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A NOTE ON THE EFFECT OF EXPECTED CHANGES IN MONETARY POLICY ON LONG-TERM INTEREST RATES

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The ability of monetary policy to affect long-term interest rates is of central importance for economics and finance. Several recent studies have shown that long-term interest rates are virtually unaffected by monetary policy. This paper develops a statistical methodology to identify the expected and unexpected changes in monetary policy as measured by the federal funds rate. The empirical evidence shows that expected changes in the funds rate cause stronger and more significant movements in the long-term rates. Further, ignoring such asymmetry can erroneously generate the insignificant responses of long-term interest rates to the changes in the monetary policy.

JEL classification codes: E5, C5
Key words: long-term interest rate, monetary policy, asymmetry

I. Introduction

The ability of monetary policy to affect long–term interest rates directly is central to traditional Keynesian theories. In the conventional view, an expansionary monetary policy translates into a decrease in nominal and real interest rates. The

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lower interest rates raise the desired level of consumption of durable goods, investment spending, and real output. However, several studies cast doubt on the significance and stability of the relationship between the federal funds rate – the primary monetary tool – and long-term interest rates. For example, Cook and Hahn (1989) estimate the responses of interest rates at different maturities to changes in the funds rate target and find the responses of long-term rates to be significant but extremely small. Edelberg and Marshall (1996) find insignificant responses of long-term bond yields to exogenous shocks to the funds rate. Evans and Marshall (1998) show that exogenous monetary policy shocks have no effect on long-term interest rates.

There have been some recent attempts to revive the interest rate channel. For example, Roley and Sellon (1995) emphasize the importance of incorporating the market anticipations of future monetary changes. They show that significant parts of the movement in 30-year Treasury Bond yields appear in advance of, rather than contemporaneously with or subsequent to, policy actions. Kuttner (2001) utilizes the future funds rate to separate the target funds rate into its expected and unexpected components and reports insignificant responses of the long-term bond yields to the expected components of the target rate. On the other hand, the responses to the unexpected components are much larger, positive, and significant. Thus, Kuttner (2001) attributes the insignificant relationship between the funds rate and long-term interest rates to the failure to distinguish between expected and unexpected movements of the Fed's monetary policy.

The objective of this study is to reexamine the transmission mechanism from the federal funds rate to long-term interest rates while allowing for the possibility of asymmetric responses of long-term interest rates to expected and unexpected changes in the monetary policy. Our analysis differs from Kuttner (2001) in two aspects. First, we apply multivariate non-linear least squares (non-linear SURE) to separate the expected and unexpected components of the funds rate. Thus, we use a statistical proxy to measure the anticipated monetary policy rather than resorting to the use of futures data. Here we must mention that Kuttner (2001) also discusses the possibility of separating both components through the application of statistical methods as opposed to his choice of using the futures markets but offers no specific results from such an investigation. We take this lead and proceed to use a statistical proxy to measure anticipated monetary policy rather than resorting to the use of futures data. We then adopt a rolling estimation technique that helps in locating the changes in causality, and we test for the robustness of our results on a monthly basis. More precisely, our samples have a fixed window of 265 months and roll forward from 1988:01 to 2004:07, which allows us to gauge the importance of each individual observation. Our results, therefore, take into account a larger database than in Kuttner (2001), where only a single analysis of the entire post-1989 period is conducted.

This paper documents that when using a statistical proxy the long-term interest rates respond asymmetrically to expected and unexpected changes in the federal funds rate. By capturing such asymmetry, monetary policy is shown to have a significant impact on long-term interest rates. However, unlike Kuttner (2001), we find the expected changes in the funds rate to be more important than the unanticipated changes. We attribute the difference in results to the use of the statistical proxy in capturing the anticipated movements in the funds rate. The intuition here is that long-term rates respond mostly to changes in economic fundamentals that can possibly be captured better by the expected movements in the federal funds rate. This difference can also be attributed to the fact that the results related to expectation forecasts based on the futures price as used by Kuttner (2001) depend on the validity of the unbiased expectation hypothesis. There have been many studies that show the importance of expectations in shaping the term structure, such as Fama (1984). Others, such as Campbell and Shiller (1991), offer conflicting evidence, while an earlier study by Mankiw and Miron (1986) demonstrates that the predictions of the expectations hypothesis fit the data better in periods where interest rate movements have been highly forecastable. Further, the work of Cox, Ingersoll, and Ross (1981) directly addresses a series of problems with the expectations hypothesis. More recently Bekaert, Hodrick, and Marshall (1997) document extreme persistence in short interest rates and prove that plausible sources of measurement error in short and long yields do not salvage the expectations hypothesis. Finally Chance and Rich (2001) thoroughly recap the shortcomings of the unbiased expectations hypothesis and are unable to explain why it remains a widespread belief (particularly among practitioners); they also provide a long list of work that evolves around the problems associated with the unbiased expectations hypothesis.

This paper is organized as follows: Section II describes the data and empirical model used to examine the causality between the federal funds rate and long-term interest rates. Section III reports the empirical results. Section IV offers concluding remarks.

II. A framework for analyzing the effects of monetary policy on long-term interest rates

The first step in examining the causal relationship between long-term interest rates and monetary policy is to estimate the Federal Reserve reaction function. While there are a number of options for the monetary measure, we follow McCallum (1983), Bernanke and Blinder (1992), Leeper (1992), Sims (1986, 1992), and Morgan (1994), and choose the first difference in the federal funds rate (Δr) as our indicator of monetary policy actions. This choice is consistent with the recognition by Laurent (1988) and Bernanke (1990) that many, if not most, recent monetary policy changes have been implemented through changes in the funds rate. To maintain the monthly information contained within the monetary measure, we introduce the first difference of the log of the industrial production (Δy) as our output measure.

In addition to the output measure, we incorporate two price measures: the first difference of the log of the consumer price index (Δp) and the spot market index for all commodities (Δcp). While the price index is included to capture an alternative non-output response to monetary shocks, the commodities price index is introduced to account for the so-called "price puzzle." As has been well documented in the literature (Dichenbaum 1992 and Christiano, Eichenbaum, and Evans 1996), the puzzle describes the empirical finding of a negative correlation between inflation and money shocks. Sims (1992) suggests that the puzzle is an outgrowth of excluding endogenous policy responses to inflationary pressure and suggests further that introducing a proxy for world commodity prices within the VAR framework may solve the puzzle. Specifically, Sims (1992) suggests that the commodity price measure may account for the fact that the Fed utilizes this information when setting its reaction function.

Finally, we include the first difference of the log of the money supply ($\Delta m2$) and total reserves (Δtr) in the Fed's reaction function. The two variables are introduced to capture demand-side adjustments. Following a large and rudimentary literature, Kim (1999) introduces $\Delta m2$ to capture the usual money demand movements. Total reserves are further introduced to capture the argument of Strongin (1995) that innovations in total reserves conducted by the Fed mainly reflect the changes in the mixture of borrowed and non-borrowed components to accommodate for innovations in the demand for total reserves. Thus, including the two variables in the federal funds equation may account for the demand shocks in $\Delta m2$ and total reserves, and may help identify the policy innovations. In summary, the Federal Reserve reaction function is based on estimating the following model:

$$\Delta r_t = \text{constant} + A_r(\text{L})\Delta r_t + A_y(\text{L})\Delta y_t + A_p(\text{L})\Delta p_t + \tag{1}$$

$$A_{cp}(\text{L})\Delta cp_t + A_{m2}(\text{L})\Delta m2_t + A_{tr}(\text{L})\Delta tr_t + \Delta r_t^u ,$$

where the lag polynomials is of the form $A(\text{L}) = a_1\text{L} + \ldots$, and the systematic part of the equation (Δr^e) can be treated as our statistical proxy of the expected changes in the funds rate at time (t). Analogously, the unexpected components of the funds rate are defined as:

$$\Delta r_t^u = \Delta r_t - \Delta r_t^e . \tag{2}$$

Then, the restricted and unrestricted equation of the long-term interest rate (base-model) measured by the 20-year Treasury Bond yield (Δlr) can be stated as follows:

$$\Delta lr_t = \text{constant} + A_{lr}(\text{L})\Delta lr_t + A_y(\text{L})\Delta y_t + A_p(\text{L})\Delta p_t + A_r(\text{L})\Delta r_t + \Delta lr_t^u , \tag{3}$$

$$\Delta lr_t = \text{constant} + A_{lr}(\text{L})\Delta lr_t + A_y(\text{L})\Delta y_t + A_p(\text{L})\Delta p_t + \tag{4}$$

$$A_{ru}(\text{L})\Delta r_t^u + A_{re}(\text{L})\Delta r_t^e + \Delta lr_t^u ,$$

where the restricted system of equations is (1), (2), and (3), and the unrestricted system of equations is (1), (2), and (4). Thus, equation (1) has at least one variable that does not enter equations (3) or (4) to solve the observational equivalence problem.

We jointly estimate each system of equations by using multivariate non-linear least squares (non-linear SURE). We adopt this estimation technique to account for the "generated regressors" problem pointed out by Pagen (1984) and the non-linearity resulting from the cross-equation restrictions imposed by rationality. The starting values of the coefficients for the joint estimation are obtained by separately estimating each equation using ordinary least squares (OLS). The convergence of the algorithm is achieved when the change from one iteration to the next in the coefficients is less than .001.

We run several statistical tests to examine the null hypothesis that the long-term interest rate responds symmetrically to expected and unexpected movements in the federal funds rate. First, we calculate the likelihood ratio statistic based upon the log determinants of the residual series of the restricted and unrestricted models. The resulting likelihood ratio statistic is distributed asymptotically as chi-squared and calculated by the following equation:

$$\chi^2 = (T - C)\left(\log\left|\Sigma_r\right| - \log\left|\Sigma_u\right|\right), \tag{5}$$

where Σ_u and Σ_r are the covariance matrices of the unrestricted and restricted models. In addition, T is the number of observations and C is the multiplier correction. Second, we use the Wald statistics to test for the hypothesis that the coefficients on the same lagged r^e and r^u in the long-term interest rate equation are equal. Third, we use the Wald statistics to test the hypothesis that the coefficients on r^e are jointly zero, and the coefficients on r^u are jointly zero in the unrestricted long-term interest rate equation (4). Finally, we use the Wald statistics to test the hypothesis that the coefficients on r are jointly zero in the restricted long-term interest rate equation (3).

We next explore the robustness of our results along four dimensions: (1) sub-sample stability of the causal relationship between the funds rate and the long-term interest rate; (2) alternative measures of interest rates; (3) different lag lengths; and (4) different specifications for the fed's reaction function and the long-term interest rate equation.

(1) Sub-sample stability. We estimate rolling window versions of the restricted and unrestricted system of equations for different periods. We choose an initial window (sample size) of 265 and we start our estimates at 1966:01, when the federal funds market began to function as a major source of bank liquidity (Meulendyke 1989). We run our initial estimation for the sample period that extends from 1966:01 to 1988:01. Then, we adjust the starting and ending dates forward by one period and we re-estimate our two systems of equations and the related statistics. The process continues through the entire sample to produce a time series of estimates ranging from 1988:01 to 2004:07. The main advantage of using the rolling window regressions is that the responses are more sensitive to including or excluding observations from the data set, which helps in locating the changes in the causality between the federal funds rate and the long-term interest rate. (We will refer to the window

rolling regression described above as the base-model throughout the paper.) To examine whether our results are attributed to the new information being incorporated or to the old information being thrown out, we conduct forward rolling regressions (forward responses) in which the starting date is kept the same for all the regressions as we extend our samples forward from 1988:01 to 2004:07.

(2) Alternative measures. We test the robustness of our results to different measurements of long-term interest rates such as 10-year and 5-year Treasury yield.

(3) Different lag lengths. We explore the effects of including different numbers of lags in the restricted and unrestricted system of equations. We start our analysis by searching for the most parsimonious specification for the restricted and unrestricted system of equations. However, the likelihood ratio and the multivariate AIC and SBC statistics suggest different lag length depending on the sample periods. Thus, we try different lag specifications from 3 to 12, and choose 12 lags with the best significance performance. We also report our statistics for 3 lags.

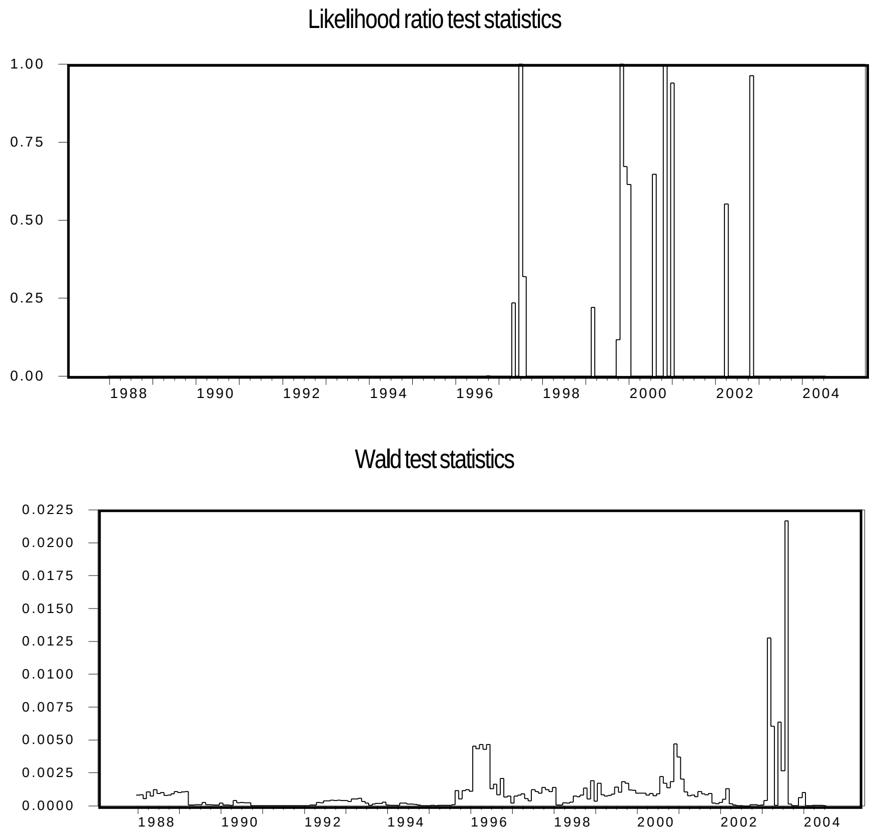
(4) Alternative specifications. We test the robustness of our results to including the lags of the Δlr in the Fed's reaction function, and to including $\Delta m2$, Δtr, and Δcp in the long-term interest rate equation.

III. Empirical results

A. Asymmetry tests

Figure 1 displays the significance levels of the likelihood ratio and Wald statistics for testing whether the 20-year Treasury yields respond asymmetrically to expected and unexpected movements in the funds rate as the sample is rolled forward from 1988:01 to 2004:07 (base model), where the date on the horizontal axis indicates the end date of the samples. For example, the tests for the sample period extending from 1976:1 to 1998:01 are presented at 1998:01 on the horizontal axis. Further, Table 1 reports the probabilities of rejecting the symmetric hypothesis for the base model and its robust specifications at the 10%, 5%, and 1% levels. Figure 1 and Table 1 overwhelmingly confirm the asymmetric responses of long-term interest rates to the expected and unexpected changes in the federal funds rate. Thus, modeling the relationship between the monetary policy and the long-term interest rates without accounting for such asymmetry can lead to model misspecification and should cast a doubt on the reported results of many studies.

Figure 1. Tests for asymmetric responses of 20-year Treasury yields to expected and unexpected movements in the funds rate



Note: Figure 1 displays the significance of the likelihood ratio and Wald statistics for asymmetry as the sample is rolled forward from 1988:01 to 2004:07 (base model), where the date on the horizontal axis indicates the end date of the samples. For example, the tests for the sample period extending from 1966:1 to 1988:01 are presented at 1988:01 on the horizontal axis, and the sample period extending from 1976:1 to 1998:01 are presented at 1998:01.

Table 1. The likelihood and Wald tests for asymmetry

Maturity	Likelihood test (%)	Wald test (%)
20 years (12 lags)		
10% level	93.4	100
5% level	93.4	100
1% level	93.4	98.9
20 years (12 lags) Forward responses		
10% level	100	100
5% level	100	100
1% level	100	98.9
20 years (3 lags)		
10% level	99.4	94.9
5% level	98.4	93.9
1% level	97.4	90.4
10 years (12 lags)		
10% level	95.4	100
5% level	94.9	100
1% level	94.4	99.4
5 years (12 lags)		
10% level	96.4	100
5% level	96.4	100
1% level	93.4	99.4

Note: Table 1 reports the probability of significant asymmetric responses at the 10%, 5% and 1% levels. The probability of rejecting the null hypothesis of symmetric response of the different interest rate to expected and unexpected changes in the federal funds is reported as the sample periods rolled from 1988:01 to 2004:07, where the initial estimation period extends from 1966:01 to 1988:01. Except for the case of "forward responses", we adjust the starting and ending dates forward by one period. For each specification, we conduct the symmetry test 199 times and calculate the probability of rejecting the null at the three significance levels.

B. Response tests of interest rate to expected and unexpected changes in the federal funds rates

Figures 2 and 3 display the window and the forward responses of the 20-year treasury yields to the funds rate and its expected and unexpected components.

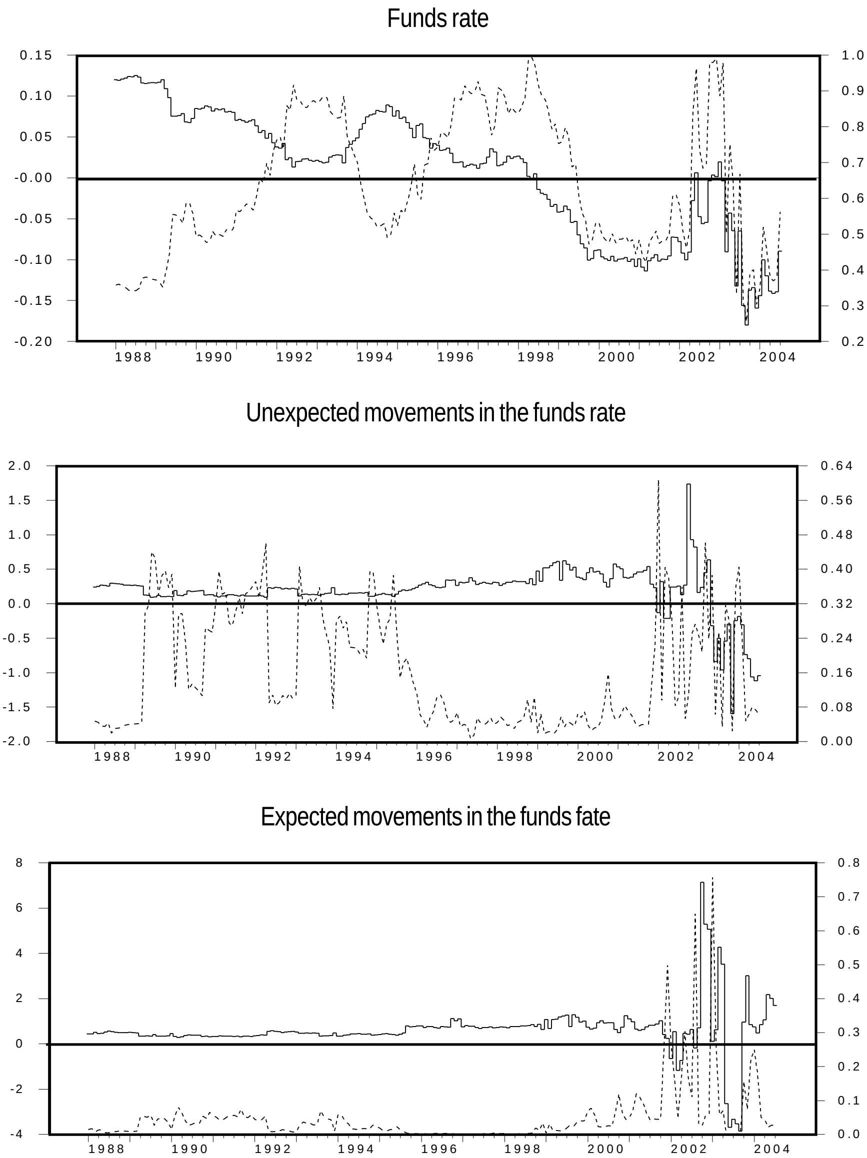
More specifically, the two figures depict the accumulated responses and their joint statistical significance at each point in time. Figures 2 and 3 reveal four interesting empirical findings. First, the responses of the 20-year Treasury Bond yields are significant only when we account for the asymmetry to expected and unexpected movements in the funds rate as specified by equation (4). Second, anticipated changes in the funds rate have a larger and more important effect on the 20-year bond yields. Third, the insignificant responses of the interest rate to the expected changes in the federal funds rate during the late 1980s and the first half of the 1990s can be attributed to dropping the significant observations between 1967 and 1973. Fourth, the channel from the anticipated and unanticipated funds rate to 20-year bond yields has been tremendously weakened in the time period between 2001:11 and 2004:07.

Finally, Table 2 reports the robustness tests of our results to different measures of interest rates and different number of lags. Table 2 illustrates the percentage of the test statistics rejected at the 10%, 5% and 1% significance levels. It also shows the average accumulated coefficients on the lags of the funds rate and its components. For example, the average summation on the 12 lags of the anticipated changes in the funds rate is .628 in the 20-year bond equation. Table 2 demonstrates that the responses to the anticipated changes in the funds rate are both more likely to be statistically significant, and larger in magnitude than are those of the funds rate and its unanticipated components. Such findings can also be extended to the responses of the 10- and 5-year bond yields. Table 2 also shows that using longer (12 lags) versus shorter lags (3 lags) does not decrease the power of the test statistics. Similarly, we find the responses to be robust to including Δlr in the fed's reaction function and to including $\Delta m2$, Δtr in the long-term interest rate equation. In the case of Δcp, we find the lagged values of it to be insignificant and highly collinear with the expected changes in the funds rate. As a result, the expected changes in the funds rate became insignificant in the long-term interest rate equation.[1] Thus, the key results of the 20-year bond yields are robust to the use of different measures of long-term interest rates and to different specifications.

Finally, our results should be interpreted with attention to several main shortcomings. First, a 22-year sub-sample includes large number of structural

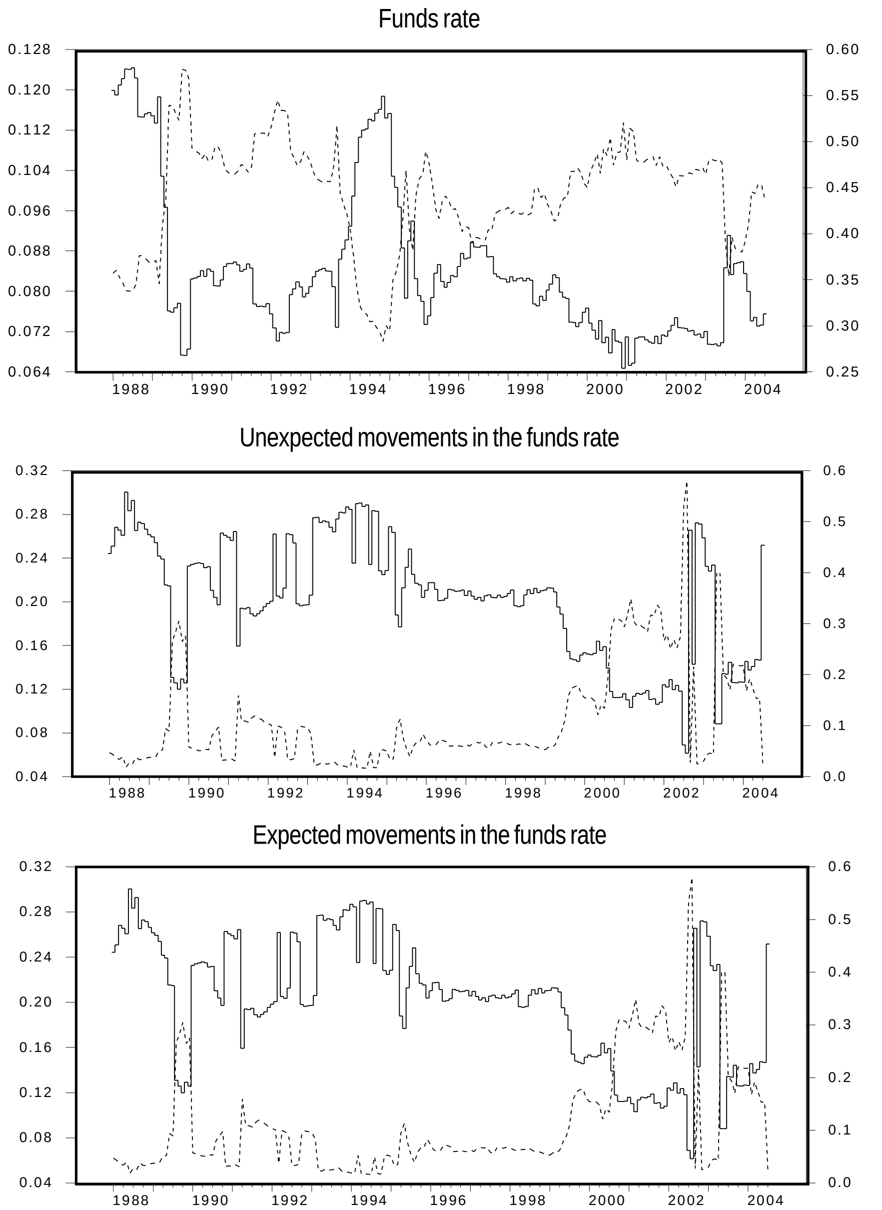
[1] The responses, which we do not report here, are available from the authors upon request.

Figure 2. Window responses of 20-year Treasury yields to the funds rate [accumulated coefficients (—) and significance level (---)]



Note: Figure 2 displays the window responses of the 20-year treasury yields to the funds rate and its expected and unexpected components as the sample is rolled forward from 1988:01 to 2004:07 (base model). For example, the accumulated coefficients and their significance represented on the horizontal axis at 1988:01 and 1998:01 are calculated from the sample periods extending from 1966:1 to 1988:01, and 1976:1 to 1998:01 respectively.

Figure 3. Forward response of 20-year Treasury yields to the funds rate [accumulated coefficients (—) and significance level (---)]



Note: Figure 3 displays the forward responses of the 20-year treasury yields to the funds rate and its expected and unexpected components as the sample is rolled forward from 1988:01 to 2004:07 while holding the starting date constant for all the samples. For example, the accumulated coefficients and their significance represented on the horizontal axis at 1988:01 and 1998:01 are calculated from the sample periods extending from 1966:1 to 1988:01, and 1966:1 to 1998:01 respectively.

Table 2. Accumulated responses of interest rates with different maturities to the funds rate

Maturity	Funds rate (%)	Anticipated funds rate (%)	Unanticipated funds rate (%)
20 years (12 lags)	(.0065)	(0.628)	(0.192)
10% level	0	90.9	48.2
5% level	0	72.3	28.6
1% level	0	29.1	0.5
20 years (12 lags) Forward responses	(0.084)	(0.405)	(0.200)
10% level	0	73.8	64.8
5% level	0	69.8	27.1
1% level	0	26.1	0
20 years (3 lags)	(0.019)	(0.639)	(0.105)
10% level	0	82.4	0.5
5% level	0	67.8	0
1% level	0	27.6	0
10 years (12 lags)	(-0.035)	(0.512)	(0.133)
10% level	0	80.9	23.6
5% level	0	56.7	4.5
1% level	0	23.6	0
5 years (12 lags)	(0.019)	(0.639)	(0.105)
10% level	0	84.9	16.0
5% level	0	69.8	7.5
1% level	0	34.6	0

Note: Table 2 reports the probability of the responses being significant at the 10%, 5% and 1% levels. The probability of rejecting the null hypothesis of statistical insignificant response of the long-term interest rates to the funds rate and its expected and unexpected components is reported as the sample periods rolled from 1988:01 to 2004:07, where the initial estimation period extends from 1966:01 to 1988:01. Except for the case of "forward responses", we adjust the starting and ending dates forward by one period. For each specification, we conduct the Wald test 199 times and calculate the probability of rejecting the null at the three significance levels. The numbers between the brackets are the average accumulated coefficients on the lags of the funds rate and its components.

changes in how monetary policy has been conducted. However, reducing the size of the widow or remodeling each period requires using smaller number of lags that will render test statistics invalid. Moreover, we are testing the robustness of our results for the sample periods between 1988:01 and 2004:06, when the Fed's policy has been characterized by both a greater transparency and consistency and very few structural breaks. Finally, any distortion resulting from imposing the same Fed function during the 1970s and the early 1980s has been introduced to both the expected and unexpected components and may not affect the relative importance of expected and unexpected changes over the periods in question. In addition, a statistical proxy such as ours suffers from the issue of data vintage raised by Kuttner (2001) and others.

IV. Conclusion and discussion

In this paper, we explore the impact of monetary policy on long-term interest rates. Our estimation methodology attempts to address the three issues raised by Kuttner (2001). In particular, we deal with the issue of model selection by using different specifications and lags, while we solve the generated-regressor problem by simultaneously estimating our system of equations. We also use a rolling technique to account for sub-sample instability and for changes in the causality between long-term interest rates and the federal funds rate.

We document the significant difference in the way long-term interest rates respond to expected and unexpected changes in the funds rate. Consequently, we show that the importance of the expected changes far exceeds that of the unexpected changes in the long-term interest rate equation. For example, we document that for the 20-year bond (when 12 lags are used) the expected change in the funds rate is significant at the 5% level 72.3% of the times, whereas the unexpected change is significant only 28.6% of the times. Furthermore, the coefficient in the former case is 0.628, while in the latter it is only 0.192. The supporting intuition here is that long-term rates respond mostly to changes in economic fundamentals that possibly can be better captured by the expected movements in the federal funds rate. We also find our results to be consistent with Mishkin (1982) where anticipated monetary policy has a more important effect on output than unanticipated changes.

We then argue that the causality between the funds rate and the long-term rates is insignificant when the asymmetric response to expected and unexpected changes in the funds rate is not considered. In this, we concur with Kuttner's (2001) results. Thus, not distinguishing between expected and unexpected changes in the federal funds rate causes failure to detect the significance of monetary policy.

Finally, the results reveal that the link between the anticipated and unanticipated movements in the funds rate and the long-term interest rate has been significantly weakened during the last few years of our study. We attribute the ineffectiveness of the Fed's policy to the fact that the market perceived the continuous decline in the funds rate to unprecedented levels as a temporary policy that will be reversed in the near future.

In conclusion, our results are Friedmanesque in the sense that monetary policy will be more effective if the movements of the funds rate are perceived to be persistent and consistent with the Fed's policy to stimulate the economy and fight inflation.

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