WHY HAVE INTEREST RATES BEEN LOW?

By

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Abstract

This paper uses an estimated interest rate rule of the Fed to argue that the low recent interest rates may be due to a change in Fed behavior. Prior to the Great Recession the Fed's behavior is consistent with the rule. During the recession the zero lower bound was hit in 2008.4. The rule unconstrained called for negative nominal interest rates during this period, and so it became inoperative. The Fed kept the interest rate at roughly zero through 2015. This was a period of low inflation and still fairly high unemployment rates, and the rule called for essentially zero interest rates through about 2010. Beginning in 2011, however, the rule called for rising interest rates, and between 2011 and 2019 the predicted interest rates from the rule are always higher than the actual rates. Between 2011 and 2019 the Fed was more expansive than its historical behavior as estimated by the rule. The COVID experience through 2022.1 also shows the Fed setting historically low interest rates beginning in 2021 in the face of rising inflation and falling unemployment. In short, the low recent interest rates may be because of a change in Fed behavior.

1 Introduction

Both nominal and real interest rates have been historically low worldwide in the last two or three decades. Why? Rachel and Smith (2017) argue that the decrease in interest rates is due to a decline in future trend growth and shifts in saving and investment preferences. Caballero, Rarhi, and Gourinchas (2017) and Gourinchas

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(2017) develop an accounting framework and argue that there has been a secular increase in capital and equity risk premia, driving down safe real rates. Mankiw (2022) uses insights from neoclassical growth theory to explain the decline. Blanchard (2019) discusses the implications of low interest rates for macro policy, as do Brumm, Feng, Kotlikoff, and Kubler (2021).

This paper takes a different approach from the recent literature and asks whether the low interest rates are due to a structural change in monetary policy. The emphasis in this paper is on the Fed, but similar considerations are likely to apply to other monetary authorities, since many are influenced by what the Fed does. The results are based on an estimated Fed interest rate rule, where the Fed responds positively in its interest rate settings to inflation and negatively to unemployment. The results suggest that interest rates prior to 2008.4, the beginning of the Great Recession, are in line with historical Fed behavior. The zero lower bound was hit in 2008.4. The rule unconstrained called for negative nominal interest rates during this period, and so it became inoperative. The Fed kept the interest rate at roughly zero through 2015. This was a period of low inflation and still fairly high unemployment rates, and the rule called for essentially zero interest rates through about 2010. Beginning in 2011, however, the rule called for rising interest rates, and between 2011 and 2019 the predicted interest rates from the rule are always higher than the actual rates. By 2019.4 the predicted short term rate is 4.17 percent compared to the actual value of 1.58. In other words, between 2011 and 2019 the Fed was more expansive than its historical behavior as estimated by the rule.

The explanation here is thus that U.S. interest rates were not historically unusual prior to 2008. They were too high during the Great Recession and two years after because of the binding zero lower bound. Between 2011 and 2019 interest rates were historically low according to the rule.

The COVID period, 2020.2–2022.1, is also of interest to analyze. The Fed kept the interest rate at essentially zero throughout the entire period. (It began raising rates in March 2022.) The rule unconstrained called for negative interest rates in

2020.3 and 2020.4. Then as unemployment began falling and inflation picked up, the rule called for large rates. In 2022.1 the rule called for a rate of 5.62 compared to the actual rate of 0.31.

2 The Estimated Fed Rule

Estimated interest rate rules go back at least to Dewald and Johnson (1963), who regressed the Treasury bill rate on a constant, the Treasury bill rate lagged once, real GNP, the unemployment rate, the balance-of-payments deficit, and the consumer price index. The next example can be found in Christian (1968). I added an estimated interest rate rule to my US model in 1978—Fair (1978).[1]

After this, McNees (1986, 1992) estimated rules in which some of the explanatory variables were the Fed's internal forecasts of various variables. Khoury (1990) provides an extensive list of estimated rules through 1986. This work all preceded Taylor's (1993) well known paper, which proposed an interest rate policy rule, since called the "Taylor rule." With hindsight, interest rate rules should probably be called Dewald-Johnson rules, since Dewald and Johnson preceded Taylor by about 30 years!

Regarding the rule estimated in Fair (1978), the left hand side variable is the three-month Treasury bill rate, denoted RS_t here, and the right hand side variables are a constant, RS_{t-1}, inflation lagged once, a measure of labor market tightness, the growth rate of real GDP current and lagged once, and the growth rate of the money supply lagged once.[2] The data are quarterly, with estimation period 1954.1–1976.2, estimation by two-stage least squares (2SLS). This is an equation in which

[1] I can remember when William Miller was chair of the Fed in 1978 he visited Yale. There was a lunch at Mory's with Jim Tobin, William Brainard, me, and a number of others. I had recently finished my estimated Fed rule, and I gave Miller an envelope that I said predicted what he would do in the next year! Unfortunately, I don't have any records of how accurate this was.

[2] The short term interest rate the Fed is assumed to control in this work is the three-month Treasury bill rate. This rate is highly correlated with the federal funds rate, and it makes little difference which is used in the empirical work.

the Fed "leans against the wind," responding positively to inflation, labor market tightness, real growth, and lagged money supply growth.

In this equation both the level of real economic activity, measured by the labor market tightness variable, and the change in real economic activity, measured by the current and lagged real GDP growth rates, affected RS_t. In the current specification of the equation these three variables are replaced by the level of the unemployment rate, UR_t, and its change, ΔUR_t. The inflation variable is now unlagged rather than lagged once; it is denoted π_t.[3]

An abrupt change in the rule occurred after its initial specification, which was in the 1979.4–1982.3 period, to be called the "early Volcker" period.[4] The stated policy of the Fed during this period was that it was focusing more on monetary aggregates than it had done before. The break between 1979:4 and 1982:3 is modeled by adding the variable $D794823_t \cdot \dot{M}1_{t-1}$ to the equation, where $\dot{M}1_{t-1}$ is the lagged percentage change in the money supply and $D794823_t$ is a dummy variable that is 1 between 1979:4 and 1982:3 and 0 otherwise. This specification reflects the fact that $\dot{M}1_{t-1}$ had a special influence on Fed behavior during the early Volcker period.

The specification for this paper excludes $\dot{M}1_{t-1}$ as an explanatory variable except for the early Volcker period. Outside of this period it has always had a minor effect on RS_t. The equation is estimated for the 1954.1–2008.3 period, which ends the quarter before the beginning of the zero lower bound, where the Fed could not follow the rule even if it wanted to. The coefficient estimates are presented in Table 1. The equation includes the lagged dependent variable and

[3]π_t is the percentage change in the personal consumption expenditure deflator at an annual rate. This is the variable that the Fed focuses on.

[4]Paul Volcker was chair of the Fed between 1979:3 and 1987:2, but the period in question is only 1979:4–1982:3.

Table 1
Estimated Interest Rate Rule
LHS Variable is RS_t

RHS Variable	Coefficient	t-statistic
cnst	0.700	4.49
RS_{t-1}	0.916	48.43
π_t	0.0836	4.45
UR_t	-0.106	-3.34
ΔUR_t	-0.822	-5.38
$D794823_t \cdot \dot{M}1_{t-1}$	0.213	9.21
ΔRS_{t-1}	0.208	3.63
ΔRS_{t-2}	-0.335	-6.68
SE	0.493	
R^2	0.969	
overid test (df = 3, p-value = 0.543)		

- Stability test (1954.1-1979.3 versus 1982.4-2008.3): Wald statistic is 9.17 (7 degrees of freedom, p-value = 0.241).
- Estimation period is 1954.1-2008.3.
- Estimation method is 2SLS; See footnote 5 for the list of first stage regressors.

two lagged bill rate changes to pick up the dynamics. The estimation method is 2SLS.[5]

The coefficient estimate for inflation in Table 1 is positive and significant, and the coefficient estimates for the unemployment rate and the change in the unemployment rate are negative and significant. The lagged money growth variable for the early Volcker period is highly significant. The dynamics are picked up by

[5]There are 11 first stage regressors. These are variables in my US model. The variables are: a constant, RS_{t-1}, π_{t-1}, UR_{t-1}, ΔUR_{t-1}, $D794823_t \cdot \dot{M}1_{t-1}$, ΔRS_{t-1}, ΔRS_{t-2}, and three exogenous variables in the US model lagged one quarter. These are the log of real per capita government purchases of goods and services, the log of real per capita government transfer payments to persons, and the log of real per capita exports. The exogenous variables are lagged once to avoid the possibility of contemporaneous correlation with the current endogenous variables.

the lagged interest rate and the two lagged changes in the interest rate, all three significant.

To test the robustness of the equation, three lagged values were added to the equation, RS_{t-4}, π_{t-1}, and UR_{t-2} (with RS_{t-4} added as a first stage regressor), and the three variables were not jointly significant (χ^2 = 3.73, 3 degrees of freedom, p-value = 0.292). The time trend t was added to the equation (also added as a first stage regressor), and it was not significant (p-value = 0.289).

A stability test was also performed. For this test the early Volcker period was excluded since the Fed announced that its behavior was different during this period. Any stability test using this period is likely to reject stability. Instead, the hypothesis tested is that the equation's coefficients are the same before 1979.4 as they are after 1982.3. (Remember the sample period begins in 1954.1 and ends in 2008.3.) This was done using a Wald test. The Wald statistic is presented in equation 3.6 in Andrews and Fair (1988). It has the advantage that it works under very general assumptions about the properties of the error terms and can be used when the estimator is 2SLS, which it is here. The Wald statistic is distributed as χ^2 with (in the present case) 7 degrees of freedom. The hypothesis of stability is not rejected. As reported in Table 1, the Wald statistic is 9.17, which has a p-value of 0.241.

There was a general view in the literature in the late 1990's that estimated interest rate rules do not have stable coefficient estimates over time. For example, Judd and Rudebusch (1998, p. 3) state "Overall, it appears that there have not been any great successes in modeling Fed behavior with a single, stable reaction function." The passing of the above stability test is thus contrary this view. One likely reason that the stability hypothesis was generally rejected is that most tests included the early Volcker period, which is clearly different from the periods both before and after. The tests in Judd and Rudebusch (1998), for example, include the early Volcker period.

What are the long run properties of the estimated rule? If there is a sustained decrease in the unemployment rate of 1.0 percentage point, how much does RS rise in the long run? This can be seen by first solving the equation dynamically using the actual values inflation and unemployment to get a base run. Then solve again with the unemployment rate 1.0 higher for each quarter. The difference for a given quarter between the predicted value from the new run and the predicted value from the base run is the effect on the interest rate. In this case the bill rate is 1.255 percentage points higher in the long run.

A similar calculation can be done for inflation. If there is a sustained increase in π_t of 1.0 percentage point, the bill rate is 0.992 percentage points higher in the long run. The Fed is thus estimated to raise the nominal rate up to the increase in the inflation rate in the long run, keeping the real rate constant. This property comes out of the estimates; no restrictions were placed on the estimation for this to happen.

3 Predicted Interest Rates from the Rule, 1954.1–2019.4

Although the estimation period ends in 2008.3, the equation can be solved beyond this period. The main experiment in this paper is to solve the rule dynamically for the 1954.1–2019.4 period and examine the differences between the predicted values from the rule and the actual values, values assumed to be set by the Fed. Solving dynamically means that after a few quarters the initial dynamic effects subside and one is observing the long run effects.

In running this experiment account must be taken of the fact that when the Fed changes RS_t this affects inflation and unemployment. In the estimation of the rule in Table 1 the endogeneity of inflation and unemployment is taken into account using 2SLS. The coefficient estimates are consistent assuming the first stage regressors are uncorrelated with the equation's error term. In the experiment, on the other hand, the rule needs to be imbedded in a model that accounts for the effect of RS_t on π_t and UR_t. In this paper my US model is used for this purpose.

The US model is described in detail in a document on my website, "Macroeconometric Modeling: 2018," which will be abbreviated "MM". Most of my past macro research, including the empirical results, is in MM. It includes chapters on methodology, econometric techniques, numerical procedures, theory, empirical specifications, testing, and results. The results in my previous macro papers have been updated through 2017 data, which provides a way of examining the sensitivity of the original results to the use of additional data.

The main properties of the model that are relevant for this paper are summarized in Fair (2022). The key properties are the following:

- Inflation expectations depend only on current and lagged values of actual inflation. The Fed does not directly affect inflation expectations. This property is strongly supported by survey evidence.

- The short term interest rate set by the Fed, RS_t, affects long term interest rates through estimated term structure equations, and these interest rates affect aggregate demand through household expenditure and housing investment equations. Aggregate demand in turn affects inflation through price and wage equations.

- The effects of RS_t on aggregate demand are modest and take time. Also, the effects of aggregate demand on inflation are modest and take time.

The US model consists of 23 estimated equations counting the rule. In the 2SLS estimation of the equations account has been taken of any serial correlation of the error terms by jointly estimating the serial correlation coefficients. The remaining error terms are taken to be shocks and to be uncorrelated with the exogenous and lagged endogenous variables. In the dynamic solution these shocks are taken to be equal to their actual values except for the shocks to the rule, which are assumed to be zero. In other words the shocks are assumed to be what they were historically except for the shocks to the rule. The shocks to the rule are estimates of how the Fed deviated each quarter from the values predicted by the rule. The predicted values from the rule are thus what the Fed would have done had it followed the rule exactly.

As noted above the rule unconstrained sometimes calls for negative rates. In the solution the interest rate was set to zero if the rule called for a negative value. For reference purposes the predicted and actual values of RS are presented in Table A in the Appendix for the entire period 1952.1–2022.1. The actual values of π_t and UR_t are also presented.

There are five subperiods of interest not counting the COVID period, which is discussed in Section 4. .

- A: 1954.1–1979.3. Pre early Volcker.
- B: 1979.4–1982.3. Early Volcker.
- C: 1982.4–2008.3. Post early Volcker to beginning of Great Recession.
- D: 2008.4–2010.4. Great Recession to 2010.
- E: 2011.1–2019.4. 2011 to Pandemic.

Table 2 presents for each subperiod the average predicted value of RS, the average actual value, and the difference between the two. These are averages of the values in Table A. Figures 1–5 plot the individual values.

The results in Table 2 and the figures are easy to summarize. For subperiods A, B, and C the rule tracks Fed behavior well. The actual and predicted values of RS_t are close. For subperiod D the Fed kept the interest rate at essentially zero for the entire period, as did the rule. During some of this subperiod the rule called for a negative interest rate, which in the solution was constrained to be zero. For subperiod E the rule began calling for positive rates in 2011.1, but the Fed kept the rate a essentially zero through 2015 (Table A). After that the actual rates

Table 2
Average Values for Five Subperiods

Period	RS	$\hat{RS}$	π	UR	# obs.
A: 1954.1–1979.3	4.41	4.29	8.85	5.39	103
B: 1979.4–1982.3	12.35	13.26	7.79	7.78	12
C: 1982.4–2008.3	4.97	4.58	2.49	5.89	104
D: 2008.4–2010.4	0.16	0.24	0.04	9.19	9
E: 2011.1–2019.4	0.61	2.07	1.45	5.85	36

- RS = actual value of RS.
- $\hat{RS}$ = predicted value of RS.
- π = actual value of π.
- UR = actual value of UR.

are positive, but always lower than the predicted rates. The average over the 36 quarters is 0.61 actual and 2.07 predicted (Table 2). By 2019.4 the predicted value is 4.17 compared to the actual value of 1.58 (Table A). The unemployment rate fell from 6.95 in 2013.4 to 3.93 in 2018.2 and remained below 4.0 for the rest of the period. These low values of the unemployment rate led the rule to predict rising interest rates. The Fed was clearly not following the rule in this period. Even though inflation remained low, had the Fed behaved as it had historically it would have raised the interest rate in response to the low unemployment rates.

An explanation of the low interest rates since the Great Recession is thus a change in Fed behavior beginning about 2011, beginning under Ben Bernanke and continuing under Janet Yellen and Jerome Powell.[6] Prior to this, interest rates were either as expected or zero because of the zero lower bound.

[6]There is no obvious statistical test of the hypothesis that Fed behavior changed beginning in 2011. For example, the end-of-sample instability test of Andrews (2003) cannot be used. There was a structural break during the early Volcker period, and the Fed could not follow the rule for much of the 2009-2013 period because of the zero lower bound constraint. One cannot assume, for example, that the Fed followed the same rule between 1954.1 and 2010.4 and then test the hypothesis that it changed behavior after that, which is what the Andrews test requires. However, the difference between the predicted values from the historically estimated rule and the actual values are large enough after 2011 to suggest a change of behavior.

Table 3
Values for the Eight COVID Quarters

Quarter	RS	$\hat{RS}$	π	UR
2020.2	0.14	NA	-3.83	12.98
2020.3	0.11	NA	4.08	8.82
2020.4	0.09	2.30	2.59	6.78
2021.1	0.05	3.34	4.06	6.21
2021.2	0.03	3.25	6.07	5.90
2021.3	0.05	3.81	6.95	5.10
2021.4	0.05	4.97	7.33	4.22
2022.1	0.31	5.62	8.29	3.81

- See Table 2 for notation.
- The solution period is 2020.4–2022.1.

4 COVID Period, 2020.2–2022.1

Values for the eight COVID quarters are presented in Table 3. The Fed kept the interest rate at essentially zero throughout the entire period. The values of inflation and unemployment for the first two quarters are extreme. Inflation was -3.83 in 2020.2 and then rose to 4.08 in 2020.3. The unemployment rate was 12.98 in 2020.2 and then fell to 8.82 in 2020.3. These values are outside of what one would expect the rule to deal with, and so the dynamic solution was begun in 2020.4 for this experiment. In 2020.4, the first quarter of the solution period, the rule called for an interest rate of 2.30, driven in part by the falling unemployment rate. As inflation picked up and the unemployment rate fell, the rule called for rising interest rates. In 2022.1 inflation was 8.29 percent, the unemployment rate was 3.81, and the predicted interest rate was 5.62. This period is thus an extreme example of a change in Fed behavior. Contrary to its historical behavior the Fed did not respond to high inflation and low unemployment.

5 Inflation and Unemployment Consequences of the Behavioral Change

As noted in Section 3, changes in RS_t have modest effects on aggregate demand and inflation in the US model and take time. The Fed affects inflation by affecting the unemployment rate, which affects inflation. Inflation expectations depend on current and past inflation; the Fed does not directly control expectations in the model—see Fair (2022). Results for part of subperiod E are presented in the first half of Table 4. These values are the same as those in Table A except that the predicted values of inflation and unemployment have been added. The differences between the actual and predicted values of inflation and unemployment are modest. The higher interest rates from the rule lead to lower inflation and higher unemployment, but the effects are modest. The peak effects are around 2017, where inflation is about 0.28 percentage points lower and the unemployment rate is around 0.54 percentage points higher.

Two other experiments are of interest to examine. In the model interest rate changes have no effect on changes in stock prices. It is not possible with quarterly data to pick up any effects of this sort. The change in stock prices is roughly a random walk. There are fairly large wealth effects in the model, and if the Fed does affect stock prices, the current results are not picking up this effect on aggregate demand and thus underestimating the Fed's effect on inflation. To examine possible stock-price effects, a calibrated stock-price equation was added to the model. The change in the value of household equity holdings as a fraction of nominal GDP was taken to be a function of the change in RS_t. The coefficient was taken to be such that a 1.0 percentage point change in RS_t results in a household equity change of 10.0 percent of nominal GDP. In 2022 nominal GDP will be roughly $25 trillion, so this would be a change in 2022 of about $2.5 trillion. A change of $2.5 trillion is roughly a change in the S&P 500 of 2,500 points. This is thus a fairly large calibrated effect of the Fed on stock prices.

Table 4
Actual and Predicted Values
2017.1–2019.5

Quarter	RS	$\hat{RS}$	π	$\hat{\pi}$	UR	$\hat{UR}$
Regular Version of US Model						
2017.1	0.59	2.65	2.47	2.20	4.57	5.11
2017.2	0.89	2.85	0.97	0.68	4.36	4.90
2017.3	1.04	2.87	1.49	1.20	4.32	4.86
2017.4	1.21	3.10	2.45	2.19	4.18	4.68
2018.1	1.56	3.42	2.40	2.13	4.03	4.52
2018.2	1.84	3.66	2.61	2.35	3.93	4.39
2018.3	2.04	3.78	1.27	1.06	3.79	4.22
2018.4	2.32	3.72	0.99	0.86	3.84	4.23
2019.1	2.39	3.70	0.76	0.66	3.83	4.19
2019.2	2.30	4.10	2.58	2.49	3.63	3.94
2019.3	1.98	4.23	0.56	0.52	3.61	3.89
2019.4	1.58	4.17	1.35	1.29	3.60	3.87
Stock Market Response						
2017.1	0.59	2.28	2.47	2.13	4.57	5.38
2017.2	0.89	2.47	0.97	0.60	4.36	5.17
2017.3	1.04	2.48	1.49	1.11	4.32	5.12
2017.4	1.21	2.73	2.45	2.12	4.18	4.93
2018.1	1.56	3.05	2.40	2.05	4.03	4.76
2018.2	1.84	3.30	2.61	2.27	3.93	4.61
2018.3	2.04	3.44	1.27	0.99	3.79	4.42
2018.4	2.32	3.39	0.99	0.82	3.84	4.42
2019.1	2.39	3.39	0.76	0.64	3.83	4.36
2019.2	2.30	3.84	2.58	2.49	3.63	4.07
2019.3	1.98	3.98	0.56	0.53	3.61	4.01
2019.4	1.58	3.91	1.35	1.27	3.60	4.00

- See Table 2 for notation.
- $\hat{\pi}$ = predicted value of π.
- $\hat{UR}$ = predicted value of UR.

Results for this version are presented in the second half of Table 4. As expected the effects on unemployment and inflation are larger. In 2017 inflation is about 0.37 percent lower and the unemployment rate is about 0.80 percent higher. These compare to 0.28 and 0.54 for the regular version, respectively. Although these effects are larger, they are not huge.

The second experiment involves the price of imports, denoted PIM, which is taken to be a cost shock variable and is an important explanatory variable in the price equation—see Fair (2021). PIM is exogenous in the US model, but it is endogenous in my multicountry (MC) model, discussed in MM. It depends on exchange rates and export prices of other countries. When the Fed, say, raises the interest rate, this leads to an appreciation of the dollar, which lowers PIM, which then lowers domestic prices. The Fed thus affects inflation through affecting exchange rates. In Table 1 in Section 4.4 in MM results are presented from raising RS_t by 1.0 percentage point. One of the endogenous variables is PIM. For purposes of this paper I have calibrated a PIM equation to roughly match these results. The solution was then done with this equation added. As expected, this led to larger decreases in inflation in subperiod E than using the regular version of the model. This effect is, however, fairly small. Inflation in 2017 is about 0.35 percentage points lower rather than 0.28.

Table 5 presents results for the COVID period. The values in the first part of the table are the same as those in Table 3 except that the predicted values of inflation and unemployment have been added. The inflation and unemployment differences are larger in this period than in subperiod E because the interest rate differences are larger. By 2022.1 inflation is 0.92 percentage points lower and the unemployment rate is 0.75 higher. Results in the middle part of Table 5 are with the calibrated stock-price equation added. In this case inflation is 1.50 percentage points lower by 2022.1 and the unemployment rate is 1.42 higher, fairly large differences. Results in the last part of Table 5 are with the calibrated PIM equation added (but not the stock-price equation). Here inflation is 1.69 percentage points lower by 2022.1,

Table 5
Actual and Predicted Values
2020.2–2022.1

Quarter	RS	$\hat{RS}$	π	$\hat{\pi}$	UR	$\hat{UR}$
Regular Version of US Model						
2020.2	0.14	NA	-3.83	NA	12.98	NA
2020.3	0.11	NA	4.08	NA	8.82	NA
2020.4	0.09	2.30	2.59	2.57	6.78	6.80
2021.1	0.05	3.34	4.06	3.98	6.21	6.31
2021.2	0.03	3.25	6.07	5.91	5.90	6.12
2021.3	0.05	3.81	6.95	6.63	5.10	5.47
2021.4	0.05	4.97	7.33	6.71	4.22	4.78
2022.1	0.31	5.62	8.29	7.37	3.81	4.56
Stock Market Response						
2020.2	0.14	NA	-3.83	NA	12.98	NA
2020.3	0.11	NA	4.08	NA	8.82	NA
2020.4	0.09	2.30	2.59	2.57	6.78	6.80
2021.1	0.05	3.28	4.06	3.93	6.21	6.36
2021.2	0.03	3.05	6.07	5.78	5.90	6.30
2021.3	0.05	3.43	6.95	6.38	5.10	5.81
2021.4	0.05	4.39	7.33	6.26	4.22	5.29
2022.1	0.31	4.86	8.29	6.79	3.81	5.23
Price of Imports Response						
2020.2	0.14	NA	-3.83	NA	12.98	NA
2020.3	0.11	NA	4.08	NA	8.82	NA
2020.4	0.09	2.24	2.59	2.16	6.78	6.80
2021.1	0.05	3.23	4.06	3.42	6.21	6.31
2021.2	0.03	3.12	6.07	5.41	5.90	6.11
2021.3	0.05	3.67	6.95	6.08	5.10	5.46
2021.4	0.05	4.80	7.33	5.96	4.22	4.75
2022.1	0.31	5.41	8.29	6.60	3.81	4.51

- See Tables 2 and 4 for notation.
- The solution period is 2020.4–2022.1.

which is also fairly large. It should be noted that because of lags in the model, long run effects are larger than short run effects, and so the results in Table 5 underestimate the long run effects on inflation and unemployment since they are primarily short run.

6 Why Did the Fed Change Its Behavior?

There is, of course, no definitive answer to this question. Laubach and Williams (2003) wrote an influential paper using Wicksell's (1936) concept of the "natural" rate of interest, denoted r^*. Their and subsequent estimates showed r^* falling. Larry Summers gave an influential speech on November 8, 2013, at the IMF Economic Forum arguing that the U.S. economy was in a period of secular stagnation. This work may have led the Fed to be less inclined than it had in the past to raise rates.

There also seemed in this period to be a general view that the Fed could control inflation through its announcements by directly controlling inflation expectations. Inflation was low during subperiod E, and if inflation can be controlled through announcements, there is no need to move early even with low and falling unemployment.[7]

The deviation of Fed behavior from the historical experience is most extreme during the COVID period. The view of the Fed up until about the beginning of 2022 was that almost all of the inflation that began in 2020.3 was due to supply and other transitory issues and that once these were over the Fed's influence on inflation expectations—its credibility—would be enough to lower inflation back down to around 2.0 percent. This turned out, of course, not to be the case. As noted above, survey evidence suggests that the Fed has almost no influence on the

[7]Part of the low inflation during subperiod E can be explained by PIM. Between the fourth quarter of 2012 and the fourth quarter of 2017 PIM fell by 9.9 percent, an annual rate of -2.1 percent. In other words, there were favorable cost shocks during this period.

inflation expectations of agents who are setting prices.

7 Conclusion

The low nominal interest rates during the Great Recession and a few years after that can be explained by the Fed reacting to the sluggish economy. If there were no zero lower bound, it would have reacted even more. This behavior is consistent with historical experience. Between 2011 and 2019, however, the Fed kept the interest rate lower than the rule called for. It did not respond much to the falling unemployment rates, contrary to what it had done historically. The historically low interest rates since 2011 can thus be explained by a change in Fed behavior. The COVID experience through 2022.1 also shows the Fed setting historically low interest rates beginning in 2021 in the face of rising inflation and falling unemployment.

This paper has focused on short term interest rates, but long rates respond to changes in short rates, and the story is the same for long rates. The focus has also been on the United States, but the s story is likely similar for other countries because of the influence of the Fed on other countries' central banks. Finally, the focus has been on nominal interest rates. If, however, the same inflation expectations value is subtracted from both the actual value of RS and the predicted value of RS, then the difference in actual versus predicted is the same each quarter. The same story holds for real rates.

Figure 1
Actual and Predicted RS
1954.1--1979.3

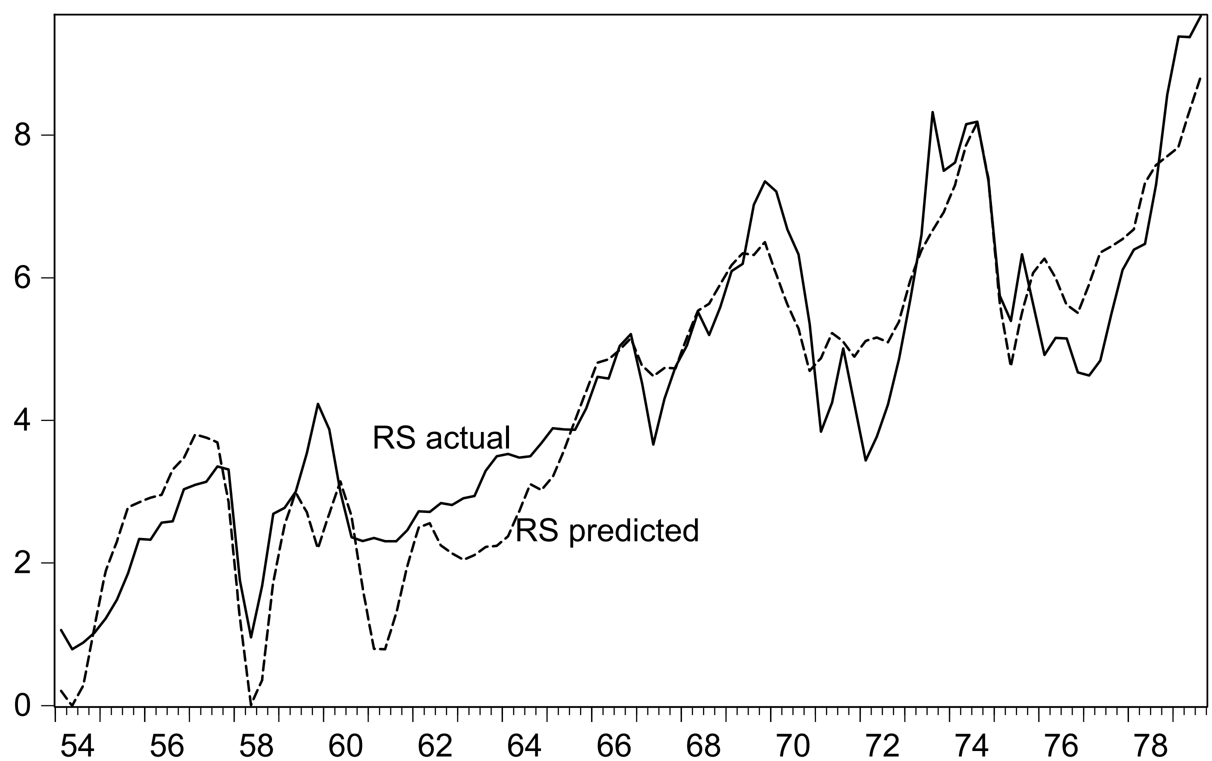


Figure 2
Actual and Predicted RS
1979.4--1982.3

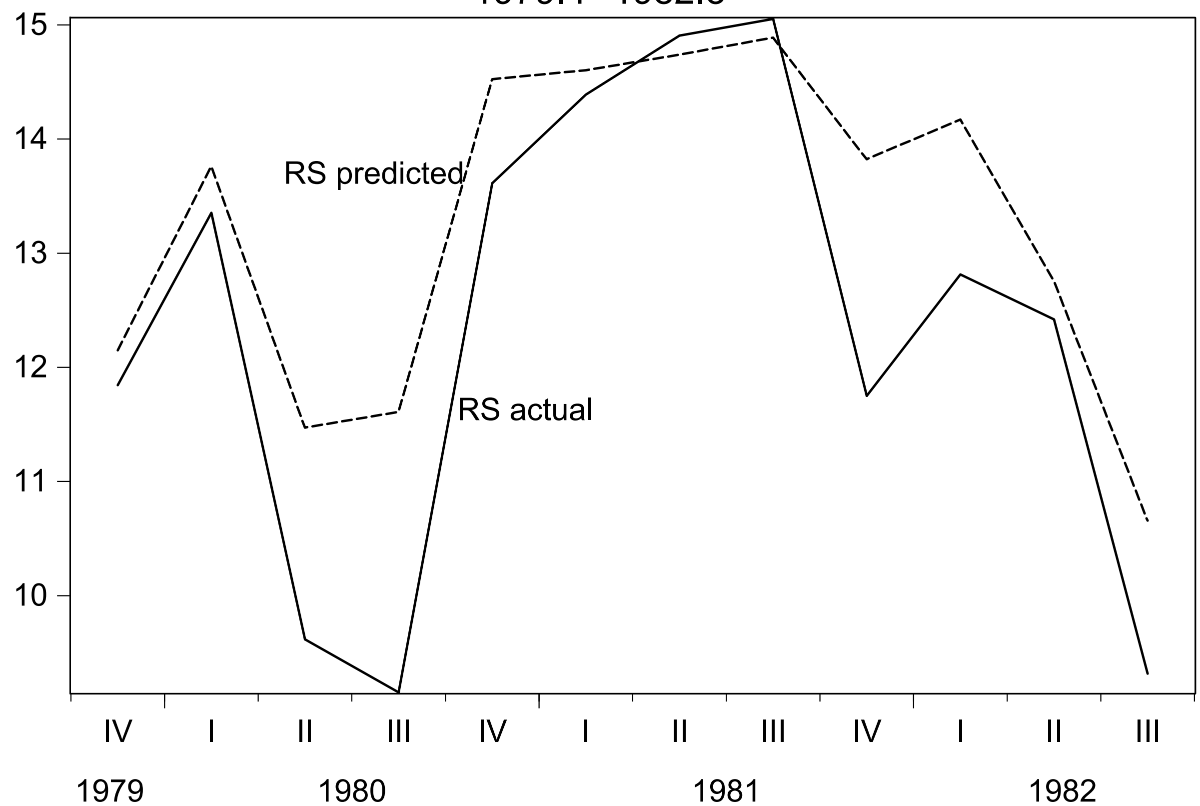


Figure 3
Actual and Predicted RS
1982.4--2008.3

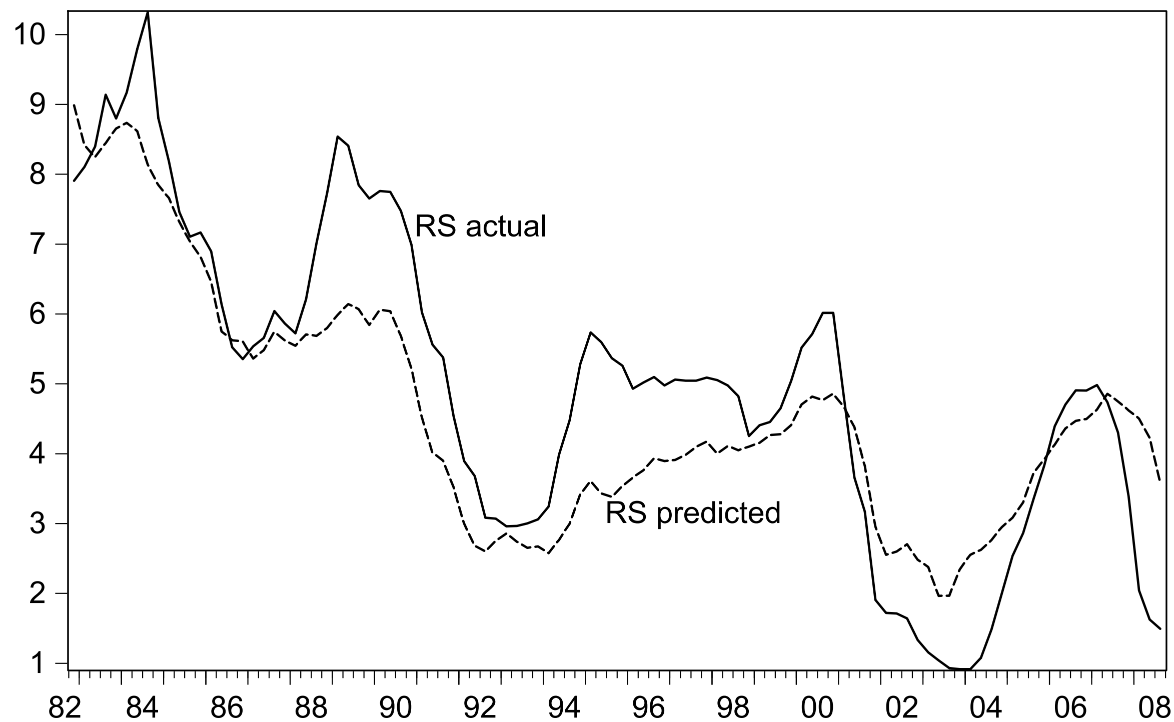


Figure 4
Actual and Predicted RS
2008.4--2010.4

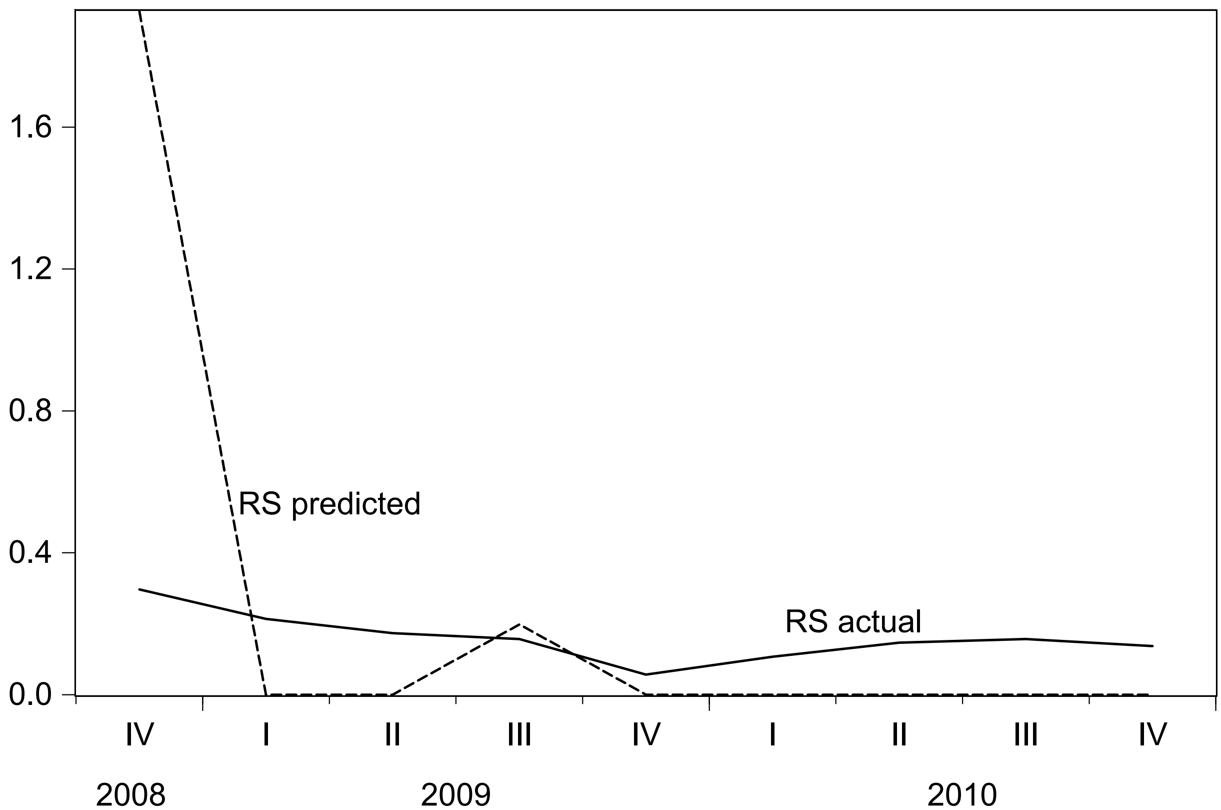
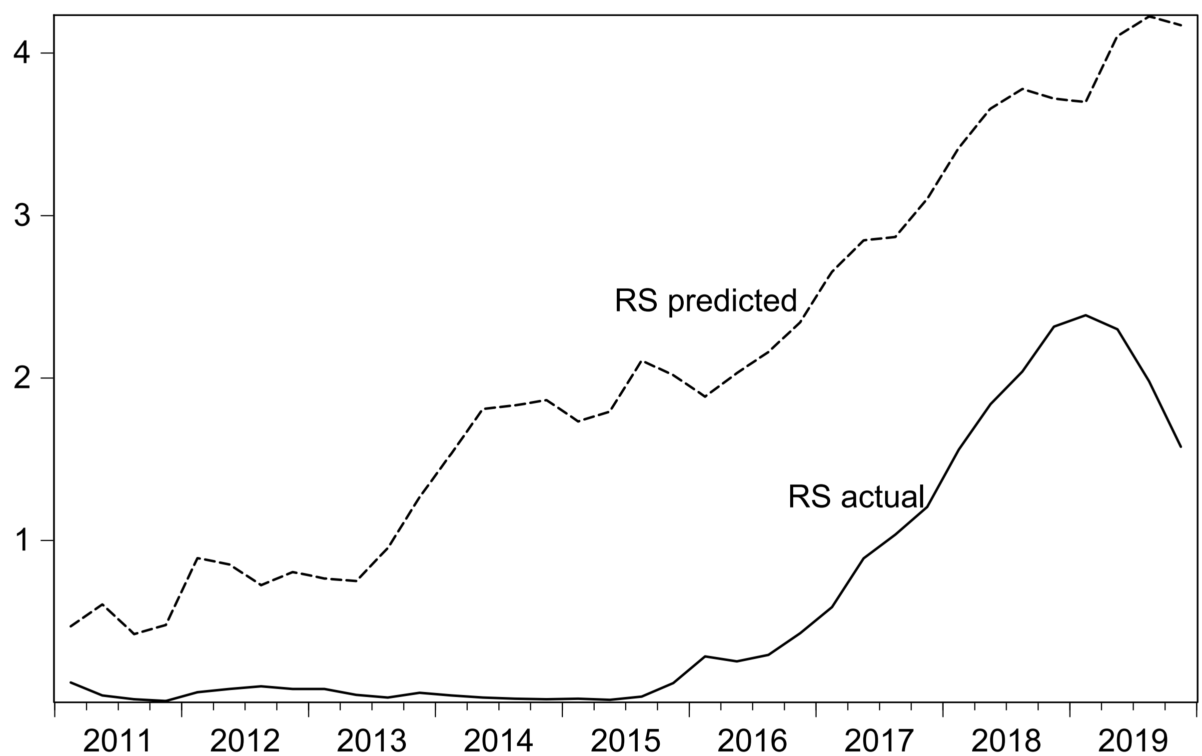


Figure 5
Actual and Predicted RS
2011.1--2019.4



APPENDIX
Table A
Data on RS, $\hat{RS}$, π, and UR
1952.1–2019.4

Quarter	RS	$\hat{RS}$	π	UR
1952.1	1.57	NA	NA	3.07
1952.2	1.65	NA	-0.19	2.98
1952.3	1.78	NA	-1.15	3.22
1952.4	1.89	NA	3.02	2.79
1953.1	1.98	NA	0.05	2.67
1953.2	2.15	NA	-0.92	2.60
1953.3	1.96	NA	1.50	2.72
1953.4	1.47	NA	-0.81	3.70
1954.1	1.06	0.21	0.09	5.23
1954.2	0.79	0.00	0.74	5.78
1954.3	0.88	0.28	-0.49	5.97
1954.4	1.02	1.10	0.69	5.36
1955.1	1.22	1.89	0.71	4.71
1955.2	1.48	2.30	2.19	4.38
1955.3	1.86	2.78	4.73	4.11
1955.4	2.34	2.85	2.55	4.21
1956.1	2.33	2.92	1.00	4.03
1956.2	2.57	2.96	2.63	4.19
1956.3	2.58	3.31	4.22	4.13
1956.4	3.03	3.47	1.64	4.10
1957.1	3.10	3.80	4.15	3.95
1957.2	3.14	3.76	1.48	4.06
1957.3	3.35	3.69	3.20	4.21
1957.4	3.31	2.86	-1.19	4.92
1958.1	1.76	1.24	-2.11	6.28
1958.2	0.96	0.01	-1.63	7.36
1958.3	1.68	0.36	0.28	7.31
1958.4	2.69	1.72	0.13	6.35
1959.1	2.77	2.53	1.82	5.80
1959.2	3.00	2.99	1.80	5.10
1959.3	3.54	2.71	1.16	5.29
1959.4	4.23	2.20	-0.07	5.59
1960.1	3.87	2.69	1.01	5.16
1960.2	2.99	3.15	2.82	5.23
1960.3	2.36	2.66	-0.46	5.55
1960.4	2.31	1.66	-0.11	6.25

Table A (continued)

Quarter	RS	$\hat{RS}$	π	UR
1961.1	2.35	0.79	-3.00	6.77
1961.2	2.30	0.79	0.81	6.97
1961.3	2.30	1.29	0.89	6.75
1961.4	2.46	1.95	1.46	6.17
1962.1	2.72	2.50	1.91	5.61
1962.2	2.72	2.56	1.90	5.48
1962.3	2.84	2.24	0.13	5.54
1962.4	2.81	2.13	0.42	5.51
1963.1	2.91	2.04	2.01	5.78
1963.2	2.94	2.11	0.59	5.68
1963.3	3.29	2.22	-0.21	5.49
1963.4	3.50	2.24	1.89	5.57
1964.1	3.53	2.37	1.57	5.46
1964.2	3.48	2.72	1.98	5.22
1964.3	3.50	3.10	2.72	4.99
1964.4	3.68	3.02	0.22	4.95
1965.1	3.89	3.20	4.07	4.87
1965.2	3.87	3.57	2.46	4.66
1965.3	3.87	4.00	3.08	4.35
1965.4	4.17	4.40	4.34	4.10
1966.1	4.61	4.81	4.63	3.85
1966.2	4.59	4.86	3.05	3.81
1966.3	5.04	4.99	4.74	3.75
1966.4	5.21	5.15	3.39	3.68
1967.1	4.51	4.77	-0.66	3.81
1967.2	3.66	4.62	1.96	3.81
1967.3	4.30	4.74	2.09	3.78
1967.4	4.75	4.73	2.49	3.92
1968.1	5.05	5.16	5.52	3.73
1968.2	5.52	5.54	3.44	3.54
1968.3	5.20	5.64	3.65	3.51
1968.4	5.59	5.91	5.20	3.39
1969.1	6.09	6.18	4.78	3.38
1969.2	6.20	6.34	5.03	3.42
1969.3	7.02	6.32	4.45	3.59
1969.4	7.35	6.50	4.88	3.58

Table A (continued)

Quarter	RS	$\hat{RS}$	π	UR
1970.1	7.21	6.05	2.33	4.16
1970.2	6.68	5.62	5.24	4.75
1970.3	6.33	5.29	2.15	5.17
1970.4	5.35	4.69	1.43	5.80
1971.1	3.84	4.87	6.36	5.91
1971.2	4.25	5.22	5.03	5.91
1971.3	5.01	5.10	3.74	5.98
1971.4	4.23	4.89	3.61	5.95
1972.1	3.44	5.11	5.38	5.77
1972.2	3.77	5.16	3.03	5.66
1972.3	4.22	5.10	4.31	5.58
1972.4	4.86	5.39	5.71	5.30
1973.1	5.70	5.97	6.75	4.95
1973.2	6.60	6.39	8.63	4.89
1973.3	8.32	6.66	7.87	4.79
1973.4	7.50	6.92	7.90	4.77
1974.1	7.62	7.30	12.46	5.09
1974.2	8.15	7.87	12.40	5.16
1974.3	8.19	8.18	13.97	5.58
1974.4	7.36	7.39	9.36	6.56
1975.1	5.75	5.65	7.82	8.22
1975.2	5.39	4.75	4.69	8.83
1975.3	6.33	5.51	7.45	8.47
1975.4	5.63	6.07	6.38	8.26
1976.1	4.92	6.27	6.19	7.72
1976.2	5.16	6.00	4.39	7.53
1976.3	5.15	5.62	6.55	7.70
1976.4	4.67	5.50	6.56	7.73
1977.1	4.63	5.91	8.73	7.49
1977.2	4.84	6.35	7.68	7.10
1977.3	5.50	6.44	7.05	6.86
1977.4	6.11	6.54	7.88	6.61
1978.1	6.39	6.68	5.92	6.33
1978.2	6.48	7.33	11.19	6.00
1978.3	7.31	7.58	9.16	6.02
1978.4	8.57	7.70	8.89	5.88

Table A (continued)

Quarter	RS	$\hat{RS}$	π	UR
1979.1	9.38	7.83	8.50	5.88
1979.2	9.38	8.35	10.37	5.71
1979.3	9.67	8.82	12.56	5.87
1979.4	11.84	12.15	9.25	5.94
1980.1	13.35	13.76	11.87	6.30
1980.2	9.62	11.47	6.33	7.32
1980.3	9.15	11.61	9.98	7.68
1980.4	13.61	14.52	10.41	7.40
1981.1	14.39	14.60	9.69	7.43
1981.2	14.91	14.74	7.42	7.40
1981.3	15.05	14.89	8.93	7.42
1981.4	11.75	13.82	6.19	8.24
1982.1	12.81	14.17	5.82	8.84
1982.2	12.42	12.76	3.59	9.43
1982.3	9.32	10.66	4.00	9.94
1982.4	7.91	8.99	3.25	10.68
1983.1	8.11	8.42	0.49	10.40
1983.2	8.40	8.25	2.81	10.10
1983.3	9.14	8.44	4.86	9.36
1983.4	8.80	8.65	3.56	8.54
1984.1	9.17	8.74	4.18	7.87
1984.2	9.80	8.62	4.36	7.48
1984.3	10.32	8.14	2.98	7.45
1984.4	8.80	7.85	2.86	7.28
1985.1	8.18	7.66	3.68	7.28
1985.2	7.46	7.32	2.47	7.29
1985.3	7.11	7.04	3.07	7.21
1985.4	7.17	6.82	2.11	7.05
1986.1	6.90	6.47	1.67	7.02
1986.2	6.14	5.75	-0.13	7.18
1986.3	5.52	5.62	3.10	6.99
1986.4	5.35	5.61	1.73	6.84
1987.1	5.54	5.36	0.33	6.62
1987.2	5.66	5.48	3.86	6.28
1987.3	6.04	5.74	4.24	6.01
1987.4	5.86	5.62	2.04	5.87

Table A (continued)

Quarter	RS	$\hat{RS}$	π	UR
1988.1	5.72	5.54	3.87	5.73
1988.2	6.21	5.71	3.74	5.49
1988.3	7.01	5.69	3.41	5.49
1988.4	7.73	5.80	4.43	5.35
1989.1	8.54	5.99	3.68	5.22
1989.2	8.41	6.14	5.03	5.24
1989.3	7.84	6.07	2.81	5.28
1989.4	7.65	5.84	2.07	5.37
1990.1	7.76	6.06	5.12	5.30
1990.2	7.75	6.04	2.06	5.34
1990.3	7.48	5.69	4.07	5.69
1990.4	6.99	5.22	3.76	6.11
1991.1	6.02	4.52	0.46	6.57
1991.2	5.56	4.01	0.66	6.82
1991.3	5.38	3.90	1.50	6.85
1991.4	4.54	3.52	0.66	7.10
1992.1	3.89	3.00	1.60	7.38
1992.2	3.68	2.68	2.82	7.59
1992.3	3.08	2.60	2.74	7.63
1992.4	3.07	2.75	3.21	7.41
1993.1	2.96	2.86	2.64	7.15
1993.2	2.97	2.74	2.86	7.07
1993.3	3.00	2.65	1.24	6.80
1993.4	3.06	2.67	2.21	6.62
1994.1	3.24	2.58	1.57	6.56
1994.2	3.99	2.76	1.76	6.17
1994.3	4.48	3.00	2.95	6.00
1994.4	5.28	3.41	3.31	5.62
1995.1	5.74	3.61	2.61	5.48
1995.2	5.60	3.43	2.88	5.67
1995.3	5.37	3.38	1.89	5.66
1995.4	5.26	3.54	1.70	5.57
1996.1	4.93	3.66	2.09	5.55
1996.2	5.02	3.76	2.56	5.47
1996.3	5.10	3.93	1.98	5.26
1996.4	4.98	3.89	2.27	5.31

Table A (continued)

Quarter	RS	$\hat{RS}$	π	UR
1997.1	5.06	3.91	2.32	5.22
1997.2	5.05	3.98	0.24	4.97
1997.3	5.05	4.09	2.09	4.86
1997.4	5.09	4.18	1.21	4.68
1998.1	5.05	4.00	-0.22	4.64
1998.2	4.98	4.11	1.47	4.41
1998.3	4.82	4.05	1.30	4.53
1998.4	4.25	4.10	2.07	4.43
1999.1	4.41	4.16	0.62	4.28
1999.2	4.45	4.27	2.93	4.25
1999.3	4.65	4.28	2.08	4.24
1999.4	5.04	4.41	2.24	4.08
2000.1	5.52	4.71	4.72	4.05
2000.2	5.71	4.82	1.91	3.95
2000.3	6.02	4.77	2.82	4.03
2000.4	6.02	4.86	2.05	3.92
2001.1	4.82	4.67	2.23	4.23
2001.2	3.66	4.38	1.31	4.41
2001.3	3.17	3.83	0.22	4.82
2001.4	1.91	2.96	0.35	5.54
2002.1	1.72	2.55	-0.13	5.71
2002.2	1.71	2.60	2.42	5.85
2002.3	1.64	2.70	1.42	5.73
2002.4	1.33	2.48	1.59	5.85
2003.1	1.16	2.38	3.07	5.87
2003.2	1.04	1.96	0.48	6.15
2003.3	0.93	1.97	2.67	6.11
2003.4	0.92	2.35	2.32	5.82
2004.1	0.92	2.55	2.74	5.69
2004.2	1.08	2.62	3.38	5.60
2004.3	1.49	2.76	3.19	5.44
2004.4	2.01	2.95	4.00	5.40
2005.1	2.54	3.08	2.63	5.29
2005.2	2.86	3.30	3.10	5.12
2005.3	3.36	3.73	5.16	4.98
2005.4	3.83	3.91	3.48	4.96

Table A (continued)

Quarter	RS	$\hat{RS}$	π	UR
2006.1	4.39	4.13	2.72	4.73
2006.2	4.70	4.36	3.44	4.67
2006.3	4.91	4.47	2.66	4.66
2006.4	4.90	4.50	0.25	4.47
2007.1	4.98	4.63	3.53	4.54
2007.2	4.74	4.86	3.12	4.51
2007.3	4.30	4.75	2.01	4.67
2007.4	3.39	4.62	3.20	4.81
2008.1	2.04	4.50	3.26	5.00
2008.2	1.63	4.23	3.63	5.34
2008.3	1.49	3.59	4.07	6.03
2008.4	0.30	1.93	-5.53	6.90
2009.1	0.21	0.00	-3.47	8.32
2009.2	0.17	0.00	-0.25	9.31
2009.3	0.16	0.20	1.54	9.63
2009.4	0.06	0.00	2.09	9.94
2010.1	0.11	0.00	1.43	9.86
2010.2	0.15	0.00	0.58	9.68
2010.3	0.16	0.00	0.73	9.50
2010.4	0.14	0.00	2.91	9.55
2011.1	0.13	0.47	3.28	9.05
2011.2	0.05	0.61	3.94	9.09
2011.3	0.02	0.42	2.05	9.02
2011.4	0.01	0.48	1.19	8.67
2012.1	0.07	0.89	2.76	8.27
2012.2	0.09	0.85	0.99	8.18
2012.3	0.10	0.72	1.44	8.01
2012.4	0.09	0.81	1.70	7.81
2013.1	0.09	0.77	0.78	7.75
2013.2	0.05	0.75	0.39	7.54
2013.3	0.03	0.95	1.50	7.26
2013.4	0.06	1.26	1.97	6.95
2014.1	0.05	1.53	2.01	6.63
2014.2	0.03	1.81	1.75	6.22
2014.3	0.03	1.83	1.49	6.09
2014.4	0.02	1.86	-0.34	5.72

Table A (continued)

Quarter	RS	$\hat{RS}$	π	UR
2015.1	0.03	1.73	-1.69	5.53
2015.2	0.02	1.79	1.67	5.43
2015.3	0.04	2.11	1.00	5.11
2015.4	0.12	2.02	-0.96	5.04
2016.1	0.29	1.89	-0.45	4.89
2016.2	0.26	2.03	2.67	4.92
2016.3	0.30	2.16	1.10	4.89
2016.4	0.43	2.34	2.14	4.78
2017.1	0.59	2.65	2.47	4.57
2017.2	0.89	2.85	0.97	4.36
2017.3	1.04	2.87	1.49	4.32
2017.4	1.21	3.10	2.45	4.18
2018.1	1.56	3.42	2.40	4.03
2018.2	1.84	3.66	2.61	3.93
2018.3	2.04	3.78	1.27	3.79
2018.4	2.32	3.72	0.99	3.84
2019.1	2.39	3.70	0.76	3.83
2019.2	2.30	4.10	2.58	3.63
2019.3	1.98	4.23	0.56	3.61
2019.4	1.58	4.17	1.35	3.60

• See Table 2 for notation.

References

[1] Andrews, Donald W.K., 2003, "End-of-Sample Instability Tests," *Econometrica*, 71, 1661–1694.

[2] Andrews, Donald W.K., and Ray C. Fair, 1988, "Inference in Nonlinear Econometric Models with Structural Change," *Review of Economic Studies*, 615–640.

[3] Blanchard, Olivier, 2019, "Public Debt and Low Interest Rates," *American Economic Review*, 109, 1197–1229.

[4] Brumm, Johannes, Xiangyu Feng, Laurence J. Kotlikoff, and Felix Kubler, 2021, "When Interest Rates Go Low, Should Public Debt Go High?" NBER Working Paper No. 28951, June.

[5] Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas, 2017, "Rents, Technical Change, and Risk Premia Accounnting for Secular Trends in Interest Rates, Returns on Capital, Earning Yields, and Factor Shares," *American Economic Review: Papers and Proceedings*, 107, 614–620.

[6] Christian, James W., 1968, "A Further Analysis of the Objectives of American Monetary Policy," *Journal of Finance*, 23, 465–477.

[7] Clarida, Richard, Jordi Galí, and Mark Gertler, 2000, "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory," *The Quarterly Journal of Economics*, 115, 147–180.

[8] Dewald, William G., and Harry G. Johnson, 1963, "An Objective Analysis of the Objectives of American Monetary Policy, 1952–61," in *Banking and Monetary Studies*, Deane Carson, ed., Homewood, Illinois: Richard D. Irwin, 171–189.

[9] Fair, Ray C., 1978, "The Sensitivity of Fiscal Policy Effects to Assumptions about the Behavior of the Federal Reserve," *Econometrica*, 46, 1165–1179.

[10] Fair, Ray C., 2018, *Macroeconometric Modeling: 2018*, *fairmodel.econ.yale.edu/mmm2/mm2018.pdf*.

[11] Fair, Ray C., 2021, "What Do Price Equations Say Abaout Future Inflation," *Business Economics*, 56, 118–128.

[12] Fair, Ray C., 2022, "A Note on the Fed's Power to Lower Inflation," *Business Economics*.

[13] Gourinchas, Pierre-Oliver, 2017, "Discussion of 'Are Low Real Interest Rates Here to Stay?"' *International Journal of Central Banking*, 13, 43–53.

[14] Judd, John P., and Glen D. Rudebusch, 1998, "Taylor's Rule and the Fed: 1970–1997," *FRBSF Economic Review*, 3, 3–16.

[15] Khoury, Salwa S., 1990, "The Federal Reserve Reaction Function: A Specification Search," in *The Political Economy of American Monetary Policy*, Thomas Mayer, ed., Cambridge: Cambridge University Press, 27–49.

[16] Laubach, Thomas, and John C. Williams, 2003, "Measuring the Natural Rate of Interest," *The Review of Economics and Statistics*, 85, 1063–1070.

[17] Mankiw, N. Gregory, 2022, "Government Debt and Capital Accumulation in an Era of Low Interest Rates," NBER Working Paper No. 3024, May.

[18] McNees, Stephen K., 1986, "Modeling the Fed: A Forward-Looking Monetary Policy Reaction Function," *New England Economic Review*, November/December, 3–8.

[19] McNees, Stephen K., 1992, "A Forward-Looking Monetary Policy Reaction Function: Continuity and Change," *New England Economic Review*, November/December, 3–13.

[20] Rachel, Lukasz, and Thomas D. Smith, 2017, "Are Low Real Interest Rates Here to Stay?" *International Journal of Central Banking*, 13, 1–42.

[21] Taylor, John B., 1993, "Discretion Versus Policy Rules in Practice," *Carnegie-Rochester Series on Public Policy*, 39, 195–214.

[22] Wicksell, Knut, 1936, *Interest and Prices*, London: Macmillian.