Deviations from Rules-Based Policy and Their Effects*

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Abstract

Rules-based monetary policy evaluation has long been central to macroeconomics. Using the original Taylor rule, a modified Taylor rule with a higher output gap coefficient, and an estimated Taylor rule, we define rules-based and discretionary eras by smaller and larger policy rule deviations, the absolute value of the difference between the actual federal funds rate and the federal funds rate prescribed by the three rules. We use tests for multiple structural changes to identify the eras so that knowledge of subsequent economic outcomes cannot influence the choice of the dates. With the original Taylor rule, monetary policy in the U.S. is characterized by a rules-based era until 1974, a discretionary era from 1974 to 1985, a rules-based era from 1985 to 2000, and a discretionary era from 2001 to 2013. With the modified Taylor rule, the rules-based era extends further into the 1970s and there is an additional rules-based period starting in 2006. We calculate various loss functions and find that economic performance is uniformly better during rules-based eras than during discretionary eras, and that the original Taylor rule provides the largest loss during discretionary periods relative to loss during rules-based periods.

* The data used in the paper can be downloaded at https://sites.google.com/site/alexrzhevskyy/files/data_rules_discretion.zip.
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1. Introduction

Rules-based monetary policy evaluation has long been central to macroeconomics, as evidenced by the seminal work of Friedman (1960), Kydland and Prescott (1977), and Taylor (1993). Extensive research has evaluated policy rules in the context of a variety of models, compared simple rules with optimal policy, and investigated the robustness of various rules. This paper focuses on deviations from rules-based policy. We calculate deviations from a variety of monetary policy rules, propose a statistical method for delineating “rules-based” and “discretionary” eras, and compare economic performance between the two eras.

There are a potentially infinite number of ways to specify policy rules, calculate deviations from the rules, and quantify the effects of deviations. In order to make the scope of this paper manageable, we will focus on three rules. The first is the Taylor (1993) rule, where the federal funds rate equals 1.0 plus 1.5 times inflation plus 0.5 times the output gap. The second is the Taylor rule with a coefficient of 1.0 on the output gap. We call this rule the “modified Taylor rule”. The third is a policy rule derived from an estimated Taylor rule. While the estimated coefficients on inflation and the output gap are very close to Taylor’s original postulated coefficients, the intercept is smaller, implying a higher inflation target.

In order to study deviations from rules-based policy, it is necessary to make a distinction between rules-based and discretionary eras. With qualitative methods, there is always the danger that, since the economic performance outcomes are known, periods with good economic performance will be identified as rules-based while periods of bad economic performance will be characterized as discretionary. In this paper, we implement a statistical methodology for dividing monetary policy into “small” and “large” deviations periods instead of choosing the eras a priori. First, we calculate policy rule deviations, the absolute value of the difference between the federal funds rate and the interest rate implied by the various rules. Next, using tests for structural change, we identify periods where the deviations are small and periods where the deviations are large. Since neither the number nor the dates of the periods is specified a priori, prior knowledge of economic outcomes cannot affect the results.

We use real-time data that was available to policymakers when interest rate decisions were made for as long a period as possible. We use real-time real GDP (or GNP) and GDP (or

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1 Taylor (1999a), Woodford (2003), and Taylor and Williams (2010) are a few examples of this research.
2 These two rules, plus three interest-rate-smoothing rules, were studied for robustness across nine estimated macroeconomic models in Taylor (1999a).
GNP deflator data from the Philadelphia Fed starting in 1965:Q4, when the data begins, and ending in 2013:Q4. We replace the federal funds rate with the shadow federal funds rate calculated by Wu and Xia (2013) starting in 2009:Q1 after the federal funds rate was constrained by the zero lower bound. We calculate inflation as the four-quarter percentage change in the GDP deflator and the output gap as the deviation from a real-time quadratic trend. We show that the real-time quadratic detrended output gaps provide a closer approximation to “reasonable” real-time output gaps, calculated using Okun’s Law, than alternatives including real-time linear and Hodrick-Prescott detrending.

We identify monetary policy eras by allowing for changes in the mean of the policy rule deviations with Bai and Perron (1998) tests for multiple structural breaks and Perron and Qu (2006) tests for multiple restricted structural changes, which restrict the mean of the deviations in the small and large deviations periods to be the same. There is no necessity that a particular policy rule will produce rules-based and discretionary eras. In order for a policy rule to define rules-based and discretionary eras, four criteria need to be satisfied. First, there needs to be at least two statistically significant unrestricted changes in the mean of the policy rule deviations. Second, the confidence intervals for the break dates cannot overlap. Third, the dates of the restricted and the unrestricted structural changes should be approximately the same. If this condition is violated but the direction of the breaks is the same with and without the restrictions, we define rules-based and discretionary eras using the Bai and Perron tests with the caveat that size of the deviations within each of the eras are not the same. Fourth, the means of the deviations in the two eras determined by the restricted tests need to be statistically different from each other.

For the original Taylor rule, the structural change tests identify significant breaks in 1974:Q3, 1985:Q1, and 2000:Q4. The results for the restricted structural change tests are almost identical, producing rules-based ears for 1966 – 1974 and 1985 – 2000 and discretionary eras for 1974 – 1984 and 2001 - 2013. These eras are similar to the eras identified by qualitative methods in Meltzer (2011) and Taylor (2012). The mean of the deviations is about 1.0 percent for the rules-based eras and 2.5 percent for the discretionary eras, with the difference statistically

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3 If there was one structural change, there would be one rules-based and one discretionary period and you could not conduct restricted structural change tests.
significant. The rules-based and discretionary eras closely correspond to periods where the deviations are below and above two percent.

There are some striking differences in the results for the modified Taylor rule with a higher output gap coefficient. The most important difference is that there is a significant break in 2006:Q3, producing an additional rules-based era for 2006 – 2013. The next most important difference is that the first break is in 1977:Q2, almost three years later than the first break for the original Taylor rule, producing an initial rules-based era for 1966 – 1977. The other rules-based era is 1984 – 1999 and the two other discretionary eras are 1977 – 1984 and 1999 – 2006.

The policy rule derived from estimating a Taylor rule does not satisfy all of the criteria for distinguishing between rules-based and discretionary eras. While both the unrestricted and the restricted structural change tests produce significant breaks in 1974:Q3 and 1987:Q2, the third significant break is 1995:Q1 for the structural change test and 2003:Q1 for the restricted structural change test. Since the direction of the breaks is the same with and without the restrictions and the other conditions are satisfied, we use the unrestricted model to define rules-based and discretionary eras.4

We analyze the effects of deviations from rules-based policies by comparing economic performance between our estimated rules-based and discretionary eras. Using six loss functions involving inflation and unemployment: Okun’s misery index, a linear absolute loss function, and four quadratic loss functions, we show that economic performance is better in rules-based than in discretionary eras. The results hold for all six rules and are robust to specifications of quadratic loss functions that put greater weight on either inflation or unemployment loss and to a specification that puts all weight on inflation loss.

While economic performance is always better in rules-based eras than in discretionary eras, the effects of the deviations differ systematically among the rules. The ratio of the loss during discretionary eras to the loss during rules-based eras is largest for the original Taylor rule, next largest for the modified Taylor rule, and smallest for the estimated Taylor rule. Using the original Taylor rule as a benchmark provides the sharpest evidence of the negative effects of deviating from policy rules.

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4 We also applied our methods to the three interest-rate-smoothing rules studied by Taylor (1999a), but they cannot distinguish between rules-based and discretionary eras.
2. Policy Rule Deviations with Real-Time Data

Taylor (1993) proposed the following monetary policy rule,

\[ i_t = \pi_t + \phi(\pi_t - \bar{\pi}) + \gamma y_t + R \]  

(1)

where \( i_t \) is the target level of the short-term nominal interest rate, \( \pi_t \) is the inflation rate, \( \bar{\pi} \) is the target level of inflation, \( y_t \) is the output gap, the percent deviation of actual real GDP from an estimate of its potential level, and \( R \) is the equilibrium level of the real interest rate. Taylor postulated 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,

\[ i_t = 1.0 + 1.5\pi_t + 0.5y_t \]  

(2)

We define Taylor rule deviations as the absolute value of the difference between the actual federal funds rate and the interest rate target implied by the original Taylor rule with the above coefficients. A rules-based era would have small deviations while an discretionary era would have large deviations. In our empirical work below, “large” and “small” are determined endogenously in the context of our statistical methods.

The federal funds rate is constrained by the zero lower bound starting in 2009:Q1 and is therefore not a good measure of Fed policy. Between 2009:Q1 and 2013:Q4 we use the shadow federal funds rate of Wu and Xia (2013). The shadow rate is calculated using a nonlinear term structure model that incorporates the effect of quantitative easing and forward guidance. The shadow rate is consistently negative between 2009:Q3 and 2013:Q4.

The implied Taylor rule interest rate is calculated from data on inflation and the output gap. Following Orphanides (2001), the vast majority of research on the Taylor rule uses real-time data that was available to policymakers at the time that interest rate setting decisions were made. The Real-Time Data Set for Macroeconomists, originated by Croushore and Stark (2001) and maintained by the Philadelphia Fed, contains vintages of nominal and real GDP (GNP before December 1991) data starting in 1965:4, with the data in each vintage extending back to 1947:1.

We construct inflation rates as the year-over-year change in the GDP Deflator, the ratio of nominal to real GDP. While the Fed has emphasized different inflation rates at different points in time, real-time GDP inflation is by far the longest available real-time inflation series. An alternative would be to splice together a series from the emphasized inflation measures at
different points in time. Even if it was possible to construct such a series with real-time data (and it is not), this would risk finding spurious evidence of different eras based on spliced data.

In order to construct the output gap, the percentage deviation of real GDP around potential GDP, the real GDP data needs to be detrended. We use real-time detrending, where the trend is calculated from 1947:1 through the vintage date. For example, the output gap for 1965:4 is the deviation from a trend calculated from 1947:Q1 to 1965:Q3, the output gap for 1966:Q1 is the deviation from a trend calculated from 1947:Q1 to 1965:Q4, and so on, replicating the information available to policymakers.5

The three leading methods of detrending are linear, quadratic, and Hodrick-Prescott (HP). Real-time output gaps using these methods are depicted in Figure 1. In contrast with output gaps constructed using revised data, where the trends are estimated for the entire sample, there is no necessity for the positive output gaps to equal the negative output gaps. While there are considerable differences among the gaps, the negative output gaps correspond closely with NBER recession dates for all three methods.

Which real-time output gap best approximates the perceptions of policymakers over this period? We can immediately rule out real-time linear detrending, as the output gap becomes negative in 1974 and stays consistently negative through 2013. The choice between real-time quadratic and HP detrended gaps requires more investigation. Nikolsko-Rzhevskyy and Papell (2012) and Nikolsko-Rzhevskyy, Papell, and Prodan (2014) use Okun’s Law, which states that the output gap equals a (negative) coefficient times the difference between current unemployment and the natural rate of unemployment, to construct “rule-of-thumb” output gaps based on real-time unemployment rates, perceptions of the natural rate of unemployment, and perceptions of the Okun’s Law coefficient. Focusing on the quarters of peak unemployment associated with the recessions in the 1970s and 1980s, the congruence between real-time Okun’s Law output gaps and real-time quadratic detrended output gaps is fairly close while the real-time HP detrended output gaps are always too small.

Additional support for using quadratic detrended output gaps comes from the past few years. According to the HP detrended output gaps, the recovery from the Great Recession has been V-shaped, with the output gap positive since 2011. With the quadratic detrended output

5 The lag reflects the fact that GDP data for a given quarter is not known until after the end of the quarter. While it would be preferable to use internal Fed (Greenbook) output gaps, these are only available from 1987 to 2007.
gaps, the recovery from the Great Recession has been flat, with the output gap between negative five and six percent since 2009. For these reasons, we use real-time quadratic detrending to construct the output gaps for the Taylor rule for the entire sample.

Deviations from the original Taylor rule are depicted in Figure 2. Panel A shows the actual federal funds rate through 2008:Q4, the shadow federal funds rate from 2009:Q1-2013:Q4, and the Taylor rule rate implied by Equation (2). Panel B illustrates the difference between the actual and implied rates, and Panel C depicts the Taylor rule deviations, the absolute value of the differences shown in Panel B. Figure 2 summarizes some well-known results from research that uses Taylor rules to conduct normative monetary policy evaluation. Compared to the implied Taylor rule rate, the actual federal funds rate is too low in the mid-to-late 1970s, too high in the early 1980s, and too low in the early-to-mid 2000s. This is consistent with Taylor (1999, 2007). The shadow federal funds rate is below the implied Taylor rule rate for 2010 – 2013.

The most widely used alternative to the original Taylor rule increases the size of the coefficient on the output gap from 0.5 to 1.0, producing the following specification.

\[ i_t = 1.0 + 1.5\pi_t + 1.0y_t \]  

We call this rule the modified Taylor rule. Taylor (1999b) analyzed deviations from this rule along with the original Taylor rule.

Deviations from the modified Taylor rule are depicted in Figure 3. Panel A shows the federal funds rate (actual and shadow) and the modified Taylor rule rate implied by Equation (3). Panel B illustrates the difference between the actual and implied rates, and Panel C depicts the modified Taylor rule deviations, the absolute value of the differences shown in Panel B. There are several important differences between the deviations from the original and modified Taylor rules. First, while the federal funds rate was below the implied original Taylor rule rate during and after the recession of 1974-1975, it closely tracks the modified Taylor rule rate. Second, the deviations during the recession of 1981-1982 are larger with the modified Taylor rule than with the original Taylor rule. Third, following the recession of 2008-2009, the shadow federal funds

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6 The quadratic detrended output gaps since 2009 are, on average, about one percentage point larger than the CBO output gaps reported in Weidner and Williams (2014).

7 Yellen (2012) called this rule the “balanced-approach” rule. We use the term “modified” in order to utilize more neutral language.
rate is below the rate implied by the original Taylor rule but above the rate implied by the modified Taylor rule.\(^8\)

The two policy rules described above use postulated coefficients which, as exercises in normative economics, do not necessarily reflect Fed behavior. There is an extensive literature on estimating Taylor rules which, as an exercise in positive economics, attempt to describe Fed actions. Using real-time data, we estimate a Taylor rule from 1965:Q4 – 2013:Q4 and use the estimated coefficients as the parameters of the policy rule. This can be interpreted as the policy rule favored by the Fed in the sense that, within the class of estimated rules with constant coefficients and inflation and the output gap as exogenous variables, it provides the best fit for the federal funds rate.\(^9\)

Using the real-time data described above, the estimated rule is as follows,

\[
i_t = 0.37 + 1.49\pi_t + 0.47y_t,
\]

\[(0.30) \quad (0.07) \quad (0.05)\]

with standard errors in parentheses. The coefficients on inflation and the output gap are remarkably close to the coefficients of the original Taylor rule. The intercept, however, is much smaller than the intercept in the original rule. With an estimated Taylor rule, you cannot independently identify the inflation target and the equilibrium real interest rate in Equation (1) from the estimates in Equation (4). If, however, you are willing to assume a value for the equilibrium real interest rate, you can back out a value for the inflation target (or vice versa). Assuming that the equilibrium real interest rate equals Taylor’s postulated value of 2 percent, the implied inflation target is 3.33 percent, considerably larger than Taylor’s 2 percent inflation target.

Deviations from the estimated Taylor rule are depicted in Figure 4. Panel A shows the federal funds rate (actual and shadow) and the estimated Taylor rule rate implied by Equation (4). Panel B illustrates the difference between the actual and implied rates, and Panel C depicts the estimated Taylor rule deviations, the absolute value of the differences shown in Panel B.

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\(^8\) The results for 1974-1975 differ from those in Taylor (1999b) because we use real-time data with quadratic detrending while he uses revised data with HP detrending. Nikolsko-Rzhevsky and Papell (2013) provide further discussion.

\(^9\) When estimating Taylor rules, it is common practice to have a weighted average of the lagged federal funds rate and the Taylor rule variables. These estimates, however, produce long-run multipliers on inflation and the output gap, which are not appropriate for specifying a policy rule. Alternatively, the lagged interest rate could be added as an exogenous variable in Equation (4). As with the interest-rate-smoothing rules discussed above, the policy rule derived from these estimates could not distinguish between rules-based and discretionary eras.
Since the coefficients on inflation and the output gap are nearly identical for the original and estimated Taylor rules, the implied federal funds rate is about 0.63 percentage points lower for the estimated than for the original rule. This decreases the deviations for the estimated compared with the original rule for the periods in the 1970s, 2000s, and 2010s when the federal funds rate is below the rate implied by the original Taylor rule and increases the deviations for the early 1980s when the federal funds rate is above the rate implied by the original Taylor rule.

3. Structural Change Tests for Rules-Based and Discretionary Eras

In order to identify monetary policy eras, we use Bai and Perron (1998, 2003a,b) tests for multiple structural breaks, allowing for changes in the mean of the deviations. We consider the following multiple linear regressions with \( m \) structural breaks (\( m+1 \) regimes):

\[
d_t = \gamma_0 + \gamma_1 DU_{1t} + \gamma_2 DU_{2t} + \ldots + \gamma_m DU_{mt} + u_t,
\]

where \( d_t \) are the policy rule deviations from Equations (2) – (4) and \( DU_{mt} = 1 \) if \( t > Tb_t \) and 0 otherwise, for all values of the break points \( Tb_t \).

The estimated break points are obtained by a global minimization of the sum of squared residuals (SSR). We consider the sequential test of \( l \) versus \( l+1 \) breaks, labeled \( Ft_l(l+1|l) \). For this test the first \( l \) breaks are estimated and taken as given. The statistic \( Ft_l(l+1|l) \) is then calculated as the maximum of the \( F \)-statistics for testing no further structural change against the alternative of one additional change in the mean when the break date is varied over all possible dates. The procedure for estimating the number of breaks suggested by Bai and Perron is based on the sequential application of the sup \( Ft_l(l+1|l) \) test. The procedure can be summarized as follows. Begin with a test of no-breaks versus a single break. If the null hypothesis of no breaks is rejected, proceed to test the null of a single break versus two breaks, and so forth. This process is repeated until the statistics fail to reject the null hypothesis of no additional breaks. The estimated number of breaks is equal to the number of rejections. Following Bai and Perron’s (2003b) recommendation to achieve test with correct size in finite samples, we use a value of the trimming parameter \( \varepsilon = 0.15 \) and a maximum number of breaks \( m = 5 \). The test has a nonstandard asymptotic distribution and critical values are provided in Bai and Perron (2003b).

\[10\] Bai and Perron (2003a) use an efficient algorithm for estimating the break points based on dynamic programming techniques. They also propose a methodology for identifying breaks if the no-break null is not rejected against the single-break alternative, which is not needed for this paper.
3. a. Original Taylor Rule

With the original Taylor rule, we find three significant breaks in the mean of the deviations and, therefore, four regimes. The results for the Bai and Perron (1998) tests are reported in Table 1(a). The breaks occur in 1974:Q3, 1985:Q1 and 2000:Q4. Based on the estimated coefficients on dummy variables we identify four regimes, with the following estimated mean of deviations (μi) in each regime:

- μ1 = γ0 = 1.47, μ2 = γ0 + γ1 = 3.30, μ3 = γ0 + γ1 + γ2 = 0.80 and μ4 = γ0 + γ1 + γ2 + γ3 = 1.97. Monetary policy in the U.S. is characterized by a Taylor rules-based (low deviations) era from 1965:Q4 to 1974:Q3, followed by a discretionary (high deviations) era from 1974:Q4 to 1985:Q1, a rules-based era from 1985:Q2 to 2000:Q4, and another discretionary era from 2001:Q1 to the end of the sample in 2013:Q4. The largest deviations were from 1974 to 1984 and the smallest deviations were from 1985 to 2000.  

One question that naturally arises is whether the breaks define distinct regimes. In order to answer this question, we report confidence intervals around the break dates in Table 1(a). The 95 percent confidence intervals are all smaller than three years and do not overlap, providing additional support for our characterization of low and high deviations eras.

While the Bai and Perron tests identify statistically significant changes in the mean of the Taylor rule deviations, they do not determine whether the means for the two higher deviations periods are statistically different from the means in the two lower deviations periods. In order to assess whether the mean of the deviations in the two rules-based and the two discretionary eras are significantly different we use the Perron and Qu (2006) restricted structural change test. We add two constraints to the multiple linear regressions model (5) in which we assume that there are three structural breaks (four regimes):

\[
γ_1 + γ_2 = 0
\]

and

\[
γ_2 + γ_3 = 0
\]

By imposing these constraints, we restrict the mean of the deviations in the two rules-based eras to be the same (μ1 = μ3) and the two discretionary eras to be the same (μ2 = μ4). In order to test for the existence of structural change, we use the supremum F-test of no structural

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11 The results for the original Taylor rule, as well as estimates using Markov-switching models, are in Nikolsko-Rzhevskyy, Papell, and Prodan (2014).
change \((m = 0)\) against an alternative of \(m = \text{three restricted structural changes}\). The estimates of the restricted break dates are constructed as the global minimizers of the restricted SSR using the method of Bai and Perron (2003b). As previously, we use a value of the trimming parameter \(\varepsilon = 0.15\). Asymptotic critical values are simulated.

The results are reported in Table 1(b) and illustrated in Figure 5. Using the tests for multiple restricted structural changes of Perron and Qu (2006), we find that the break dates are nearly identical with the ones previously found when testing for unrestricted changes: 1974:Q3, 1985:Q1 and 2001:Q1. Because the break dates with restricted and unrestricted structural change are almost identical, we use the break dates with restricted structural change for Figure 5. We identify four regimes with the following coefficients:
\[
\mu_1 = \mu_3 = 1.08 \quad \text{and} \quad \mu_2 = \mu_4 = 2.61.
\]
The deviations in the discretionary eras from 1974:Q4 to 1985:Q1 and 2001:Q2 to 2013:Q4 are significantly higher than the deviations in the rules-based eras from 1965:Q4 to 1974:Q3 and 1985:Q2 to 2001:Q1, as the null of no structural change can be rejected against the alternative of three restricted structural changes at the one percent significance level.

The differences between the rules-based and discretionary eras are economically as well as statistically significant. The Taylor rule deviations are almost three times larger in the discretionary eras than in the rules-based eras using Perron and Qu tests and are almost four times larger in the most discretionary era (1974 to 1984) than in the least discretionary era (1985 to 2000) using Bai and Perron tests.

3.b. Modified Taylor Rule

With the modified Taylor rule, we find four significant breaks in the mean of the deviations and, therefore, five regimes. The results for the Bai and Perron (1998) tests are reported in Table 2(a) and illustrated in Figure 5. The breaks occur in 1977:Q4, 1984:Q4, 1999:Q1, and 2006:Q3. Based on the estimated coefficients on dummy variables we identify five regimes, with the following estimated mean of deviations \((\mu_i)\) in each regime: \(\mu_1 = \gamma_0 = 1.78\), \(\mu_2 = \gamma_0 + \gamma_1 = 4.40\), \(\mu_3 = \gamma_0 + \gamma_1 + \gamma_2 = 0.90\), \(\mu_4 = \gamma_0 + \gamma_1 + \gamma_2 + \gamma_3 = 3.54\) and \(\mu_5 = \gamma_0 + \gamma_1 + \gamma_2 + \gamma_3 + \gamma_4 = 1.49\). Monetary policy in the U.S. is characterized by a Taylor rules-based (low deviations) era from 1965:Q4 to 1977:Q4, followed by a discretionary (high deviations) era from 1978:Q1 to 1984:Q4, a rules-based era from 1985:Q to 1999:Q1, another discretionary era from 1999:Q2 to 2006:Q3, and a final rules-based era from 2006:Q4 to the end of the sample in 2013:Q4. The confidence intervals do not overlap, indicating that the breaks
define distinct regimes. The largest deviations were from 1978 to 1984 and the smallest deviations were from 1985 to 1999.

The most important difference between the original and the modified Taylor rules is that, with the original rule, the final discretionary period extends from 2001 – 2013 but, with the modified rule with a higher output gap coefficient, there is an additional rules-based period from 2007 – 2013. This is in accord with Rosenberg (2012), who shows that a Taylor rule with an output gap coefficient of 1.0 provides a closer fit to the interest rate forecasts of FOMC members than a Taylor rule with an output gap coefficient of 0.5, and with Yellen (2012), who shows that the interest rates implied by the modified Taylor rule are closer to those calculated from the optimal control path of the FRB/US model than the interest rates implied by the original Taylor rule.

Starting in 2009, many commentators have noted that, since the original Taylor rule implies a small positive interest rate, it is not consistent with the Fed’s policies of quantitative easing and forward guidance. What is striking about our results is that, by using the shadow federal funds rate calculated by Wu and Xia (2013), we show Fed policy since 2007 is both discretionary from the perspective of the original Taylor rule and rules-based from the perspective of the modified Taylor rule.

Another distinction between the two rules is that, with the original Taylor rule, the first discretionary period starts at the end of 1974 while, for the modified Taylor rule, the first discretionary period starts at the beginning of 1978. Since 1974 – 1978 was a period where the Fed failed to bring down inflation following the oil shock of 1973 – 1974, the results for the original, but not the modified, Taylor rule provides evidence of the costs of deviating from rules-based policy. A third distinction is that the start of the last discretionary era in 1999:Q1 is about two years earlier than with the original Taylor rule.

We also performed the Perron and Qu (2006) restricted structural change test for the deviations from the modified Taylor rule. Since there are four significant breaks with the Bai and Perron (1998) test, we add an additional break and restriction to Equations (5) – (7):

\[ \gamma_3 + \gamma_4 = 0 \]  

By imposing these constraints, we restrict the mean of the deviations in the three rules-based eras to be the same \( (\mu_1 = \mu_3 = \mu_5) \) and the two discretionary eras to be the same \( (\mu_2 = \mu_4) \).
The results are reported in Table 2(b) and illustrated in Figure 5. As with the original Taylor rule, we find that the break dates are nearly identical with the ones found when testing for unrestricted changes: 1977:Q2, 1984:Q3, 1999:Q2, and 2006:Q3, and so we use the break dates with restricted structural change Figure 5. We identify four regimes with the following coefficients: $\mu_1 = \mu_3 = \mu_5 = 1.34$ and $\mu_2 = \mu_4 = 3.97$. The deviations in the discretionary eras from 1977:Q3 to 1984:Q3 and 1999:Q2 to 2006:Q3 are significantly higher than the deviations in the rules-based eras from 1965:Q4 to 1977:Q3, 1985:Q4 to 1999:Q2 and 2006:Q4 to 2013:Q4, as the null of no structural change can be rejected against the alternative of three restricted structural changes at the one percent significance level. The results for the restricted structural change tests for the original and modified Taylor rules show that both rules can distinguish between rules-based and discretionary eras, albeit with important differences in the dates of the eras.

### 3.c. Estimated Taylor Rule

Since both the original and the modified Taylor rules are normative, they do not necessarily reflect monetary policy practiced by the Fed. We also evaluate a “positive” rule which is derived from the estimated interest rate reaction function using real-time data in Equation (4). As discussed above, while the coefficients on inflation and the output gap are very close to those of the original Taylor rule, the intercept is much smaller, implying a higher inflation target.

As with the normative rules, we test for structural change in the deviations of the (estimated) policy rule. The results for the Bai and Perron (1998) tests are reported in Table 3(a) and illustrated in Figure 5. The breaks occur in 1974:Q3, 1987:Q2 and 1995:Q1. While the first break exactly coincides with the first break for the original Taylor rule, the second break is two years later and the third break is six years earlier. Based on the estimated coefficients on dummy variables we identify four regimes, with the following estimated mean of deviations ($\mu_i$) in each regime: $\mu_1 = \gamma_0 = 1.20$, $\mu_2 = \gamma_0 + \gamma_1 = 3.07$, $\mu_3 = \gamma_0 + \gamma_1 + \gamma_2 = 0.73$ and $\mu_4 = \gamma_0 + \gamma_1 + \gamma_2 + \gamma_3 = 1.90$. Monetary policy in the U.S. is characterized by a Taylor rules-based (low deviations) era from 1965:4 until 1974:Q3, followed by a discretionary (high deviations) era from 1974:Q4 – 1987:Q2, a rules-based era from 1987:Q3 – 1995:Q1, and a discretionary era from 1995:Q2 until the end of the sample in 2013:Q4. The confidence intervals do not overlap, indicating that the breaks define distinct regimes. The largest deviations are from 1974 to 1987 and the smallest deviations are from 1987 to 1995.
We also performed the Perron and Qu (2006) restricted structural change test for the deviations from the estimated Taylor rule. The results are reported in Table 3(b). The breaks occur in 1974:Q3, 1987:Q2 and 2003:Q1. We identify four regimes with the following coefficients: \( \mu_1 = \mu_3 = 1.08 \) and \( \mu_2 = \mu_4 = 2.34 \). The deviations in the discretionary eras from 1974:Q4 – 1987:Q2 and 2003:Q2 – 2013:Q4 are significantly higher than the deviations in the rules-based eras from 1965:Q4 – 1974:Q3 and 1987:Q3 – 2003:Q1, as the null of no structural change can be rejected against the alternative of three restricted structural changes at the one percent significance level.

While the first two break dates, 1974:Q3 and 1987:Q2, are identical to the ones found when testing for unrestricted changes, the third break, 2003:Q1, occurs eight years later, violating one of our conditions for a policy rule to produce rules-based and discretionary eras. Since the direction of the breaks is the same with and without the restrictions and the other conditions are satisfied, we use the breaks from the unrestricted tests to depict rules-based and discretionary eras in Figure 5, with the caveat that size of the deviations within each of the eras are not the same.

4. Policy Evaluation for Rules-Based and Discretionary Eras

We have identified rules-based and discretionary eras by conducting tests for structural change of the deviations from three policy rules: the original Taylor rule, a modified Taylor rule with a higher output gap coefficient, and an estimated Taylor rule. We proceed to compare economic performance in two dimensions - between rules-based and discretionary eras for each policy rule and among the three policy rules.

Corresponding to the Fed’s dual mandate, macroeconomic performance is usually evaluated in terms of inflation and unemployment. Typically, a loss function is calculated as the sum of inflation loss and unemployment loss, with the better policy being the one that produces a smaller loss function.

We calculate six loss functions. The best-known loss function is the Okun misery index, which is simply the sum of inflation and unemployment, so inflation loss equals the inflation rate and unemployment loss equals the unemployment rate. This loss function, however, assumes that optimal inflation and unemployment are both zero, which does not account for either a preference for low inflation over zero inflation or for the natural rate hypothesis. We therefore
calculate a linear absolute loss function, where inflation loss is the absolute value of inflation minus target inflation, which we assume equals two percent, and unemployment loss is the absolute value of unemployment minus the natural rate of unemployment. Next, we report a quadratic loss function, where inflation loss is inflation minus target inflation squared and unemployment loss is unemployment minus the natural rate of unemployment squared. Compared to the linear loss function, the quadratic loss function favors moderate inflation and unemployment over high inflation and low unemployment or low inflation and high unemployment.\footnote{Woodford (2003) discusses the theoretical advantages of quadratic loss functions.}

While the three loss functions place equal weight on inflation and unemployment loss, there are many other possibilities. Woodford (2003), for example, argues that for quadratic loss functions, the weight on inflation loss should be much higher than the weight on unemployment loss. Conversely, Grant (2013) uses survey data to estimate that the public values a one percentage point decrease in unemployment as much as a two to five percentage point decrease in inflation, and argues that this is consistent with studies of the macroeconomics of happiness. We investigate the robustness of our results to alternative weights by calculating quadratic loss functions with a weight of 3:1 on inflation loss relative to unemployment loss and a weight of 3:1 on unemployment loss relative to inflation loss. Finally, we consider a quadratic loss function where all of the weight is placed on inflation loss.\footnote{All of our quadratic loss functions are included in the general quadratic loss function used by Taylor (1979).}

We compute loss functions for the rules-based and discretionary eras. For the original and modified Taylor rules, we use the Perron and Qu (2006) tests for restricted structural change to determine the breaks because the break dates are similar with tests for unrestricted and restricted structural change. For the estimated Taylor rule, we use the Bai and Perron (2003) test for unrestricted structural change to determine the breaks because the break dates are different with tests for unrestricted and restricted structural change. The eras are those depicted in Figure 5. Since we are evaluating policy outcomes, we use currently available (revised) data for inflation, unemployment, and the natural rate of unemployment rather than real-time data.

The average loss during discretionary eras is uniformly greater than the average loss during policy rule eras. As reported in Table 4, this holds for each of the 18 possible cases – six loss functions times three policy rules. The magnitude of the loss differences is substantial. For
example, the difference between the average loss during discretionary and rules-based eras for
the linear absolute loss function with the original Taylor rule is about 1.7 percentage points.
Since this loss function places equal weight on inflation and unemployment loss, we can use
Okun’s Law to calculate the implied output gap difference as if all of the loss was attributed to
unemployment loss. With an Okun’s Law coefficient of 2.5, the implied average output gap
difference is 4.25 percent. When one considers that the fall in real GDP from the peak in
December 2007 to the trough in June 2009 was about 5.4 percent, a 4.25 percent difference in the
implied output gap between rules-based and discretionary eras over an almost 50 year period
provides clear evidence of the negative effects of deviating from rules-based policy.

While economic performance in rules-based eras is uniformly better than economic
performance in discretionary eras, there are substantial differences among the policy rules. Table
4 also reports the ratio of the average loss during discretionary eras to the average loss during
rules-based eras. Since all of the ratios are positive, a higher value for a given loss function
means that the rule provides a sharper delineation between rules-based and discretionary eras.
The loss ratio for the original Taylor rule is greater than the loss ratio for the modified Taylor
rule for all six loss functions and, in turn, the loss ratio for the modified Taylor rule is greater
than the loss ratio for the estimated Taylor rule for five of the six loss functions.\(^{14}\) In every case,
the original Taylor rule provides the strongest evidence of the costs of deviating from rules-based
policy.

5. Conclusions

Comparison of rules-based and discretionary monetary policy has been central to
macroeconomics since the publication of the seminal Kydland and Prescott (1977) article. In a
Taylor (2012) identifies the late 1960s and 1970s as a period of discretionary policy, 1980 to
1984 as a transition, 1985 to 2003 as the rules-based era, and 2003 – 2012 (and possibly beyond)
as the ad hoc era. He argues that economic performance in the rules-based period was vastly
superior to that in the ad hoc period and, while correlation does not prove causation, the timing
of events supports the interpretation that (good or bad) policy causes (good or bad) economic
performance rather than causation going in the opposite direction.

\(^{14}\) The only exception is the loss function which places greater weight on unemployment loss than on inflation loss.
The first purpose of this paper is to statistically identify rules-based and discretionary periods. We calculate deviations from three policy rules: the original Taylor rule, a modified Taylor rule with a higher output gap coefficient, and an estimated Taylor rule, and identify rules-based and discretionary eras using tests for unrestricted and restricted structural change that rely solely on the data so that prior knowledge of economic outcomes cannot affect the results. With the original Taylor rule, the division between rules-based and discretionary eras is broadly consistent with Taylor’s narrative. With the modified Taylor rule, the rules-based era extends further into the 1970s and there is an additional rules-based period starting in 2006, consistent with Yellen (2012) and the Fed’s continued use of quantitative easing and forward guidance. With the estimated Taylor rule, the eras identified by the restricted and unrestricted tests differ, providing a less clear delineation.

The second purpose of the paper is to analyze the effects of deviating from the policy rules. For each of the three policy rules, we calculate six loss functions based on inflation and unemployment loss and evaluate the rules based on minimizing economic loss. First, rules are preferred to discretion. For all 18 cases, economic loss during discretionary eras is greater than economic loss during rules-based eras. Second, the original Taylor rule maximizes the benefit from rules-based policy. For each of the six loss functions, the original Taylor rule produces the largest ratio of the average loss during discretionary eras to the average loss during rules-based eras. The modified Taylor rule is preferred to the estimated Taylor rule in five of the six cases.

Once the federal funds rate hit the zero lower bound in December 2008, debates over Fed policy have been conducted in the context of two versions of the Taylor rule, with proponents of quantitative easing and forward guidance arguing that the additional stimulus is consistent with the modified Taylor rule and skeptics arguing that it represents a deviation from the original Taylor rule. This paper quantifies the debate, providing evidence that the period since 2006 can be characterized as discretionary with respect to the original Taylor rule but rules-based with respect to the modified Taylor rule. In a post written following Janet Yellen’s inaugural congressional hearing, Taylor (2014) argued for legislation that would require the Fed to report on its policy rule and, if it deviated from the rule, to report to the House Committee on Financial Services and the Senate Banking Committee about the reasons why. Regarding the choice of the rule, he wrote that “It would be a rule of its own choosing – that’s the responsibility of the Fed.” While this is in accord with our findings that systematic deviations from rules-based policy are
detrimental, it does not go far enough. The choice among policy rules matters. In order to maximize the benefit from rules-based policy, the Fed should choose the rule with the largest difference in economic loss between discretionary and rules-based periods. In the class of the rules we studied, that choice is the original Taylor rule.
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Nikolsko-Rzhevskyy, Alex, Prodan, Ruxandra and David Papell (2014), “(Taylor) Rules versus Discretion in U.S. Monetary Policy, unpublished, University of Houston


Weidner, Justin and John C. Williams (2014), “Update of How Big is the Output Gap?” unpublished, Federal Reserve Bank of San Francisco, February 27


Yellen, Janet (2012), “Perspectives on Monetary Policy,” speech at the Boston Economic Club Dinner, June 6
Table 1. Original Taylor Rule

a) Tests for Multiple Structural Changes
\[ d_i = \gamma_0 + \gamma_1DU_{1t} + \gamma_2DU_{2t} + \gamma_3DU_{3t} + u_t \]

<table>
<thead>
<tr>
<th>SupF test (sequential method)</th>
<th>Critical values (1%)</th>
<th>Break dates</th>
<th>Coefficients</th>
<th>95% Confidence Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>SupF(3</td>
<td>2) = 50.74*</td>
<td>12.29</td>
<td>1974:Q3</td>
<td>( \gamma_0 = 1.468 )</td>
</tr>
<tr>
<td>SupF(1</td>
<td>0) = 32.63*</td>
<td>13.89</td>
<td>1985:Q1</td>
<td>( \gamma_1 = 1.835 )</td>
</tr>
<tr>
<td>SupF(2</td>
<td>1) = 53.27*</td>
<td>14.80</td>
<td>2000:Q4</td>
<td>( \gamma_2 = -2.506 )</td>
</tr>
</tbody>
</table>

b) Tests for Multiple Restricted Structural Changes
\[ d_i = \gamma_0 + \gamma_1DU_{1t} + \gamma_2DU_{2t} + \gamma_3DU_{3t} + u_t, \ \gamma_1 + \gamma_2 = 0 \text{ and } \gamma_2 + \gamma_3 = 0 \]

<table>
<thead>
<tr>
<th>SupF test</th>
<th>Critical values (1%)</th>
<th>Break dates</th>
<th>Coefficients</th>
<th>95% Confidence Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>85.46*</td>
<td>17.17</td>
<td></td>
<td>( \gamma_0 = 1.075 )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1974:Q3</td>
<td>( \gamma_1 = 1.531 )</td>
<td>1971:Q1 - 1975:Q3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1985:Q1</td>
<td>( \gamma_2 = -1.531 )</td>
<td>1984:Q4 - 1988:Q3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2001:Q1</td>
<td>( \gamma_3 = 1.531 )</td>
<td>1999:Q1 - 2001:Q3</td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Modified Taylor Rule

a) Tests for Multiple Structural Changes

\[ d_t = \gamma_0 + \gamma_1 DU_{r1} + \gamma_2 DU_{2r} + \gamma_3 DU_{3t} + \gamma_4 DU_{4t} + u_t \]

<table>
<thead>
<tr>
<th>SupF test (sequential method)</th>
<th>Critical values (1%)</th>
<th>Break dates</th>
<th>Coefficients</th>
<th>95% Confidence Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>SupF(4</td>
<td>3) = 63.05*</td>
<td>8.58</td>
<td>1977:Q4</td>
<td>( \gamma_1 = 2.616 )</td>
</tr>
<tr>
<td>SupF(1</td>
<td>0) = 11.42*</td>
<td>10.13</td>
<td>1984:Q4</td>
<td>( \gamma_2 = -3.494 )</td>
</tr>
<tr>
<td>SupF(2</td>
<td>1) = 65.41*</td>
<td>11.14</td>
<td>1999:Q1</td>
<td>( \gamma_3 = 2.631 )</td>
</tr>
<tr>
<td>SupF(3</td>
<td>2) = 62.95*</td>
<td>11.83</td>
<td>2006:Q3</td>
<td>( \gamma_4 = -2.041 )</td>
</tr>
</tbody>
</table>

b) Tests for Multiple Restricted Structural Changes

\[ d_t = \gamma_0 + \gamma_1 DU_{r1} + \gamma_2 DU_{2r} + \gamma_3 DU_{3t} + \gamma_4 DU_{4t} + u_t, \gamma_1 + \gamma_2 = 0, \gamma_2 + \gamma_3 = 0 \text{ and } \gamma_3 + \gamma_4 = 0 \]

<table>
<thead>
<tr>
<th>SupF test</th>
<th>Critical values (1%)</th>
<th>Break dates</th>
<th>Coefficients</th>
<th>95% Confidence Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.14*</td>
<td>18.82</td>
<td></td>
<td>( \gamma_0 = 1.344 )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1977:Q2</td>
<td>( \gamma_1 = 2.629 )</td>
<td>1974:Q4 - 1978:Q3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1984:Q3</td>
<td>( \gamma_2 = -2.629 )</td>
<td>1984:Q2 - 1987:Q1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1999:Q2</td>
<td>( \gamma_3 = 2.629 )</td>
<td>1998:Q4 - 1999:Q3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2006:Q3</td>
<td>( \gamma_4 = -2.629 )</td>
<td>2006:Q1 - 2007:Q1</td>
</tr>
</tbody>
</table>
Table 3. Estimated Taylor Rule

**a) Tests for Multiple Structural Changes**

\[ d_t = \gamma_0 + \gamma_1 DU_{1t} + \gamma_2 DU_{2t} + \gamma_3 DU_{3t} + u_t \]

<table>
<thead>
<tr>
<th>SupF test (sequential method)</th>
<th>Critical values (5%)</th>
<th>Break dates</th>
<th>Coefficients</th>
<th>95% Confidence Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>SupF(1</td>
<td>0) = 34.95*</td>
<td>8.58</td>
<td>1974:Q3</td>
<td>( \gamma_0 = 1.20 )</td>
</tr>
<tr>
<td>SupF(2</td>
<td>1) = 56.47*</td>
<td>10.13</td>
<td>1987:Q2</td>
<td>( \gamma_1 = 1.867 )</td>
</tr>
<tr>
<td>SupF(3</td>
<td>2) = 11.15*</td>
<td>11.14</td>
<td>1995:Q1</td>
<td>( \gamma_3 = 0.664 )</td>
</tr>
</tbody>
</table>

**b) Tests for Multiple Restricted Structural Changes**

\[ d_t = \gamma_0 + \gamma_1 DU_{1t} + \gamma_2 DU_{2t} + \gamma_3 DU_{3t} + u_t, \quad \gamma_1 + \gamma_2 = 0 \quad \text{and} \quad \gamma_2 + \gamma_3 = 0 \]

<table>
<thead>
<tr>
<th>SupF test (sequential method)</th>
<th>Critical values (1%)</th>
<th>Break dates</th>
<th>Coefficients</th>
<th>95% Confidence Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>85.46*</td>
<td>17.17</td>
<td>1974:Q3</td>
<td>( \gamma_0 = 1.077 )</td>
<td>1968:Q4 - 1975:Q1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1987:Q2</td>
<td>( \gamma_2 = -1.259 )</td>
<td>1986:Q4 - 1993:Q1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2003:Q1</td>
<td>( \gamma_3 = 1.259 )</td>
<td>2000:Q1 - 2003:Q4</td>
</tr>
</tbody>
</table>
Table 4. Loss Functions for the policy rules

<table>
<thead>
<tr>
<th></th>
<th>Average Loss During Rules-Based Eras (1)</th>
<th>Average Loss During Discretionary Eras (2)</th>
<th>Ratio (2)/(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Misery Index L = Inflation + Unemployment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Original Taylor Rule</td>
<td>8.50</td>
<td>11.16</td>
<td>1.31</td>
</tr>
<tr>
<td>Modified Taylor Rule</td>
<td>9.34</td>
<td>10.80</td>
<td>1.15</td>
</tr>
<tr>
<td>Estimated Taylor Rule</td>
<td>9.12</td>
<td>10.13</td>
<td>1.11</td>
</tr>
<tr>
<td>**Linear Absolute Loss Function L =</td>
<td>Inflation - 2%</td>
<td>+</td>
<td>Unemployment - Natural Rate</td>
</tr>
<tr>
<td>Original Taylor Rule</td>
<td>2.31</td>
<td>3.98</td>
<td>1.72</td>
</tr>
<tr>
<td>Modified Taylor Rule</td>
<td>2.86</td>
<td>3.70</td>
<td>1.29</td>
</tr>
<tr>
<td>Estimated Taylor Rule</td>
<td>2.92</td>
<td>3.22</td>
<td>1.10</td>
</tr>
<tr>
<td><strong>Quadratic Loss Function L = (Inflation - 2%)^2 + (Unemployment - Natural Rate)^2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Original Taylor Rule</td>
<td>5.06</td>
<td>16.07</td>
<td>3.17</td>
</tr>
<tr>
<td>Modified Taylor Rule</td>
<td>8.26</td>
<td>15.26</td>
<td>1.85</td>
</tr>
<tr>
<td>Estimated Taylor Rule</td>
<td>7.13</td>
<td>12.09</td>
<td>1.70</td>
</tr>
<tr>
<td><em><em>Quadratic Loss Function L = 3/2</em>(Inflation - 2%)^2 + 1/2</em>(Unemployment - Natural Rate)^2**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Original Taylor Rule</td>
<td>6.19</td>
<td>19.78</td>
<td>3.19</td>
</tr>
<tr>
<td>Modified Taylor Rule</td>
<td>9.43</td>
<td>20.43</td>
<td>2.16</td>
</tr>
<tr>
<td>Estimated Taylor Rule</td>
<td>8.88</td>
<td>14.79</td>
<td>1.66</td>
</tr>
<tr>
<td><em><em>Quadratic Loss Function L =1/2</em>(Inflation - 2%)^2 + 3/2</em>(Unemployment - Natural Rate)^2**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Original Taylor Rule</td>
<td>3.93</td>
<td>12.36</td>
<td>3.15</td>
</tr>
<tr>
<td>Modified Taylor Rule</td>
<td>7.09</td>
<td>10.09</td>
<td>1.42</td>
</tr>
<tr>
<td>Estimated Taylor Rule</td>
<td>5.38</td>
<td>9.38</td>
<td>1.74</td>
</tr>
<tr>
<td><strong>Quadratic Loss Function L = (Inflation - 2%)^2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Original Taylor Rule</td>
<td>3.66</td>
<td>11.75</td>
<td>3.21</td>
</tr>
<tr>
<td>Modified Taylor Rule</td>
<td>5.30</td>
<td>12.80</td>
<td>2.42</td>
</tr>
<tr>
<td>Estimated Taylor Rule</td>
<td>5.31</td>
<td>8.75</td>
<td>1.65</td>
</tr>
</tbody>
</table>

Note: The loss functions were computed with the eras determined by the structural change test for the Estimated Taylor Rule and the eras determined by the restricted structural change test for the Original Taylor Rule and the Modified Taylor Rule.
Figure 1. Real-time Output Gaps with Linear, Quadratic and Hodrick-Prescott Detrending
Figure 2. Deviations from the Original Taylor Rule

Panel A. The Federal Funds Rate and the Implied Rate

Panel B. The Difference between the Actual and the Implied Rates

Panel C. Deviations from the Original Taylor Rule
Figure 3. Deviations from the Modified Taylor Rule

Panel A. The Federal Funds Rate and the Implied Rate

Panel B. The Difference between the Actual and Implied Rates

Panel C. Deviations from the Modified Taylor Rule
Figure 4. Deviations from the Estimated Taylor Rule

Panel A. The Federal Funds Rate and the Implied Rate

Panel B. The Difference between the Actual and Implied Rates

Panel C. Deviations from the Estimated Taylor Rule
Figure 5. Structural Change Tests for Taylor Rule Deviations

A. Original Taylor Rule: Restricted Structural Change Model

B. Modified Taylor Rule: Restricted Structural Change Model
C. Estimated Taylor Rule: Structural Change Model