Monetary Policy and Long-term Interest Rates

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Abstract

This paper documents some new empirical results about the monetary policy and long-term interest rates in the United States. It shows that changes in the monetary policy stance are more predictable to the bond market in the 1990s than in the 1970s. This shift in the predictability of the monetary policy actions affects the policy's impact on long-term interest rates as well as the forecasting power of the yield spread for the future changes in short-term interest rates.

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1 Introduction

The target federal funds rate is the most important indicator of the monetary policy stance in the United States. Since the bond market is the key link in the transmission of the monetary policy, the effect of changes in the target rate on long-term interest rates has been the focus of a long strand of literatures. For example, Cook and Hahn (1989) find that the one-day responses of bond rates to changes in the target federal funds rate have been large and significant from 1974 through 1979. Other studies, such as Roley and Sellon (1995), have found that the impact of the target federal funds rate seems to be time-varying, and in particular, has become much smaller in more recent years.

Such changes in the monetary policy effect may not be puzzling, however. Given the forward-looking nature of the bond market, the effect of a change in the target federal funds rate on market interest rates depends crucially on whether or not the policy action is anticipated. As pointed out by Kuttner (2001), the previous studies did not distinguish between anticipated and unanticipated policy actions. Using data from the future market for federal funds to separate changes in the target federal funds rate into anticipated and unanticipated components, Kuttner (2001) finds that the unanticipated policy changes continues to have a large and significant impact on long-term interest rates from 1989 to 2000.[1]

In this paper I provide further empirical evidence on the predictability of the monetary policy actions and the policy's impact on long-term interest rates in the United States. In particular, I compare the forecasting ability of long-term interest rates for the monetary policy actions during the 1990s to that in the early period from 1974 to 1979. Based on a bi-variate Vector Auto-regression (VAR) model, I find that changes in long-term interest rates in fact Granger-cause changes in the target federal funds rate, but not vice versa, during 1990-2001. Changes in the interest rate target are predicted by changes in long-term interest rate in the 1990s. In sharp contrast, during 1974-1979, changes in long-term interest rates are found not to Granger-cause changes in the monetary policy's target rate. Changes in the target

[1] Since the future market for federal funds was established in 1989, one limit of this study is that it can only be applied to the post-1989 period. Other empirical studies on the impact of monetary policy actions on long-term interest rates include Fuhrer (1995), Rudebush (1995), Mehra (1996), Balduzzi, Bertola and Foresi (1997) etc. Akhtar (1995) provides a survey of early empirical studies on this issue.

federal funds rate are mostly unanticipated by the bond market during the period between 1974 and 1979. These results support conclusion in Kuttner (2001) that simple regressions of market interest rates on the target federal funds rate can be miss-leading because the changes in the interest rate target were "contaminated" by expected policy moves in the later period.

The finding of the current paper is consistent with those of a few other studies on financial market forecasts of short-term interest rates. For example, Poole and Rasche (2000) and Poole, Rasche and Thornton (2002) provided evidence based on case studies that the federal funds future market has become better able to anticipate the decisions by Federal Open Market Committee (FOMC) since 1994. Lange, Sack and Whitesell (2001) show that the financial market's ability to forecast the federal funds rate has increased in more recent years. Swanson (2004) attributes these improvements to increased transparency of the monetary policy in the 1990s.

A popular approach to examine the impact on long-term interest rates of the unanticipated element of the monetary policy is by estimating the impulse response functions from a VAR (e.g. Edelberg and Marshall, 1996, and Evans and Marshall, 1998, among others). A VAR is the reduced form of a structural system of endogenous macroeconomic variables. The dynamic relationship among the economic variables is conditional on the particular way the monetary policy reacts to macroeconomic developments. A shift in the monetary policy behavior will likely introduce structural changes in the system, and lead to different responses to even exogenous monetary shocks.[2] Using the target federal funds rate and the yield on 10-year Treasury bond, I find that the impulse response functions are indeed very different across the two periods (1974-1979 and 1990-2001) and are consistent with the varying predictability of the monetary policy.

The difference in the predictability of the monetary policy may also account for the different properties of the yield curve during 1974-1979 and in the 1990s. The expectation theory of the term structure of interest rates holds that the spread between long and short interest rates predicts future changes in the short rate. But empirical evidence is at best mixed, and usually goes against the hypothesis (e.g. Campbell and Shiller, 1991). While time-varying risk premiums can potentially explain the failure of the expectation theory, I argue in the current paper that the shift in the monetary policy behavior also plays an important role. In particular, unpredictable

[2] This is just another example of Lucas Critique.

monetary policy actions can eliminate any predictable movements in the short-term interest rate, so that the slope of the yield curve contains no information about the future change in the short-term interest rate. Indeed, I find that the yield spread has no forecasting power for future changes in the short-term interest rate during 1974-1979. In contrast, the yield spread has a large and significant forecast power during 1990-2001 when monetary policy was found to be more predictable to the bond market than in the earlier period.[3]

2 Predictability of Monetary Policy Actions

It is widely understood that the Federal Reserve's interest rate policy is guided by some policy rule, particularly so in more recent periods. For example Taylor (1993) recommends that the monetary policy should respond in a systematic way to inflation and output gap. Several empirical studies, such as Clarida Gali and Gertler (1997) among other, have estimated various versions of the policy reaction function. On the other hand, since financial markets are forward-looking, the current asset prices, and in particular, long-term interest rates, should incorporate expectations of the future macroeconomic developments (such as inflation) as well as the monetary policy's reactions. Long-term interest rates should have a significant forecasting power for the future policy actions if the monetary policy is indeed predictable.

To examine the predictability of the monetary policy, I therefore use a bi-variate VAR that includes weekly changes in the target federal funds rate and weekly changes in the yield on 10-year government bond. I test whether or not changes in the 10-year interest rate Granger-cause changes in the monetary policy's target rate, and vice versa. The test is done separately for the two periods: 1974-1979 and 1990-2001. The first period corresponds to the one studied in Cook and Hahn (1989) and also in Rudebusch (1995). The second period corresponds roughly to the one studied in Kuttner (2001). The data on the target federal funds rate during 1974-1979 are taken from Rudebusch (1995). In the second period, the series of the target federal funds rate is obtained from Federal Reserve Bank of New York City. In both periods, the data on the 10-year interest rate are obtained from Board

[3]Mankiw and Miron (1986) and McCallum (1994) also attribute the empirical rejection of the expectation hypothesis to the influence of monetary policy.

of Governors of the Federal Reserve System. These series are plotted in Figure 1 and their summary statistics are reported in Table 1.

Table 1. Summary Statistics

09/13/1974 - 09/21/1979	Average	Std Dev	Auto-corr	Correlation
Target Federal Funds Rate	6.92	2.06	0.9976	1.0000
10-year Treasury Yield	8.03	0.62	0.9902	0.7793
07/13/1990 - 12/28/2001	Average	Std Dev	Auto-corr	Correlation
Target Federal Funds Rate	4.98	1.26	0.9967	1.0000
10-year Treasury Yield	6.38	1.01	0.9945	0.3634

We can clearly see that both the long-term interest rate and the target federal funds rate are highly persistent in both periods with an auto-correlation coefficient of more than 0.99. In fact, the standard test fails to reject the unit root hypothesis in these time series. Our Granger-causality tests are therefore conducted on the first-order difference of these time series.[4] It is also interesting to notice that the target federal funds rate has a higher standard deviation, and the 10-year rate has a lower standard deviation and higher correlation with the policy target rate during the first period (1974-1979) than in the second period (1990-2001).

Table 2 and Table 3 report the results from Granger-causality tests for the two periods respectively. In each case, we include up to 8 lags in the bi-variate VAR model.[5] In the tables, ΔT_t is the weekly change in the target federal funds rate, ΔY_t is the weekly change in the yield on 10-year Treasury bonds. Numbers in parentheses are p-values. Large χ^2-statistics, or small p-values, reject the null hypothesis.

[4] I also performed Granger-causality tests on the levels of these interest rates, the results are virtually the same as those reported in Table 2 and Table 3.

[5] The tests are also done for VARs with more lags (up to 15). The results are very similar.

Table 2. χ^2-statistics from Granger-causality Test 1974 - 1979

Lag Length	H_0: ΔT_t doesn't cause ΔY_t	H_0: ΔY_t doesn't cause ΔT_t
1 lag	4.4580 (0.0347)	0.0034 (0.9538)
2 lags	3.5119 (0.1717)	0.5747 (0.7502)
3 lags	4.2809 (0.2327)	1.2322 (0.7453)
4 lags	5.3411 (0.2541)	1.3074 (0.8601)
5 lags	6.2259 (0.2849)	1.3635 (0.9283)
6 lags	10.1921 (0.1168)	1.7416 (0.9419)
7 lags	10.3189 (0.1712)	3.3441 (0.8515)
8 lags	10.3848 (0.2390)	5.8153 (0.6679)

Table 3. χ^2-statistics from Granger-causality Test 1990 - 2001

Lag Length	H_0: ΔT_t doesn't cause ΔY_t	H_0: ΔY_t doesn't cause ΔT_t
1 lag	1.9496 (0.1626)	7.2545 (0.0071)
2 lags	3.6531 (0.1610)	9.2875 (0.0096)
3 lags	5.0777 (0.1662)	9.3978 (0.0244)
4 lags	6.9040 (0.1411)	15.9181 (0.0031)
5 lags	7.0173 (0.2194)	16.3539 (0.0059)
6 lags	7.0123 (0.3197)	19.6082 (0.0033)
7 lags	7.4133 (0.3871)	28.1056 (0.0002)
8 lags	8.6161 (0.3757)	28.5389 (0.0004)

(Note: ΔT_t is the first-order difference of the federal funds rate target, ΔY_t is the first-order difference of the yield on 10-year Treasury bonds. Numbers in parentheses are p-values. Large χ^2-statistics, or small p-values, reject the null hypothesis.)

The sharpest contrast between the results in these two tables is that, during the period between 1990 and 2001, the data strongly rejected the null hypothesis that changes in the long-term interest rate, ΔY_t, don't Granger-cause changes in the target federal funds rate, ΔT_t; while during the earlier period between 1974 and 1979, however, we can not reject that changes in the bond rate don't Granger-cause changes in the target rate. In other words, the bond market are able to predict changes in the monetary policy's target rate, or monetary policy seems to be responding to information that has already been impounded into the bond price during 1990-2001. In contrast, during 1974-1979, most changes in the target federal funds rate are not predicted by the bond market.

The differences across these two periods can also be seen in the test that whether or not changes in the target federal funds rate, ΔT_t, Granger-cause changes in the 10-year interest rate, ΔY_t. For the period between 1990 and 2001, we can not reject null hypothesis that ΔT_t doesn't Granger-cause ΔY_t for all lags. For the earlier period between 1974 and 1979, however, we reject the null hypothesis at 5% level for 1-lag VAR, suggesting that changes in the target federal funds rate may have different effects on the long-term interest rate across these two periods.

It should be stressed that the variables included in the Granger-causality test are *changes* in the 10-year interest rate and *changes* in the target federal funds rate, not their *levels*. Presumable the bond rate incorporates expectations about the future short-term interest rate, so it may not come as a surprise to find the long-term bond rate Granger-causes the short-term target federal funds rate (see Hamilton 1994). It is different, however, to find that changes in the 10-year rate Granger-causes changes in the target rate, particularly when both series are highly persistent and seem to follow a random walk.

Such varying predictability of the monetary policy should also be reflected in the different impacts of the policy actions on long-term interest rates. If a change in the target federal funds rate is anticipated by the bond market, that policy move should have little effect on long-term interest rates. On the other hand, if a change in the interest rate target is largely unexpected, it should have a significant effect on long-term interest rates. Table 4 reports the results from regressions of weekly change in the 10-year rate on the weekly changes in the target federal funds rate for the 1974-1979 period and the 1990-2001 period respectively.

Table 4. The Impact of Monetary Policy:

	1974 - 1979	1990 - 2001
$\hat{\alpha}$	0.0048	-0.0055
	(0.0061)	(0.0053)
$\hat{\beta}$	0.1815*	0.0183
	(0.0351)	(0.0483)
R^2	0.0838	0.0003

(Note: This table reports the estimation results from the regression $\Delta Y_t = \hat{\alpha} + \hat{\beta}\Delta T_t$, where ΔT_t is the weekly change of the federal funds rate target, ΔY_t is the weekly change of the yield on 10-year Treasury bond. Numbers in parentheses are Newey-West standard errors. * means the estimate is significant at 1% level.)

Consistent with the results from the Granger-causality tests, we can easily see that during the late period between 1990 and 2001 when monetary policy actions are mostly predictable to the bond market, a change in the target federal funds rate has a very small and insignificant effect on the long-term interest rate. In contrast, in the early period between 1974 and 1979 when the bond market seems unable to predict the monetary policy actions, a change in the target federal funds rate has a large and significant effect on the long-term interest rate. In particular, during 1974-1979, an one percent increase in the target rate leads to an increase in the 10-year rate of about 18 base points. R^2 of the linear regression is also much larger during 1974-1979 than that in 1990-2001.[6] It should be noticed that the regression estimated in the current paper is different from those in Kuttner (2001) and Cook and Hahn (1989), where the regressions are conditional on that there is a change in the target federal funds rate.

Using the data from 1989 to 2000, Kuttner (2001) separates changes in the target federal funds rate into anticipated and unanticipated components, and estimates the daily response of long-term interest rates to an unanticipated policy change. He finds that an one percent unanticipated increase in the target federal funds rate will lead to 22 base points increase in the 10-year rate when the regression is estimated on all FOMC meeting dates, including dates on which the interest rate target is unchanged (Table 5, p537). It is interesting to notice that this estimate is very similar to the 18 base points result in Table 4 for 1974-1979. This further confirms that the changes in the target federal funds rate are mostly unanticipated by the bond market from 1974 to 1979.

3 Impulse Response Functions

Given the feedback nature of the monetary policy, another popular approach to investigate the effect of an unanticipated policy change is to estimate the impulse response functions of a VAR. The systematic or the predictable component of the monetary policy can be captured by the conditional mean function of the regression equation for the target federal funds rate, while the unanticipated component of the monetary policy can be identified by the exogenous innovation to the policy instrument with the minimum number of

[6] F-test also strongly rejects the null hypothesis that the slope coefficient β is constant across these two periods.

restrictions. Christiano, Eichenbaum and Evans (1999) provide an excellent survey of the recent applications of VAR in the empirical studies of the monetary policy effects.

Nonetheless, a VAR is a reduced-form system that summarizes the dynamic relations among endogenous economic variables. A shift of a structural relation, such as the interaction between the monetary policy and the bond market, will result in different dynamic responses of the system to even exogenous economic shocks. I therefore estimate a bi-variate VAR using the weekly data on the 10-year interest rate and the target federal funds rate for 1974-1979 and 1990-2001 separately. The impulse response functions are reported in Figure 2 and Figure 3, which plot the responses to one standard deviation innovations together with ± 2 standard errors under Cholesky decompositions.[7]

In Figure 2, we can see that, during 1974-1979, there are large and significant responses in the long-term interest rate to an exogenous shock to the target federal funds rate (the lower-left panel), while the responses of the target federal funds rate to an exogenous shock to the long-term rate are almost zero (the upper-right panel). During 1990-2001, however, we get a completely different picture. In sharp contrast, as we can see from Figure 3, there are small and insignificant responses in the long-term interest rate to an exogenous shock to the target federal funds rate (the lower-left panel), while the responses of the target federal funds rate to an exogenous shock to the long-term rate are large and significant (the upper-right panel).

These differences in the impulse response functions highlight the effects of the shift in the monetary policy behavior across these two periods, and are consistent with the results from the Granger-causality tests in the above section. Presumably, exogenous shocks to the long-term interest rate incorporate innovations in other fundamental macroeconomic variables, especially the expected inflation. During the first period (1974-1979), however, the target federal funds rate is not responsive to such innovations at all (the upper-right panel of Figure 2), suggesting that the monetary policy doesn't seem to be following any systematic policy rule in that period. Changes in the monetary policy stance are mostly unpredictable to the financial market. Such monetary policy therefore makes the target federal funds rate behave like a pure random walk. An exogenous monetary policy shock will have persistent effects on the *level* of the short-term interest rate, as can be seen

[7]The results are not sensitive to the ordering of the VAR.

in the upper-left panel of Figure 2. In fact, the effect of an exogenous monetary policy shock on the target federal funds rate doesn't die out even after 200 weeks during the period between 1974 and 1979. On the other hand, abstracting from the risk premiums, long-term interest rates are determined as averages of the expected future short-term interest rate. If the monetary policy's effect on the short-term interest rate is persistent, long-term interest rates will also respond significantly to such policy shocks, as shown in the lower-left panel of Figure 2.

During the second period between 1990 and 2001, however, the monetary policy seems to be guided more closely under some systematic policy rule. As the upper-right panel of Figure 3 shows, there are large and significant responses in the target federal funds rate to innovations in the bond market. Such rule-based monetary policy actions therefore introduce predictable variations in the target federal funds rate. An exogenous monetary policy shock will have much less persistent effect on the short-term interest rate (upper-right panel of Figure 3). In fact, the response of the target federal funds rate completely dies out after 100 weeks during the period between 1990 and 2001. Hence, an exogenous monetary policy shock will have much smaller effect on the long-term interest rate due to averaging (lower-left panel of Figure 3) during 1990-2001 compared to the period between 1974 and 1979.

4 Term Structure Implications

It has long been recognized that, due to its major influence on the short-term interest rate, the monetary policy plays an important role in affecting the properties of the yield curve. For example, Mankiw and Miron (1986) argue that the apparent failure of the expectation theory of the term structure of interest rates can be attributed to the effect of the monetary policy. They show that the yield spread in fact has significant forecasting power for the future changes in the short-term interest rate prior to the establishment of the Federal Reserve System. They further argue that since the Fed tries to stabilize or smooth the short-term interest rate, the monetary policy induces a random walk behavior in the short-term interest rate. The expected future short-term interest rate is therefore equal to the current short-term rate. In such a case, even if the expectation theory holds for the term structure of interest rates, the slope of the yield curve will not be able to forecast the future changes in the short rate, and empirical evidence for the expectation theory can not be obtained.

In this section, I compare the forecasting power of the yield spread during 1974-1979 to that in 1990-2001. I argue that the different properties of the yield curve are mainly due to the varying predictability of the monetary policy across time, not due to interest rate smoothing by the Fed.

More specifically, the Fed is presumably smoothing the short-term interest rate in both 1974-1979 and 1990-2001 periods. The standard econometric test can not reject the unit root hypothesis for the target federal funds rate in both periods. Moreover, the standard deviations of the target federal funds rate are 2.0625 and 1.2557 respectively for 1974-1979 and 1990-2001, and the standard deviations of the weekly change in the target federal funds rate are 0.1371 and 0.1000 respectively for 1974-1979 and 1990-2001. These summary statistics suggest that the monetary policy seems more "smoothing", if not the same, in the second period than in the first period. However, as we can easily see from Table 5 that the yield spread has very different forecasting powers for the future changes in short-term interest rate across these two periods.

Table 5. Forecasting Power of the Yield Curve

	ΔY_{t+1}^{3M} on $(Y_t^{6M} - Y_t^{3M})$		ΔY_{t+1}^{1M} on $(Y_t^{6M} - Y_t^{1M})$		ΔY_{t+1}^{1M} on $(Y_t^{3M} - Y_t^{1M})$	
	1974 - 1979	1990 - 2001	1974 - 1979	1990 - 2001	1974 - 1979	1990 - 2001
$\hat{\alpha}$	0.0044	-0.0286	-0.0006	-0.0365	-.0.0092	-0.0396
	(0.0421)	(0.0061)	(0.0325)	(0.0074)	(0.0424)	(0.0086)
$\hat{\beta}$	-0.0079	0.1965*	0.0067	0.3329*	0.0137	0.1719*
	(0.0749)	(0.0389)	(0.0858)	(0.0724)	(0.0423)	(0.0353)
R^2	0.0001	0.0861	0.0000	0.1647	0.0006	0.1223

(Note: This table reports the estimation results from regressions of the following form: $\Delta Y_{t+1}^{\text{short}} = \hat{\alpha} + \hat{\beta}(Y_t^{\text{long}} - Y_t^{\text{short}}$, where $\Delta Y_{t+1}^{\text{short}}$ is the first order difference of a short-term interest rate, and $Y_t^{\text{long}} - Y_t^{\text{short}}$ is the spread between a long-rate and the short rate. In the above table, Y_t^{1M}, Y_t^{3M} and Y_t^{6M} are the 1-month, 3-month and 6-month interest rate respectively. Numbers in parentheses are Newey-West standard errors. * means the estimate is significant at 1% level.)

During the period between 1974 and 1979 when the monetary policy actions seem unpredictable to the bond market, the yield spread has almost none forecasting ability for the future changes in the short-term interest rate. Not only the estimated coefficient is small and insignificant, R^2 from the regression is also very close to zero. In sharp contrast, during the period between 1990 and 2001 when the monetary policy actions are found to be more predictable to the bond market, the yield spread has a large and significant forecasting power for the future changes in the short rate. In particular, all the estimated coefficients are significant at 1% level, and R^2 of the forecasting regression ranges from 8.6% to 16.5%.

This suggests that the lack of forecasting ability of the yield curve slope is probably not due to interest rate smoothing by the Fed. It has more to do with the varying predictability of the monetary policy actions. On one hand, predictable changes in the monetary policy introduce predictable changes in the short-term interest rate. On the other hand, if the policy actions are anticipated by the bond market, the current long-term interest rates will incorporate such information, therefore the yield spread predicts the future changes in the short-term interest rate.

5 Concluding Remarks

The monetary policy adopted by the Fed is unlikely to remain constant over time. Progresses in our understanding of the economy as well as institutional changes all affect the way the policy is conducted, which in turn affects how the policy interacts with the rest of the economy. Many empirical studies on the monetary policy, however, have focused on isolating and estimating the effects of exogenous policy shocks. The current paper provides some empirical results about how the monetary policy has shifted over time and how the shift has affected the monetary policy's effect on long-term interest rates and changed the properties of the yield curve.

A natural extension of the current paper is to further explore the consequences of the changing behavior of the monetary policy through a fully specified structural model. In fact, there have been a few studies that explicitly incorporate the monetary policy's reaction function into equilibrium models of the term structure of interest rates, including Hördahl, Tristani and Vestin (2004), Rudebush and Wu (2004), Burashi and Jiltsov (2005), Ravenna and Seppälä (2005) among others. In particular, Burashi and Jiltsov (2005) argue that monetary policy shocks and time-varying inflation risk premiums are the explanation for the rejection of the expectation theory of the term structure of interest rates, while Ravenna and Seppälä (2005) find that instead it is the systematic monetary policy adopted by the Fed that drives the empirical phenomenon. The results of the current paper may help to choose from different explanations and impose disciplines on the structural models that aim at explaining the interactions between the monetary policy and the bond market.

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Figure 1A. Target Federal Fund Rate and Long-Term Interest Rate 1974-1979

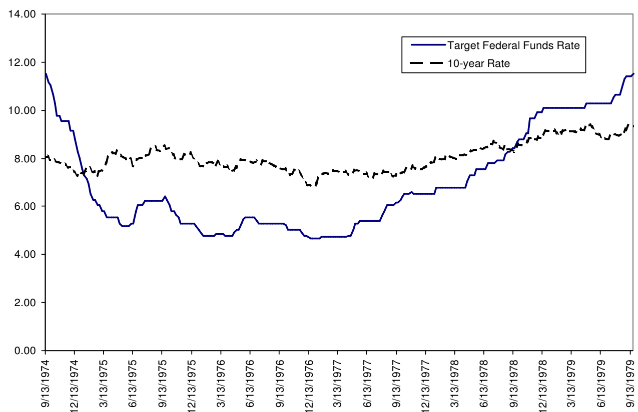

Figure 1B. Target Fedreal Funds Rate and Long-Term Interest Rate 1990-2001

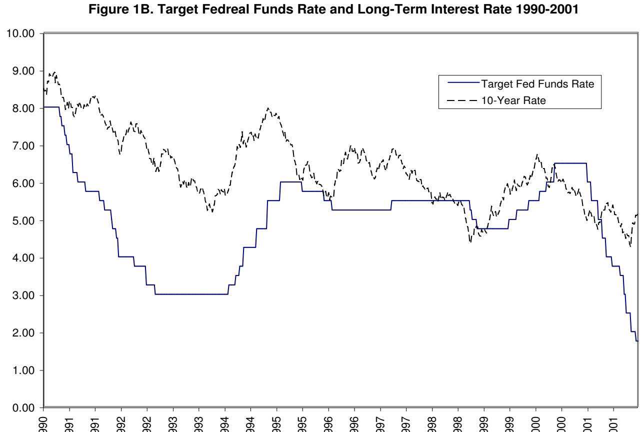

Figure 2 Impulse Response Functions from bi-variate VAR 1974-1979
TART is the target federal funds rate
BOND is the 10-year Treasury bond yield

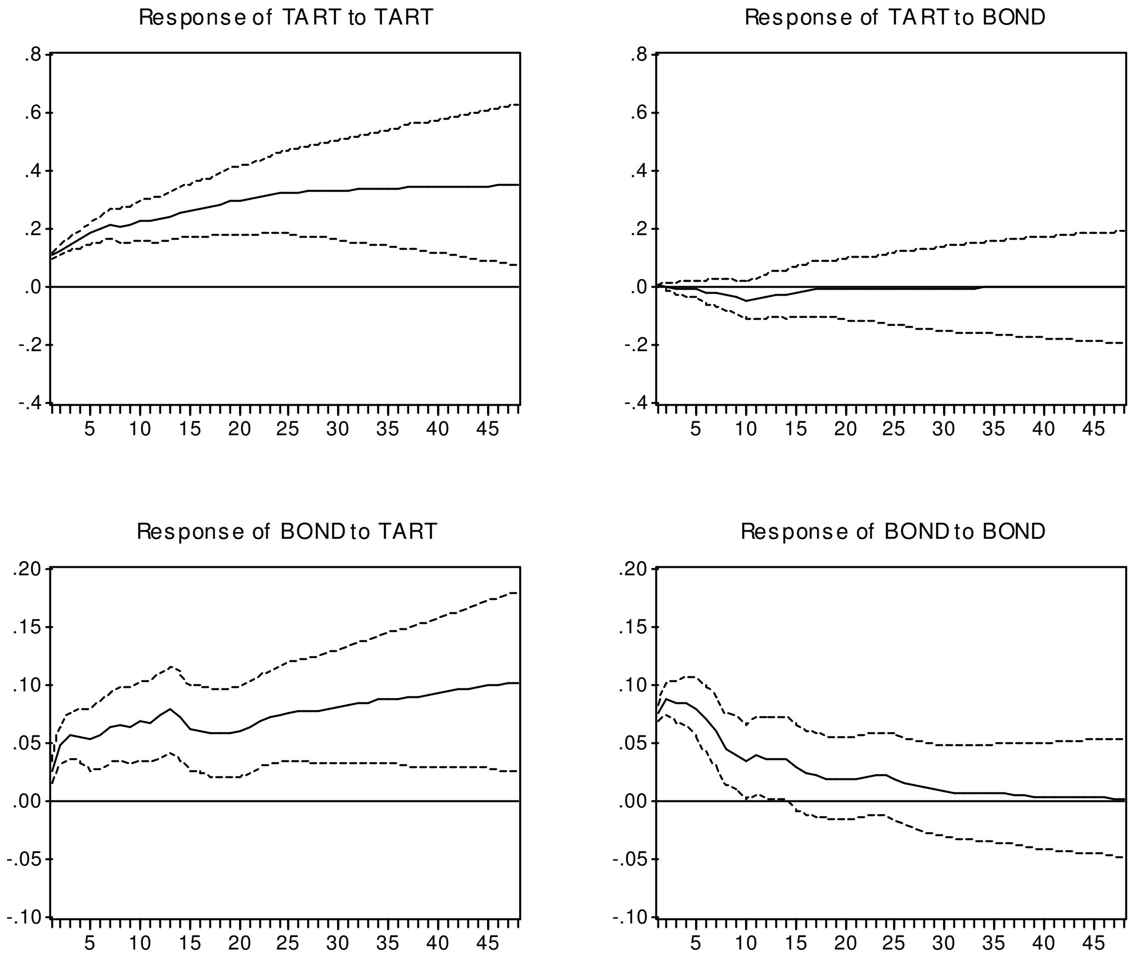

Figure 3 Impulse-Response Functions from Bi-variate VAR 1990-2001
TART is the target federal funds rate
BOND is the 10-year Treasury bond yield