(Taylor) Rules versus Discretion in U.S. Monetary Policy[*]

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Abstract

The Taylor rule has been the dominant metric for monetary policy evaluation over the past 20 years, and it has become common practice to identify periods where policy either adheres closely to or deviates from the Taylor rule benchmark. The purpose of this paper is to identify (Taylor) rules-based and discretionary eras solely from the data so that knowledge of subsequent economic outcomes cannot influence the choice of the dates. We define Taylor rules-based and discretionary eras by smaller and larger Taylor rule deviations, the absolute value of the difference between the actual federal funds rate and the federal funds rate prescribed by the original Taylor rule, and use tests for multiple structural changes and Markov switching models to identify the eras. Monetary policy in the U.S. is characterized by a Taylor rules-based (low deviations) era until 1974, a discretionary (high deviations) era from 1974 to about 1985, a rules-based era from about 1985 to 2000, and a discretionary era from 2001 to 2013. The Taylor rule deviations are about three times as large in the discretionary eras than in the rules-based eras. The discretionary and rules-based eras closely correspond to periods where the Taylor rule deviations are above and below two percent. We calculate various loss functions and find that economic performance is uniformly better during (Taylor) rules-based eras than during discretionary eras.

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1. Introduction

Comparison of rules-based and discretionary monetary policy has been central to macroeconomics since the publication of the seminal Kydland and Prescott (1977) article. While there are a great variety of policy rules, the Taylor (1993) rule, where the Fed raises the interest rate when inflation rises above target and/or output rises above potential, has received the most attention. Questions ranging from whether Fed policy was too stimulative in the 1970s, on track in the 1980s and 1990s, and again too stimulative in the 2000s, contributing to the Great Inflation, Great Moderation, and the Great Recession, respectively, have all been extensively analyzed in the context of the Taylor rule.

In a recent essay, "Monetary Policy Rules Work and Discretion Doesn't: A Tale of Two Eras," Taylor (2012a) 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.

Identification of monetary policy eras is fraught with peril. Whatever the rule, 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 ad hoc.

In this paper, we propose and implement a statistical methodology for dividing monetary policy into Taylor-rules-based and discretionary eras. We first calculate Taylor rule deviations, the difference between the federal funds rate and the interest rate implied by the Taylor (1993) rule, 1.0 plus 1.5 times inflation plus 0.5 times the output gap, which assumes that the target inflation rate and the equilibrium real interest rate both equal 2.0 percent. Next, using tests for structural change and Markov switching methods, we identify Taylor rules-based eras where the deviations are small and discretionary eras where the deviations are large. With both methods, neither the number nor the dates of the regimes is specified a priori, and so prior knowledge of economic outcomes cannot affect the results.

Calculating Taylor rule deviations necessitates some choices and compromises. We want to use real-time data that was available to policymakers when interest rate decisions were made for as long a period as possible. While it would be ideal to use internal Fed (Greenbook) output gaps, these are only available from 1987 to 2007. We use real-time real GDP (or GNP) and GDP (or 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 (2014) starting in 2009:Q1 after the federal funds rate was constrained by the zero lower bound. We calculate inflation as the 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 with Bai and Perron (1998) tests for multiple structural breaks, allowing for changes in the mean of the Taylor rule deviations. Commencing with the start of the data in 1965:4, monetary policy in the U.S. is characterized by a Taylor rules-based (low deviations) era until 1974:Q3, followed by a discretionary (high deviations) era from 1974:Q4 – 1985:Q1, a rules-based era from 1985:Q2 – 2000:Q4, and another discretionary era from 2001:Q1 to the end of the sample in 2013:Q4. The dates of the breaks are almost identical if tests for multiple restricted structural changes of Perron and Qu (2006), which restrict the mean of the deviations in the two rules-based and two discretionary eras to be the same, are used instead. During the discretionary periods of the 1970s and 2000s, the federal funds rate is consistently below the rate implied by the Taylor rule while, in the early 1980s, the actual rate is above the implied Taylor rule rate. The size of the deviations in the discretionary eras is more than three times as large as in the rules-based eras.

We also use Markov switching methods of Hamilton (1989), where the monetary policy eras are defined by high and low Taylor rule deviation states. Most of the regime dates are close to those found with tests for structural change. The first Taylor rules-based (low deviations) era ends in 1974:Q3, followed by a discretionary (high deviations) era from 1974:Q4 – 1986:Q1, a rules-based era from 1986:Q2 – 2001:Q1, and another discretionary era starting in 2001:Q2. The differences in the results between the methods occur at the beginning and end of the sample. With Markov switching, there a discretionary era from 1965:Q4 – 1968:Q4 and the high deviations era starting in 2001 is interrupted by several short low deviations periods. [1] The

[1] The tests for structural change do not allow for breaks in the first and last fifteen percent of the data.

discretionary and rules-based eras closely correspond to periods where the Taylor rule deviations are above and below two percent. As with the tests for structural change, the size of the deviations is more than three times as large in the discretionary eras than in the rules-based eras.

We evaluate Taylor's assertion that monetary policy rules work better than discretion by comparing economic performance between our estimated rules-based and discretionary eras. Using three loss functions involving inflation and unemployment: Okun's misery index, a linear absolute loss function, and a quadratic loss function, we show that economic performance is uniformly better in (Taylor) rules-based eras than in discretionary eras. The results are robust to specifications that put greater weight on either inflation or unemployment loss. They are also robust to deleting either the Volcker disinflation period and/or the post-2008 period from the discretionary eras.

Using two well-known econometric methodologies, structural change tests and Markov switching models, we identify Taylor rules-based and discretionary eras from the data instead of choosing the eras *a priori*. Since our classification of rules-based and discretionary eras is not influenced by economic outcomes, it provides an improved basis for dating rules-based and discretionary eras and, therefore, for evaluating the effects of monetary policy rules versus discretion.[2]

2. Taylor Rule Deviations with Real-Time Data

Taylor (1993) proposed the following monetary policy rule,

$$i_t = \pi_t + \phi(\pi_t - \overline{\pi}) + \gamma y_t + R \qquad (1)$$

where i_t is the target level of the short-term nominal interest rate, π_t is the inflation rate, $\overline{\pi}$ 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,

$$i_t = 1.0 + 1.5\pi_t + 0.5 y_t \qquad (2)$$

[2] We restrict the analysis in this paper to the original Taylor rule. In Nikolsko-Rzhevskyy, Papell, and Prodan (2014), we use structural change, but not Markov switching, methods to compare the original Taylor rule with several modifications.

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 Taylor rule with the above coefficients. A rules-based era would have small deviations while a discretionary era would have large deviations. In our empirical work below, "large" and "small" are determined endogenously in the context of our statistical methods.[3]

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 (2014). 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.[4]

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

[3] When estimating Taylor rules, it is common practice to include the lagged interest rate in order to capture interest rate smoothing. Following Levin, Wieland, and Williams (1999), we applied our methods to the original Taylor rule with a coefficient on the lagged interest rate of unity, but the resultant rule did not distinguish between rules-based and discretionary eras.

[4] Because the shadow rate is based on full-sample estimation of a dynamic term structure model, the Taylor rule deviations after 2008 are not real-time data. We estimated the structural change and Markov switching models with data ending in 2008:Q4, and the results are virtually the same as with the data through 2013:Q4.

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 most 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 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. We focus on the quarters of peak unemployment associated with various recessions, and investigate the congruence between real-time Okun's Law output gaps and real-time output gaps computed with various detrending methods.

The peak unemployment rates associated with the two recessions of the 1970s were 6.0% in 1971:Q4 and 8.9% in 1975:Q2. Using a variety of sources, Nikolsko-Rzhevskyy and Papell (2012) identify natural rates of unemployment of 5.2% in 1971 and 5.5% in 1975 and an Okun's Law coefficient of 3.0 as plausible estimates for the times. Using these numbers, the real-time Okun's Law output gap is for 1972:Q1, (assuming a one-quarter lag before the GDP data was released), is -2.4%. This is close to the output gaps constructed by real-time linear and quadratic detrending, -2.2% and -2.9%, respectively, but higher than the real-time HP filtered gap of 0.0%. For 1975:Q3, the real-time Okun's Law output gap is -10.2%. This is again close to the output gaps constructed by real-time linear and quadratic detrending, -10.8% and -10.4%, respectively, but higher than the real-time HP filtered gap of -5.9%.

A similar pattern is observed for the early 1980s, where the peak unemployment rate associated with the 1980 and 1982 recessions is 10.7% in 1982:Q4. According to the 1983 Economic Report of the President, between 6 and 7 percent of unemployment for 1982 was

[5] The lag reflects the fact that GDP data for a given quarter is not known until after the end of the quarter.

structural, and Gordon (1984) identifies an Okun's Law coefficient of -2.5.[6] Using 6.5% as the natural rate of unemployment, the real-time Okun's Law output gap for 1983:Q1 was -10.5%, higher than the real-time linear, quadratic, and HP gaps of -9.72%, -6.49%, and -4.58%, respectively. As in the 1970s, the Okun's Law gap is closer to the linear and quadratic gaps than to the HP gap.

During the 1970s and early 1980s, the Okun's Law metric does not provide a basis to choose between the real-time linear and quadratic output gaps. More recently, however, real-time linear output gaps fail the rule-of-thumb test. As shown in Figure 1, the gap becomes negative in 1974:Q2 and, with the exception of 1999:Q4 and 2000:Q1, is negative for every quarter in the ensuing 39 years. This is a consequence of the well-known productivity slowdown, where growth rates declined starting in 1973 relative to the period between World War II and 1972. The HP gaps do not fare much better. The gaps for the 1990 and 2001 recessions are almost as large as for the 1980 and 1982 recessions, and the gap is positive in 2011 - 2013. For these reasons, we use real-time quadratic detrending to construct the output gaps for the Taylor rule for the entire sample.

Taylor rule deviations 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 1970s, too high in the early 1980s, and too low in the early-to-mid 2000s. This is consistent with Taylor (1999), who characterized the 1970s and early 1980s as periods of policy mistakes, although he qualified the characterization of the early 1980s as a mistake on the grounds that the high interest rates were necessary to bring down inflation, and Taylor (2007), who argued that the housing boom was caused by too low interest rates in 2002-2006.[7]

[6] The 1983 Economic report of the President was completed in February 1983 and the Preface to Gordon (1984) is dated September 1983, so these are good sources of real-time data for 1983:1.
[7] Our methods do not identify the cause(s) of the deviations which, from Equation (1), are some combination of the coefficients on the inflation and output gaps, the target level of inflation, and the equilibrium real interest rate.

3. Structural Change

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

$$d_t = \gamma_0 + \gamma_1 DU_{1t} + \gamma_2 DU_{2t} + \ldots \gamma_m DU_{mt} + u_t, \tag{3}$$

where d_t are the Taylor rule deviations from Equation (2) 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 $Ft\ (l+1|l)$. For this test the first l breaks are estimated and taken as given. The statistic sup $Ft\ (l+1|l)$ 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 $Ft\ (l+1|l)$ 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).[8]

Using the above test we find three significant breaks in the mean of the Taylor rule deviation and, therefore, four regimes. The results are reported in Table 1 and illustrated in Figure 3. The timing of the breaks occurs 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 (μ_i) in each regime: $\mu_1 = \gamma_0 = 1.47$ for t < 1974:Q3, $\mu_2 = \gamma_0 + \gamma_1 =$ 3.30 for 1974:Q4 < t < 1985:Q1, $\mu_3 = \gamma_0 + \gamma_1 + \gamma_2 = 0.80$ for 1985:Q2 < t < 2000:Q4 and $\mu_4 =$

[8] 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 methodology, which is not needed for this paper.

$\gamma_0 + \gamma_1 + \gamma_2 + \gamma_3$ = 1.97 for 2001:Q1 < t < 2013:Q4. Consequently, starting in 1965:4, monetary policy in the U.S. is characterized by a Taylor rules-based (low deviations) era until 1974:Q3, followed by a discretionary (high deviations) era from 1974:Q4 – 1985:Q1, a rules-based era from 1985:Q2 – 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. 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 (3) in which we assume that there are three structural breaks (four regimes):

$$\gamma_1 + \gamma_2 = 0 \tag{4}$$

and

$$\gamma_2 + \gamma_3 = 0 \tag{5}$$

By imposing these constraints, we restrict the mean of the deviations in the two rules-based eras to be the same ($\mu_1 = \mu_3$) and the two discretionary eras to be the same ($\mu_2 = \mu_4$). In order to test for the existence of structural change, we use the supremum F-test of no structural change (m = 0) against an alternative of m = 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.[9]

The results are reported in Table 2. 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

[9] A code written in the Gauss language is available from Perron and Qu (2006).

previously found when testing for unrestricted changes: 1974:Q3, 1985:Q1 and 2001:Q1.[10] We identify four regimes with the following coefficients: $\mu_1 = \mu_3 = 1.05$ for t < 1974:Q3 and 1985:Q2 < t < 2001:Q1 and $\mu_2 = \mu_4 = 2.58$ for 1974:Q4 < t < 1985:Q1 and 2001:Q2 < t < 2013:Q4. The deviations in the discretionary eras are significantly higher than the deviations in the rules-based eras, 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.

It is often asserted that, because monetary policymaking is forward looking, Taylor rules should be evaluated using forecasted instead of realized variables. We investigate the implications for our results by estimating Bai and Perron models with four-quarter-ahead Greenbook inflation forecasts, which are available from 1973:Q3 – 2007:Q4, complemented by SPF forecasts for 2008:Q1-2013:Q4 for consistency with the other models.[11] The results are reported in Table 3 and depicted in Figure 4. The breaks are 1984:Q3 and 2001:Q1. Because the data starts in 1973:Q3, we cannot identify the start of the 1970s discretionary era. There is a high deviations era through 1984:Q3, a low deviations era from 1984:Q4 – 2001:Q1 and a high deviations era from 2001:Q2- 2013:Q4. The confidence intervals do not overlap. Over the same span of data, the results with forecasted inflation are similar to those with realized inflation.

4. Markov Switching

We proceed to apply the Markov Switching (MS) model of Hamilton (1989) to the Taylor rule deviations series. While a simple two-state MS model allows for a large number of potential regime changes, the dynamics is limited to only the two regimes as the economy switches back and forth between them.

As before, d_t denotes the absolute deviation of the funds rate from the 1993 Taylor rule. The model postulates the existence of an unobserved variable (s_t) that takes on two values, 1 and

[10] Because the break dates in Table 2 are almost identical to those in Table 1, they are also depicted by Figure 3.
[11] While one-quarter-ahead inflation forecasts are available earlier, one-quarter inflation (realized or forecasted) is much noisier than the annualized inflation rates normally used to estimate Taylor rules.

2, and characterizes the "state" (or regime) that the policy is in at time t. When $s_t = 1$, the Taylor rule deviation d_t is assumed to be distributed $N(\mu_1, \sigma_1^2)$, whereas when $s_t = 2$, d_t is assumed to be distributed $N(\mu_2, \sigma_2^2)$. If $\mu_1 < \mu_2$, we say that in regime 1 the Fed was running a rules-based monetary policy, while in regime 2 the policy was discretionary. Thus the model postulates that:

$$d_t = \mu_{St} + \varepsilon_{St} \tag{6}$$

where the unobserved state variable (s_t) is governed by the following transition probabilities:

$$\Pr[s_t = 1 | s_{t-1} = 1] = p_{11} \tag{7}$$

$$\Pr[s_t = 2 | s_{t-1} = 2] = p_{22} \tag{8}$$

Large values of p_{ss} generate inertia, resulting in persistent monetary policy regimes. The parameter vector $\theta = \{\mu_1, \mu_2, \sigma_1, \sigma_2$, and $p_{11}, p_{22}\}$ can be estimated by maximum likelihood using the procedure described in Hamilton (1989). The results are available in Table 4 with the state distribution presented in Figure 5.

The algorithm identifies two separate persistent regimes with the estimated probabilities p_{11}=0.94 and p_{22}=0.95. As with the tests for structural change, the results are economically as well as statistically significant. The size of the deviations is more than three times as large in the discretionary eras (μ_2=2.78) than in the rules-based eras (μ_1=0.78), with the difference between the regimes being highly significant.[12] If we look at the estimated state distribution, most of the regime dates are close to those found with tests for structural change. The first Taylor rules-based (S=1, low deviations, small μ) era ends in 1974:Q3, followed by a discretionary (S=2, high deviations, large μ) era from 1974:Q4 – 1986:Q1, a rules-based era from 1986:Q2 – 2001:Q1, and another discretionary era from 2001:Q2 to 2006:Q2.

The Markov switching methods identify several regime switches that are not found with the structural change tests. There is an additional discretionary era from 1965:Q4 – 1968:Q4 and four regime switches between 2006:Q3 and 2011:Q2. The results support characterizing the

[12] The t-statistic for a test that $\mu_1 = \mu_2$ is 13.70, so the hypothesis that the two coefficients are the same can be rejected at the 1 percent level.

period since 2001 as a discretionary era, as 37 quarters are in high deviations regimes and 15 quarters are in low deviations regimes.[13]

According to Figure 5, the division between rules-based and discretionary eras occurs when the Taylor rule deviations equal two percentage points, as almost all of the rules-based eras are when the deviations are below two percent and almost all of the discretionary eras are when the deviations are above two percent. While not an exact metric, it provides a useful benchmark for dividing policy between the eras.

The Markov switching model described above chooses regimes based on switches in both the mean and variance of the Taylor rule deviations. Sims and Zha (2006) and Liu, Waggoner, and Zha (2011) investigate regime switches in U.S. monetary policy and find that their best fitting models do not allow for changes in the inflation target or the coefficients of either the policy rule or the private sector equations, but only in the variances of the structural disturbances. While they estimate changes in monetary policy reaction functions while we estimate changes in Taylor rule deviations based on a Taylor rule with postulated coefficients, their results suggest that it is worth investigating whether our results for Taylor rule deviations are driven by changes in the mean, the variance, or both.

We estimate two additional versions of the Markov switching model. The first allows the mean, but not the variance, to switch between the states. This corresponds to the specification of the structural change model, where the breaks are determined solely by the change in the mean of the Taylor rule deviations. The results are reported in Table 5 with the state distribution depicted in Figure 6. Although the correspondence is not exact, the results are broadly consistent with those of the model where both the mean and variance of the Taylor rule deviations are allowed to switch between states, and it is clear that the results from that model are not driven solely by changes in the variance.

The second additional version of the Markov switching model allows both the mean and the variance of the Taylor rule deviations to switch between states, but does not constrain the dates of the mean and variance switches to be the same. The results are reported in Table 6 with the state distribution for the mean and variance illustrated in Figure 7. The state distribution for the mean is broadly consistent with the state distributions of the model where both the mean and

[13] We also estimated Markov switching models with forecasted inflation. Over the same span of data, the results with forecasted inflation are similar to those with realized inflation.

variance of the Taylor rule deviations are allowed to switch between states and the model where only the mean is allowed to switch, although the correspondence is again not exact. The state distribution for the variance, in contrast, is very different than any of the state distributions for the mean. It is clear that the division between Taylor rule-based and discretionary eras is driven by changes in the mean, not the variance, of the Taylor rule deviations.[14]

5. Historical Perspective on our Statistical Results

Using narrative methods, Taylor (2012a) follows Meltzer (2011) in calling 1985 to 2003 a rules-based era and 2003 – 2012 an ad hoc era. The 1985 start of the rules-based era exactly corresponds to our results with tests for structural change and closely corresponds to our results with Markov switching. The 2003 start of Meltzer's and Taylor's ad hoc eras, however, is two years later than the start of our discretionary era (using both methods). Figure 2 provides visual, as well as statistical, support for dating the start of the ad hoc era in 2001 instead of 2003. While it is clear that the large divergence started in 2003, the actual federal funds rate was below the prescribed rate from 2001 onwards.

Visual support for dating the start of the ad hoc era in 2001 instead of 2003 is also provided in Figure 8, which depicts the actual federal funds rate and the rate prescribed by the Taylor rule from 1996 to 2006 using real-time CPI inflation and Greenbook output gaps. This figure was introduced by Poole (2007) and reproduced in Taylor (2012a), who used it to justify dating the start of the ad hoc era in 2003.[15] While it is again clear that the large divergence started in 2003, the actual federal funds rate was below the prescribed rate from 2000 onwards.

According to our Markov switching models, there is a rules-based era from 2006:Q3 – 2007:Q4. Taylor (2007) depicts the actual federal funds rate and an alternative path where the federal funds rate follows a Taylor rule with the coefficients in Equation (2), but smoothed to have 25 basis point increment adjustments.[16] The actual and alternative paths depart in 2002:Q2 and merge again in 2006:Q3. This is exactly in accord with our results, where the short-lived rules-based era starts in 2006:Q3.

[14] Another version of the Markov switching model would allow the deviations d_t in Equation (6) to depend on lagged deviations d_{t-1}. In that specification, rules-based and discretionary eras would be also defined by the change in the deviations, which is not in accord with the Taylor rule.

[15] The only difference between our figure and the figure in Poole (2007) is that Poole used Congressional Budget Office real-time output gap data starting in 2000:11 because the Greenbook data wasn't publicly available, while we use Greenbook data throughout.

[16] Taylor (2007) reports that using the unsmoothed path in Poole (2007) gives similar results.

The Markov switching models also identify a discretionary era from 1965:Q4 (when the real-time data begins) through 1968:Q4. Narrative support for this statistical result is contained in Taylor (2012b), who argues that while the economic policies of the Kennedy and Johnson administrations (except for the income tax cut of 1964) were "of the temporary, targeted variety", policies of the Nixon administration through mid-1971 followed steadier, long-term, and more predictable precepts. This ended on August 15, 1971, when Nixon imposed wage and price controls, and the interventionist policies continued through the Ford and Carter administrations. This is in accord with the results of our Markov switching models, where a rules-based era first replaced a discretionary era in 1969:Q1, exactly coinciding with the start of the Nixon administration. Our methods, however, do not date the end of the rules-based era until 1974:Q3

6. "Monetary Policy Rules Work and Discretion Doesn't"

While the objective of this paper has been to identify (Taylor) rules-based and discretionary eras solely from the data, the motivation for conducting the research stems from the belief in the superiority of rules-based to discretionary policymaking. We proceed to evaluate Taylor's assertion that "monetary policy rules work and discretion doesn't" by comparing economic performance between our estimated rules-based and discretionary eras.

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 three 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 accounts for neither the preference for low inflation over low inflation nor 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. Finally, 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.[17]

We compute loss functions for our (Taylor) rules-based and discretionary eras, with the eras determined by structural change and Markov switching methods. We use Bai and Perron tests for multiple structural changes and the Markov switching model with switching mean and variance, and so the eras are depicted in Figures 3 and 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 loss functions are reported in Table 7. For all six cases, defined by two methods and three loss functions, the loss during discretionary eras is higher than the loss during rules-based eras. For the linear absolute loss function, the average loss during the discretionary eras is about 1.5 percentage points higher than the average loss during the rules-based eras. The average loss differential is higher for the Okun misery index, but that loss function does not incorporate the natural rate of unemployment or a non-zero inflation target. With the quadratic loss function, the average loss during discretionary eras is 2.5 times the average loss during (Taylor) rules-based eras for the Markov switching model and over 3.0 times the average loss during (Taylor) rules-based eras for the structural change model.

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. The results, reported in Table 7, show that the average loss during discretionary eras is higher than the average loss during Taylor

[17] The quadratic loss function is identical to the loss function in Hall and Taylor (1997) except that they set target inflation equal to zero. Woodford (2003) discusses the theoretical advantages of quadratic loss functions.

rules-based eras regardless of whether higher weight is placed on inflation or unemployment loss. Finally, we consider a quadratic loss function where all of the weight is placed on inflation loss. The result that the average loss during discretionary eras is higher than the average loss during Taylor rules-based eras is even robust to this extreme loss function.

One reaction to these results is that there is a reverse-causality problem. While deviating from a rule can cause bad economic outcomes, bad economic outcomes can also lead monetary policy to deviate from a simple rule. Two examples that are often cited are the early 1980s, where interest rates were raised above those implied by the Taylor rule in order to bring down inflation, and the post-2008 period, where monetary policy was arguably more stimulative than implied by the Taylor rule because financial instability lowered equilibrium real interest rates. We investigate whether our results are driven by these periods by calculating loss functions that delete either 1980:Q4-1985:Q1 and/or 2009Q1-2013:Q4 from the discretionary periods. The dates for the Volcker disinflation period were chosen by the periods for which the federal funds rate was more than two percentage points above the rate implied by the Taylor rule. The post-2008 period is when we use the shadow federal funds rate to calculate the Taylor rule deviations.

The results are reported in Table 8. The first column reports the loss ratio, the average loss during discretionary eras divided by the average loss during rules-based eras, for the full sample. This is simply the second column divided by the first column of Table 7, and is greater than one for all loss functions with eras calculated by either Markov switching or structural change methods. The second column depicts the loss ratio for the sample which deletes the Volcker disinflation period. While all of the loss ratios decrease, reflecting the combination of high inflation and high unemployment during that period, they are all above one. The third column deletes the post-2008 period. Comparing the first and third columns, 11 of the 12 loss ratios increase when the post-2008 observations are deleted, and all of the loss ratios are above one. The fourth column deletes both the Volcker disinflation and post-2008 observations and all of the loss ratios are above one. The result that economic performance is better in rules-based than discretionary eras is robust to deleting either the Volcker disinflation and/or the post-2008 periods.

7. Conclusions

The superiority of rules versus discretion has been a recurring theme for the conduct of monetary policy for over 30 years. During the past 20 years, the most common metric for monetary policy evaluation has been the Taylor rule where, in its original form, the prescribed federal funds interest rate is equal to 1.0 plus 1.5 times the inflation rate plus 0.5 times the output gap. Periods in which the federal funds rate adhered relatively closely to the Taylor rule prescribed rate, notably the mid-1980s and the 1990s, are often associated with good economic outcomes while periods in which the federal funds rate was further removed from the Taylor rule prescribed rate, notably the 1970s and (more controversially) the early-to-mid 2000s, are often associated with bad economic outcomes.

The purpose of this paper is to identify (Taylor) rules-based and discretionary eras from the data rather than choosing them *a priori*. Choosing the dates of the eras endogenously is important because, if they are picked exogenously, there is always the possibility that knowledge of subsequent economic outcomes will influence the choice of the dates. We define Taylor rules-based and discretionary eras by smaller and larger Taylor rule deviations, the absolute value of the difference between the actual federal funds rate and the federal funds rate prescribed by the original Taylor rule, and use tests for multiple structural changes and Markov switching models to identify the eras.

Monetary policy in the U.S. is characterized by a Taylor rules-based (low deviations) era until 1974, a discretionary (high deviations) era from 1974 to about 1985, a rules-based era from about 1985 to 2000, and a discretionary era from 2001 to 2013. The Taylor rule deviations are about three times as large in the discretionary eras than in the rules-based eras and are almost four times larger in the most discretionary era (1974 to 1984) than in the least discretionary era (1985 to 2000). These results are very similar between the two methods. With the Markov switching models, we also identify a discretionary era from 1965 to 1968. The discretionary and rules-based eras closely correspond to periods where the Taylor rule deviations are above and below two percent.

These results both accord with and reinforce previous work that identifies monetary policy eras less formally. Meltzer (2011) and Taylor (2012a) call 1985 to 2003 a rules-based era and 2003 – 2012 an ad hoc era, Taylor (2007) emphasizes the large Taylor rule deviations from 2002 to 2006, Poole (2007) depicts Taylor rule deviations starting in 2001, and Taylor (2012b) discusses the transition from discretionary policymaking during the Kennedy and Johnson administrations through 1968 to more rules-based policymaking at the start of the Nixon administration in 1969.

Using three loss functions involving inflation and unemployment: Okun's misery index, a linear absolute loss function, and a quadratic loss function, we show that economic performance is uniformly better in (Taylor) rules-based eras than in discretionary eras. The results are robust to specifications that put greater weight on either inflation or unemployment loss and to deleting either the Volcker disinflation and/or the post-2008 periods from the discretionary eras. In contrast to previous work, our results are not subject to the criticism that the choice of eras was influenced by subsequent outcomes. They therefore provide a better basis to argue that "monetary policy rules work and discretion doesn't." [18]

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[18] Taylor (2012a), page 1017.

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Table 1. Tests for Multiple Structural Changes

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

SupF test (sequential method)	Critical values (1%)	Break dates	Coefficients	95% Confidence Intervals
			$\gamma_0 = 1.468$	
SupF(3| 2) = 50.74*	12.29	1974:Q3	$\gamma_1 = 1.835$	1972:Q3 - 1975:Q2
SupF(1| 0) = 32.63*	13.89	1985:Q1	$\gamma_2 = -2.506$	1984:Q4 - 1986:Q2
SupF(2| 1) = 53.27*	14.80	2000:Q4	$\gamma_3 = 1.174$	1999:Q2 - 2001:Q2

Table 2. Tests for Multiple Restricted Structural Changes

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

SupF test	Critical value (1%)	Break dates	Coefficients	95% Confidence Intervals
85.46*	17.17		$\gamma_0 = 1.075$	
		1974:Q3	$\gamma_1 = 1.531$	1971:Q1 - 1975:Q3
		1985:Q1	$\gamma_2 = -1.531$	1984:Q4 - 1988:Q3
		2001:Q1	$\gamma_3 = 1.531$	1999:Q1 - 2001:Q3

Table 3. Tests for Multiple Structural Changes with Inflation Forecasts

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

SupF test (sequential method)	Critical values (1%)	Break dates	Coefficients	95% Confidence Intervals
			$\gamma_0 = 3.182$	
SupF(1| 0) = 53.17*	12.29	1984:Q3	$\gamma_1 = -2.363$	1983:Q2 - 1986:Q4
SupF(2| 1) = 42.36*	13.89	2001:Q1	$\gamma_2 = 0.893$	1998:Q2 - 2002:Q1

Note: These tests use Greenbook inflation forecasts from 1973:Q3 – 2007:Q4.

Table 4. Markov Switching Model: Switching Mean and Variance

	State s=1 (Rule-based policy)	State s=2 (Discretion)
μ_s	0.781 (0.070)	2.779 (0.137)
σ_s	0.548 (0.052)	1.177 (0.089)
p_{ss}	0.942 (0.026)	0.952 (0.024)

Table 5. Markov Switching Model: Switching Mean, Constant Variance

	State s=1 (Rule-based policy)	State s=2 (Discretion)
μ_s	1.050 (0.103)	3.202 (0.175)
σ_s	0.896 (0.051)	
p_{ss}	0.916 (0.043)	0.957 (0.021)

Table 6. Markov Switching Model: Switching Mean and Independently Switching Variance

	State s=1 (Rule-based policy)	State s=2 (Discretion)
μ_s	0.786 (0.069)	2.492 (0.089)
σ_s	0.598 (0.039)	2.089 (0.350)
p^{mean}_{ss}	0.985 (0.203)	0.906 (0.303)
p^{var}_{ss}	0.946 (0.161)	0.942 (0.155)

Table 7. Loss Functions for the Policy Rules

	Average Loss During Rules-Based Eras	Average Loss During Discretionary Eras
Misery Index L = Inflation + Unemployment		
Markov Switching	8.74	10.83
Structural Change	8.50	11.16
Linear Absolute Loss Function L = |Inflation - 2%| + |Unemployment - Natural Rate|		
Markov Switching	2.37	3.87
Structural Change	2.31	3.98
Quadratic Loss Function L = $(\text{Inflation} - 2\%)^2 + (\text{Unemployment} - \text{Natural Rate})^2$		
Markov Switching	5.91	14.86
Structural Change	5.06	16.07
Quadratic Loss Function L =$3/2*(\text{Inflation} - 2\%)^2 + 1/2*(\text{Unemployment} - \text{Natural Rate})^2$		
Markov Switching	6.57	18.96
Structural Change	6.19	19.78
Quadratic Loss Function L = $1/2*(\text{Inflation} - 2\%)^2 + 3/2*(\text{Unemployment} - \text{Natural Rate})^2$		
Markov Switching	5.25	10.76
Structural Change	3.93	12.36
Quadratic Loss Function L = $(\text{Inflation} - 2\%)^2$		
Markov Switching	3.62	11.53
Structural Change	3.66	11.75

Table 8. Loss Ratios between Discretionary Eras and Rules-Based Eras

	Full Sample (1)	Volcker Disinflation Period Deleted (2)	Post-2008 Period Deleted (3)	Volcker Disinflation and Post-2008 Period Deleted (4)
Panel A: Misery Index L = Inflation + Unemployment				
Markov Switching	1.24	1.15	1.28	1.18
Structural Change	1.31	1.23	1.35	1.25
Panel B: Linear Absolute Loss Function L = |Inflation - 2%| + |Unemployment - Natural Rate|				
Markov Switching	1.63	1.42	1.89	1.63
Structural Change	1.73	1.51	1.74	1.46
Panel C: Quadratic Loss Function L = (Inflation - 2%)^2 + (Unemployment - Natural Rate)^2				
Markov Switching	2.51	2.09	3.36	2.79
Structural Change	3.18	2.72	3.41	2.85
Panel D: Quadratic Loss Function L = 3/2*(Inflation - 2%)^2 + 1/2*(Unemployment - Natural Rate)^2				
Markov Switching	2.89	2.44	3.41	2.94
Structural Change	3.20	2.73	3.78	3.34
Panel E: Quadratic Loss Function L =1/2*Inflation - 2%)^2 + 3/2*(Unemployment - Natural Rate)^2				
Markov Switching	2.05	1.65	3.25	2.51
Structural Change	3.15	2.69	2.81	2.08
Panel F: Quadratic Loss Function L = (Inflation - 2%)^2				
Markov Switching	3.19	2.72	3.45	3.04
Structural Change	3.21	2.75	4.04	3.68

Note: The loss ratios (the average loss during discretionary eras divided by the average loss during rules-based eras) are computed after deleting the 1980:Q4-1985:Q1 period from the full sample in Column 2, deleting the 2009Q1-2013:Q4 period in Column 3 and deleting both periods in Column 4.

Figure 1. Real-time Output Gaps using Linear, Quadratic, and Hodrick-Prescott Detrending

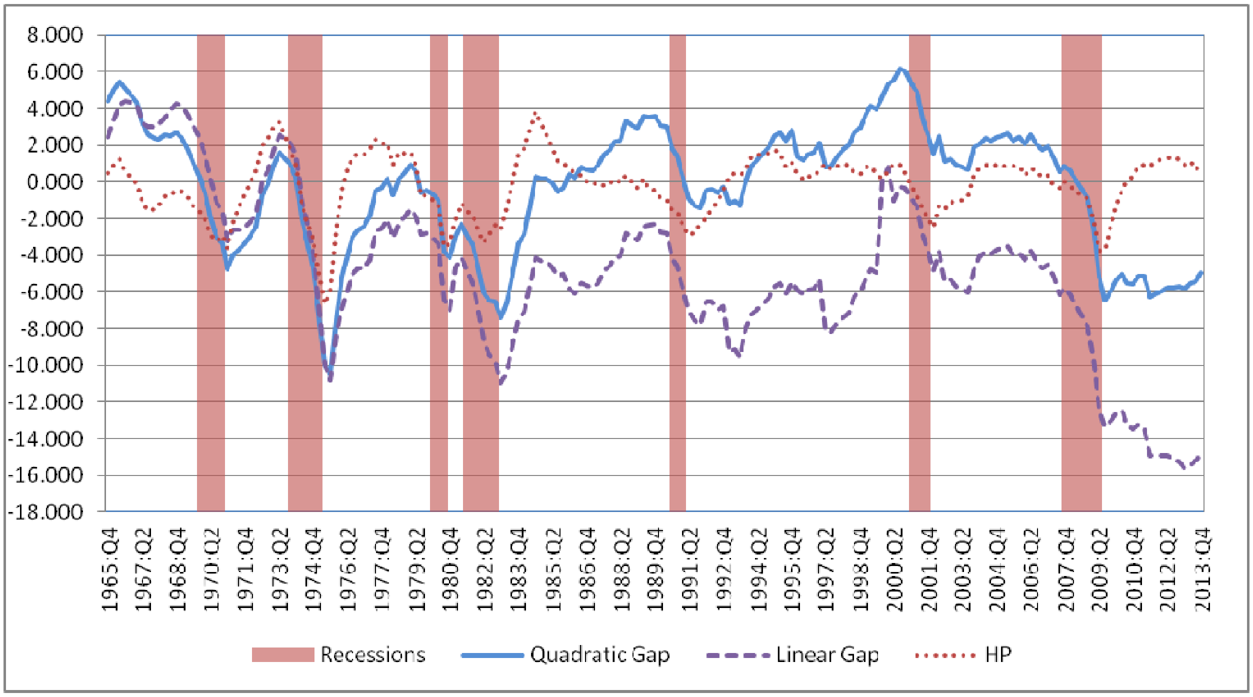
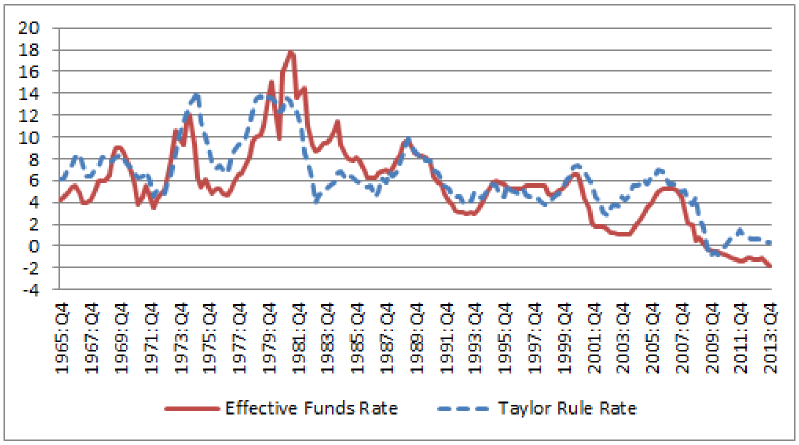
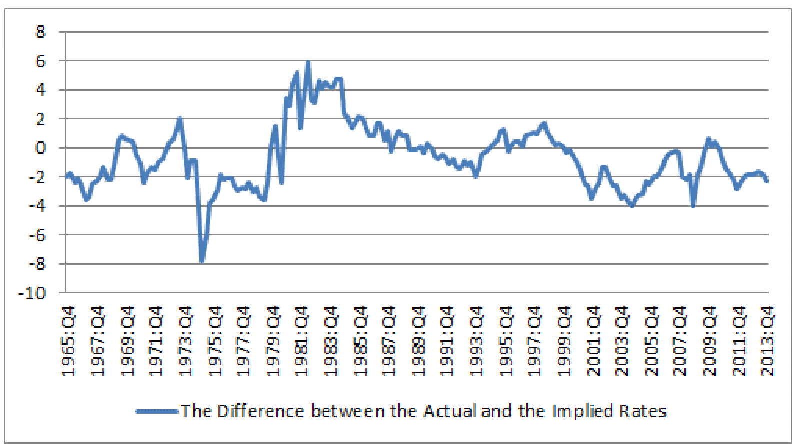


Figure 2. Deviations from the Taylor Rule

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 Taylor Rule

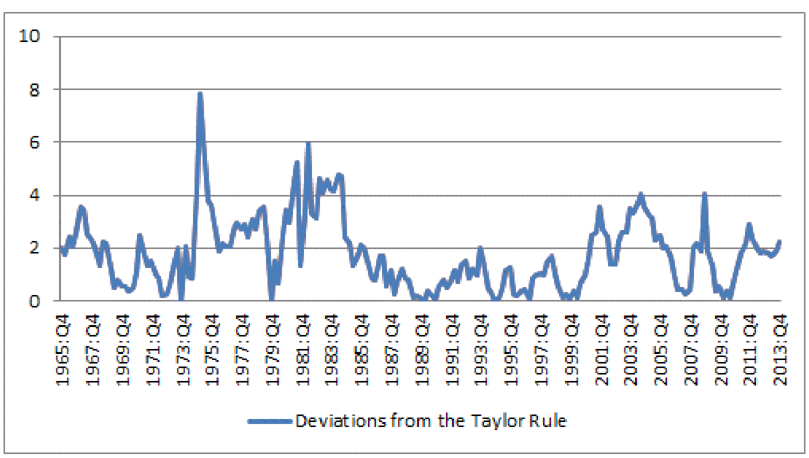


Figure 3. Structural Change Tests for Taylor Rule Deviations

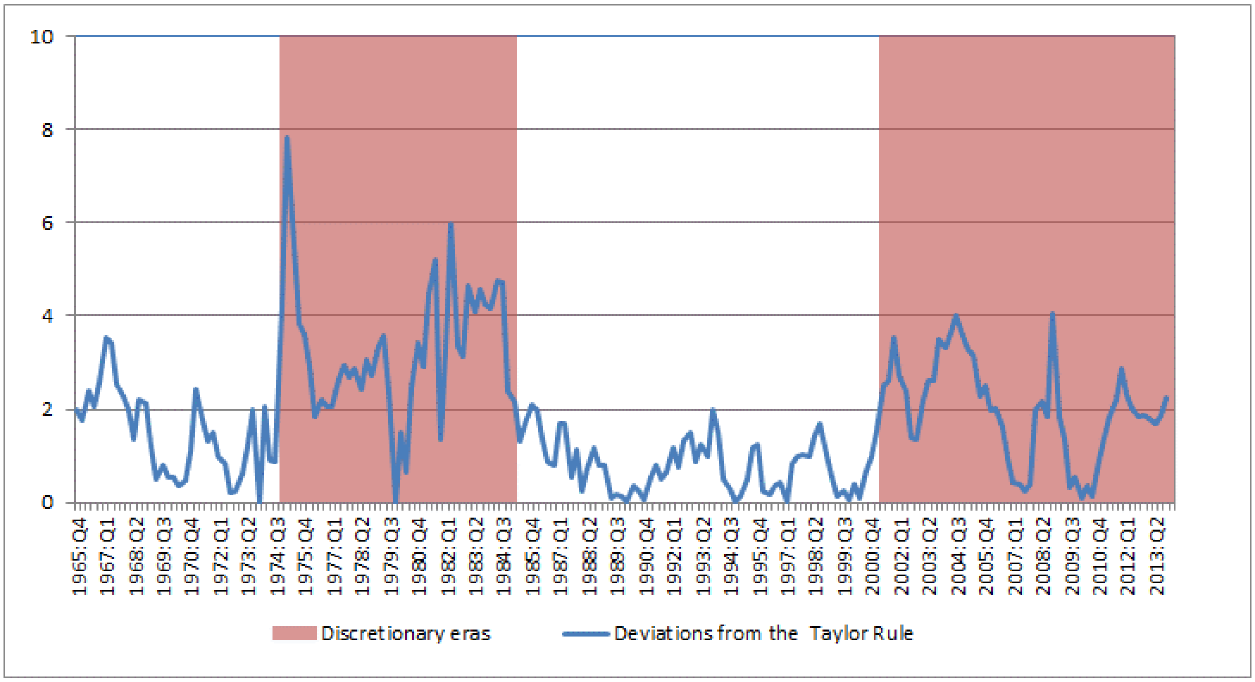


Figure 4. Structural Change Tests with Four-Quarter-Ahead Greenbook Inflation Forecasts

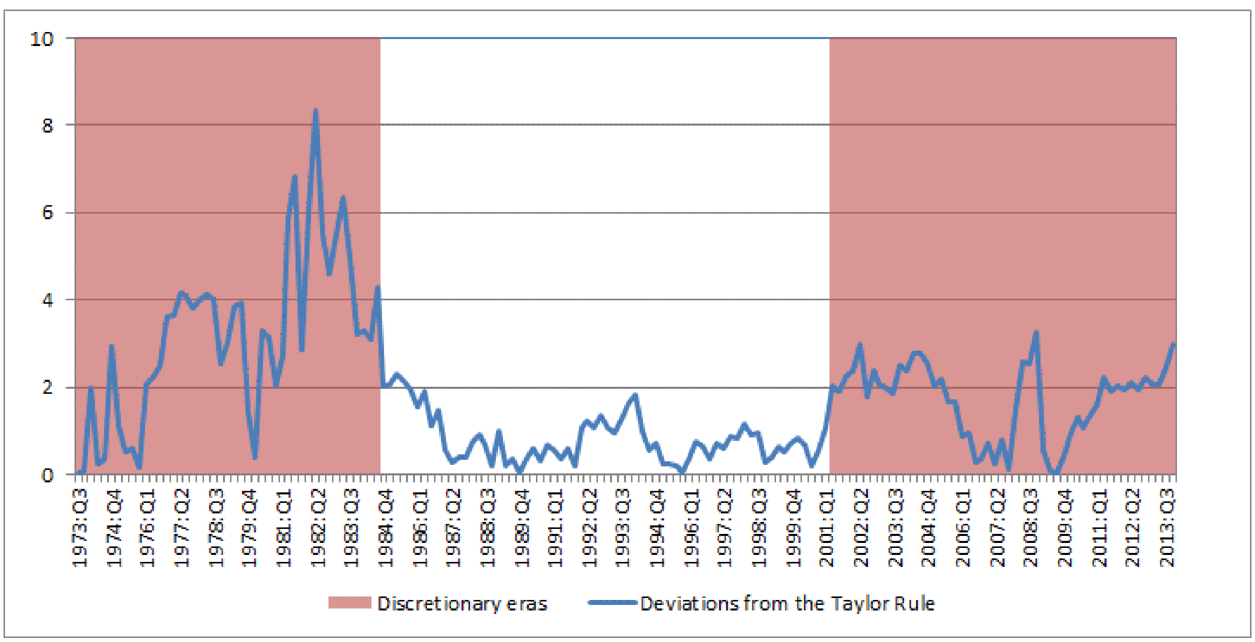


Figure 5. Markov Switching Model: Switching Mean and Variance

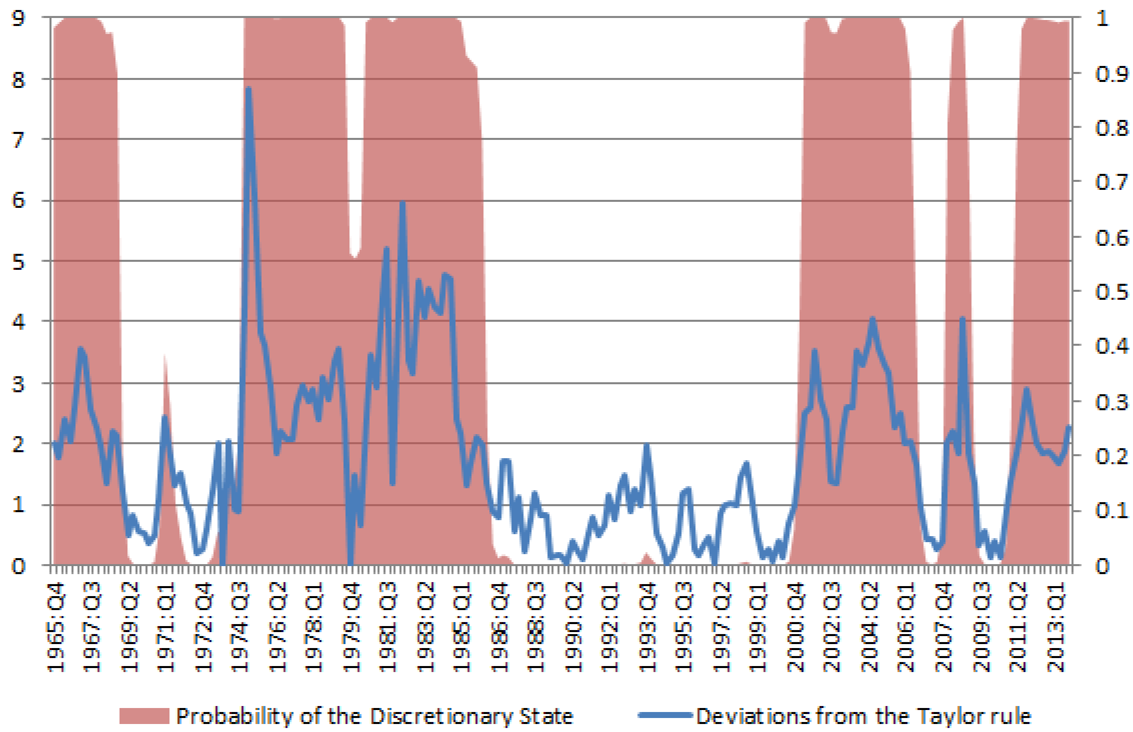


Figure 6. Markov Switching Model: Switching Mean, Constant Variance

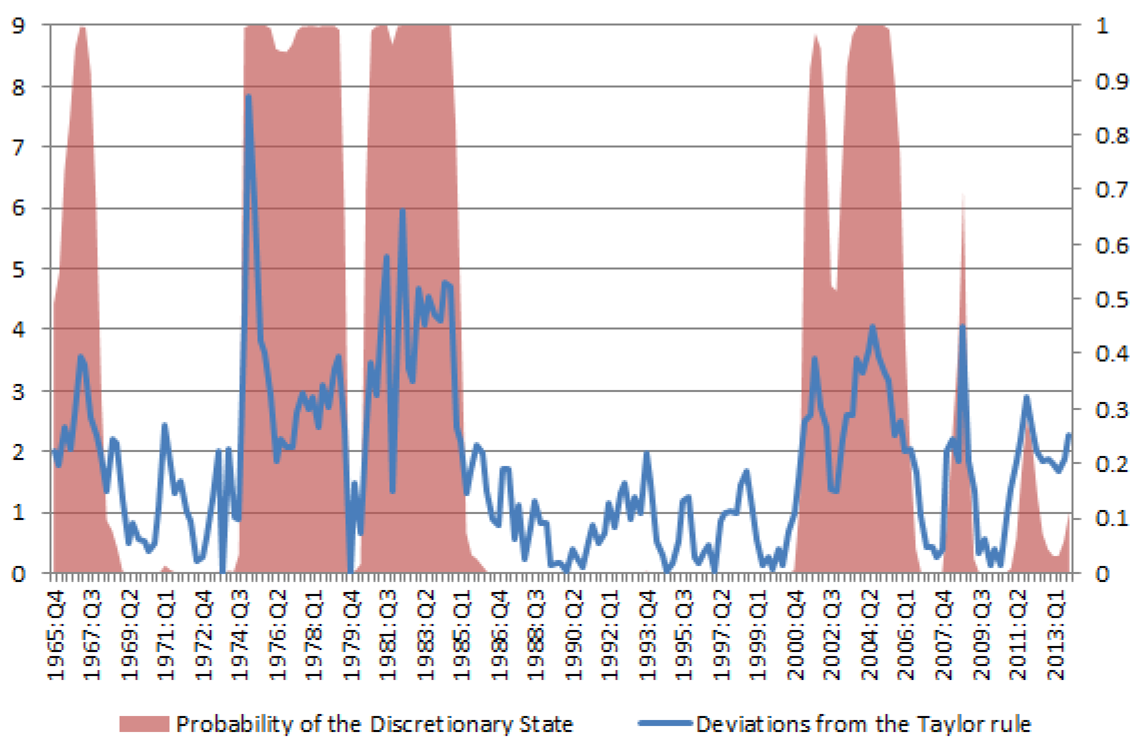


Figure 7. Markov Switching Model: Independently Switching Mean and Variance

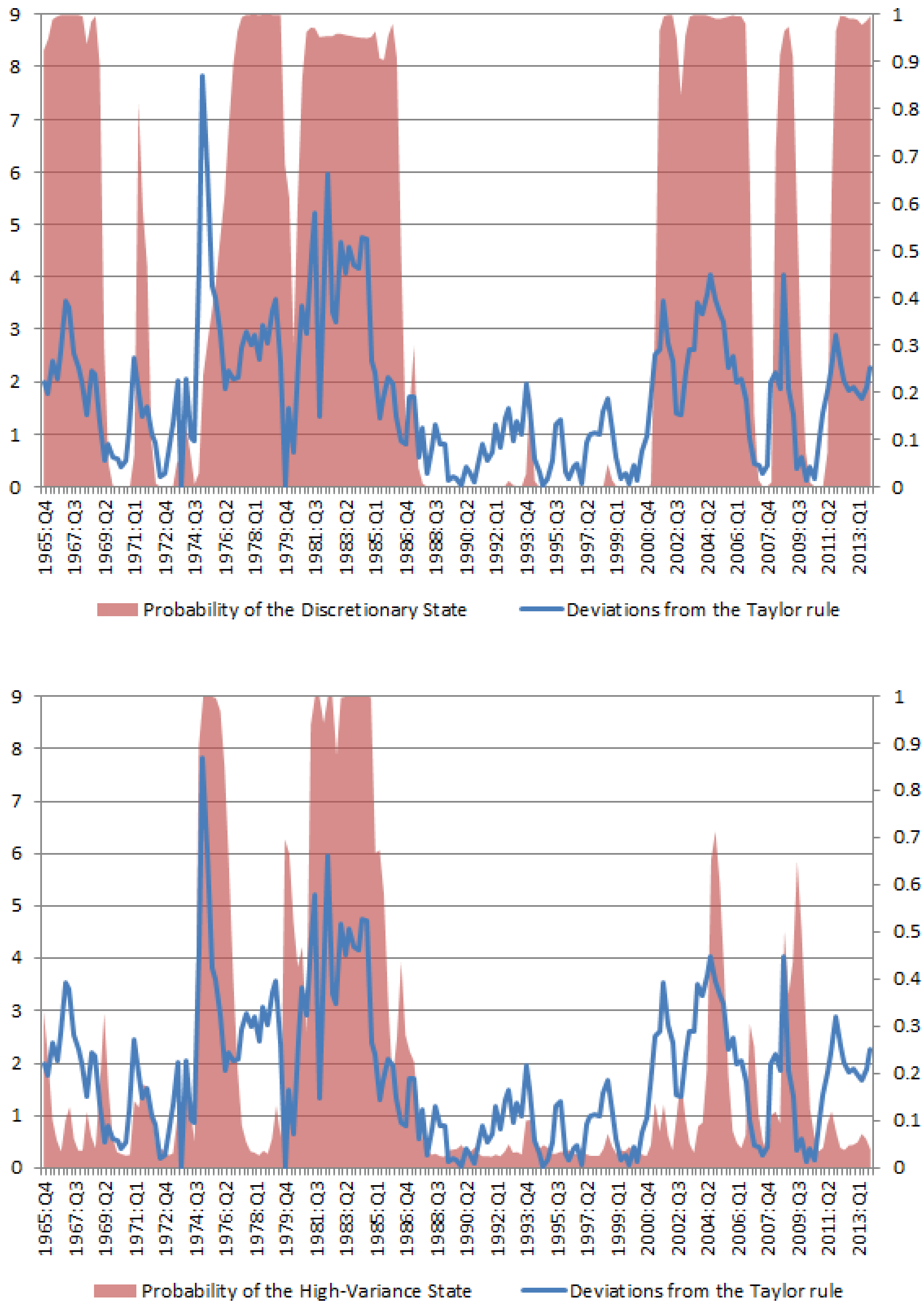


Figure 8. Actual and Prescribed Rates from 1996 to 2006 using Greenbook Output Gaps

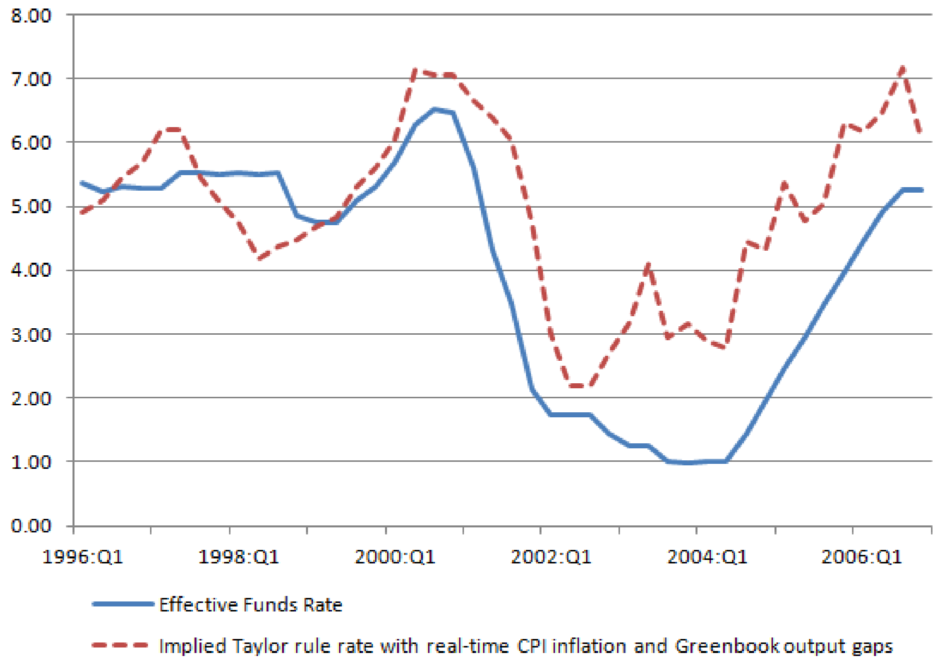


Figure 9. Inflation and Unemployment