The Taylor Principle, Interest Rate Smoothing and Fed Policy in the 1970s and 1980s*

Yash Mehra**
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Abstract

Using a real time estimate of the output gap, this article estimates Taylor-type policy rules that predict the actual behavior of the funds rate during two sample periods, 1968Q1 to 1979Q2 and 1979Q3 to 1987Q4. The inflation rate response coefficient is close to unity over the first sub period and well above unity over the second, suggesting Fed policy violated the Taylor principle during the first period. The adjustment of the funds rate in response to fundamentals is not as rapid during the first period as it is during the second. Together these results support the conventional view that the Fed was "too timid" and "too sluggish" during the late 1960s and the 1970s. Though the Fed smoothes interest rates, the degree of smoothing exhibited is far less than what was previously estimated. The funds rate response to its fundamentals is complete within one year during the first period and within one quarter during the second.

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** Federal Reserve Bank of Richmond, Yash.Mehra@rich.frb.org

1. Introduction

During the late 1960s and 1970s inflation steadily increased, whereas during the early 1980s inflation declined. This contrast in the inflation performance of the U.S. economy has sparked interest in identifying the nature of monetary policy pursued by the Federal Reserve. One widely held view is that monetary policy has been broadly consistent with Taylor-type policy rules in which the funds rate target responds to actual or expected inflation and the level of the output gap. A key coefficient in these estimated policy rules is the inflation response coefficient, which measures the long-term response of the funds rate to the inflation rate. Taylor (1999a) and Clarida, Gali and Gertler (2000) provide evidence that indicates the inflation response coefficient was below unity during the late 1960s and 1970s, whereas it was well above unity during the early 1980s. This empirical result implies that the Fed did not respond aggressively to inflation during the first period, whereas it did during the second period. This explanation of the poor inflation performance of the U.S. economy in the 1970s relative to the 1980s has received further support from recent research on monetary policy rules. That research indicates the inflation response coefficient in feedback policy rules must be set well above unity in order to avoid undesirable economic outcomes (Taylor 1999b). This requirement is often referred to as the Taylor principle.[1]

The evidence discussed above in Taylor (1999a) and Clarida et al. (2000) that actual Fed policy may have violated the Taylor principle during the late 1960s and 1970s is based on policy rules that are estimated using revised data. As documented recently in Orphanides (1999) and Orphanides and Norden (1999), estimates of inflation and, in particular, of output gap levels have been substantially revised over time. Hence, policy prescriptions based on real-time estimates of the variables used in policy rules may differ substantially from those derived using later estimates, making inferences about the nature of actual policy suspect. In that context, taking the baseline Taylor rule originally proposed in Taylor (1993) and using real-time estimates of output gaps prepared by the Council of Economic Advisors, Orphanides (2000) shows that the funds rate settings that

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[1] Taylor (1999b) highlights the connection between the size of the inflation response coefficient and inflation stability. McCallum (2001) points out monetary policy rules that violate the Taylor principle may result in multiple, though stable, solutions that are of an undesirable economic nature.

would have been suggested by the baseline Taylor rule during the 1970s do not greatly differ from actual policy during that period.[2] Since the inflation response coefficient in the baseline Taylor rule is above unity, this finding raises serious doubts about the stabilization properties of the policy rules that satisfy the Taylor principle.

In this article, I reexamine the nature of actual Fed policy during the 1970s and 1980s. In particular, I estimate Taylor-type policy rules using real-time data and then investigate how well estimated rules predict the actual path of the funds rate and whether or not they satisfy the Taylor principle. This exercise differs from the one in Orphanides (2000), where it is assumed that the policy rule followed during the 1970s is in fact the baseline Taylor rule. Since the baseline Taylor rule that is used is not estimated from data, it is difficult to know how robust results are to small departures in the magnitudes of inflation and output gap coefficients assumed in this rule.

Orphanides (2000) uses estimates of output gaps prepared by the Council of Economic Advisors (CEA) and asserts them as the "official" series used by the Fed. This assertion has been questioned. Taylor (2000) argues that the Council's estimates of potential GDP were politicized as early as the late 1960s and hence were ignored by contemporary economists such as Arthur Burns and Alan Greenspan. Taylor also argues that real-time output gaps derived from the Council's estimates (e.g., -15 percent in 1975) are too pessimistic. In this article, I use alternative real-time estimates of output gaps generated using a simple linear trend fitted to actual historical data on output. I use a linear trend because most economists then believed macroeconomic time series possessed deterministic time trends during the 1960s and early 1970s. The alternative real-time output gaps are pessimistic, but not as much as those in Orphanides (2000).

The baseline Taylor rule used in Orphanides (2000) assumes that the Fed responds to a smoothed inflation rate and adjusts the funds rate in response to changes in fundamentals without any delay. In particular, the baseline Taylor rule does not assume the presence of partial adjustment, implying that the Fed does not smooth short-run changes in interest rates. This feature of the baseline Taylor rule is in sharp contrast to the

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[2] The baseline Taylor rule makes the assumptions that the inflation response coefficient is 1.5, the output response coefficient is .5, the real rate of interest is 2 percent, and the Fed's inflation target is 2 percent.

evidence in previous empirical work that indicates the presence of considerable interest rate smoothing in Fed behavior (Clarida et. al. 2000). But the empirical evidence in previous work is based on policy rules that are estimated using revised data. Hence, I investigate whether the degree of monetary policy inertia exhibited in previous work is robust to the use of real-time data.

The empirical work in this article considers Taylor-type policy rules and focuses on explaining the actual behavior of the funds rate during two sample periods, 1968Q1 to 1979Q2 and 1979Q3 to 1987Q4.[3] This empirical work suggests the following observations. First, Taylor-type policy rules based on alternative real-time output gaps are consistent with the actual funds rate settings during these two periods. In the first period, the actual funds rate settings are predicted well by an estimated Taylor rule in which the funds rate responds to the lagged inflation rate and the output gap. In the second period, the actual funds rate settings are predicted well by a *modified* Taylor rule in which the funds rate responds to the bond rate, in addition to responding to the lagged inflation rate and the output gap.

Second, the inflation and output response coefficients in these estimated policy rules have correct signs and are generally significant. The inflation response coefficient is well above unity during the second period, but not during the first. This result means that actual Fed policy violated the Taylor principle during the first period, a contrast to the result in Orphanides (2000), where actual Fed policy is shown to be consistent with the baseline Taylor rule that satisfies the Taylor principle, but uses estimates of output gaps prepared by the Council of Economic Advisors. Together these results indicate that Orphanides' (2000) conclusion that actual Fed policy did not violate the Taylor principle is not robust to the use of an alternative estimate of output gaps. The results here also indicate that policy was "preemptive" during the second period as the Fed responded to the bond rate in an attempt to establish credibility.[4]

Third, the policy rules estimated here are consistent with the presence of interest rate smoothing in Fed behavior during the first period, but not during the second. The results here indicate that the Fed adjusted the funds rate to its desired level within one

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[3] The first period is close to one studied by Orphanides (2000). The second period spans Paul Volcker's term as Fed Chairman.

year during the first period and within one quarter during the second. The extent of monetary policy inertia estimated is far less than what was reported in previous empirical work. Together the results above indicate that the Fed was "too timid" and "too sluggish" during the first period.

The plan of this article is as follows. Section 2 describes the policy rules and real-time data used in estimation and section 3 presents the empirical results. Concluding observations are given in section 4.

2. The Model and the Method

2.1. Conventional and Modified Taylor Rules

The conventional Taylor rule studied here can be derived using the following equations.

$$FR_t^* = a_0 + a_1(INFL_{t-1} - INFL^*) + a_2 GAP_{t-1}; \qquad (1)$$

$$FR_t = r\,FR_{t-1} + (1-r)FR_t^* + v_t; \quad 0 \leq r \leq 1; \qquad (2)$$

where *FR* is the actual funds rate; *FR** is the Fed's funds rate target for period t; *INFL* is actual inflation; *INFL** is the Fed's inflation target; *GAP* is the level of the output gap; and *v* is the disturbance term. The policy rule in (1) specifies the economic determinants of the funds rate target. It is assumed that the Fed has a target for inflation and a target for the level of output. The Fed raises its funds rate target if past inflation and output are high relative to their respective target levels. Equation (2) specifies the actual funds rate as a weighted average of the last-period funds rate and the current-period funds rate target, indicating the Fed smoothes interest rate changes in the short run (Goodfriend [1991]). The magnitude of the partial adjustment parameter r measures the degree of interest rate smoothing in Fed behavior.

If we substitute (1) into (2), we get (3), which is the conventional Taylor rule.

$$FR_t = a_{00} + r\,FR_{t-1} + (1-r)a_1 INFL_{t-1} + (1-r)a_2 GAP_{t-1} + v_t$$
$$where \quad a_{00} = (a_0 - a_1 INFL^*)(1-r) \qquad (3)$$

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[4] This result is in line with one in Mehra (2001).

The funds rate in policy rule (3) responds to the lagged inflation rate, the output gap and the lagged actual funds rate.

Taylor (1999a, p. 339) points out that monetary policy during the early 1980s may have been tighter than what is indicated by the baseline Taylor rule (Taylor [1993]). Such a tighter policy response may have been necessary to keep expectations of inflation from rising and to help establish the credibility of the Fed, as noted in Goodfriend (1993). Mehra (2001) presents evidence that indicates the Fed responded to inflation scares during the 1980s, as reflected in the bond rate, and that the Taylor rule modified to include such responses helped predict actual policy well during this period. In view of such evidence, the Taylor rule for this period is estimated including the bond rate as in (4).

$$FR_t^* = a_0 + a_1(INFL_{t-1} - INFL^*) + a_2 GAP_{t-1} + a_3(BR_t - INF_{t-1}) \qquad (4)$$

where BR is the bond rate. If we substitute (4) into (2), we get the modified Taylor rule (5).

$$\begin{aligned} FR_t &= a_{00} + r\,FR_{t-1} + (1-r)a_1 INFL_{t-1} + (1-r)a_2 GAP_{t-1} \\ &\quad + (1-r)a_3(BR_t - INF_{t-1}) + v_t \qquad (5) \\ \textit{where} \quad a_{00} &= (a_0 - a_1 INFL^*)(1-r) \end{aligned}$$

The funds rate in policy rule (5) responds to the bond rate, in addition to responding to the lagged inflation rate, the output gap, and the actual funds rate.

2.2. Partial Adjustment Taylor Rules and Interest Rate Smoothing

The policy rules in (3) and (5) assume partial adjustment and therefore include the lagged value of the actual funds rate. The presence of the lagged dependent variable in these policy rules is often interpreted as reflecting the presence of interest rate smoothing in Fed behavior. The Fed’s adjustment of the policy rate to its desired level suggested by economic fundamentals is spread over time. This can be seen if we express the policy rule in (3) as in (6), substituting past values of the fundamentals for the lagged dependent variable.

$$FR_t = w_0 + \sum_{s=1}^{\infty} w_{1s} INFL_{t-s} + \sum_{s=1}^{\infty} w_{2s} GAP_{t-s} + e_t$$

$$\text{where} \quad w_0 = (a_0 - a_1 INFL^*)$$

$$w_{1s} = a_1(1-r)r^{s-1}, w_{2s} = a_2(1-r)r^{s-1}, e_t = \sum_{s=1}^{\infty} r^{s-1} v_{t-s} \qquad (6)$$

The reformulation of policy rule (3) as in (6) makes it clear that the Fed's reaction to the lagged value of funds rate in (3) is capturing the Fed's response to inflation and output in periods t-2 and before. This reformulation also makes it clear that Taylor-type policy rules can be alternatively estimated using solely the lagged values of the inflation rate and the output gap. The sum of coefficients that appears on the lagged values of the inflation rate or the output gap then measures the long-term response of the policy rate to the pertinent variable. Thus, the absence of the lagged dependent variable in policy rule (6) does not necessarily mean there is no monetary policy inertia.

In previous empirical work, many analysts have estimated the Taylor rule including the lagged value of the dependent variable as in (3), using quarterly observations on the inflation rate and output gap. The estimated coefficient that appears on the lagged dependent variable in these partial adjustment policy rules is generally significant. This empirical result is often interpreted to indicate the presence of interest rate smoothing in Fed behavior (Clarida et. al. 2000). However, other analysts have estimated the policy rules without the lagged dependent variable, but using instead quarterly observations on a smoothed inflation rate (Taylor 1999a). This specification is stated in (7).

$$FR_t^* = a_0 + a_1 (INF_{t-1}^s - INFL^*) + a_2 GAP_{t-1}, \qquad (7)$$

$$\text{where } FR_t^* = FR_t$$

$$INF_{t-1}^s = (INF_{t-1} + INF_{t-2} + INF_{t-3} + INF_{t-4})/4$$

where INF_{t-1}^s is a smoothed inflation rate measured by the average value of the inflation rate over the past four quarters and the other variables are defined as before. The absence of partial adjustment in (7) does not necessarily imply the absence of interest rate smoothing in Fed behavior. The policy rule in which the funds rate target responds to a smoothed inflation rate implies the Fed adjusts its funds rate target by taking into account the *average* behavior of inflation over several past quarters, not just a single quarter.

Hence, reacting to smoothed values of the inflation rate and /or the output gap is therefore equivalent to responding to past values of the economic fundamentals. This formulation implies that the Fed’s adjustment of the policy rate to its desired level is spread over time.[5]

2.3. Data, Definition of Economic Variables, and Estimation Procedure

The empirical work here estimates the policy rules in (3) and (5) using quarterly data over two sample periods, 1968Q1 to 1979Q2 and 1979Q3 to 1987Q4. All interest rate data used is the average value in the first month of the quarter. The funds rate is the effective federal funds rate and the bond rate is the nominal yield on ten-year U.S. Treasury bonds. The real-time estimates of the inflation rate and output gaps during the sample periods studied are generated using the real-time data compiled by Croushore and Stark (1999). The real-time quarterly value of the inflation rate for any given quarter (1968Q1for example) is the end-of-sample value of the annualized, quarterly percentage change series constructed using the available real-time price series that starts in 1953Q1 and ends in that quarter. The estimates of potential output for each quarter over 1968Q1 to 1979Q2 are generated fitting each time a linear time trend using historical data on output available each quarter. Thus the real-time value of the output gap in 1968Q1 is the end-of-sample value of the residual from the linear time trend regression, fitted using the available historical data on real output that begins in 1953Q1 and ends in 1968Q1. A similar procedure is used to generate estimates of the output gap over 1979Q3 to 1987Q4, except that a quadratic time trend is employed and the historical output series used starts in 1959Q1.

For the first period, the procedure of estimating trend output using a linear time trend is reasonable, because for most of this time period it was thought that economic time series, including potential output, follow deterministic time trends. Since the economy grew quite strongly during the 1950s and the 1960s, the linear trend procedure generates growth estimates of trend output that are optimistic. This deterministic view of

[5] In this rule, a permanent one percentage point increase in the quarterly inflation rate in period t will get reflected fully in the funds rate target a year later. Hence the Fed’s

the potential was of course shown to be deficient by the experience of the late 1960s and the 1970s when inflation rose.

The productivity slowdown of the 1970s made it clear that potential output could not be approximated by a simple linear trend. Over the 1970s, a variety of alternative methods emerged including initially the segmented linear trend and the production function approach. It was also during the late 1970s that the new thinking on the econometrics of time series with unit roots began to undermine the popularity of segmented time trends to measure the potential. Hence, for the period 1979Q3 to 1987Q4 I use a quadratic time trend to estimate the level of output gap, as in Clarida et al. (2000).[6]

Figures 1 and 2 provide a cursory look at real-time estimates of the inflation rate and output gaps. In order to get a sense of the size and nature of revisions in measures of inflation and output over the periods studied, I also chart those measures based on the data currently available in 2000. Figure 1 charts the data for the period 1968Q1 to 1979Q2 and Figure 2 for 1979Q3 to 1987Q4. If we focus on the inflation rate for the first period, real-time estimates of the inflation rate do not differ much from those generated using the revised data (see Figure 1A). In contrast, estimates of the output gap based on the revised data differ substantially from those derived using real-time data. As can be seen in Figure 1B, real-time estimates of output gaps are pessimistic in the 1970s, but not quite so much as argued in Orphanides (2000). The gap between the revised and real-time estimate of the output gap was about 1 percentage point at the start of the sample in 1968Q1, but then it increased considerably during the early 1970s - exceeding almost 9 percentage points during the first quarter of 1975 (see Figure 1B). In contrast, the output gap series in Orphanides (2000) shows a gap of 15 percent in the mid-1970s.

Figure 2 charts the data for the period 1979Q3 to 1987Q4. As can be seen, the revised estimates of inflation do not differ consistently from those based on real-time data. However, estimates of the output gap based on real-time data still differ consistently

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response to an increase in the inflation rate is spread over time.

[6] For this period I examine the sensitivity of results to the choice of an alternative de-trending procedure used to estimate the potential output. In particular, real-time estimates of output gaps were also generated using alternatively a linear trend and a Hodrick-Prescott filter.

from those based on the revised data. In contrast to the first period, real-time estimates of the output gap appear mostly optimistic following the 1980 recession, indicating the presence of less slack than indicated by revised estimates. The gap between the revised and real-time estimates of the output gap has not varied as much, however, in the 1980s as it did in the 1970s.

The policy rules in (3) and (5) include the lagged value of the funds rate. Ordinary least squares are inconsistent if the disturbance term in these policy rules is serially correlated. The presence of serial correlation implies the disturbance term (v_t in (3) or (5)) is correlated with the lagged funds rate (FR_{t-1}) included in these policy rules (Johnston 1972). Furthermore, the policy rule in (5) includes the current-period bond rate, which may also be correlated with the disturbance term. I therefore estimate the policy rules using the instrument variables procedure. The reformulation of the policy rule in (6) makes it clear that the lagged funds rate in these policy rules may be capturing the response of policy to inflation and the output gap in periods t-2 and before. Past values of the inflation rate and the output gap are thus good instrument candidates for the lagged funds rate.[7] The instrument set for the policy rule in (3) consists of a constant and three past values of the inflation rate and the output gap.[8] For the modified Taylor rule, the instrument set is expanded to include past values of money growth and the spread

[7] The autocorrelation function fitted to residuals from the conventional Taylor rule (3) estimated over the first period 1968Q1 to 1979Q2 is consistent with the presence of first-order serial correlation. In contrast, the autocorrelation function fitted to residuals from the modified Taylor rule (5) estimated over 1979Q3 to 1987Q4 indicates the residuals are not serially correlated (see Table 3 for the first four autocorrelations). These results imply that the instrument set used to estimate the Taylor rule should include past values of inflation and output gaps that begin in period t-2. In contrast the instrument set used to estimate the modified Taylor rule can include lagged values beginning in period t-1.

[8] Since in the presence of serial correlation the lagged dependent variable is correlated with the disturbance term, the lagged funds rate is not in the instrument set used to estimate the policy rule. In this case, instrument variables procedure is implemented using a two-step procedure. In step one, the lagged funds rate (FR_{t-1}) is regressed on past values of inflation and output gap using ordinary least squares and obtain the predicted funds rate (FR_{t-1}^{p}). In step two, the predicted funds rate is substituted for the lagged funds rate and the policy rule is estimated using ordinary least squares, correcting standard errors for the presence of serial correlation (Johnston 1972, p. 318).

between the bond rate and the funds rate. The real-time money growth (M2) included in the instruments set is constructed using the historical time series compiled by Croushore and Stark (1999).

3. Empirical Results

3.1. Estimates of Policy Rules

Table 1 presents instrument variables estimates of the conventional and modified Taylor rules specified as in (3) and (5), respectively. Panel A presents the estimates for the period 1968Q1 to 1979Q2 and Panel B for the period 1979Q3 to 1987Q4. I estimate the rules with and without smoothing the inflation rate.[9] If we focus on estimates of the conventional Taylor rule for the earlier period, we see that inflation and output gap variables appear with expected signs and are statistically significant (see t-values in parentheses below estimates in Panel A, Table 1). Those estimates indicate that the funds rate rises if the inflation rate rises, or if actual output is above the potential. The inflation response coefficient is .9 to 1.2 and the output response coefficient is .54 to .56. The t-statistic that tests the hypothesis that the inflation response coefficient is unity is small, implying the policy rule during this period violated the Taylor principle. The estimated partial adjustment coefficient r is zero if the Taylor rule is estimated using a smoothed inflation rate. In case the inflation rate is not smoothed, the partial adjustment coefficient is .65, indicating 35 percent of a desired change in the policy rate is reflected in the funds rate within the quarter of the change. This result means that during this period the Fed's adjustment of the funds rate to its desired level is complete within less than a year.

Panel B in Table 1 presents estimates of the modified Taylor rule (5) for the period 1979Q3 to 1987Q4. As can be seen, inflation and the bond rate variables have expected signs and are significant. The inflation response coefficient is 1.7 to 1.8. The t-statistic that tests the hypothesis that the inflation response coefficient is unity is large, suggesting the inflation response coefficient is well above unity. The output gap response coefficient is positive, but this is significant only if the policy rule is estimated using a smoothed inflation rate. Finally, as can be seen in Panel B of Table 1, the estimated partial adjustment coefficient r is zero, whether or not the inflation rate is smoothed. This result indicates that during this period 100 percent of a desired change in the policy rate is reflected in the funds rate within the quarter of the change.

3.2. Assessing the Predictive Accuracy of Policy Rules

I now assess how well these estimated Taylor-type policy rules predict the actual behavior of the funds rate during the two sample periods considered here. Figures 3 and 4 provide a casual look at the performance of these rules in predicting actual funds rate settings. Figure 3 charts the funds rate predicted by the conventional Taylor rule in the late 1960s and the 1970s. I use the Taylor rule that is estimated with a smoothed inflation rate and with r set to zero. Figure 4 does so using the modified Taylor rule in the 1980s. (The estimates of these policy rules are reported in rows 1 and 4 of Table 3). Actual values of the funds rate are also charted. These figures clearly indicate that the policy rules estimated here track the actual settings of the funds rate over these two periods very well. In particular, the conventional Taylor rule estimated here closely tracks actual funds rate settings during the late 1960s and the 1970s.

In order to further assess whether actual funds rate settings systematically differ from those prescribed by these estimated policy rules, I perform the test of unbiasedness with the following regression (8).

$$FR_t = a + b\, PFR_t + e_t; \qquad (8)$$

where FR is the actual funds rate and *PFR* is the value predicted by the estimated policy rule. The predicted values used are the dynamic within-sample values, generated using actual values of the inflation rate and the output gap. The predicted funds rate is an unbiased predictor of the actual funds rate if $a = 0$ and $b = 1$ in (8).

Table 2 reports estimates of regression (8). Panel A presents results using the conventional Taylor rule for the period 1968Q1 to 1979Q2 and Panel B does so using the modified Taylor rule for the period 1981Q1 to 1987Q4. I present results using the policy rules estimated with and without smoothing the inflation rate. If we focus on the results from policy rules that smooth the inflation rate, the conventional Taylor rule provides

[9] Following Taylor (1999a), quarterly data on the output gap variable is not smoothed.

unbiased forecasts of the actual funds rate for the first period and the modified Taylor rule does so for the second period. The estimated coefficient that appears on the predicted funds rate variable PFR in (8) is close to unity for both policy rules. $c_1^2(2)$ is the Chi-squared statistic that tests the null hypothesis that $(a, b) = (0, 1)$. This statistic is not significant, suggesting the conventional and modified Taylor rules provide unbiased forecasts of actual funds rate settings during these two periods.

If we focus on results from policy rules that do not smooth the inflation rate, one can see results vary across sample periods and are sensitive to whether or not the partial adjustment coefficient is set to zero. In particular, focusing on the results for the period 1968Q1 to 1979Q2, one can see that the conventional Taylor rule provides unbiased forecasts of actual funds rate settings only if the partial adjustment coefficient r is not set to zero. This result implies the Fed slowly adjusted the funds rate to its economic fundamental during this sample period. In contrast, over the period 1979Q3 to 1987Q4 the modified Taylor-rule provides unbiased forecasts of actual funds rate settings even if the partial adjustment coefficient r is set to zero. This result implies that the Fed rapidly adjusted the funds rate in response to economic fundamentals during this period. Together these results indicate that during the late 1960s and the 1970s the Fed was “too timid” and “too sluggish” in adjusting the funds rate in response to changes in economic fundamentals including the inflation rate.

3.3. Additional Results

In this section I discuss some additional estimates that suggest the results here are robust to few changes in the specification of the policy rule. In the Taylor rules discussed above the partial adjustment coefficient r is not significant if the rules are estimated using a smoothed inflation rate. Table 3 presents estimates derived by setting the partial adjustment coefficient r to zero. Those policy rules yield identical conclusions about the determinants of the policy rule. In particular, the policy rate continues to respond significantly to the inflation rate and the output gap. Moreover, the inflation response coefficient is well above unity only during the second period (compare estimates in rows 1 and 2 and in rows 4 and 5, Table 3).

Rows 3 and 6 of Table 3 present estimates that use the revised data and the smoothed inflation rate. In the first period, the use of revised as opposed to real-time data yields an estimate of the quarterly partial adjustment coefficient r that is now significant, implying the presence of monetary policy inertia during this period (compare estimates in rows 2 and 3, Table 3). Moreover, the estimated inflation response coefficient is now below unity at .83. In contrast, the use of revised as opposed to real-time data has no effect on estimates of the policy rule over the second period. In particular, the inflation response coefficient is still well above unity and the partial adjustment coefficient r is not significant. Together these results suggest that the high estimates of the quarterly partial adjustment coefficient reported in previous research may be due to the use of revised, as opposed to real-time, data. Moreover, previously estimated policy rules ignore the response of the policy rate to the bond rate (Taylor 1999a, Clarida et. al. 2000).

4. Concluding Observations

This paper presents and estimates Taylor-type policy rules for the two sample periods 1968Q1 to 1979Q2 and 1979Q3 to 1987Q4, using real-time data on inflation and the output gap. The results indicate that these policy rules track actual funds rate settings fairly well during these two sample periods.

Recent research on monetary policy rules indicate that in order to avoid undesirable economic outcomes, feedback monetary policy rules like those estimated here should satisfy the Taylor principle, which is that the inflation response coefficient should be set well above unity. The policy rules estimated using real-time data indicate that Fed policy during the late 1960s and the 1970s probably violated the Taylor principle. This result is in line with the previous evidence in Taylor (1999a) and Clarida et. al. (2000) that used revised data, but not in line with one in Orphanides (2000) based on real-time data. The use of somewhat different estimates of output gaps reverses the conclusion in Orphanides that Fed policy during the late 1960s and the 1970s satisfied the Taylor principle.

The empirical work is consistent with the presence of partial adjustment inertia, suggesting that the Fed has smoothed the adjustment of the policy rate to economic fundamentals. However, the extent of interest rate smoothing exhibited by the policy rules estimated here is less than what is indicated by policy rules in previous empirical work. The partial adjustment coefficients estimated here indicate the adjustment was complete within one year during the late 1960s and the 1970s and within one quarter during the early 1980s. The use of real-time as opposed to revised data may partly account for these different results. The much faster speed of adjustment estimated here supports the view in Rudebusch (2001) that in reality the Fed may not be as sluggish as is widely believed.

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Table 1

Instrumental Variables Estimates of Policy Rules

Inflation	a_1	a_2	a_3	r	t_s	*SER*
Panel A: Taylor Rule; 1968Q1-1979Q2						
Smoothed	1.2	.54		-.10	1.0	1.27
	(7.2)	(5.4)		(.24)		
Not Smoothed	.9	.56		.65	.0	1.30
	(2.1)	(1.8)		(4.1)		
Panel B: Modified Taylor Rule; 1979Q3-1987Q4						
Smoothed	1.8	.24	.73	-.20	31.2*	1.51
	(13.1)	(2.2)	(5.4)	(1.4)		
Not Smootheed	1.7	.15	.98	.12	7.3*	2.01
	(7.1)	(.80)	(4.1)	(.62)		

Notes: The coefficients (with t-values in parentheses) reported above are instrument variables (IV) estimates from policy rules of the form

$$FR_t = r\,FR_{t-1} + (1-r)(a_0 + a_1 INF_{t-1} + a_2 GAP_{t-1}) \qquad (1)$$

$$FR_t = r\,FR_{t-1} + (1-r)(a_0 + a_1 INF_{t-1} + a_2 GAP_{t-1} + a_3(BR_t - INF_{t-1})) \qquad (2)$$

where FR is the federal funds rate; INF is the inflation rate; GAP is the level of the output gap and BR is the bond rate. The inflation data when smoothed is the four-quarter moving averages of quarterly inflation rates. The policy rules are estimated using instrumental variables. For policy rules in (1), the instrument set consists of a constant and the past three values of inflation and the output gap. For estimating policy rules in (2), the instrument set is expanded to include past values of the funds rate, the spread, and money growth. The reported t-values have been corrected for the presence of serial correlation. t_s is a t-statistic that tests $a_1 = 1$. *SER* is the standard error of regression.

* Significant at the 5 percent level

Table 2

Test of Unbiasedness

Panel A: Taylor Rule; 1968Q1-1979Q2

	Partial Adjustment Parameter ρ = 0			PartialAdjustment Parameter ρ # 0		
	f_0	f_1	c^2	f_0	f_1	c^2
Inflation Smoothed	-.10	1.0	.62			
	(.2)	(8.8)				
Inflation Not Smoothed	2.3	.67	7.0*	-.5	1.1	.54
	(2.5)	(5.4)		(.5)	(6.6)	

Panel B: Modified Taylor Rule; 1981Q1-1987Q4

	Partial Adjustment Parameter ρ = 0			Partial Adjustment Parameter ρ # 0		
	f_0	f_1	c^2	f_0	f_1	c^2
Inflation Smoothed	-.21	1.0	1.0	.0	1.0	.78
	(.3)	(19.7)		(.1)	(18.8)	
Inflation Not Smoothed	.23	.97	.07	.0	1.0	.01
	(.3)	(9.8)		(.1)	(9.9)	

Notes: The coefficients (with t-values in parentheses) reported above are from regressions of the form $FR_t = f_0 + f_1 PFR_t + u_t$, where FR is the actual federal funds rate, and PFR is the funds rate predicted by the relevant policy rule. The predicted values used are the dynamic, within sample values, generated using policy rules reported in Table 1. The predicted funds rate is an unbiased predictor of actual if $f_0 = 0, f_1 = 1.0$. c^2 is the Chi-squared statistic that tests the null that $f_0 = 0, f_1 = 1.0$ and is distributed Chi-square with two degrees of freedom.

• Significant at the 5 percent level

Table 3

Additional Results

Panel A: Taylor Rule; 1968Q1-1979Q2

Row Number	a_1	a_2	r	t_s	SER	r_1	r_2	r_3	r_4
1. Real/Smoothed/ OLS	1.2 (6.9)	.55 (6.3)		1.0	1.26	.6	.1	.0	.0
2. Real/Smoothed/ IV	1.2 (7.2)	.54 (5.4)	-.10 (.2)	1.0	1.27	.6	.1	.0	.0
3. Final/Smoothed/ IV	.83 (1.8)	1.5 (2.7)	.73 (5.3)	.1	.88	.3	-.3	-.2	.1

Panel B: Modified Taylor Rule; 1979Q3-1987Q4

	a_1	a_2	a_3	r	t_s	SER	r_1	r_2	r_3	r_4
4.Real/Smoothed/ IV	1.8 (10.7)	.26 (2.0)	.74 (4.5)		22.5	1.53	-.2	-.1	.1	-.2
5.Real/Smoothed/ IV	1.8 (13.1)	.25 (2.2)	.74 (5.4)	-.2 (1.4)	33.2	1.51	-.1	-.2	.1	-.3
6.Final/Smoothed/ IV	1.5 (14.7)	.16 (1.7)	.70 (4.9)	-.2 (1.5)	26.2	1.52	-.1	-.2	.1	-.1

Notes: The coefficients (with t-values in parentheses) reported above are from policy rules of the form given in Table 1. $r_1, r_2, r_3,$ *and* r_4 are the first four autocorrelations of the residuals from the relevant policy rule. Real/Smoothed/OLS means the relevant policy rule is estimated using real-time data, a smoothed inflation rate, and ordinary least squares. Final means the final data and IV is instrument variables estimates. Rows 1 through 3 contains estimates of the Taylor rule and rows 4 through 6 contain estimates of the modified Taylor rule.

Figure 1A

Inflation:1968Q1-1979Q2

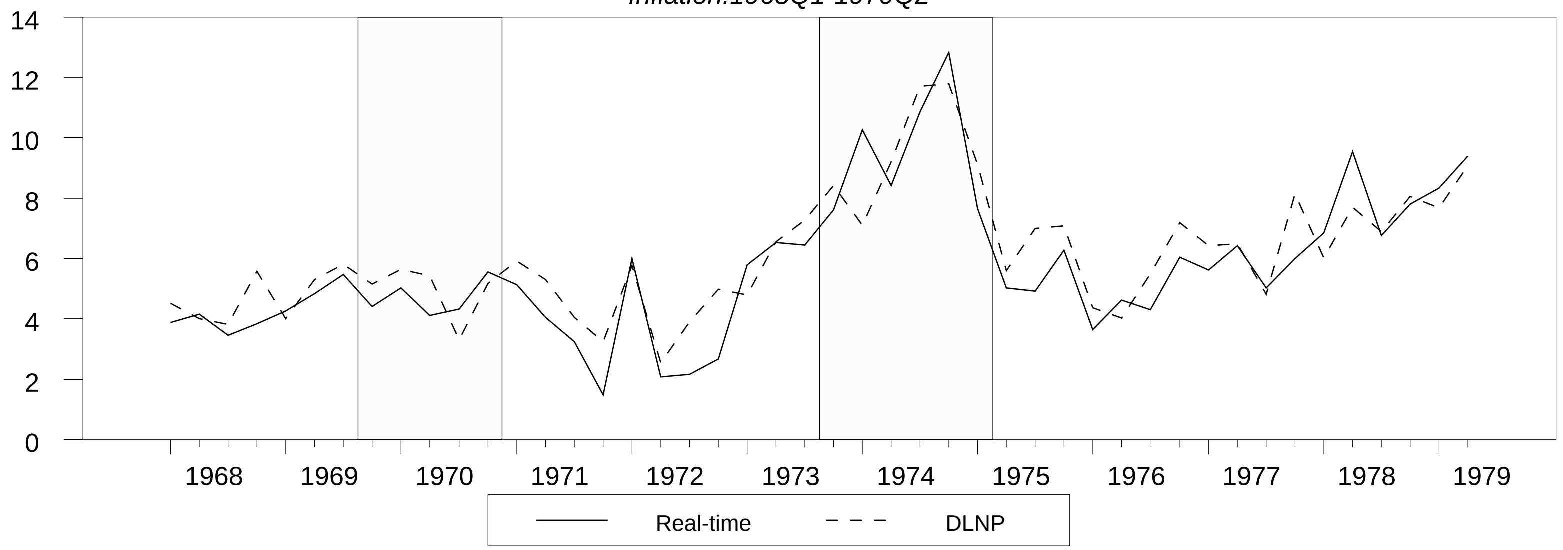


Figure 1B

Output Gap:1968Q1-1979Q2

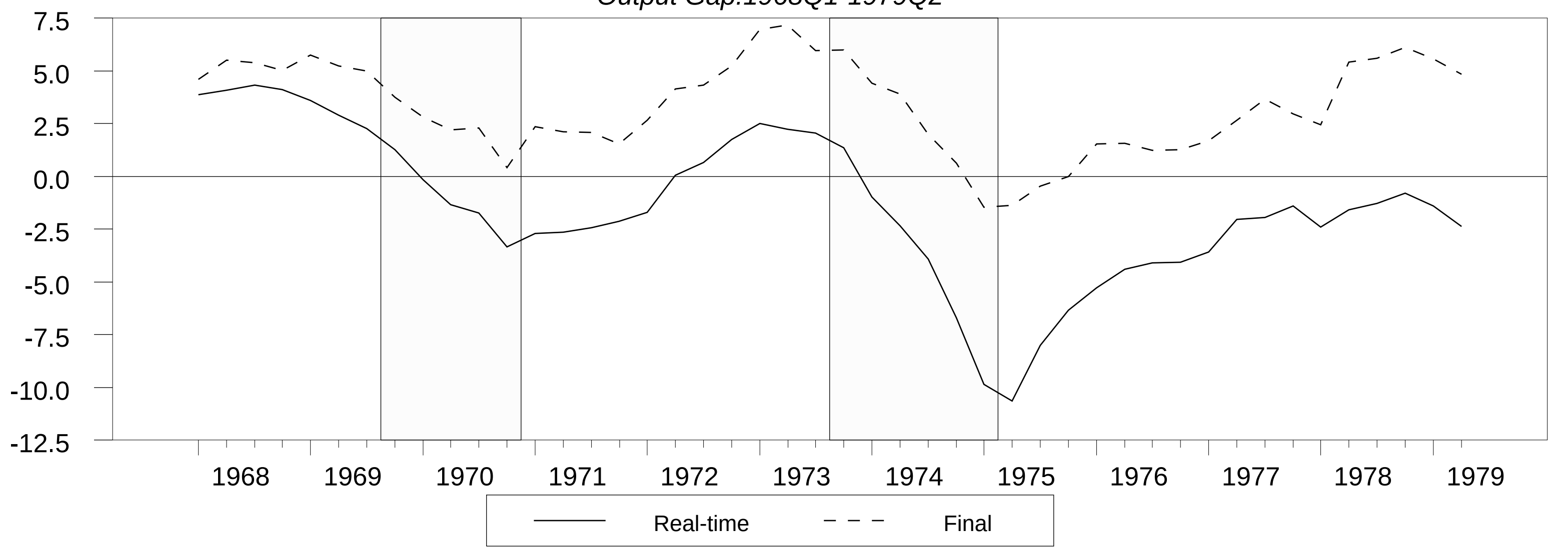


Figure 2A

Inflation: 1979Q3-1987Q4

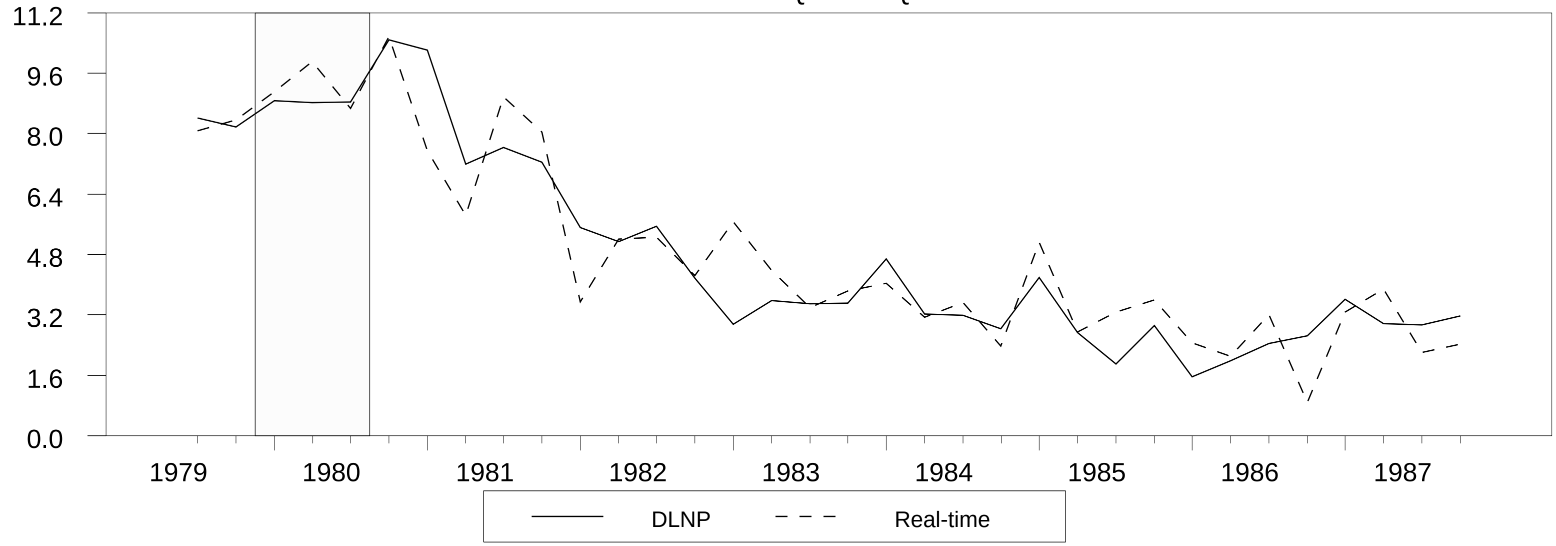
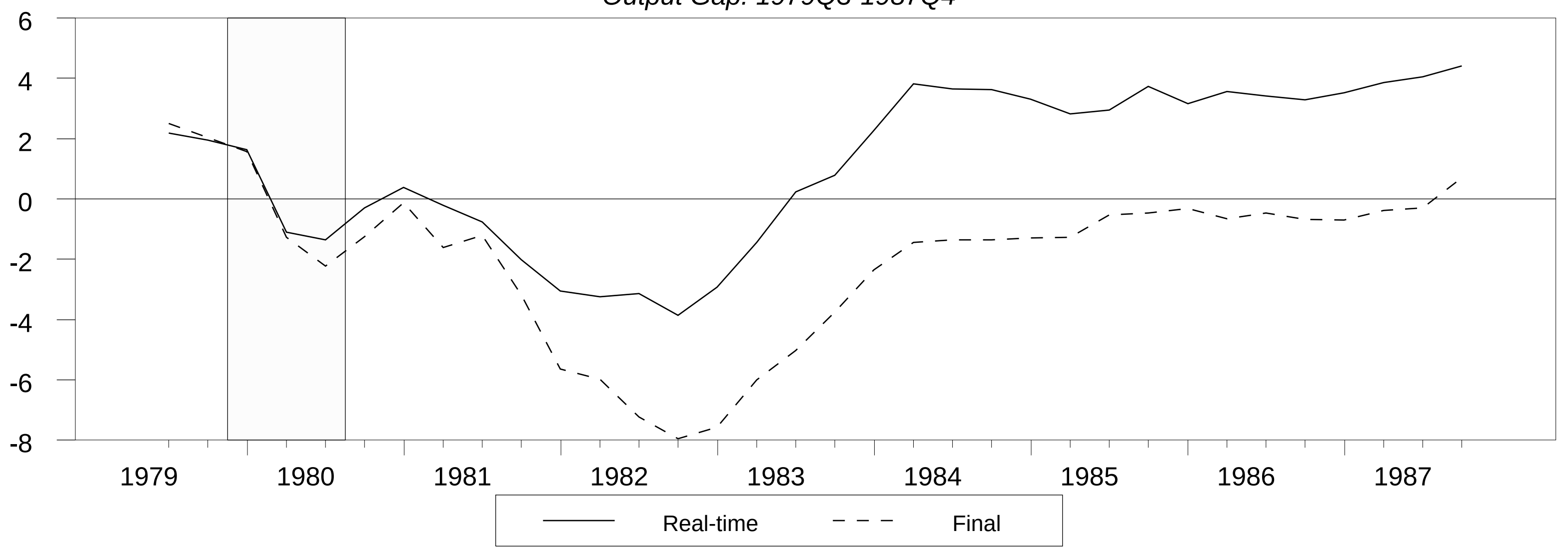


Figure 2B

Output Gap: 1979Q3-1987Q4



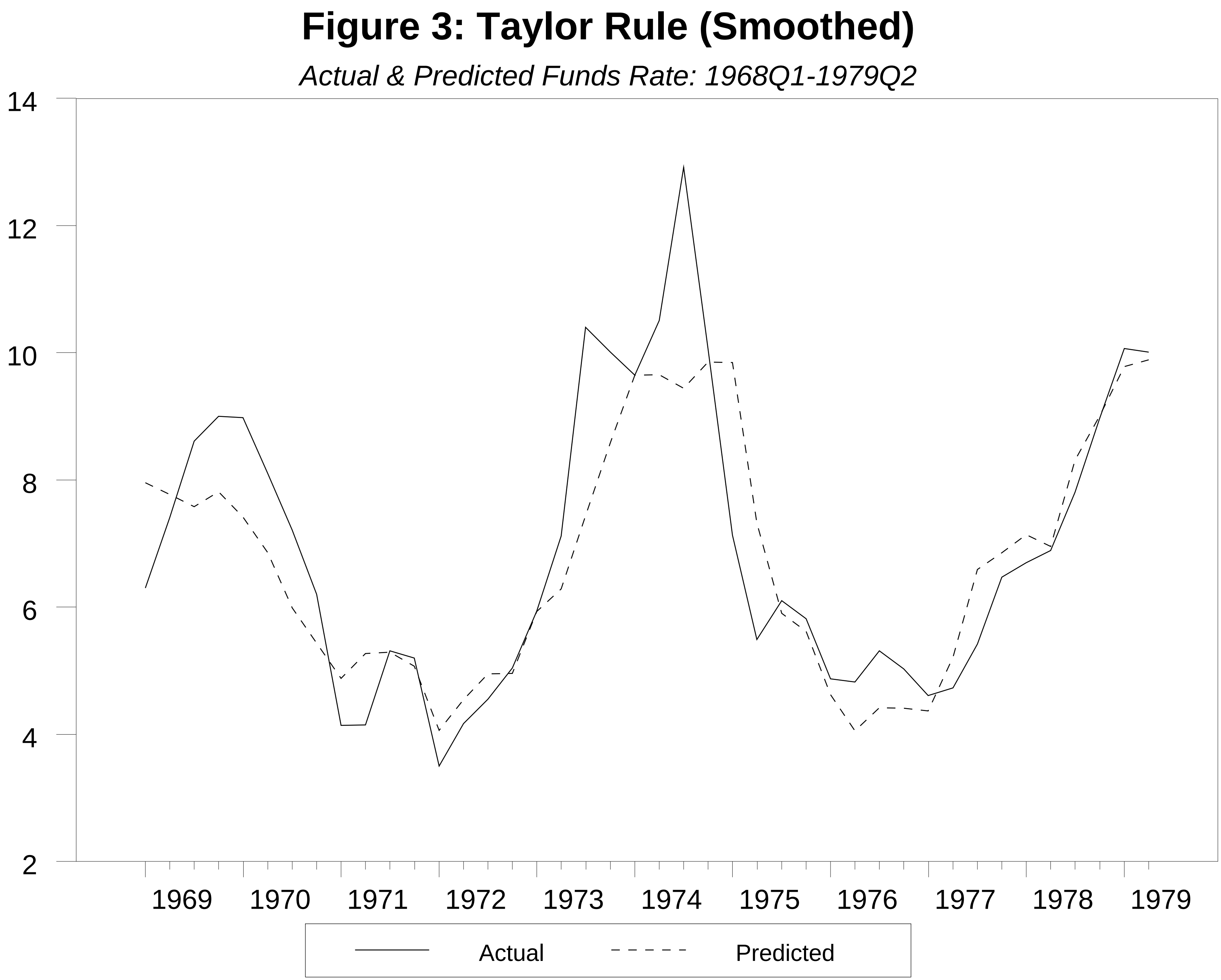


Figure 3: Taylor Rule (Smoothed)
Actual & Predicted Funds Rate: 1968Q1-1979Q2
14
12
10
8
6
4
2
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
Actual
Predicted

Figure 4: Modified Taylor Rule (Smoothed)

Actual & Predicted Funds Rate: 1981Q1-1987Q4