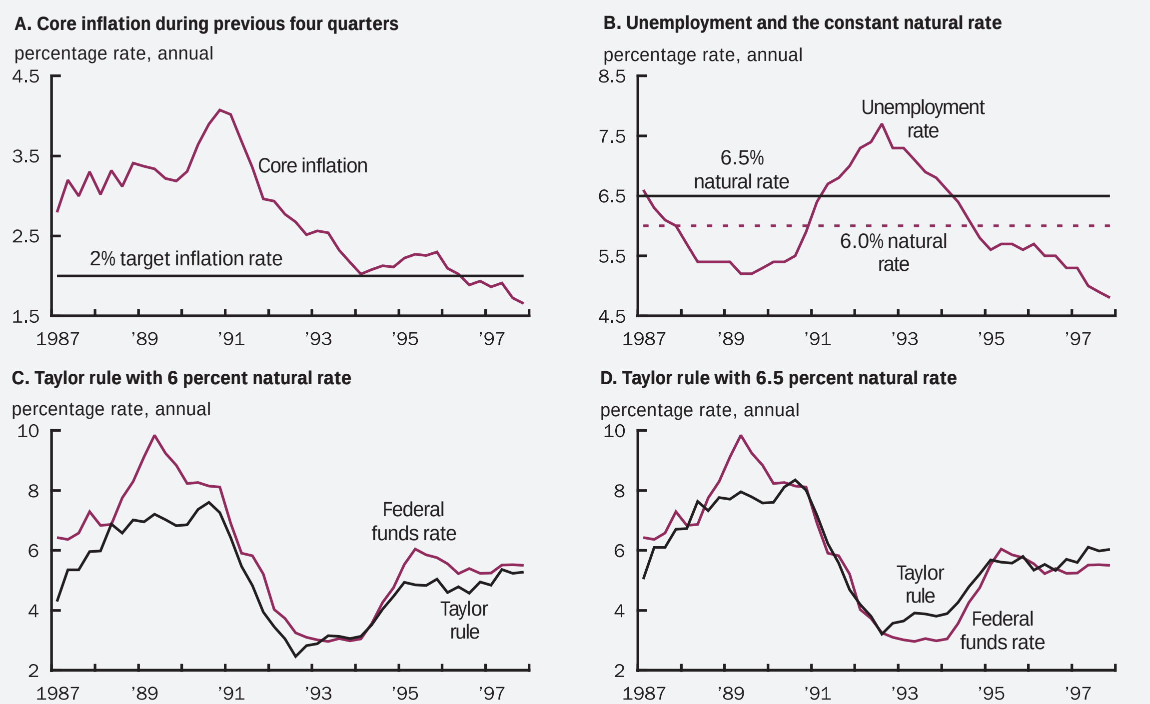
The most controversial aspect of this rule is the selection of the natural rate of unemployment. Until recently, many economists argued forcefully that the natural rate of unemployment was 6 percent (Gordon, 1997). However, in recent years, the unemployment rate has fallen below 6 percent and inflation has continued to fall. Possible inferences are 1) the theory is wrong and there is no relationship between unemployment and inflation; 2) the natural rate of unemployment varies over time and has fallen well below 6 percent currently; 3) the natural rate was always below 6 percent but economists' inference about its value has been wrong until lately; 4) the theory is right with 6 percent, but our measures of inflation do not properly reflect true inflationary pressures; or 5) something else is afoot. Next, I consider several alternatives.

Time-invariant natural rates

Figure 5 displays two implementations of the unemployment/CPI Taylor rule. The natural rate is assumed to be 6 percent in one case, and 6.5 percent in the other. There is some evidence that the natural rate was as high as 6.5 percent in 1987, which is when my analysis of the unemployment/CPI Taylor rule begins (Braun, 1990). Since both rules assume that the target inflation rate is 2 percent, the only differences come about due to the unemployment rate assumptions.

FIGURE 5

The Taylor rule with a time invariant natural rate



Assuming the natural rate to be 6.5 percent results in a higher projected path than when 6 percent is assumed. For example, the 6 percent rule implies that the unemployment rate was below the natural rate from late 1987 through late 1990 and thus contributed to a higher than otherwise funds rate. However, the 6.5 percent rule implied a still more contractionary policy setting during all of 1987 and into early 1991. Nevertheless, neither rule can account for the large run-up in the funds rate in 1989. Similarly, Orphanides's analysis of the Taylor rule with real-time GDP data could not account for the 1989 episode. Apparently the initial GDP releases and the unemployment data painted a similar picture of the economy. According to this analysis using real-time data, the 1989 funds rate was *surprisingly* high given the data at the time. Recalling that Taylor's original implementation largely accounted for the 1989 period, that success was an apparently fortuitous outcome due to either 1) subsequent data revisions unknown at the time of the monetary policy deliberations or 2) the fact that Taylor's estimate of trend GDP assumed knowledge of future GDP.

Figure 5 also shows the 6.5 percent rule matches well the reduction in the funds rate from late 1990 through mid-1992, while the 6 percent rule better matches the bottoming out of the funds rate in 1993. As the unemployment rate remained relatively steady in 1995, the 6.5 percent rule better captured the level of the funds rate.

Although these rules do capture some of the broad movements in the funds rate path over this period, the prediction errors are sizable. Another unsettling fact is that neither of these rules dominates the other. The assumption of a constant natural rate of unemployment may be the source of this conflict.

Time-varying natural rates of unemployment

An alternative is to allow the natural rate of unemployment to vary over time. King, Stock, and Watson (1995) study the relationship between inflation and the unemployment rate. They specify an econometric model that can be used to estimate a time-varying NAIRU—that value of the unemployment rate, which if maintained, would forecast no long-run change in the inflation rate. Their statistical model assumes that inflation evolves depending upon its own past history and the history of the unemployment gap. They model the natural rate as an unobserved random walk. I estimated their model over the sample period 1970–86 using the Kalman Filter methods they employed.[15]

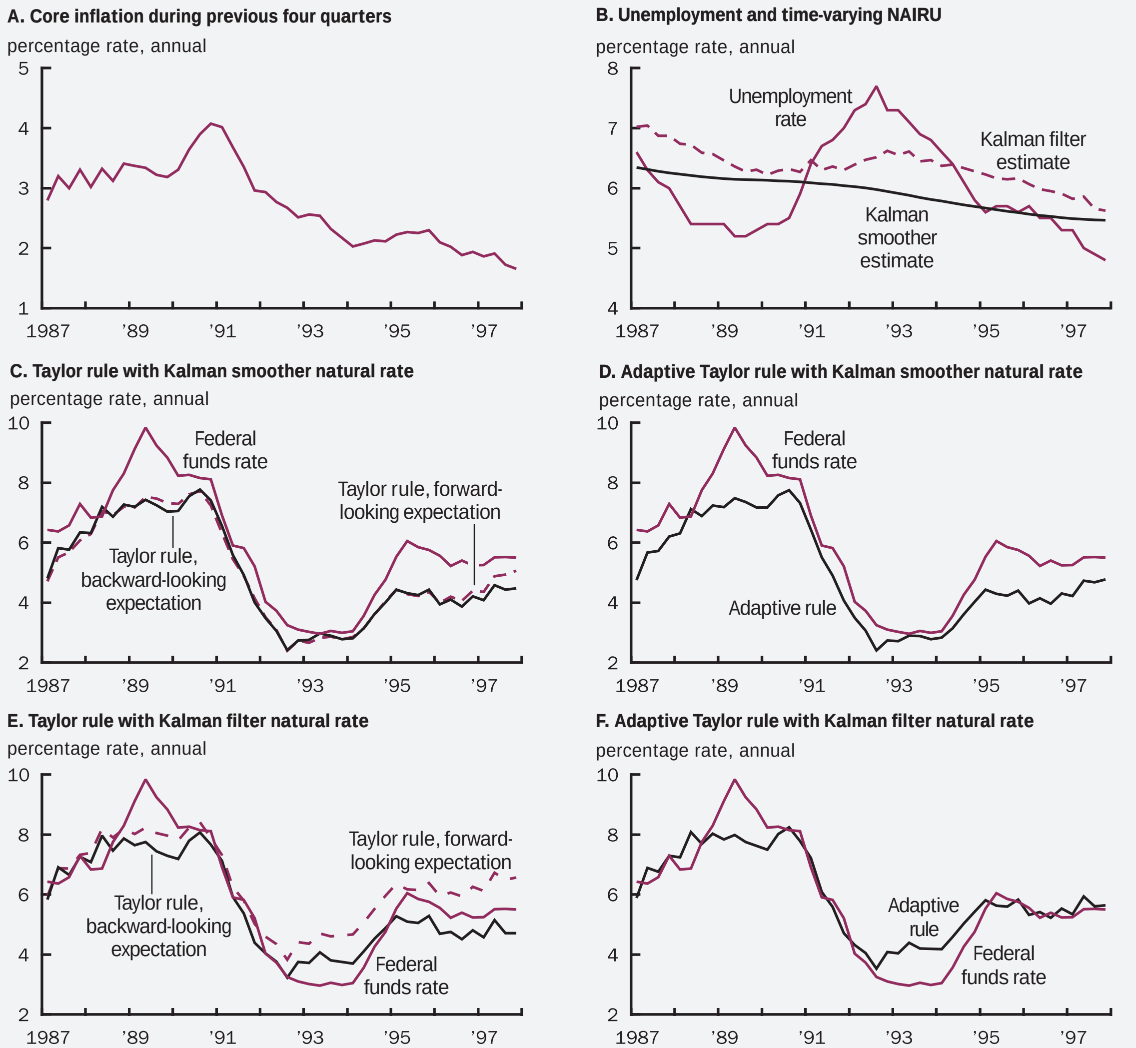
Figure 6 displays the unemployment rate and two measures of the time-varying NAIRU for the period 1987–97, using the estimated coefficients from the 1970–86 sample period. The first measure comes from the Kalman filter, and is a real-time measure (NAIRU-KF). For example, the NAIRU-KF estimate in July 1987 is a function of the data known at that date in 1987 and no future data. The second measure comes from the Kalman smoother (NAIRU-KS). The measure NAIRU-KS provides a statistically more accurate assessment of the NAIRU, but it is constructed using all of the data through 1997. This means that the 1987 estimate is a function of 1997 data, and so could not have been known in real time. The NAIRU-KS estimates have the flavor of historical data that are continually revised as new data are released. In this sense, the analysis using NAIRU-KS is similar to Taylor's analysis using historically revised GDP data. Notice that the real-time NAIRU is above the smoothed NAIRU; consequently, the real-time assessment of the inflation-unemployment data suggests more inflationary pressures over the 1987–97 period than the full-sample Kalman smoother estimate. In the unemployment/CPI Taylor rule, this means that the funds rate path will be higher using the real-time NAIRU estimates.

Figure 6 displays six alternative settings of the unemployment/CPI Taylor rule. Panels C and D of figure 6 use the NAIRU-KS measure for the unemployment gap, while panels E and F use the real-time NAIRU-KF measure. In panels C and E, the black line is the rule referred to in equation 2, while the colored line is a *forward-looking* measure. In this latter case, the inflation gap is measured as the difference between the forecasted average inflation rate over the next 12 months minus the inflation target. The inflation forecast is computed using King–Stock–Watson's inflation model. Panels D and F contain an *adaptive rule*: Inflationary expectations in the inflation gap are taken to be a simple average of the backward-looking and forward-looking inflation measures. Inflationary expectations of this form have been suggested by Fuhrer and Moore (1995) and Roberts (1998). The adaptive rule is neither well-grounded in economic theory nor an optimal forecast of inflation based upon any particular statistical model. However, the adaptive rule does impart an additional degree of inertia into inflationary expectations beyond the forward-looking measure. Many business and economic forecasters who use judgmental forecasting methods employ expectations mechanisms like this one. See Roberts (1998) for a discussion of this point.

In figure 6, the unemployment/CPI Taylor rules that use the Kalman smoother NAIRU generate a funds rate forecast that is almost always below the actual federal funds rate. As I discussed above, this is related to the fact that the NAIRU-KS is below the real-time NAIRU-KF over the sample period 1987–97.

FIGURE 6

The Taylor rule with a time varying natural rate



The real-time Taylor rules in figure 6 better match the level of the funds rate from 1987 to 1992, except for the much higher rates in late 1988–89. From 1992 to 1997, the forward-looking, real-time path is higher than the backward-looking measures and also higher than the actual funds rate path. From late 1994 to 1997, the actual funds rate is between the forward- and backward-looking rules; consequently, the adaptive rule matches the level of the funds rate rather well during this period.

Relative to the time-invariant NAIRU rules, the time-varying rules seem to capture more of the funds rate movement over this period. However, even the best match (adaptive NAIRU-KF in panel F) has substantial forecast errors in 1988–89 and 1992–94. Before comparing these rules to the futures market forecasts, one more rule will be considered.

Partial adjustment rules

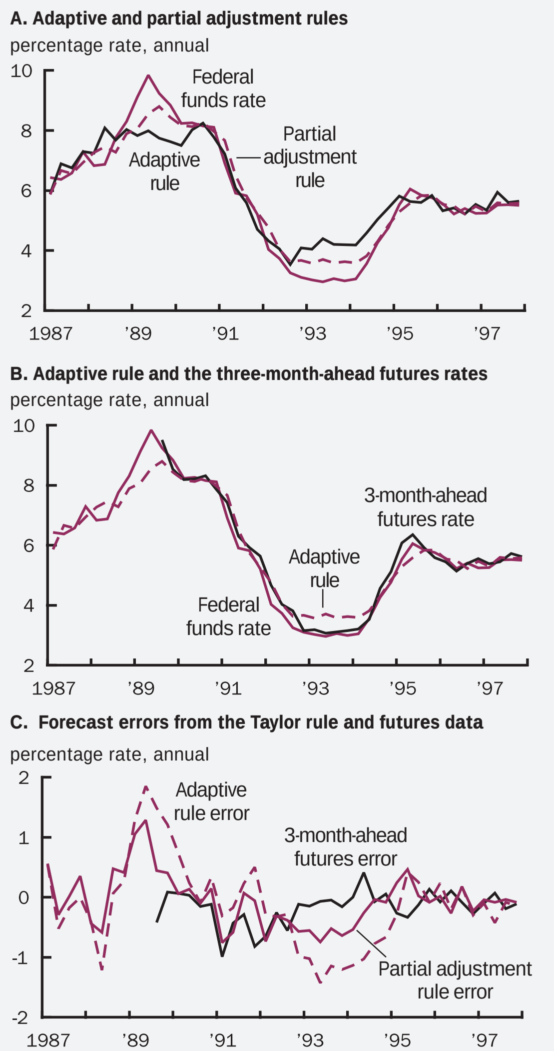
The Taylor-type rules that I have considered so far make no reference to the past history of interest rates. However, the futures market clearly uses that information. Additionally, economists often simply assume that an objective of central bankers is to smooth interest rate fluctuations over short periods of time (see Goodfriend, 1991). So it is of some interest to consider how a partial adjustment Taylor rule would have performed over this sample period.[16] The partial adjustment rule is

$$FF_t = FF_{t-1} + \lambda [r_t + \pi_t + \frac{1}{2} okun^* (u^*_t - u_t) + \frac{1}{2} (\pi_t - \pi^*_t) - FF_{t-1}],$$

where λ is a coefficient between zero and one. Suppose that λ is $\frac{1}{2}$. This rule says that the funds rate should be set equal to its value last period plus an amount that moves the funds rate halfway toward its desired value according to the unemployment/CPI Taylor rule specified in equation 2. Panel A of figure 7 displays the adaptive Taylor rule and the partial adjustment rule that is computed with λ equal to $\frac{1}{2}$. The biggest difference in the rules is during the period mid-1992 through 1994. This is the period when the adaptive rule misses the roughly 18-month period when the federal funds rate was near 3 percent. Predictably, the partial adjustment rule essentially splits the difference between the two. Similarly, in 1989 when the funds rate was surprisingly high relative to the predicted path of the unemployment/CPI Taylor rule, the partial adjustment rule is closer to the actual funds rate path.

FIGURE 7

A revised look at the Taylor rule and the futures market



Panel B of figure 7 displays the three-month-ahead futures rate and the partial adjustment unemployment/CPI Taylor rule against the actual federal funds rate. Recall that futures data only begin in 1989. The futures data track the path of the federal funds rate more closely than the Taylor rule. As panel C shows, the forecast errors are much larger for the adaptive Taylor rule. From 1989 to 1997, the standard deviation of the futures forecast error is 28 basis points. The adaptive Taylor rule has a standard deviation of 74 basis points over the same period. The partial adjustment rule represents a substantial improvement toward the futures market data; the standard deviation is only 42 basis points.

Although the partial adjustment rule has a standard deviation 50 percent higher than the futures data, the broad contours of the implied funds rate path seem to track the actual fund rate data reasonably well. Perhaps this justifies the adaptive, partial adjustment unemployment/CPI Taylor rule's use as a rough description of monetary policy actions for the purposes of evaluating alternative econometric models of the monetary transmission mechanism. For the most part, this policy rule seems like a plausible approximation of the path of the federal funds rate over the period 1987 through 1997. The rule captures three objectives that are often attributed to central banks: inflation fighting, countercyclical stabilization, and interest rate smoothing.

Conclusion

How are monetary objectives translated into month-to-month monetary policy decisions? John Taylor (1993) argued that monetary policy from 1987 to 1992 followed a simple, rule-like behavior. This article has evaluated the ability of several alternative Taylor rules to match the federal funds futures forecasts of the funds rate using data that was available to all participants at the time. The article confirms research findings by Orphanides (1997) that data revisions played an important role in Taylor's original finding that his rule matched the path of the funds rate over this period. Using the unemployment rate and core CPI, I have found that some versions of a Taylor rule roughly match the broad movements of the funds rate from 1987 to 1997. These Taylor rule forecasts, however, have a standard deviation 50 percent larger than the implied forecasts from the federal funds futures market contracts. Perhaps this is close enough to justify using Taylor-type policy rules in evaluating econometric models of industrial economies. But more research on this question is needed.

NOTES

[1]See Bernanke and Mihov (1996) for a discussion of the empirical relevance of this assertion.

[2]An alternative formulation of monetary policy rules in practice is to use vector autoregression (VAR) models. Christiano, Eichenbaum, and Evans (1998) provides a survey of this literature.

[3]Rudebusch (1997) has also criticized statistical analyses of monetary policy reaction functions which used revised data that were unavailable to policymakers at the time of their decisions.

[4]Orphanides (1997) discusses this alternative policy rule in general terms, but leaves it for others to consider in more depth.

[5]Similarly, Rudebusch (1997) points out that VAR policy rules performed poorly relative to the futures market.

[6]Evans and Kuttner (1998) discuss how small deviations from market efficiency can influence statistical analyses with futures data.

[7]The conference was held in November 1992, and the conference volume was published in late 1993.

[8]As an analogy, imagine being instructed to drive from downtown Chicago to Washington, DC. The policy rule is analogous to the written instructions detailing the highways and exits you are to take. Imagine how much more difficult the journey would be if you were not allowed to periodically check the highway signs along the side of the road to make sure that you hadn't taken a wrong turn.

[9]My implementation of the Taylor rule here provides its forecast with a slight data advantage over the futures data. The advantage lies solely in the output gap measure: It is the contemporaneous deviation of real GDP from trend, although real GDP is actually reported with a lag. The treatment of inflation does not provide an advantage, since it is the average inflation rate from the prior four quarters.

[10]See Orphanides (1997) for an extended discussion of this critique.

[11]The data and projections came from the Board's green book analysis. These data are available to the public five years later. Consequently, Orphanides's analysis can only extend through 1992.

[12]Vogel and Boucek (1992); and Fuerbringer (1992a).

[13]Harper (1992); and Fuerbringer (1992b).

[14]Since the average CPI inflation rate has been higher than the GDP deflator used in equation 1 over the sample period, a slightly higher π^* might be appropriate for equation 2. The contours of the analysis that follows, however, are essentially unchanged.

[15]I assumed that the standard deviation of the shock to the natural rate of unemployment was 0.1. This is near the middle range of the values considered by King, Stock, and Watson (1995). For more details, see their description of the model.

[16]Clarida, Gali, and Gertler (1997) consider partial adjustment Taylor rules and find they fit the U.S. experience well over the period 1979–94.

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