Real-Time Historical Analysis of Monetary Policy Rules*

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Abstract

The size of the output gap coefficient is the key determinant of whether quantitative easing since 2009 and continued near-zero interest rates can be justified by a Taylor rule. Fed Chair Ben Bernanke and Vice-Chair Janet Yellen have argued that John Taylor proposed a monetary policy rule with a larger output gap coefficient in his 1999 paper than in his 1993 paper, and have used this argument to justify negative prescribed interest rates in 2009-2010 and near-zero interest rates through 2015. While Taylor neither proposed nor advocated a different rule in 1999 than in 1993, he did not draw a distinction between the implications of the two rules. In accord with common practice at the time, Taylor used revised data. We show that, using real-time data available to policymakers (although not to Taylor when he wrote the paper), there is a sharp difference in the implications of rules with a smaller and a larger output gap coefficient. If John Taylor had been able to use real-time data in his 1999 paper, the importance of the distinction between Taylor’s original rule with a smaller output gap coefficient and other rules with a larger coefficient would have been evident much earlier.

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“Well, there are different versions of the Taylor Rule, and there’s no particular reason to pick the one that he picked in 1993. In fact, he preferred a different one in 1999 which, if you use that one, gives you a much different answer.” Ben Bernanke, testimony before the Senate Banking Committee, March 1, 2011. (Taylor, 2011)

“John Taylor has proposed two simple and well-known policy rules. The rule that Taylor proposed in 1993 incorporates a fairly modest response to economic slack. Later, in a 1999 study, he considered a variant of that rule that was twice as responsive to slack.” Janet Yellen, speech at the Money Marketeers of New York University, April 11, 2012. (Yellen 2012a)

“I did not propose or advocate another rule in 1999.” John Taylor, April 13, 2012. (Taylor 2012)

1. Introduction

When should the Fed start to raise interest rates above the zero lower bound? Should the Fed have engaged in quantitative easing in 2009 and 2010? Did the Fed lower the interest rate too much in 2003 – 2005? Debate surrounding these questions has been primarily conducted in the context of Taylor rules. First proposed in Taylor (1993), these rules have become the dominant metric for both normative and positive monetary policy analysis.

In its original form, the Taylor rule prescribes that the Fed conduct policy according to a rule where the federal funds rate equals one plus 1.5 times the inflation rate plus 0.5 times the output gap. In Taylor (1999), he also considered a rule with an output gap coefficient of 1.0. Alternatively, the Taylor rule can be formulated with the unemployment gap as the measure of real economic activity. With an Okun’s Law coefficient of 2.0, a coefficient of 0.5 on the output gap is equivalent to a coefficient of 1.0 on the unemployment gap, and a coefficient of 1.0 on the output gap is equivalent to a coefficient of 2.0 on the unemployment gap.

After the federal funds rate hit the zero lower bound in December 2008, there was a great deal of debate over whether the implied Taylor rule interest rate was negative. If the answer is yes, this provides a justification for the Fed’s subsequent quantitative easing but, if the answer is no, the Taylor rule does not provide a rationale for quantitative easing. Although the details differ among the various papers, part of the answer is clear. Taylor rules with higher output or unemployment gap coefficients produced negative implied interest rates, while those with lower coefficients did not. For example, the unemployment rate in early 2011 was 9.0 percent and inflation (depending on the exact measure) was about 2.0 percent. If the natural rate of unemployment was 5.0 percent, the unemployment gap was -4.0 percent. While a Taylor rule with a lower unemployment gap coefficient prescribes a zero federal funds rate, the same rule with a higher unemployment gap coefficient would prescribe a rate of negative 4.0 percent. With low inflation,

Examples include Guha (2009), Meyer (2009), Rudebusch (2009, 2010), and Taylor (2009, 2010).
almost all of the differences in the Taylor rule prescriptions come from the size of the output or unemployment gap coefficients.

Following its January 2012 meeting, the Federal Open Market Committee (FOMC) issued a statement that future economic conditions are “likely to warrant exceptionally low levels for the Federal Funds rate at least through late 2014.” The committee also issued interest rate projections of the individual FOMC members. The median projection was that the rate would stay unchanged through 2013 before rising to 0.75 percent in 2014. Rosenberg (2012) analyzes these projections in the context of various Taylor rules. Using the FOMC members’ projections for inflation and unemployment, he shows that their interest rate projections are much more consistent with a Taylor rule with a higher unemployment gap coefficient, which prescribes an interest rate of 0.60 percent at end-2014, than with a Taylor rule with a lower unemployment gap coefficient, which prescribes an interest rate of 2.10 percent at end-2014.

More recently, there have been several important developments in the FOMCs public policy stance. In September 2012, the FOMC extended the expected date of liftoff of the federal funds rate until mid-2015 and, in December 2012, it specified that it anticipated holding the federal funds rate at the effective zero lower bound as long as the unemployment rate remained above 6.5 percent and inflation expectations were consistent with the Fed’s targets. This was reaffirmed by the March 2013 FOMC participants’ assessments of the appropriate timing of policy firming, where 13 of the 19 participants anticipated that the first increase of the federal funds rate would occur in 2015. Taylor (2013) shows that waiting until 2015 to first increase the federal funds rate is more consistent with a Taylor rule with an output gap coefficient of 1.0 than a Taylor rule with an output gap coefficient of 0.5.

Taylor’s (2007) contention that the Fed lowered the interest rate too much in 2003 to 2005, fueling the housing price bubble and (subsequently) the Great Recession, was also framed in terms of the difference between the federal funds rate and the prescribed Taylor rule rate. Although the counter-arguments, such as Kohn (2007) and Bernanke (2010), focus on the appropriate measure of inflation, Nikolsko-Rzhevskyy and Papell (2012b) show that, whatever measure is used, the gap between the actual and the prescribed federal funds rate is larger with Taylor’s original lower output gap coefficient than with a larger output gap coefficient.

Bernanke (2011) added a new element to the debate. Rather than simply advocating a Taylor rule with a larger output gap coefficient to justify a prescribed negative interest rate, he argued that Taylor preferred a different rule in 1999 than in 1993. Yellen (2012a) made the same argument in the context of the projected path of the federal funds rate through 2014, contending that Taylor proposed different rules in 1993 and 1993 and expressing a preference for the 1999 rule with the larger output gap coefficient.
Taylor (2011, 2012) takes issue with both contentions, stating that he neither proposed nor advocated a different rule in 1999 than he did in 1993.²

It is clearly not correct to say that Taylor proposed or advocated a different rule in 1999 than he proposed in 1993, referring in Taylor (1999) to a rule with an output gap coefficient of 0.5 as “the policy rule I suggested” and to a rule with an output gap coefficient of 1.0 as a rule that “others have suggested” (page 325). But this is not the complete answer. In his analysis of “policy mistakes” in the 1960s and 1970s and “on-track” policy in the late 1980s and 1990s, Taylor never draws a distinction between the Federal Funds Rates prescribed by the two rules, only to the difference between the prescribed and the actual rates (pages 336 – 339).

The central point of this paper is that Taylor did not draw a distinction between the two rules because he used revised data that was not available to policymakers. Taylor (1999) creates output gaps using revised data with a Hodrick-Prescott filter. Not only does this incorporate data revisions subsequent to the policy decision, it uses ex post data to calculate the trend. We construct real-time output gaps using linear detrending from 1965:Q4 to 1987:Q2 and use real-time gaps constructed by the Fed from 1987:Q3 to 1997:Q3, and find substantial differences in the prescribed rates from the two rules. Taylor’s revised output gaps are much smaller than our real-time gaps during and following recessions, minimizing the effect of using rules with different output gap coefficients.

It is important to understand the distinction between real-time data available to policymakers and real-time data available to researchers. While the real-time output gaps that we use were all available to policymakers, none were available to Taylor when he wrote the paper. The linear detrended output gaps were constructed using real-time GNP data from the Philadelphia Fed Real-Time Data Set for Macroeconomists, which was not available until the release of Croushore and Stark (1999). The internal Fed real-time output gaps were also not publicly available in 1997, and are now released with about a five-year lag.

Taylor (1999) identified several “policy mistakes” where the federal funds rate was either above or below the prescribed Taylor rule rate, as well as periods where policy was “on track” with the federal funds rate about equal to the implied Taylor rule rate. The largest policy mistake was for the 1970s, where the federal funds rate was below the rates prescribed by both rules for virtually the entire decade, leading Taylor to call it “the second most serious monetary policy mistake in twentieth-century U.S. history, the most serious being the Great Depression.” The picture is very different with real-time data. With Taylor’s original rule, the federal funds rate is below the prescribed rate, although the magnitude of the discrepancy is smaller than with revised data. With a more accommodative rule with a larger output gap coefficient, the gaps are much smaller and, following the recession of 1974-1975, are even reversed.

² In Yellen (2012b), she refers to the 1999 rule as the “balanced-approach” rule.
Taylor identified the 1990s as a period where policy was on track. Using real-time data, we focus on policy following the recession of 1990-1991, where the Fed lowered and subsequently raised its policy rate. While the rate prescribed by Taylor’s original rule tracks the actual federal funds rate very closely from 1991 through 1994, the rate prescribed by a rule with a larger output gap coefficient falls considerably below the actual rate in 1992 and 1993.

These two episodes are instructive because it is generally agreed that monetary policy following the recession of 1974-1975 was too stimulative and contributed to the Great Inflation while monetary policy following the 1990-1991 recession was about right and contributed to the Great Moderation. With revised data, it makes little difference whether policy evaluation is conducted using a Taylor rule with a smaller or a larger output gap coefficient. Monetary policy was too stimulative in the 1970s and on track in the 1990s. With real-time data, it makes a great deal of difference. While monetary policy was too stimulative in the 1970s and on track in the 1990s using Taylor’s original rule with a smaller output gap coefficient, it was on track in the 1970s and not sufficiently stimulative in the 1990s using a rule with a larger output gap coefficient.

The size of the output gap coefficient has been the key element in the debate over whether the prescribed Taylor rule interest rate has been negative since 2009, and all signs indicate that it will be the key element in the debate over when the Fed should start to raise the interest rate. Taylor’s (1999) use of revised GNP data with HP detrending gave the impression that the size of the coefficient was of secondary importance, and allowed Fed Chair Ben Bernanke and Vice-Chair Janet Yellen to portray the choice among rules as arbitrary. If John Taylor had been able to use real-time data in his 1999 paper, the importance of the distinction between Taylor’s original rule with a smaller output gap coefficient and other rules with a larger coefficient would have been evident much earlier.

2. Taylor’s Rule and its Modifications

Following Taylor (1993), the monetary policy rule postulated to be followed by central banks can be specified as

\[ i_t = \pi_t + \phi(\pi_t - \pi^*) + \gamma y_t + r^* \]

where \( i_t \) is the federal funds rate, \( \pi_t \) is the inflation rate, \( \pi^* \) is the target level of inflation, \( y_t \) is the output gap, or percent deviation of actual real GDP from an estimate of its potential level, and \( r^* \) is the equilibrium level of the real interest rate. The inflation is the annualized rate over the previous year. It is assumed that the target for the short-term nominal interest rate is achieved within the period so there is no distinction between the actual and target nominal interest rate.
According to the Taylor rule, the central bank raises the target for the short-term nominal interest rate if inflation rises above its desired level and/or output is above potential output. The target level of the output deviation from its natural rate $y_t$ is 0 because, according to the natural rate hypothesis, output cannot permanently exceed potential output. The target level of inflation is positive because it is generally believed that deflation is much worse for an economy than low inflation.

The parameters $\pi^*$ and $r^*$ in equation (1) can be combined into one constant term $\mu = r^* - \phi \pi^*$, which leads to the following equation,

\begin{equation}
\hat{i}_t = \mu + \lambda \pi_t + \gamma y_t
\end{equation}

where $\lambda = 1 + \phi$. Taylor assumed that the output and inflation gaps enter the central bank’s reaction function with equal weights of 0.5 and that the equilibrium level of the real interest rate and the inflation target were both equal to 2 percent, producing the following equation,

\begin{equation}
\hat{i}_t = 1.0 + 1.5 \pi_t + 0.5 y_t
\end{equation}

A modification of Taylor’s original rule that was used in Taylor (1999) for normative analysis uses an output gap coefficient of 1.0 instead of 0.5. The rationale for this adjustment is usually based on estimates of past Fed behavior, but sometimes it is also claimed that a larger coefficient is optimal in the context of DSGE models. Incorporating this modification produces the following equation.

\begin{equation}
\hat{i}_t = 1.0 + 1.5 \pi_t + 1.0 y_t
\end{equation}

There are many other modifications of Taylor rules, including using forecasted instead of realized inflation, incorporating the unemployment gap instead of the output gap, including a lagged interest rate and/or the real exchange rate, and using a different equilibrium real interest rate and/or inflation target. Since the focus of this paper is the analysis of different output gap coefficients with real-time data in the context of the results in Taylor (1999), we will not explore any of these modifications.

3. Taylor Rules with Real-Time Data

Following Orphanides (2001), it has become standard practice to use real-time data that was available to policymakers at the time that interest rate setting decisions were made for both positive and normative analysis. Data on nominal and real GNP/GDP (and therefore inflation measured by the GNP/GDP deflator) was published by the Commerce Department in the monthly publication, Survey of Current Business, starting in 1947:1, and real-time quarterly vintages starting in 1965:4 are available on
Calculating real-time output gaps is more problematic. While the Greenbook output gap is currently available from 1987:1 – 2006:4, there is no prior record of an internal Fed output gap. While Orphanides (2003 a, b) uses real-time output gaps published by the Council of Economic Advisors (CEA), these gaps have been criticized by Taylor (2000) as being too large, and Cecchetti et al (2007) propose using real-time Hodrick-Prescott (HP) detrending. Real-time detrending involves calculating the percentage deviation of real GNP from its trend, using data from the start of the sample to the time that policy decisions were made, and updating the trend each quarter. In Nikolsko-Rzhevskyy and Papell (2012a), we show that, using Okun’s Law with real-time natural rates of unemployment for various years in the 1970s as a benchmark, the CEA gaps are too large, the real-time HP filtered gaps are too small, but real-time linear and quadratic gaps are reasonable. In addition, we argue below that, during the recession of 1981-1982, real-time quadratic and HP gaps are too small while real-time linear gaps are reasonable. Since linear detrending was the leading method used at the time and produces reasonable gaps, we use real-time linear detrending to calculate real-time output gaps from 1965:4 to 1986:4.

In order to match Taylor’s revised data as closely as possible, we take GNP/GDP and inflation data from the 1997:4 vintage, for which the last data is for 1997:3, and construct output gaps using HP detrending with $\lambda = 1600$. While Taylor’s revised data starts in 1960:1, real-time quarterly U.S. GNP and inflation data does not exist before 1965:4, and so we cannot evaluate Taylor’s results for the early 1960s.

4. Taylor Rules from the 1960s to the 1990s

Taylor (1999) characterizes the federal funds rate as too low in the late 1960s, too low in the 1970s, on track in 1979-1981, too high in 1982-1984, and on track in the late 1980s and 1990s. These results were based on output gaps calculated with revised data using HP detrending. We now document how his results are affected by the use of real-time data.

4.1 Taylor Rules in the Late 1960s

When inflation started to rise in the mid-1960s, the Fed, according to the Taylor principle, should have raised the interest rate by more than the inflation rate. Figure 1 depicts the actual federal funds rate and the rate prescribed by two policy rules. Following Taylor (1999), we call Taylor’s original rule in Equation (3), with an output gap coefficient of 0.1, Rule 1, and the alternate rule in Equation (4), with an output gap coefficient of 1.0, Rule 2.

The results with revised data are shown in the top panel of Figure 1. The federal funds rate is below both of the prescribed rates from 1965:Q4 to 1969:Q2. While the prescribed rate with Rule 2 is

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3 While the output gap was not included in the Greenbook, it was constructed and used by the Board staff in generating Greenbook forecasts. The data are available on the Federal Reserve Bank of Philadelphia web site.
slightly above the prescribed rate with Rule 1, the difference between the two prescribed rates is considerably smaller than the difference between the prescribed and actual rates. The results with real-time data are shown in the bottom panel of Figure 1. While the federal funds rate is again below both of the prescribed rates from 1965:Q4 to 1969:Q2, there are considerable differences between the results with revised and real-time data. First, the discrepancy between the prescribed and actual rates is larger with real-time than with revised data. The average output gap between 1965:4 and 1969:2 is 3.65 percent with real-time linearly detrended data and 1.11 percent with revised HP detrended data, raising the prescribed interest rate with real-time data. Second, the difference between the two prescribed rules is greater with real-time data, again reflecting the larger output gaps, although smaller than the difference between the prescribed and actual rates.

The use of real-time data reinforces Taylor’s conclusion that the late 1960s was an example of a policy mistake, as the difference between the actual and prescribed rates is larger with real-time than with revised data for both rules. While it is clear why Taylor did not draw a distinction between the rates implied by the two rules with revised data, the distinction is obvious with real-time data.

4.2 Taylor Rules in the 1970s

Monetary policy in the 1970s is widely regarded as being too stimulative. This is illustrated in the top panel of Figure 2, which plots the federal funds rate and the interest rate implied by the two rules with revised data. The actual interest rate is below both of the prescribed rates from 1971 through 1979. There is very little difference in the rates implied by the two rules, and the gap between the federal funds rate and the rate implied by either of the rules is much larger than the gap between the rates prescribed by the two rules. Taylor (1999) describes deviations from the baseline in the 1970s as the second most serious policy mistake in twentieth-century U.S. history (the Great Depression of the 1930s being the most serious). He argues that, while there is uncertainty regarding its causes, there is little doubt that it was responsible for the Great Inflation of the 1970s and, if a policy closer to that implied by the Taylor rule was followed, the rise in inflation may have been avoided.

The picture is very different with real-time data. As depicted in the bottom panel of Figure 2, the federal funds rate is again below the rate implied by Rule 1 with Taylor’s original output gap coefficient except for when the Fed was sharply raising the interest rate in 1973, although the difference is smaller with real-time data. With Rule 2, however, the prescribed and actual rates move closely together, with alternating periods where each is higher. We focus on the periods following recessions, as the decision of how long to keep interest rates low in order to stimulate the economy without causing inflation is a key component of conducting successful monetary policy. For the period following the recession of 1969:4 – 1970:4, the interest rate implied by Rule 2 is both lower and closer to the actual federal funds rate than the
rate implied by Taylor’s original Rule 1. For the period following the 1973:4 – 1975:1 recession, the rate implied by Rule 2 is below the actual federal funds rate between 1975:2 and 1977:1.

Is Taylor’s HP detrended output gap or our real-time linear detrended output gap a more reasonable number from the perspective of policymakers at the time? The standard method of calculating output gaps in the mid-1970s was to use Okun’s Law, which states that the output gap equals -3.0 times the difference between unemployment and the natural rate of unemployment. The largest unemployment rate for the 1970s was 8.9 percent in 1975:2. Based on the papers of Hall (1974), Modigliani and Papademos (1975), Wachter (1976), and Gordon (1977), we believe that a perceived natural rate of unemployment of 5.5 percent in 1975 is consistent with contemporaneous research that was available to policymakers. Using Okun’s Law with a coefficient of -3.0, the real-time output gap for 1975:3 (incorporating the one-quarter lag before the data was released) was -10.2 percent. Taylor’s HP detrended output gap of -4.2 percent implies a natural rate of unemployment of 7.5 percent, higher than any current or revised estimate. Our real-time linear output gap estimate of -10.8 percent implies a natural rate of unemployment of 5.3 percent, much closer to perceptions at the time.

Why did Taylor’s use of HP detrended data mask the difference between rules with output coefficients of 0.5 and 1.0? Looking again at 1975:2, the implied interest rate in Taylor (1999) with an output gap coefficient of 1.0 is 2.1 percentage points lower than the rate with a coefficient of 0.5. While this can be seen from the top panel of Figure 2 and from his Figure 7.5, the two implied rates converge by 1976 and the 2.1 percentage point difference is dwarfed by the 8 percentage point difference between the actual Federal Funds rate and the average of the two implied rates. With the real-time linear detrended output gaps in the bottom panel of Figure 2, the difference between the interest rates implied by the two rules is as large as the difference between the rates implied by a rule with a coefficient of 0.5 and the actual Federal Funds rate. Since monetary policy in the early 1970s did not succeed in bringing down inflation and policy in the mid-1970s let to subsequent higher inflation, it is clear that Taylor would have drawn a distinction between the two rules if he had access to our real-time data.

4.3 Taylor Rules in 1979-1984

Starting in 1979:3, the federal funds rate increased sharply in conjunction with the Fed’s attempt to bring down inflation, rising from 10 percent in 1979:2 to 15 percent in 1980:1. While it fell during the subsequent two quarters with the imposition of credit controls, it rose to almost 18 percent in 1981:2 and

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4 While Okun (1962) used -3.3 and current work uses -2.0 or lower, a coefficient of -3.0 was the standard for the 1970s.
5 Most of these papers were published in Brookings Papers on Economic Activity. Nikolsko-Rzhevskyy and Papell (2012a) provide a more extensive argument.
6 The real-time quadratic detrended output gap is -10.4 percent, very close to the real-time linear detrended gap. The real-time HP filtered output gap used by Levin and Taylor (2012) is -5.9 percent, implying an unrealistically high natural rate of unemployment of 6.9 percent.
did not fall below 10 percent until 1982:4. Taylor’s analysis of this period is shown in the top panel of Figure 3. With revised data, there is a close fit between the federal funds rate and the implied Taylor rule interest rate in 1979 and 1980, but the actual rate is well above the rate implied by either of the two rules during 1982-1984. Although the gap is typically about three and can be as high as five percentage points, Taylor views that this period has less claim to being judged a policy mistake than the 1970s because of the Fed’s need to establish credibility and keep inflation expectations from rising following the high inflation rates of the 1970s.

The federal funds rate implied by the two rules with real-time data, as well as the actual rate, is depicted in the bottom panel of Figure 3. Both the gap between the actual and implied federal funds rates and the gap between the rates implied by the two rules are larger with real-time than with revised data. Moreover, the rate implied by the rule with an output gap coefficient of 0.5 is smaller than the actual rate and the rate implied by the rule with an output gap coefficient of 1.0 is smaller than the rate implied by the rule with an output gap coefficient of 0.5. With the larger output gap coefficient, the implied federal funds rate hits the zero lower bound from 1982:4 to 1984:1.

We again use Okun’s Law to ask whether Taylor’s revised HP detrended output gaps or our real-time linear detrended output gaps are more reasonable from the perspective of policymakers at the time. The peak unemployment rate associated with the 1981-1982 recession was 10.7 percent in 1982:4. The third edition of Gordon’s (1984) macroeconomics textbook, completed in September 1983, uses an Okun’s Law coefficient of 2.5 and a natural rate of unemployment of 6.0 percent and the 1983 Economic Report of the President identified the lower limit of unemployment below which inflation will tend to increase as between 6 and 7 percent. The real-time linear and revised HP detrended output gaps for 1982:4 are -9.72 and -4.58 percent while the Okun’s Law gaps are -11.75 and -10.5 percent with a natural rate of unemployment of 6.0 and 6.5 percent, respectively. While both detrended output gaps are smaller than the Okun’s law gaps, the real-time linear detrended gap is much closer than the revised HP detrended gap. Using Okun’s Law, Taylor’s revised HP detrended output gap of -4.58 percent implies a natural rate of unemployment of 8.9 percent. Our real-time linear output gap of -9.72 percent implies a natural rate of unemployment of 6.8 percent, again much closer to perceptions at the time.\footnote{Real-time quadratic and HP filtered output gaps are -6.49 and -2.35 percent, implying unrealistically high natural rates of unemployment of 8.1 and 9.8 percent, respectively.}

While the gap between the actual and implied federal funds rates and the gap between the rates implied by the two policy rules are both larger with real-time linearly detrended than with revised HP detrended data, that does not imply Taylor’s conclusion would have been altered if he had been able to use real-time data. If the Fed’s need to establish credibility and keep inflation expectations from rising
justifies higher than Taylor-rule-implied interest rates, then the question of how much higher is beyond the scope of the paper.

4.4 Taylor Rules in the Late 1980s and 1990s

Monetary policy in the late 1980s and 1990s is generally regarded as successful. The close fit between the federal funds rate and the implied Taylor rule interest rate with revised data is depicted in the top panel of Figure 4. The fit is very close between 1987 and 1992 (although not as close as in Taylor (1993) with linear detrended revised data), with only minor divergences through 1997:3. The fit between the interest rates implied by the two rules is even closer than the fit between the actual and implied rates and it is clear why Taylor (1999) did not draw a distinction between the rules.

The picture is again very different with real-time data. As depicted in the bottom panel of Figure 4, the interest rates implied by the two rules are very similar from 1987:1 to 1991:1 and from 1994:3 to 1997:3. Between 1991:2 and 1994:2, however, the rates diverge. The interest rate implied by Taylor’s original Rule 1 with an output gap coefficient of 0.5 is very close to the federal funds rate, while the rate implied by the alternative Rule 2 with an output gap coefficient of 1.0 falls below the actual rate, with the largest discrepancies occurring in 1992.

The result that changing the output gap coefficient from 0.5 to 1.0 causes a substantial change in policy differs from the findings in Taylor (1999). According to the top panel of Figure 4 and his Figure 7.6, the implied FFR with a coefficient of 1.0 is only slightly below the implied rate with a coefficient of 0.5. The answer to the discrepancy again comes from the different output gap measures. The highest unemployment rates during or following the 1990-1991 recession occurred in 1992, with rates of 7.4 percent in 1992:1 and 7.6 percent in 1992:2 and 1992:3. Using HP detrending with revised data to calculate output gaps, the most negative output gap during the 1990s is -1.92 percent in 1992:1, falling to -1.23 percent in 1992:2 and -1.07 percent in 1992:3. With the internal Fed output gaps, the most negative gap is much larger, at -4.1 percent in 1992:1, -3.7 percent in 1992:2, and -4.1 percent in 1992:3.

Using Okun’s Law as an approximation, we again ask whether Taylor’s HP detrended output gaps with revised data are a reasonable measure of what people would have used at the time. In Hall and Taylor’s (1991) macroeconomics textbook, they report the natural rate of unemployment as approximately 6 percent and, on the same page, depict output gaps using Okun’s law with a coefficient of -3.0 and a natural rate of unemployment of 5.5 percent. Focusing on 1992:1, where Taylor’s output gap is the most negative, the implied natural rate of unemployment is 6.76 percent with the HP detrended gap and 6.03 percent with the internal Fed gap. In 1992:2 the implied natural rate of unemployment is 7.20 percent with the HP detrended gap and 6.37 percent with the internal Fed gap and in 1992:3 the implied natural rate of unemployment is 7.25 percent with the HP detrended gap and 6.23 percent with the
internal Fed gap. As we found above for the 1970s, the natural rates of unemployment implied by Taylor’s HP detrended output gaps are too high to be consistent with perceptions at the time.

Taylor’s use of HP detrended output gaps with revised data masks the difference between rules with output coefficients of 0.5 and 1.0 for two reasons. First, with a maximum output gap of about 2 percent, the maximum difference between the implied interest rates is about 1 percent. With real-time Greenbook output gaps, the maximum gap is about 4 percent, implying a 2 percent difference in the implied FFR. Second, as can be seen from the top panel of Figure 4, the implied interest rate with either coefficient is above the actual FFR for 1992 and 1993, so that the choice of coefficient does not change his result. In the bottom panel of Figure 4, with the implied and actual interest rates very close for Taylor’s original Rule 1, modifying the coefficient changes the result by lowering the implied FFR below the actual FFR.

Using revised data, Taylor (1999) described monetary policy as being “on track” in the late 1980s and 1990s and did not draw a distinction between the interest rates implied by the two rules. With real-time data, the interest rates implied by the two rules diverge following the recession of 1990-1991, and policy is only “on track” during this period with respect to Taylor’s original Rule 1. Since policy in 1992 and 1993 succeeded in stimulating the economy out of the recession without causing higher inflation, the policy success of the 1990s should be judged in terms of Taylor’s original rule.

5. Conclusions

There is widespread agreement that the Taylor rule provides a useful benchmark for conducting monetary policy analysis. There is, however, almost equally widespread disagreement about exactly what constitutes the Taylor rule. While this disagreement takes a number of forms, the most important involves the size of the output gap coefficient. This issue is important because a Taylor rule with a higher, but not a lower, output gap coefficient can be used to justify low interest rates in 2002 – 2005, quantitative easing in 2009 – 2011, and continued near-zero interest rates through 2015.

Bernanke (2011) and Yellen (2012a) have recently justified the use of a Taylor rule with a higher output gap coefficient for monetary policy analysis on the grounds that Taylor proposed a different rule in his 1999 paper than in his 1993 paper, while Taylor (2011, 2012) has forcefully disagreed. What is the source of the disagreement? Reading Taylor (1999), it is clear that he neither proposed nor advocated a different rule than in Taylor (1993), but also that he did not make a distinction between the federal funds rates implied the different rules, only between the rates implied by the rules and the actual rate.

This paper has shown that Taylor did not distinguish between the rates implied by the two rules because he used revised data with a Hodrick-Prescott filter to construct the output gap rather than real-time data available to policymakers (but not to Taylor when he wrote the paper). While internal Fed (Greenbook) output gap data does not exist before 1987, we show that real-time linear detrending
provides a good approximation to output gaps constructed from a real-time Okun’s Law calculation in the earlier period.

We focus here on two important historical episodes. It is generally agreed that monetary policy in the early and mid-1970s was too stimulative, contributing to subsequent high inflation. With revised data, the federal funds rates implied by the two rules are similar and considerably above the actual rates while, with real-time linearly detrended data, only the rates implied by the rule with the smaller output gap coefficient are above the actual rates. With real-time data, the conclusion that the early and mid-1970s constituted a “policy mistake” is only obtained by a Taylor rule with a smaller output gap coefficient. With a larger coefficient, one would conclude that policy was appropriately stimulative, a conclusion that is inconsistent with the onset of the Great Inflation.

It is also generally agreed that monetary policy was “on track” in the early 1990s, contributing to the Great Moderation. With revised data, the federal funds rates implied by the two rules are similar and approximately equal to the actual rates while, with real-time Greenbook data, only the rates implied by the rule with the smaller output gap coefficient are similar to the actual rates while the rates implied by the rule with the larger output gap coefficient are considerably lower than the actual rates. With real-time data, the conclusion that monetary policy was “on track” in the early 1990s is only obtained by a Taylor rule with a smaller output gap coefficient. With a larger coefficient, one would conclude that policy was not sufficiently stimulative, a conclusion that is inconsistent with the continued Great Moderation.

The size of the output gap coefficient in the Taylor rule has been a key element in monetary policy debates since the attainment of the zero lower bound for the federal funds rate in late 2008. Taylor’s (1999) use of revised GNP data with HP detrending masked the differences between the rules with smaller and larger coefficients, giving the mistaken impression that the choice of coefficients was of secondary importance. If Taylor had been able to use real-time data, it would have been clear all along that only the rule with the smaller coefficient is appropriate for historical analysis of monetary policy rules.
References

2. Bernanke, Ben, 2011, Testimony before the Senate Banking Committee, March 1


Figure 1
Figure 2: Rules with Revised Data: 1969:Q4 – 1979:Q4

Figure 3: Rules with Real-Time Data: 1969:Q4 – 1979:Q4


Figure 3


Figure 4