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Changes in the Relationship Between the Long-Term Interest Rate and its Determinants

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Abstract

This paper assesses the relative importance of alternative explanations for the rise in long-term interest rates in the United States from October 1993 to April 1994. Standard econometric models of the term structure are shown to have a structural break in the early 1980s. An important reason for this change in the traditional term structure relationship appears to be an increase in the responsiveness of long-term rates to changes in the stance of monetary policy. Augmented term structure models that explicitly incorporate the role of monetary policy in determining the level of long-term rates are then constructed. These models track variations in the long-term rate better than traditional term structure models, but still leave a significant fraction of the recent increase in long-term rates unexplained.

JEL Classification Numbers: E4, E5

1/ P.A.V.B. Swamy and numerous colleagues at the Fund provided helpful comments on earlier versions of this paper. Any errors and all opinions expressed in this paper are the responsibility of the authors.

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Summary

From October 1993 to April 1994, long-term interest rates in the United States rose by about 1 1/2 percentage points, substantially more than the increase in short-term rates and despite the relatively stable inflation during this period. The purpose of this paper is to assess the quantitative importance of various explanations for the increase in long-term rates and to investigate whether this increase can be explained using standard models of the term structure of interest rates.

This study finds evidence that the estimated coefficients from a standard term structure equation--that models the long rate as a function of a long distributed lag on realized short-term rates--may have changed substantially since the early 1980s. Further, this equation performs poorly after 1993, apparently because it is unable to capture adequately the important role of expectations regarding current and prospective monetary policy in determining the level of long-term interest rates.

The responsiveness of the long-term rate to monetary policy appears to have increased since the early 1980s. This is illustrated by comparing changes in long- and short-term rates during periods of monetary policy tightening. In addition, it is shown that the estimated coefficient from a simple regression of the change in the long-term rate on the change in the federal funds rate has more than doubled since 1989.

The standard term structure equation is then augmented by the addition of variables that proxy for the stance of monetary policy and that attempt to control for the effects of portfolio shifts. The augmented equation tracks variations in the long-term rate significantly better than the traditional term structure equation. However, the augmented specification also shows signs of a structural break in the 1980s. The coefficients on the monetary policy, economic activity, and portfolio shift variables increase in absolute magnitude when the equation is estimated over the 1984-94 period. Thus, an important finding of this paper is that the sensitivity of long-term interest rates to changes in current and prospective monetary policy has increased significantly since the early 1980s.

I. Introduction

From October 1993 to April 1994, long-term interest rates in the United States rose by about 1 1/2 percentage points, substantially more than the increase in short-term rates and despite the relatively stable inflation during this period. Financial market observers have attributed this increase in long-term rates to several inter-related factors: (1) the February 1994 rise in short-term rates raised the expectation of further increases in short-term rates as the Federal Reserve tightened monetary conditions; (2) the unexpectedly rapid growth of GDP in late 1993 and early 1994 substantially narrowed economic slack and may have raised the expected rate of inflation; and (3) the decline in long-term rates during the first ten months of 1993 had overshot the equilibrium level.

The purpose of this paper is to assess the quantitative importance of these and other possible explanations for the recent increase in long-term rates and to investigate whether this increase can be explained using standard models of the term structure of interest rates. This study finds evidence that the estimated coefficients from standard models of the term structure may have changed substantially since the early 1980s. Apparently, one reason for this change has been the increased sensitivity of long-term rates to changes in short-term rates and to prospective inflation. The empirical findings reported below suggest that the responsiveness of long-term interest rates to changes in the stance of monetary policy and accompanying changes in short-term interest rates has more than doubled in the late 1980s and early 1990s compared with earlier periods. However, these results do not necessarily imply that economic activity has become more sensitive to monetary policy; recent research suggests that economic activity may have become less sensitive to long-term interest rates.

The next section of this paper briefly reviews the evolution of interest rates and inflation and discusses the responsiveness of long-term rates to policy-related changes in short-term rates during periods of monetary policy tightening. Section 3 presents evidence for a structural break in the mid-1980s in the standard model of the term structure of interest rates. This section then presents alternative models of the term structure that explicitly account for the role of monetary policy in determining the level of long-term rates. Although these models perform significantly better than the standard model in explaining variations in long-term rates, they leave a large fraction of the sharp decline and subsequent rebound in long-term rates during the 1993-94 period unexplained. Section 4 summarizes the main findings of the paper.

II. Responsiveness of Long-Term Rates to Underlying Determinants

Over long spans of time, the long-term interest rate can be expressed as the sum of a relatively stable real rate and a more variable inflation premium. From 1981, when nominal yields on Treasury bonds of all maturities peaked, long-term interest rates declined steadily until October 1993. Most of the decline in rates from 1981 to 1993 appears to have been associated with a drop in the average levels of actual and expected inflation, although real interest rates also declined somewhat during this period. 1/ However, since October 1993, long-term interest rates have increased by 1 3/4 percentage points, compared with a 1 1/4 percentage point rise in short-term rates and despite stable inflation. This large and rapid rise in long-term interest rates suggests that other factors may be important in explaining movements in long-term rates.

The remainder of this section presents preliminary evidence on the relationship between the long-term rate and its determinants. This descriptive evidence suggests that the relationship between short- and long-term interest rates changed significantly in the 1980s.

Table 1 summarizes the changes in long- and short-term interest rates following episodes of monetary policy tightening. 2/ From 1955 through 1968, the average duration for periods of monetary policy tightening was about five quarters. During these episodes of tightening, the federal funds rate, which is the market interest rate that is most directly affected by monetary policy, rose on average by 1 1/2 percentage points and the rate on ten-year Treasury notes rose by an average of 1/2 percentage point. 3/ However, since the 1970s, the average duration for monetary policy tightening increased by more than two quarters and the average rise in the federal funds and ten-year Treasury rates during periods of tightening increased to 3 and 1 1/2 percentage points respectively. 4/

1/ By 1993, the yield on ten-year Treasury notes was 8 percentage points lower than its historical peak in 1981. During this period, CPI inflation fell by more than 7 percentage points.

2/ The timing of monetary policy tightening is based upon research done by Boschen and Mills (1994, forthcoming), who inferred the timing from the minutes of Federal Open Market Committee meetings from 1953 through 1991. The associated changes in interest rates and other variables shown in the table are based upon the authors' calculations.

3/ Apart from the federal funds rate, the other short-term rates most affected by monetary policy are Treasury bill rates. In addition to the effects of changes in monetary policy, interest rates on short-term private sector debt such as commercial paper could exhibit large variations because of changes in the market assessment of the issuer's default risk.

4/ Table 1 also indicates that, from 1955 to 1988, the average level of the real federal funds rate at the beginning of periods of monetary tightening was 2 1/2 percent and the effect of the tightening was to raise it by 1/2 percentage point. With the real federal funds rate under 1 percent in the first quarter of 1994, this would suggest that a 2 to 3 percentage point rise in the real federal funds rate would be consistent with past episodes of monetary tightening, especially the more recent episodes.

Table 1. United States: Effects of Federal Reserve Tightening

Period When Policy Tightening Occurred	Number of Quarters of Tightening	Cumulative Change in Federal Funds Rate		Cumulative Change in Ten-Year Bond Rate		Levels at Start of Tightening: Federal Funds Rate		Levels at Start of Tightening: Ten-Year Note Rate	
		Nominal	Real 1/	Nominal	Real 1/	Nominal	Real 1/	Nominal	Real 1/
1955-II	5.0	1.20	-0.29	0.32	0.53	1.49	1.99	2.76	2.33
1959-II	4.0	1.37	1.41	0.23	0.74	3.08	2.62	4.26	1.68
1962-II	3.0	0.32	0.33	0.03	0.07	2.61	1.26	3.87	2.60
1965-I	8.0	1.59	-0.79	0.80	0.03	3.97	2.68	4.20	2.93
1967-IV	3.0	1.81	0.62	0.10	-2.87	4.17	1.24	5.64	3.07
1968-IV	6.0	2.66	1.06	1.72	--	5.92	1.29	5.77	2.36
1973-I	7.0	5.55	-1.79	1.36	-0.88	6.54	2.42	6.60	2.47
1978-II	15.0	6.30	3.75	5.77	0.23	7.28	0.26	8.32	1.97
1983-III	5.0	1.93	0.16	1.24	3.51	9.46	6.93	11.63	4.74
1987-II	2.0	0.19	-0.27	0.53	0.52	6.65	2.86	8.34	5.44
1988-II	7.0	1.46	0.81	-1.00	-2.29	8.61	4.02	7.91	3.54
1994-I						3.15	0.80	5.86	2.85
Averages									
From 1955 to 1968	4.83	1.49	0.39	0.53	-0.25		1.85		2.50
From 1973 to 1988	7.20	3.09	0.53	1.58	0.22		3.30		3.63
From 1955 to 1988	5.91	2.22	0.45	1.01	-0.04		2.51		3.01

Sources: Boschen and Mills (1994); and staff calculations.

1/ Real interest rates were calculated as the nominal rate minus the 12-month change in the CPI in the case of the federal funds rate and minus a 3-year moving average of the CPI inflation rate in the case of the 10-year rate.

When short-term rates change, long-term rates have typically changed in the same direction as the change in short rates but by a smaller amount. Comparing average increases during periods of tightening, the ten-year rate increased by about a third of the rise in the federal funds rate in the period from 1955 to 1970, although this proportion has risen to about 50 percent since the 1970s (see Table 1).

The estimated coefficient from a simple regression of the change in the yield on ten-year Treasury notes on the change in the federal funds rate can show more precisely how long-term rates have reacted to changes in monetary conditions during a given sample period. Recursive regressions using a rolling sample can generate a time series showing how the average sensitivity of the long-term rate changes over time. Chart 1 shows a plot of the estimated coefficients from such a procedure covering the period from 1970 to 1993. 1/

It is particularly noteworthy that the size of the estimated coefficient doubled in the period since 1989 compared with the average value of this coefficient in the period from 1970 to 1989. This change is consistent with a number of recent developments in financial markets that may have speeded up the passthrough of short-term interest rate changes to long-term rates. 2/ Another explanation for the increased responsiveness of long-term rates is that investor expectations regarding the future path of short-term rates may have become more forward looking and, therefore, more dependent upon recent rather than lagged interest rate changes.

III. The Term Structure of Interest Rates

Building upon the descriptive evidence presented in the previous section, this section presents a more rigorous investigation of the relationship between the long-term rate and its determinants. First, a standard term structure equation that links short- and long-term interest rates is estimated and tests for structural breaks in this relationship are conducted. This baseline equation is then modified to allow for additional factors that may influence the long-term rate in the short run. The relative performance of the two equations in tracking variations in the

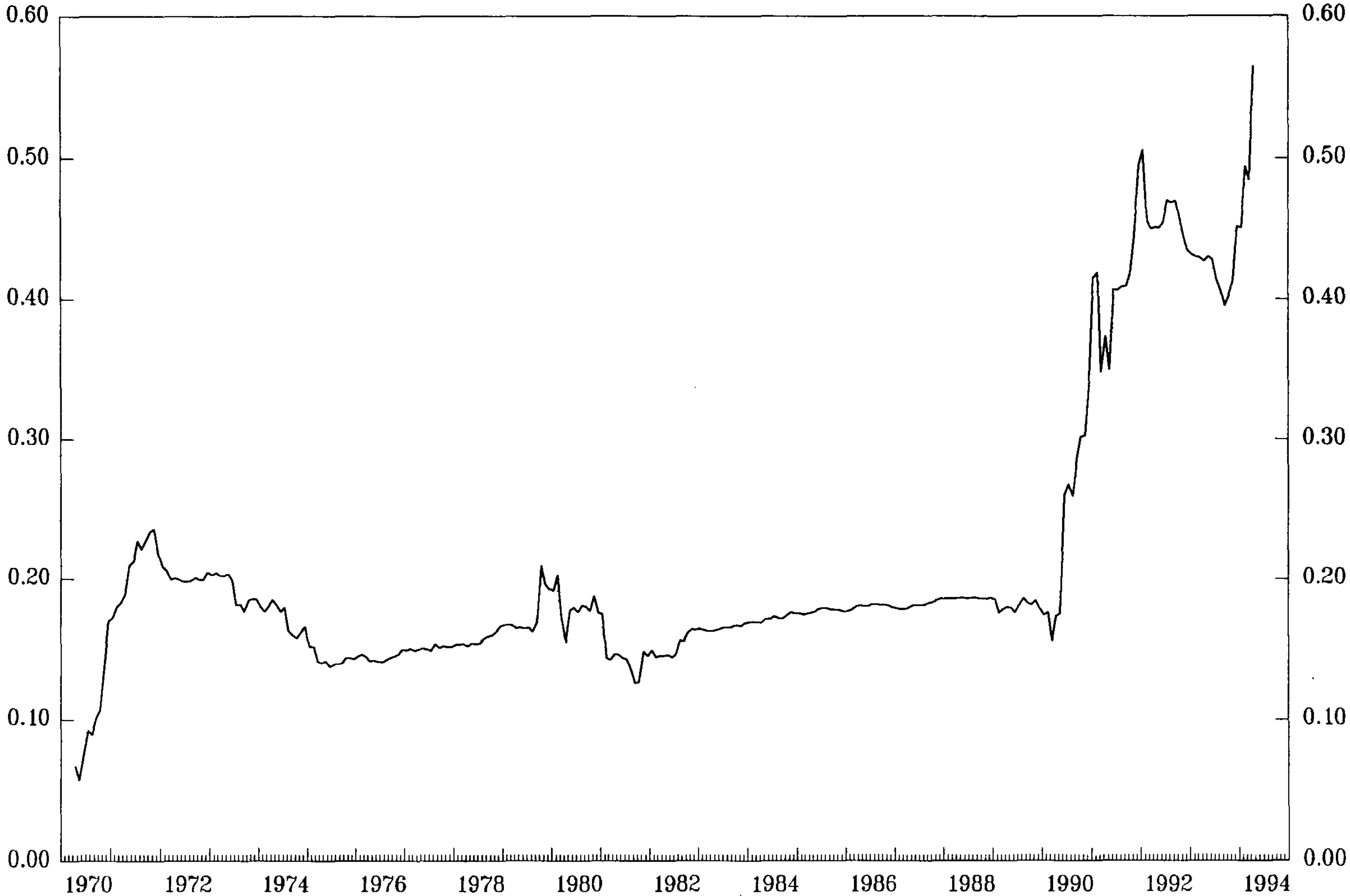
1/ Each regression spanned a period of ten years and the ten-year window was rolled forward one month at a time to produce the time series for the estimated coefficient. While writing a previous draft of this paper, we learnt that a similar chart was earlier constructed by Cohen and Wenninger (1994).

2/ Some of these changes include new instruments in mortgage and corporate finance such as adjustable-rate mortgages, mortgage-backed securities, and interest rate swaps. These instruments allow borrowers more flexibility in arbitraging short- and long-term interest rate differentials. These instruments could also lead to more efficient financial markets that exhibit fewer "preferred habitats" that may have caused interest rates at particular maturities to be sticky in the past.

CHART 1

UNITED STATES

THE SENSITIVITY OF THE 10-YEAR TREASURY RATE TO THE FEDERAL FUNDS RATE 1/



Source: Staff calculation.

1/ Regression coefficient of the change in the 10-year treasury rate on the change in the federal funds rate. Recursive regressions were done with a 10-year window.

long-term rate is then compared over the full sample and also over specific subsamples.

1. A standard term structure equation

The expectations hypothesis of the term structure of interest rates provides a framework for estimating the level of long-term interest rates. 1/ A commonly used specification postulates that the long-term interest rate is a function of expected future short-term rates and a term premium, where the latter is usually assumed to be constant over time (see, e.g., Shiller (1990)). In practice, this specification is implemented by using a long distributed lag on past short-term interest rates as a proxy for expected future short-term rates. 2/

The first column of Table 2 shows estimates of the standard equation for the sample period January 1960 through April 1994. 3/ The coefficients on the polynomial distributed lag sum to 1.05 and the restriction that the coefficients sum to unity can not be rejected at conventional levels of statistical significance (i.e., the long-term rate tends to equal the short-term rate plus a term premium). The sum of the contemporaneous and five lagged coefficients of the short-term interest rate is 0.313, indicating that almost a third of the long-run increase in the ten-year rate occurs in the first six months. Estimating the standard equation from January 1960 to December 1983 yields a pattern of coefficients similar to the estimates for the full sample period, as shown in the second column of Table 2.

However, the coefficients change considerably when the estimation is done over the period 1984-94, as shown in the third column of Table 2. The point estimates of the lag coefficients are generally smaller; they sum to only about 0.6 and are not statistically significant. This result shows

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1/ The term structure of interest rates is the relationship between the yield and the time to maturity on securities that differ only in their time to maturity. Shiller (1990) provides a comprehensive review of the term structure literature.

2/ Most econometric models used for policy analysis specify a term structure equation where expected future short-term rates are modelled with a distributed lag on short rates spanning a period of about five years (see Brayton and Mauskopf, 1985). Competing hypotheses regarding expectations formation differ largely in the nature of the restrictions placed upon the lags and on the variables assumed to be in investors' information sets.

3/ The econometric results reported in this paper were obtained using Micro-TSP Version 7.0. Lovell and Selover (1994) have reported there may be subtle differences across econometric packages in optimization procedures etc. We checked all our computations using RATS Version 4.0 and found that there were occasionally small (but, for our purposes, negligible) differences in the point estimates for the regressions with AR(1) corrections.

Table 2. United States: Long Rates as a Function of a Distributed Lag on Short Rates

	1960:1- 1994:4	1960:1- 1983:12	1984:1- 1994:4
Constant	1.163	0.693	4.194
TBILL(0)	0.059 *	0.066 *	0.031
TBILL(1)	0.056 *	0.063 *	0.030
TBILL(2)	0.053 *	0.059 *	0.029
TBILL(12)	0.031 *	0.032 *	0.019
TBILL(36)	0.004	0.002	0.004
TBILL(60)	0.015	0.024 *	0.002
Sum of lagged coefficients	1.049 *	1.131 *	0.593
Standard error of regression	0.298	0.292	0.307
DW statistic	1.35	1.44	1.16

Notes: TBILL(k) indicates the coefficient on the three-month Treasury bill rate lagged k periods. The dependent variable is the rate for the constant-maturity ten-year Treasury note. All regressions reported in this table were run with an AR(1) correction.

* Indicates that a coefficient is significant at the 5 percent level.

that the relationship between long-term and short-term rates, as captured by the standard term structure equation, has changed since the first half of the 1980s. Split-sample Chow tests revealed statistically significant breaks in the coefficient estimates for this equation when the sample was split after 1983. In the next subsection, we investigate some modifications to the standard equation that may improve its performance and may help to explain the reasons for the structural break in this relationship.

2. <u>The effect of monetary policy on the term premium</u>

This section of the paper proposes several modifications to the standard empirical specification of the term structure equation. In formulating expectations of future short-term interest rates, investors are assumed to take into account several additional factors, particularly the stance of monetary policy and its effect on future inflation and growth. Appendix 1 describes the vector autoregression techniques that were used to determine the variables that appeared to be statistically important in explaining variations in the long-term rate.

A simple modification to the standard term structure specification is to allow the term premium to vary as a function of current and expected monetary policy, while expectations of future short-term rates continue to be determined by lagged short-term rates. The Boschen-Mills policy index (MILBOSC) is used as a proxy for the stance of monetary policy, varying from a strongly anti-inflationary stance (assigned a value of -2) to one that is strongly stimulative (assigned a value of +2). 1/ The desired stance of monetary policy is assumed to be implemented through "tactical" changes in the federal funds rate (DFEDFUND). Signals from these tactical moves would usually occur between meetings of the Federal Open Market Committee (FOMC) to adjust the degree of restraint or ease in credit markets because of changes in credit market conditions.

More precisely, the tactical changes in the federal funds rate were defined as the residuals from a regression of the actual monthly changes in the federal funds rate on the Boschen-Mills monetary policy index. These residuals capture the tactical implementation of the FOMC's decision which could include a phased increase in the federal funds rate, as distinct from the strategic shifts in the stance of monetary policy as captured by the Boschen-Mills index. 2/ The spread between the six-month commercial paper and six-month Treasury bill rates (SPRD-6CP/6TB) is also used as a proxy

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1/ The values of the index through 1991 were taken from Boschen and Mills (1994). In consultation with John Boschen, the time series was extended to include the period January 1992 through May 1994. The index takes on integer values ranging from -2 to +2. Intermediate values of the index are -1 (a stance relatively more concerned about inflation), 0 (a neutral stance), and +1 (a relatively stimulative stance).

2/ Not all of the changes in the federal funds rate are necessarily policy related. Shocks to the demand for bank reserves may also be reflected in sharp but short-lived changes in the federal funds rate.

for changes in monetary policy. 1/ Investors are assumed to base their expectations of prospective changes in monetary policy on the degree of slack in the economy. The level of capacity utilization is one of many statistics that can summarize the degree of upward pressure on prices caused by declines in economic slack. 2/

In order to control for the effects of monetary policy on the other independent variables in our specification, we used residuals from a series of independent bivariate regressions of all of the relevant variables (including, as described above, the change in the federal funds rate) on the monetary policy index. This procedure implies that the coefficient on the monetary policy index has a modified interpretation. It captures both the direct effect of the monetary policy stance on long-term interest rates and the indirect effect of monetary policy operating through the federal funds rate, the capacity utilization rate and the relevant spreads. 3/

There still remains the possibility of bias in the OLS coefficients as the monetary policy index may not be a perfect proxy for the actual stance of monetary policy as perceived by financial market participants. We used instrumental variables (IV) estimation to circumvent this potential errors-in-variables problem. The instruments we used were lagged values of the dependent and independent variables and the current and lagged values of CPI inflation and the unemployment rate. Although the estimated coefficients were different in some cases, none of our qualitative conclusions was altered. These results are reported in Appendix 2. In the discussion that follows, we focus on the results from the ordinary least squares (OLS) estimates.

1/ Friedman and Kuttner (1992) have argued that this spread helps to predict future economic activity and could be useful as an information variable in guiding monetary policy.

2/ Other activity variables such as the industrial production index, the unemployment rate, and the rate of growth of nonagricultural employment did not enter significantly into any of the specifications that included the capacity utilization rate. In addition, the choice of activity variables had little effect on the other coefficients. Tests were also run for the effects of exchange rate changes on the long-term rate. Estimated coefficients on bilateral (dollar-mark, dollar-yen) and trade-weighted effective exchange rates were insignificant and generally very small in magnitude.

3/ Consider, for instance, the following functional relationships:

$$y = f(x(z), z)$$

A least squares regression of y on x and z would yield the respective partial derivatives as the regression coefficients. Regressing x on z and using the residuals in place of x would make the coefficient on z equal to $f_x(dx/dz) + f_z$. Thus, in this latter regression, the coefficient on z would be the sum of the direct effect of z on y and the indirect effect of z on y through its effect on x. In the results reported in Table 3, z represents the monetary policy index and x represents the other independent variables that are first regressed on this index and whose residuals are then included in the regression. We thank P.A.V.B. Swamy for educating us on this point.

The first column of Table 3 shows that, in addition to a distributed lag of the short-term interest rate, these proxies for current and prospective monetary policy are indeed significant factors affecting the level of long-term interest rates. The coefficient on the Boschen-Mills index is negative, suggesting that tight monetary policy (i.e., a value of -1 or -2 for the index) increases the level of the long-term interest rate. 1/ For a given stance of monetary policy, the estimated effects of the level of capacity utilization and changes in the federal funds rate on the level of long-term rates are both significantly positive.

3. The effect of portfolio shifts on the long-term Treasury rate

Portfolio shifts arising from financial management activity also could affect the level of long-term Treasury rates. In constructing portfolios with particular financial attributes in terms of maturities, yields, and sensitivity to shifts in interest rates, investors often rely on the liquidity in Treasury securities (or associated financial instruments) to rebalance their portfolios following shifts in other interest rates. This became a particularly important factor in the late 1980s when financial innovations allowed investors to arbitrage a wide range of debt instruments more efficiently. 2/

To test for the effects of portfolio shifts on the long-term interest rate, two measures of default risk were included in the specification: (i) the spread between AAA corporate bonds and 20-year Treasury notes (SPRD-AAA/20) and (ii) the spread between BAA and AAA corporate bonds (SPRD-BAA/AAA). A drop in the default risk associated with corporate bonds, as indicated by a narrowing of the size of these two spreads, would encourage investors to sell Treasury notes in favor of non-government debt instruments, thereby driving up the yield on Treasury notes. The second column of Table 3 shows that the estimated coefficients on both these

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1/ In order to examine the possibility of asymmetric interest rate responses to monetary tightening or loosening, two variables were constructed that separately measure monetary tightening and easing. The OLS coefficients on these two variables were similar and not statistically different from one another or from the coefficient on MILBOSC, implying the absence of significant asymmetries in the response of long rates to a tightening or easing in the stance of monetary policy. However, the IV estimates (not reported here) suggest that, since 1984, long-term interest rates have been more responsive to monetary tightening than to monetary easing.

2/ For example, some analysts have suggested that, during 1993, faster-than-anticipated prepayments caused portfolio managers of mutual funds in mortgage-backed securities to buy ten-year Treasury notes to help rebalance their portfolios and maintain the desired average maturity. This activity may have contributed to the rapid downward movement in the ten-year rate during that period.

Table 3. United States: Factors Accounting for Movements in Long-Term Interest Rates

	(1) 1960:1-1994:4	(2) 1960:1-1994:4	(3) 1960:1-1983:12	(4) 1984:1-1994:4
Constant	0.720 (1.24)	0.263 (0.26)	-0.658 (0.88)	1.633 (1.96)
MILBOSC	-0.312 (5.50)	-0.394 (8.04)	-0.334 (6.41)	-0.825 (6.87)
DFEDFUND	0.113 (5.71)	0.080 (5.16)	0.083 (5.41)	0.101 (1.60)
CAPUTIL	0.063 (3.32)	0.036 (2.18)	0.017 (0.99)	0.166 (3.95)
SPRD-6CP/6TB	-0.003 (0.96)	0.127 (2.54)	0.039 (0.79)	0.804 (4.88)
SPRD-BAA/AAA	--	-1.052 (10.34)	-1.166 (10.67)	-0.986 (4.08)
SPRD-AAA/20	--	-1.056 (11.34)	-0.865 (8.06)	-1.271 (7.66)
Sum of coefficients on three-month Treasury-bill	1.116 (12.69)	1.212 (8.50)	1.295 (11.44)	1.028 (8.96)
Standard error of regression	0.276	0.219	0.207	0.211
DW statistic	1.55	1.29	1.35	1.55

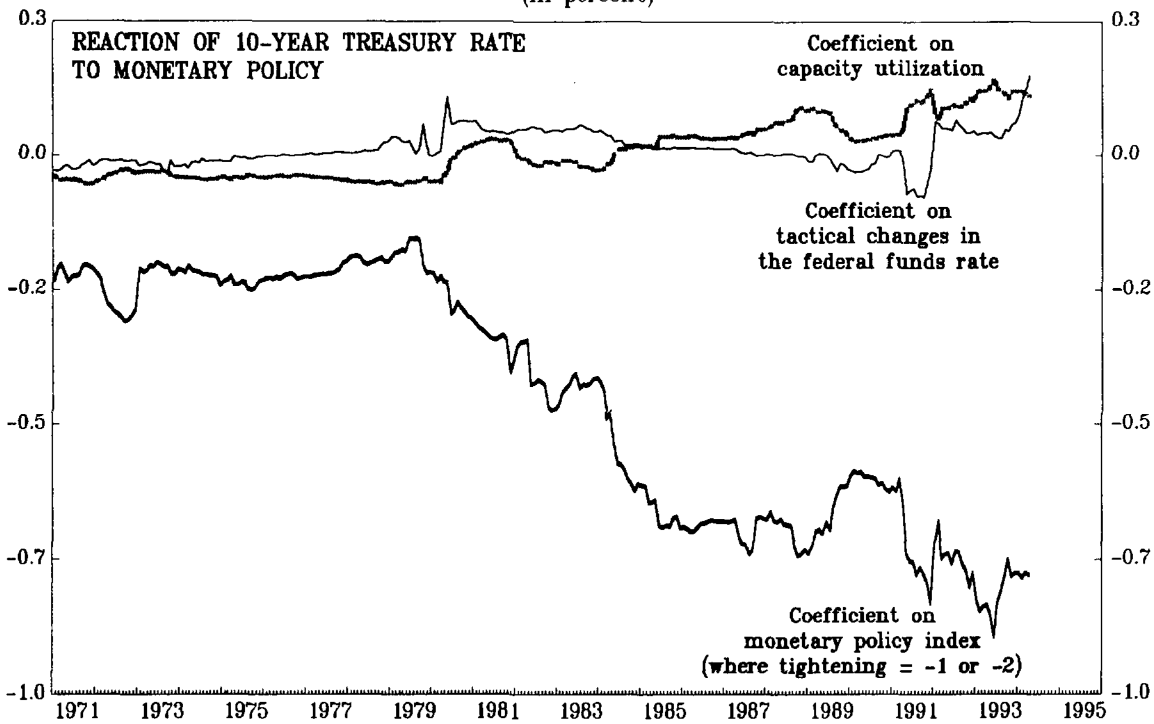
Notes: All regressions reported in this table were estimated with an AR(1) correction. The dependent variable was the rate on the constant-maturity ten-year Treasury note. The mnemonics DFEDFUND, CAPUTIL, SPRD-6CP/6TB, SPRD-BBB/AAA, and SPRD-AAA/20 represent the residuals of these variables from regressions on MILBOSC. Absolute values of t-statistics are reported in parentheses below the coefficients.

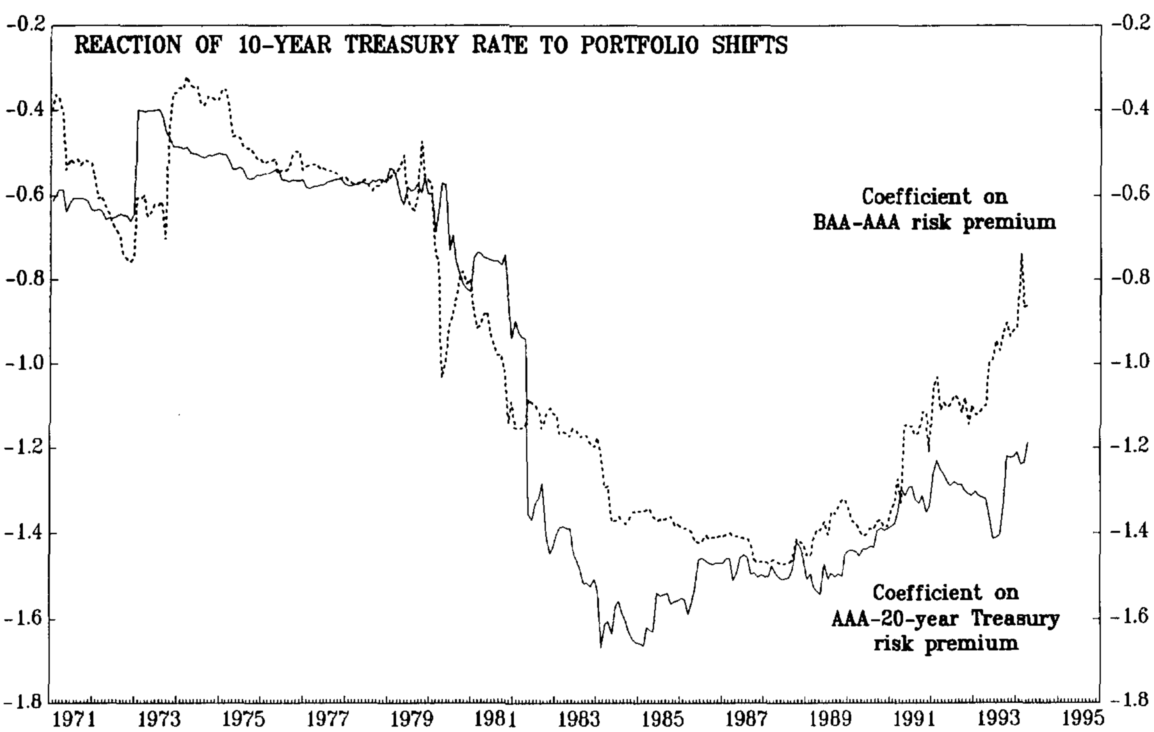
CHART 2

UNITED STATES

REACTION OF LONG-TERM RATE TO MONETARY POLICY AND PORTFOLIO SHIFTS

(In percent)





Source: Staff calculation.

variables are significantly negative and large in absolute value, suggesting that such private sector portfolio shifts could play a role in determining the level of long-term Treasury rates. 1/

4. Stability of the term structure equations

To examine the stability of the coefficients from the modified term structure equation that includes monetary policy, economic activity, and portfolio shift variables, the regression was recursively estimated over a rolling ten-year window of data. Chart 2 plots the coefficients from this set of recursive regressions. The variation over time of the coefficient on the monetary policy index (MILBOSC) strongly suggests a break in the relationship between the stance of monetary policy and the level of long-term rates in the early 1980s. The quantitative effect of monetary tightening on long-term rates appears to have become substantially larger after 1984. In addition, the coefficients on tactical changes in the federal funds rate (DFEDFUND) from the recursive regressions show that the effect of DFEDFUND on long rates may have become more volatile after 1990.

Split-sample Chow tests for a structural break in the equation between the pre- and post-1984 periods confirmed the presence of a change in the estimated coefficients. The third column of Table 3 shows the regression coefficients for the equation estimated during the period from February 1961 to December 1993 and the fourth column shows the coefficients estimated from January 1984 to April 1994.

A key result is that the absolute values of the coefficients on the indicator of monetary policy tightening (MILBOSC) and capacity utilization (CAPUTIL) are substantially higher when estimated using data from 1984-94 compared with the estimates from 1961-83. This result indicates that the sensitivity of long-term interest rates to current and prospective monetary policy has increased substantially in the last few years. Comparing the estimates for the two subsamples, the monetary policy coefficients imply that a tightening of monetary policy would raise long-term rates by about 1/4 percentage point more in the latter sub-period than in the earlier

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1/ Again, to avoid the spillover effects from monetary policy that might affect the perceived risks associated with corporate bonds, the spreads used in the regression were the residuals from a regression of the spreads on the Boschen-Mills monetary policy index. Since March 1993, this adjusted risk premium between AAA and 20-year Treasury bonds has dropped by more than 1/2 percentage point, implying an upward stimulus to the ten-year rate of about the same size.

sub-period. 1/ It should be noted, however, that this apparent increased sensitivity of long-term rates to monetary policy does not necessarily imply there is a larger effect of monetary policy on aggregate demand. There is some evidence of a concurrent weakening in the transmission of monetary policy to aggregate demand through the interest rate channel in the 1980s (see, e.g., Mauskopf, 1990).

Moreover, comparing the estimates of the augmented equation and the standard specification for the post-1984 period (the last columns of Tables 2 and 3) shows that including the monetary policy, economic activity, and portfolio shift variables restores the statistical significance and the size of the estimated coefficients of the original proxy for expected future short-term rates (the long distributed lag on short-term rates). That is, in the augmented equation estimated over the post-1984 period, the sum of the coefficients on the distributed lag on short-term rates is very close to the sum of these coefficients from the standard equation estimated over the 1960-83 subsample (second column of Table 2). This result suggests that the standard equation broke down after 1984 because it was not able to capture adequately the relatively more important role of expectations regarding current and prospective monetary policy in determining the level of long-term interest rates.

5. Overall performance of alternative term structure equations

The two panels of Chart 3 show the actual and predicted levels, based on the standard and augmented term structure equations, for the rate on ten-year Treasury notes. In the top panel, these equations were estimated over the full sample (1960-94) while the bottom panel uses estimates of the two equations over the period 1984-94. Both panels show that the augmented equation that includes monetary policy, economic activity, and portfolio shift variables appears to be more successful in predicting the variability of the ten-year rate. Not surprisingly, because of the structural break in both equations during the mid-1980s, neither equation does well in predicting the ten-year rate after 1984 when the equations are estimated over the full sample.

When estimated over the period 1984-94, the augmented equation has a standard error two-thirds the size of the standard term structure equation and the root mean square error of the augmented equation was a third of

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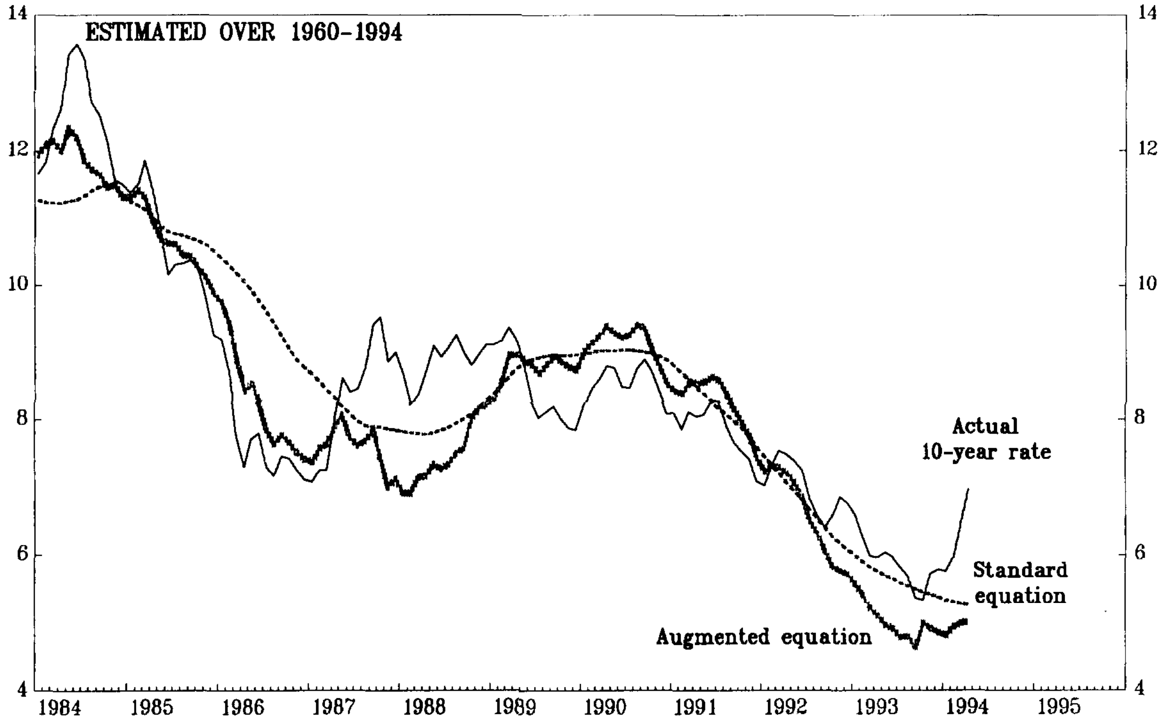
1/ The sum of the absolute values of the coefficients on MILBOSC, DFEDFUND, and the lagged coefficients on the three-month Treasury bill rate may be interpreted as the effect on the long rate of an unanticipated tightening of monetary policy (a change in the MILBOSC index from zero to -1) that ultimately raises the federal funds rate and expected future Treasury bill rates by 1 percentage point. The sum of these coefficients is 1.71 for the 1960-83 sub-sample and increases to 1.95 for the 1984-94 sub-sample.

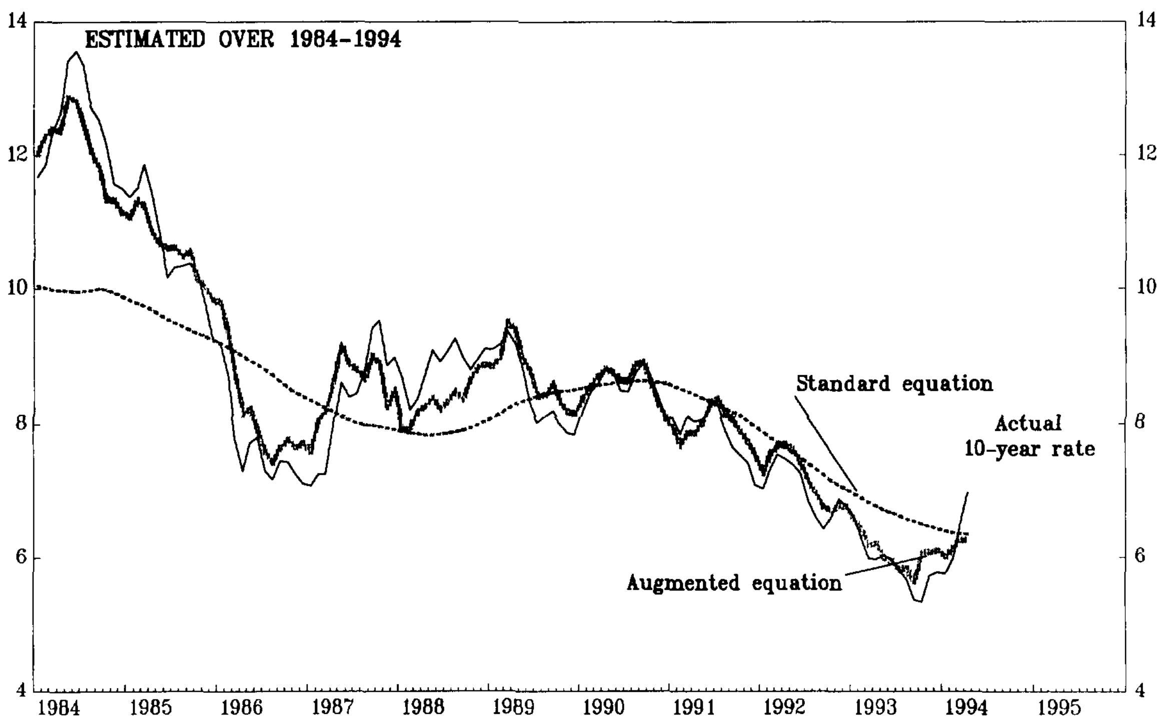
CHART 3

UNITED STATES

PREDICTED AND ACTUAL 10-YEAR TREASURY RATE 1/

(In percent)





Source: Staff calculation.

1/ Predicted values are from the estimated term-structure equation with the autoregressive error term set to zero.

that for the standard equation. 1/ By controlling for monetary policy, the augmented equation overpredicted the ten-year rate in October 1993 by much less than the standard equation (3/4 percentage point compared with 1 1/4 percentage points). From October 1993 through April 1994, the sum of squared residuals was more than two times larger in the standard equation than in the augmented equation.

When estimated over the 1984 to 1994 subsample, both equations underpredicted the decline in the long-term rate in the latter half of 1993. In October 1993, the long-term rate was about 1/2 percentage point below the level predicted by the augmented term-structure equation. Hence, part of the rise in the long-term rate since then may be interpreted as a rebound in this rate to a level more consistent with economic fundamentals. 2/

During 1993, the errors from the standard term structure equation were consistently larger than the errors from the augmented equation. In addition, the augmented equation closely tracked the rise in the ten-year interest rate between October 1993 and March 1994, during which time the standard equation predicted the ten-year rate would decline. However, both equations underpredicted the rise in the ten-year rate since February 1994 by 60 to 70 basis points. Thus, although the augmented equation tracks the actual long-term rate much better than the standard term structure equation, both equations explain less than half of the 1 percentage point increase in the ten-year rate between February and April 1994. 3/

IV. Conclusions

The main finding of this paper is that the sensitivity of long-term interest rates to changes in current and prospective monetary policy has increased significantly since the early 1980s. Evidence was presented suggesting that the standard equation used for modelling the term structure

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1/ The root mean square error for the augmented equation was 0.41 compared to 1.13 for the standard equation over the period January 1984 to April 1994.

2/ In his June 21, 1994 testimony before the Subcommittee on International Finance and Monetary Policy, Under Secretary Lawrence Summers observed that "this year's rise [in Treasury bond yields] has also been, in part, a correction of the remarkable decline in yields which we observed last year."

3/ The 70 basis point error for April 1994 from the augmented equation shown in Chart 3 suggests that bond market investors were acting as though the monetary policy stance would soon shift again towards one that was 'strongly' directed toward reducing inflation (i.e., that the Boschen-Mills index would shift from -1 to -2). The IV estimates of the augmented equation yield an even better fit after 1984 than either the standard specification or the augmented equation estimated by OLS. The IV equation's error was only 5 basis points for April 1994 and rises to 45 basis points in the post-sample period from May to September 1994 (Chart 5 in Appendix 2).

of interest rates broke down after 1994 because it was not able to capture adequately the important role of expectations regarding current and prospective monetary policy in determining the level of long-term interest rates.

The responsiveness of the long-term rate, as measured by the yield on ten-year government bonds, to monetary policy apparently has increased since the early 1980s. This was illustrated by comparing changes in long- and short-term rates during periods of monetary policy tightening. In addition, it was shown that the estimated coefficient from a simple regression of the change in the long-term rate on the change in the federal funds rate has more than doubled since 1989.

The standard specification for the term structure equation was augmented by the addition of variables that proxy for the stance of monetary policy and that attempted to control for the effects of portfolio shifts. The augmented equation tracked variations in the long-term rate significantly better than the traditional term structure equation that models the long rate as a function of a long distributed lag on realized short-term rates.

The estimates showed that the standard term structure equation has undergone a structural change since the mid-1980s. The augmented specification also showed signs of a structural break. The coefficients on the monetary policy, economic activity, and portfolio shift variables increased in absolute magnitude when the equation was estimated over the 1984-94 period. This supports the hypothesis that the sensitivity of long-term rates to current and prospective monetary policy and portfolio shifts increased after 1984. However, because there is evidence that the relation between long-term interest rates and aggregate demand may also have changed since the early 1980s, these results do not necessarily imply a greater sensitivity of aggregate economic activity to monetary policy actions.

Although the augmented equation has tracked variations in the long-term rate significantly better than the traditional term structure equation since the mid-1980s, both of these equations leave unexplained a large part of the increase in long-term rates between February and April 1994. One possibility is that financial market participants have factored in a further monetary tightening and, consequently, anticipate higher future short-term rates than the economic and monetary policy indicators that were used in the analysis would suggest.

A VAR-Based Decomposition of Interest Rate Changes

This appendix uses a vector autoregression (VAR) framework to determine a set of factors that could affect the variation in long-term interest rates. Apart from shifts in short-term rates directly related to actual changes in monetary policy, expected future short-term rates also depend upon other factors, especially prospective changes in monetary policy, changes in the demand for credit, and portfolio shifts among credit instruments. In particular, expectations regarding prospective monetary policy are likely to be a function of leading indicators of inflation and growth, such as the level of capacity utilization.

Variance decompositions based on a VAR model estimated from January 1980 through April 1994 were used to evaluate the degree to which some of these factors can help forecast short- and long-term interest rates. The VAR model makes it possible to decompose the forecast error over an arbitrary forecast horizon and apportion the variance in the errors at any point among a set of explanatory factors. For example, the k period-ahead forecast error for the long-term rate is defined as the difference between the actual value of the long-term rate and its forecast from the VAR as of k periods earlier. The forecast error is attributable to unanticipated disturbances over the last k periods in all of the variables included in the VAR. Such a variance decomposition is useful in assessing the relative contribution of each factor, at a given forecast horizon, for explaining the forecast error in a particular interest rate. 1/ Consequently, the VAR framework can be used to determine a set of variables with the greatest potential for improving the forecasting properties of models of short- and long-term interest rates.

The variables included in the VARs, apart from the short- and long-term interest rates themselves, were: (1) the Boschen-Mills index showing the stance of monetary policy; (2) tactical changes in the federal funds rate (constructed as described in Section 3); and (3) the level of capacity utilization in manufacturing. The top panel of Chart 4 presents the variance decomposition for the three-month Treasury bill rate. Over a horizon of about a year, the forecast errors appear to be largely explained by unanticipated tactical changes in the federal funds rate (about 40 percent) and movements in the lagged levels of the short-term rate itself (about 25 percent). After one year, the monetary policy index alone accounts for more than half of the total variance. Over a period of three to five years (the likely holding period for ten-year Treasury bonds), expectations regarding monetary policy appear to be the dominant factor in accounting for the errors in predicting the expected path of short-term rates.

1/ By construction, the relative contributions of different factors to the total variance of the forecast error of a particular interest rate variable will sum to 100 percent at each time horizon. Part of the total variance in the forecast error of any variable is explained by its own lagged values.

The bottom panel of Chart 4 presents the variance decomposition for the ten-year Treasury note, using the same set of explanatory variables described above. Over horizons of less than 12 months, forecast errors in the long-term interest rate are attributable to unanticipated changes in the level of capacity utilization and lagged levels of the long-term rate itself. However, the relative contributions of some of the monetary policy proxies (the Boschen-Mills index and the prospective changes in monetary policy and inflation as proxied by the capacity utilization rate) begin to dominate the other factors after about a year. Over horizons beyond two years, the contribution of the Boschen-Mills index to variations in the long-term rate is over 50 percent.

Interestingly, the capacity utilization measure consistently accounts for about a third of the total variation in the forecast errors at a horizon of around 12 months for both short- and long-term rates. The relative importance of this variable in explaining movements in both interest rates may arise from its effectiveness as a proxy for future monetary policy actions or for changes in inflation expectations. For instance, an increase in the capacity utilization rate may cause investors to either revise upward their expectations of changes in future short-term rates, as monetary policy acts to cut off incipient inflation, or demand a higher inflation premium in long-term bond yields should the credibility of the inflation-fighting resolve of monetary authorities be in question.

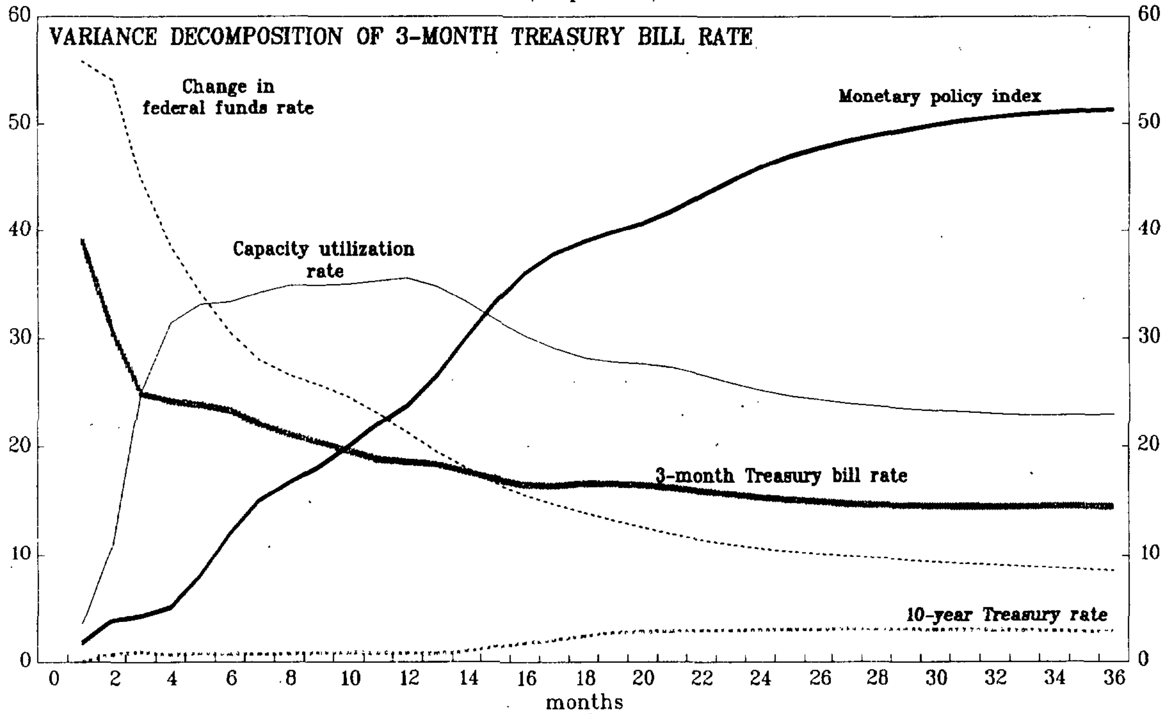
The variance decompositions presented in Chart 4 indicate that, in addition to current and past short-term rates, all of the variables used in the VARs above appear to play a role in contributing to movements in the long-term rate.

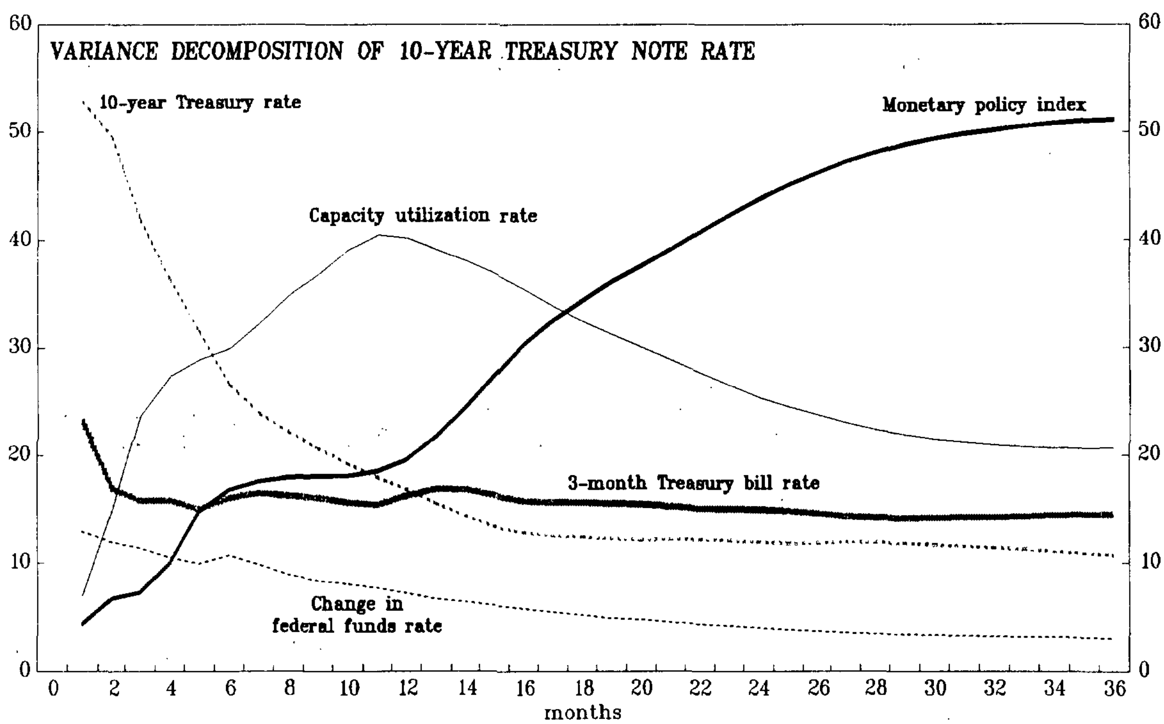
CHART 4

UNITED STATES

VARIANCE DECOMPOSITION FOR LONG- AND SHORT-TERM INTEREST RATES 1/

(In percent)





Source: Staff calculation.

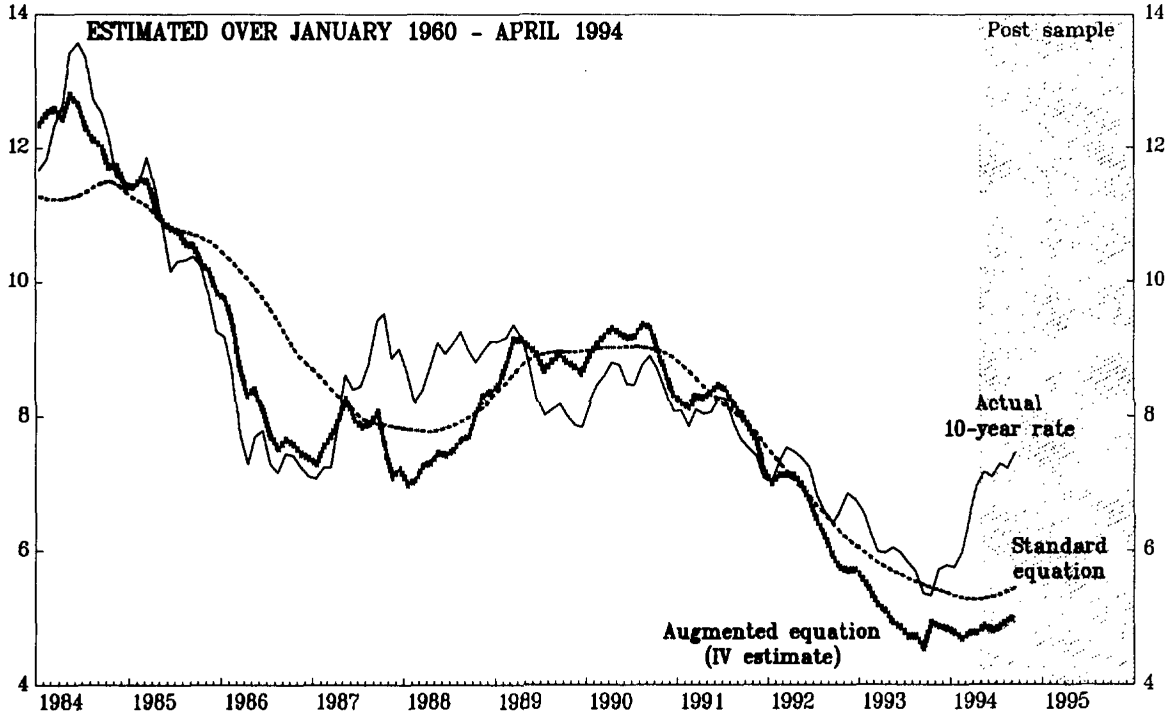
1/ Variance decomposition based upon a VAR model with 12 lags estimated from January 1980 to April 1994.

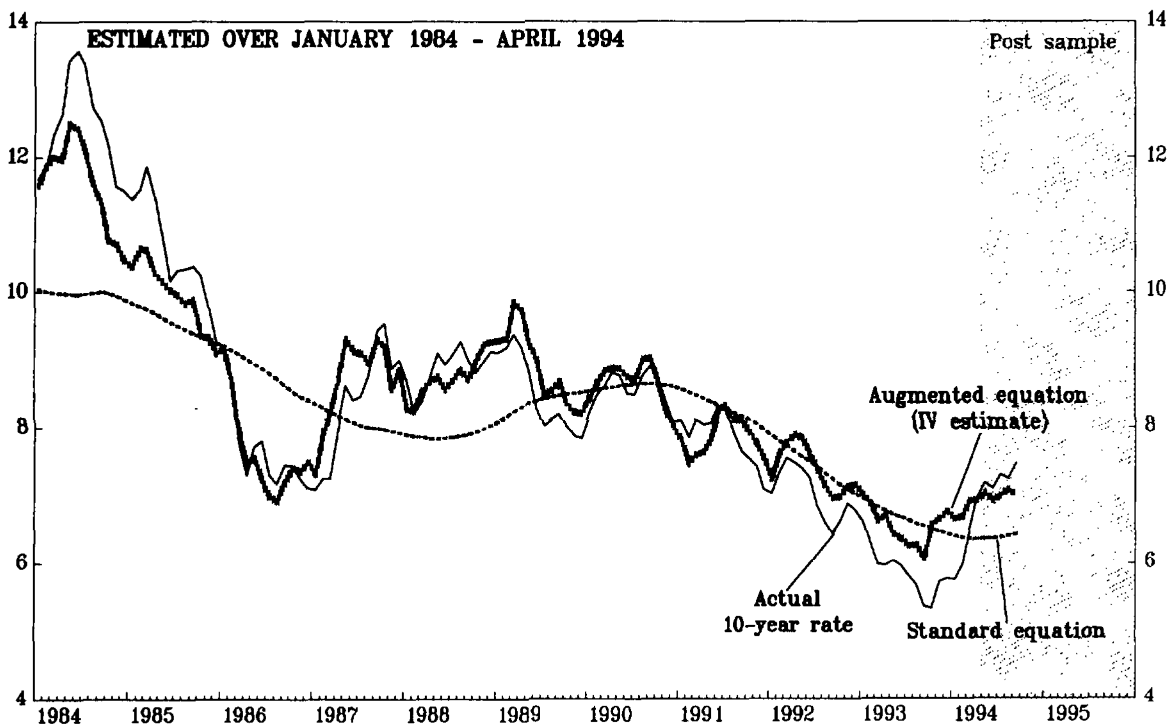
CHART 5

UNITED STATES

PREDICTED (IV ESTIMATION) AND ACTUAL 10-YEAR TREASURY RATE 1/

(In percent)





Source: Staff calculation.

1/ Predicted values are from the IV estimated term-structure equation with the autoregressive error term set to zero.

United States: Factors Accounting for Movements in Long-Term Interest Rates: Instrumental Variables Estimates

	(1) 1960:1-1994:4	(2) 1961:2-1994:4	(3) 1960:2-1983:12	(4) 1984:1-1994:4
Constant	0.571 (0.83)	-0.053 (0.05)	-0.133 (0.13)	3.377 (7.20)
MILBOSC	-0.400 (3.40)	-0.591 (5.78)	-0.469 (4.60)	-1.112 (4.12)
DFEDFUND	0.119 (5.82)	0.079 (4.80)	0.083 (5.22)	0.084 (1.27)
CAPUTIL	0.084 (2.57)	0.080 (2.85)	0.039 (1.47)	0.259 (3.04)
SPRD-6CP/6TB	-0.009 (0.14)	0.151 (2.90)	0.066 (1.25)	0.809 (4.62)
SPRD-BAA/AAA	--	-1.097 (11.22)	-0.907 (8.01)	-1.307 (7.46)
SPRD-AAA/20	--	-1.043 (9.90)	-1.163 (10.34)	-0.955 (3.29)
Sum of coefficients on three-month Treasury-bill	1.139 (11.11)	1.257 (8.47)	1.210 (8.23)	0.806 (18.60)
Standard error of regression	0.283	0.227	0.213	0.221
DW statistic	1.57	1.33	1.36	1.71

Notes: The IV regressions reported in this table were estimated with an AR(1) correction. The dependent variable was the rate on the constant-maturity ten-year Treasury note. The mnemonics DFEDFUND, CAPUTIL, SPRD-6CP/6TB, SPRD-BBB/AAA, and SPRD-AAA/20 represent the residuals of these variables from regressions on MILBOSC. The instrument list included current and lagged values of these 5 variables, the unemployment rate, and CPI inflation. Absolute values of t-statistics are reported in parentheses below the coefficients.

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