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Author(s): David P. Simon

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Expectations and the Treasury Bill-Federal Funds Rate Spread over Recent Monetary Policy Regimes

DAVID P. SIMON*

ABSTRACT

This paper shows that the spread between the 3-month Treasury bill and the federal funds rate has significant predictive power for the future change in the federal funds rate during the volatile nonborrowed reserves operating regime, but it has less and no predictive power during the borrowed reserves regime and the federal funds targeting regime, respectively. These findings suggest that Treasury bill rates forecast future federal funds rates most accurately when the Federal Reserve follows a well-defined rule that does not smooth the impact of shocks on the federal funds rate.

THIS PAPER EXAMINES HOW accurately 3-month Treasury bill rates forecast future levels of the federal funds rate across monetary policy operating regimes from January 1972 to November 1987 using weekly overlapping data. Term structure theory maintains that Treasury bill rates should reflect expected future levels of the federal funds rate, as well as its current level, although changing perceptions of risk may also affect the spread between Treasury bill and federal funds rates. The accuracy of these forecasts sheds light on the extent to which Treasury bill rates are driven by accurate perceptions of the near-term stance of monetary policy, rather than fluctuating around the current federal funds rate according to a risk premium.¹ If the spread largely reflects a volatile risk premium, the monetary policy transmission process is affected and the Federal Reserve may have less control over short-term Treasury bill rates and perhaps over the entire term structure.

Although changes in the volatility of both federal funds and Treasury bill rates across monetary policy operating regimes are well documented in the money supply announcement literature, the degree to which Treasury bill rates accurately forecast future levels of the federal funds rate across policy regimes has not been examined.² Several papers, including Roley (1982, 1983), Cornell (1983),

* Economist, Division of Monetary Affairs, Board of Governors of the Federal Reserve System, Washington, D.C. The author would like to thank John Duca, Steve Lumpkin, Brian Madigan, John Rea, Robert Williamson, an anonymous referee, and the editor for helpful comments, Robert Cumby and John Huizinga for making their software available to me, and Peter Nagan for survey data. The views expressed here are those of the author and do not necessarily reflect the views of the Federal Reserve Board or any other members of its staff. Any errors are my own.

¹ As pointed out by a referee, a third possibility is that bill rates may be unbiased but not very powerful predictors of the level of future federal funds rates.

² Melton and Roley (1988) show that the standard deviation of weekly percentage changes in the federal funds rate increased about four times during the nonborrowed reserves period from October

Engle and Frankel (1984), and Hardouvelis (1984), demonstrate the increased response of interest rates to the unanticipated component of money supply announcements over the nonborrowed reserves operating regime. Under this procedure, the announcement of a greater-than-anticipated increase in the money supply is followed by a firming of the federal funds rate owing to an unchanged supply of nonborrowed reserves in the face of an increased demand for required reserves. Because the federal funds rate is expected to remain firm over the near term, Treasury bill rates also increase.³ Loeys (1983) and Roley (1986) show that the interest rate response to money supply shocks falls after the abandonment of the nonborrowed reserves operating procedure and the de-emphasis of M1 as an intermediate target in October 1982.

By examining subperiods from January 1972 through September 1979, October 1979 through October 1982, and November 1982 through November 1987, this paper provides evidence concerning the effect of different monetary policy operating procedures, associated with varying degrees of federal funds rate smoothing, on how accurately Treasury bill rates reflect future levels of the federal funds rate or the stance of monetary policy. These periods correspond roughly to the following monetary policy regimes: a federal funds rate targeting regime with low interest rate volatility because shocks to the reserves market are offset through open market operations; a nonborrowed reserves operating regime with high interest rate volatility because of the increased emphasis on M1 as an intermediate target and because the supply of nonborrowed reserves is not typically changed in response to shocks; and a borrowed reserves regime with an intermediate degree of interest rate volatility because a level of borrowing at the discount window over a maintenance period is targeted and the Open Market Desk attempts to offset shocks to required reserves or the demand for excess reserves through a change in the supply of nonborrowed reserves. Additional evidence on the extent to which the relative forecasting performance of the spread between Treasury bill and federal funds rates across different monetary policy operating regimes can be attributed to the relative accuracy of expectations is garnered from the Goldsmith-Nagan *Reporting on Governments and Bond and Money Market Letter* survey.

In Section I, term structure theory is briefly reviewed, a particular risk premium specification is advocated, and the model is derived. The econometric methodology and the data are discussed in Section II. The results are discussed in Section III. In Section IV, the accuracy of the Goldsmith-Nagan surveys is examined, and the implications of the findings are discussed in Section V.

I. The Model

Rational expectations implies that the interest rate on a longer-term security can be expressed as a weighted average of current and expected future short-

1979 to October 1982 relative to the period from October 1977 to October 1979, while, from October 1982 to February 1987, volatility was about half of the level of the nonborrowed reserves period. The authors also show that the volatility of the 3-month Treasury bill rate doubled during the nonborrowed reserves period but fell back to pre-October 1979 levels after October 1982.

³ Cornell (1983) and Engle and Frankel (1984) argue that the rise in interest rates reflects an anticipation of tighter policy rather than an inflation premium because of the increase in the foreign exchange value of the dollar.

term interest rates over the life of the longer-term security, plus a risk premium. Expectations affect the spread between Treasury bill and federal funds rates because corporations with funds to invest can either buy a Treasury bill or invest in consecutive overnight repurchase agreements, which are closely linked to the federal funds rate.⁴ Treasury bill rates are also linked to current and expected future federal funds rates because security dealers finance the bulk of their Treasury bill inventories in the repurchase agreement market, which is closely tied to the federal funds market.

Federal funds are reserves loaned between banks and other depository institutions that are required to hold reserves with the Federal Reserve System. Federal funds are subject to credit risk because they are typically booked without a formal written contract on an uncollateralized basis. When concerns about the soundness of the banking system heighten, the increased demand for safety lowers Treasury bill rates relative to bank instrument rates, including the federal funds rate. If the risk premium is not properly specified, changing perceptions of banking system risk may obscure the forecasts of future federal funds rates implicit in Treasury bill rates.

Although increased perceptions of banking system risk may have a relatively small effect on overnight federal funds rates because credit risk exposure is only overnight, the increased preference for the safety of Treasury bills relative to bank instruments lowers bill rates relative to current and expected future federal funds rates. Therefore, the risk premium should reflect the extent to which Treasury bill rates are low relative to current and expected future federal funds rates. In this paper, the risk premium is proxied by the spread between 3-month Eurodollar time deposit and Treasury bill rates, a financial market barometer of bank safety.⁵ This spread is shown in Figure 1 with the Treasury bill rate converted to a coupon equivalent basis and adjusted for the exemption from state and local taxes using the roughly 10 percent marginal rate estimated by Cook and Lawler (1983).⁶ The sharp increases in the spread reflect crises in the financial system including the failures at Franklin and Herstatt Banks in 1974, the silver crisis in 1980, the failure of Penn Square and the related problems at Continental in 1982, and the flight to short-term Treasury bills following the stock market crash in 1987.

⁴ A survey of corporate cash management practices by Kamath et al. (1985) indicates that repurchase agreements and Treasury bills are the most and the fifth most widely used money market instruments, respectively.

⁵ In addition, a risk premium might arise because of volatility, although the direction of the effect is ambiguous. Ho and Saunders (1985) develop a micro theoretic model of the federal funds market which suggests that the typically positive spread between the federal funds rate and very short-term Treasury bill rates reflects a risk premium that is a function of the uncertainty that banks face in managing their reserve positions. Thus, increased volatility decreases Treasury bill rates relative to the federal funds rate. However, one could argue that increased volatility might cause risk-averse investors with short investment horizons to lower their exposure to interest rate fluctuations by shortening the duration of their investments, which would increase the 3-month Treasury bill rate relative to the federal funds rate. In either case, the coefficients on risk premium terms based on lagged interest rate volatility were highly insignificant for all of the subperiods.

⁶ Cook and Lawler (1983) estimate an implied marginal state and local tax rate from regressions of the spread between CD and Treasury bill rates on the CD rate. The coefficient on the CD rate is the implied marginal tax rate.

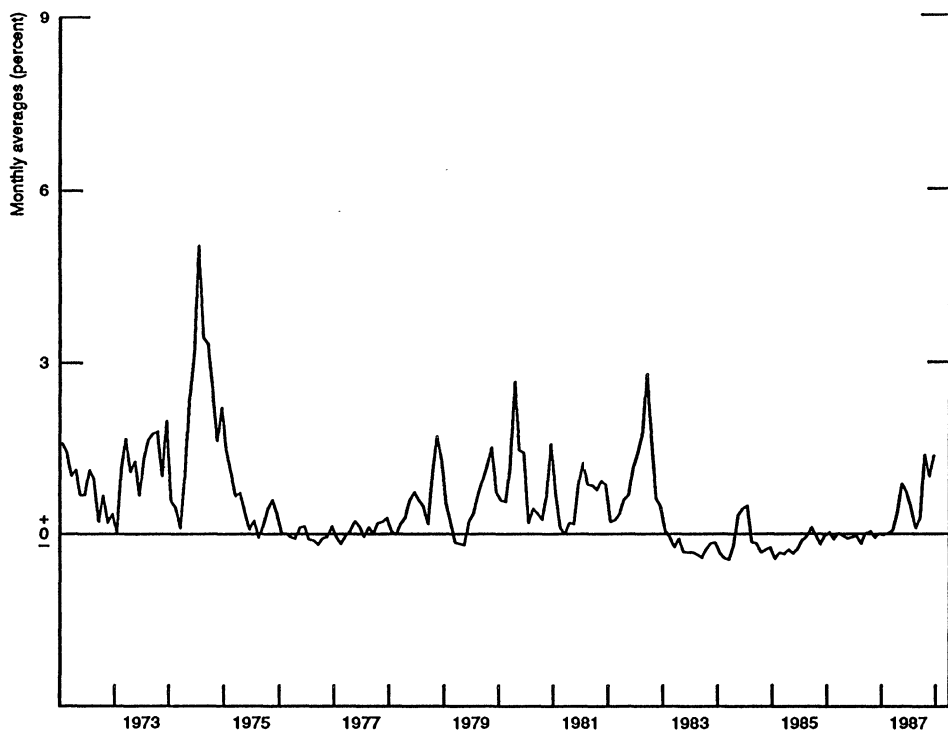


Figure 1. Tax-adjusted spread between 3-month Eurodollar and Treasury bill rates with an assumed 10 percent state and local tax rate. The data are monthly averages of daily observations from 1972 to 1988 and are expressed in percent.

Equation (1) expresses the tax-adjusted 3-month Treasury bill rate as a weighted average of the current federal funds rate and the expected future federal funds rates over the 91 days to maturity, minus a constant and a time-varying risk premium. RTB_t is the tax-adjusted rate on the most recently auctioned 3-month Treasury bill at the close of business each Thursday, RFF_t and $E_t(RFF_{t+i})$ are the actual overnight federal funds rate on Thursday and the expected future overnight federal funds rates over the life of the Treasury bill, and $REURO_t$ is the 3-month Eurodollar time deposit rate.⁷ A linear approximation commonly used in the term structure literature is employed here. (See Shiller, Campbell, and Shoenholtz (1983) and Mankiw and Summers (1984).) The time-varying risk premium has a negative sign because increased risk lowers Treasury bill rates relative to current and expected future federal funds rates. The constant term reflects the possibility of a constant risk premium and has a negative sign.

$$RTB_t = -\phi + (RFF_t/91) + E_t \sum_{i=1}^{90} (RFF_{t+i}/91) - \theta (REURO_t - RTB_t). \quad (1)$$

⁷ Three-month Treasury bills are auctioned each Monday and issued on Thursday, except for holidays. When Thursday is a holiday, bills are issued on Friday as 90- and 181-day bills, in which case Friday data are used. Treasury bill rates are assumed to be tax-adjusted from this point on.

Rearranging equation (1) results in

$$E_t \sum_{i=1}^{90} (RFF_{t+i}/90) - RFF_t = (91/90)\phi + 91/90(RTB_t - RFF_t) + (91/90)\theta (REURO_t - RTB_t). \quad (2)$$

In equation (3), the actual average federal funds rate over the remaining life of the Treasury bill is expressed as the sum of the expected average rate plus a forecast error, orthogonal to available information by rational expectations:

$$\sum_{i=1}^{90} (RFF_{t+i})/90 = E_t \sum_{i=1}^{90} (RFF_{t+i}/90) + u_{t+i}. \quad (3)$$

Equation (4) is derived by substituting equation (3) into equation (2), which is estimated both with and without a time-varying risk premium term where $b_0 = (91/90)\phi$, $b_1 = 91/90$, and $b_2 = (91/90)\theta$.

$$\sum_{i=1}^{90} (RFF_{t+i}/90) - RFF_t = b_0 + b_1 (RTB_t - RFF_t) + b_2 (REURO_t - RTB_t) + u_{t+i}. \quad (4)$$

If the risk premium is either adequately proxied or unimportant and if expectations are rational, estimates of b_1 should not be different from 91/90, or approximately 1, and b_2 should be positive since increased concerns about bank safety should cause investors to require a higher return in federal funds relative to Treasury bills. Misspecification of the risk premium may bias downward the coefficient on the Treasury bill-federal funds rate spread, because a low Treasury bill rate relative to the federal funds rate during periods of increased concerns about the banking system may reflect an increased demand for the safety of Treasury bills rather than expectations of lower federal funds rates.

II. Econometric Methodology and the Data

The error term follows an MA(12) process because, with a forecast horizon of 13 weeks and with weekly observations, the forecast error realized in week $t + 13$ will be correlated with forecast errors realized in weeks $t + 1$ through $t + 12$. Although OLS estimates of the parameters are consistent, the estimates of the variance-covariance matrix are not. The variance-covariance matrix is consistently estimated with the method outlined in Hansen (1982), which incorporates a modification suggested by White (1980) for heteroskedasticity.⁸

The data are from the Federal Reserve data base. The federal funds rate is a transactions-weighted average daily rate. The Treasury bill rate is a bid quote at the close of business in New York, while the Eurodollar rate is a London noon

⁸ The formula for the variance-covariance matrix of the parameter estimates in this paper, V , is

$$V = T^2(X'X)^{-1}\hat{\Omega}(X'X)^{-1},$$

where X is the $T \times K$ matrix of explanatory variables, T is the number of observations, K is the

bid rate.⁹ For comparability with federal funds and Eurodollar rates, the Treasury bill rate is converted to a coupon equivalent basis and is adjusted for its exemption from state and local taxes, assumed to be 10 percent. All rates are converted to a 365-day basis.

III. The Results

Table I shows the regression results without a time-varying risk premium. For the entire January 1972 to November 1987 period, the coefficient on the Treasury bill-federal funds rate spread is positive and significantly greater than zero, but it is significantly less than the theoretically expected value of one. However, the only subperiod with significant predictive power is during the nonborrowed reserves period from October 1979 through October 1982, when the coefficient on the spread is both significantly greater than zero at a one percent level and not significantly different from one. For the other subperiods, the coefficients on the Treasury bill-federal funds rate spread have the expected sign but are not significantly greater than zero. For all of the subperiods and for the entire period, the constant term is not significantly different from zero. Wald tests indicate that the coefficients are highly unstable across subperiods.

Table II shows that including a time-varying risk premium qualitatively alters the results only during the borrowed reserves period from November 1982 to November 1987. For this subperiod, the coefficient on the Treasury bill-federal funds rate spread is now significantly greater than zero at the five percent level, although it remains significantly less than one.¹⁰ The coefficient on the time-varying risk premium term is the expected sign and is significantly greater than zero at the one percent level.¹¹

For the entire period and for the other subperiods, the inclusion of a time-varying risk, premium has little qualitative effect on the predictive power of the Treasury bill-federal funds rate spread. For the entire sample, the coefficient on

number of explanatory variables, and $\hat{\Omega}$ is equal to

$$\hat{\Omega} = \sum_{s=-N+1}^{N-1} \left[(1/T) \sum_{t=1}^T X_t' \hat{e}_t \hat{e}_{t-s} X_{t-s} \right],$$

where the $\hat{e}$ terms are residuals from OLS estimates and the error term follows an MA($N-1$) process. Although this method does not guarantee that the variance-covariance matrix is positive definite, it is in all of the empirical work in this paper.

⁹ While using a London noon rate could introduce measurement error, similar results are obtained with the 3-month certificate of deposit rate instead of the Eurodollar rate.

¹⁰ Another possible regime change is the shift from lagged to current reserve requirements in February 1984. Separate regressions from November 1982 to February 1984 indicate significant predictive power and a coefficient on the spread that is not significantly different from one, both with and without a risk premium, but no predictive power with either specification from February 1984 to November 1987. The finding of significant predictive power in the November 1982 to February 1984 period should be interpreted cautiously because of the small sample size. Nonetheless, the implication is that the significant predictive power found from November 1982 to November 1987 is due to the early part of the period.

¹¹ However, a Wald test indicates that including a time-varying risk premium does not significantly change the coefficient on the Treasury bill-federal funds rate spread.

Table I

Estimates of the Predictive Power of the Spread between 3-Month Treasury Bill and Federal Funds Rates for Future Changes in the Federal Funds Rate

The dependent variable is the average level of the federal funds rate over the next 90 days minus the current overnight federal funds rate, and the independent variable is the spread between the 3-month Treasury bill rate and the federal funds rate on Thursday of week t . The equations are estimated with weekly data from January 1972 to November 1987 using OLS with corrections for an MA(12) error and for heteroskedasticity.

$\sum_{i=1}^{90} (RFF_{t+i}/90) - RFF_t = b_0 + b_1(RTB_t - RFF_t) + u_{t+i}$				
Coefficient ^a	Time Period			
	1/6/72-11/26/87	1/6/72-10/4/79	10/11/79-10/28/82	11/5/82-11/26/87
$\hat{b}_0$	-.02 (.13)	.15 (.13)	.09 (.46)	-.16 (.09)
$\hat{b}_1$	.50** (.17)	.20 (.13)	1.1** (.30)	.25 (.18)
$\bar{R}^2$	.14	.07	.31	.05
SEE	1.1	.69	2.01	.50
Wald statistics for stability ^b	—	—	19.3**	32.2**

^a Standard errors are in parentheses. Two asterisks indicate coefficients that are significantly different from zero at the 99% confidence level.

^b The Wald statistics for stability test the equality of the estimated coefficients from one subperiod with the previous subperiod's estimated coefficients and have chi-square distributions with 2 degrees of freedom.

the Treasury bill-federal funds rate spread is again significantly positive and the time-varying risk premium is insignificant. Over the federal funds rate targeting regime, the coefficient on the Treasury bill-federal funds rate spread is again not significantly greater than zero, and, over the nonborrowed reserves period, the Treasury bill-federal funds rate spread is again both significantly greater than zero at the one percent level and not different from its theoretically expected value of one. However, for both of these subperiods, the coefficient on the time-varying risk premium has the wrong sign and is significant, although the constant term now has the expected sign and is significant over the federal funds targeting regime.¹²

IV. Survey Evidence on the Accuracy of Expectations

In this section, the Goldsmith-Nagan *Reporting on Governments* survey of financial economists is examined to provide additional evidence on the accuracy of

¹² One possible explanation for the wrong sign on the time-varying risk premium term is that the Federal Reserve eases and the federal funds rate falls during periods of heightened concern about the banking system. Regressions of the same dependent variable on just a constant and the time-varying risk premium indicate that the funds rate falls when the risk premium increases from 1972 to 1979 and from 1979 to 1982, but not from 1982 to 1987. However, this systematic tendency should be reflected in the Treasury bill-federal funds rate spread. Another potential explanation may be that, when the federal funds rate is expected to rise, banks lengthen the maturity of their debt, which diminishes the supply of 3-month Eurodollar time deposits, perhaps narrowing the 3-month Eurodollar-Treasury bill rate spread.

Table II

Estimates of the Effect of Including a Risk Premium on the Predictive Power of the Spread between 3-Month Treasury Bill and Federal Funds Rates for Future Changes in the Federal Funds Rate

The dependent variable is the average level of the federal funds rate over the next 90 days minus the current overnight federal funds rate, and the independent variables are the spreads between 3-month Treasury bill and federal funds rates and between 3-month Eurodollar and Treasury bill rates on Thursday of week t . The equations are estimated with weekly data from January 1972 to November 1987 using OLS with corrections for an MA(12) error and for heteroskedasticity.

$\sum_{i=1}^{90} (RFF_{t+i}/90) - RFF_t = b_0 + b_1(RTB_t - RFF_t) + b_2(REURO_t - RTB_t) + u_{t+i}$				
Coefficient ^a	Time Period			
	1/6/72-11/26/87	1/6/72-10/4/79	10/11/79-10/28/82	11/5/82-11/26/87
$\hat{b}_0$	-.01 (.11)	.47** (.15)	.88 (.50)	-.21* (.09)
$\hat{b}_1$	.49* (.19)	-.18 (.19)	.83** (.21)	.44* (.19)
$\hat{b}_2$	-.02 (.13)	-.44* (.20)	-.98** (.34)	.37** (.13)
$\bar{R}^2$	.14	.17	.38	.11
SEE	1.1	.65	1.9	.49
Wald statistics for stability ^b	—	—	57.6**	216**
Wald statistics for specification	.01	4.1**	1.6	1.1

^a Standard errors are in parentheses. One and two asterisks indicate coefficients that are significantly different from zero at the 95% and 99% confidence levels, respectively.

^b Wald statistics for stability test the equality of the estimated coefficients across subperiods, while Wald statistics for specification test the equality of the estimated coefficients on the Treasury bill-federal funds rate spread with and without a risk premium. These statistics have chi-square distributions with 3 and 1 degrees of freedom.

expectations across monetary policy regimes. The survey polls about 40 economists near the end of each quarter for their predictions of the weekly average federal funds rate at the end of the next quarter.¹³ The forecasting properties of the survey are examined in the following regression equation, where the dependent variable is the actual one-quarter ahead change of the federal funds rate and the independent variable is the one-quarter ahead expected change in the federal funds rate, as measured by the mean survey response.¹⁴

$$RFF_{t+1} - RFF_t = b_0 + b_1 [E_t(RFF)_{t+1} - RFF_t] + u_{t+1}. \quad (5)$$

If forecasts are rational, b_0 should not be different from zero, b_1 should not be different from one, and the residual should not be autocorrelated. The above

¹³ While the survey forecasts are not directly comparable to the yield spread forecasts because the economists are polled quarterly for the average federal funds rate for the statement week including the quarter-end, they provide additional information on the accuracy of financial market expectations.

¹⁴ The survey is mailed out about two weeks prior to the end of each quarter. The change and the expected change in the federal funds rate are from the week average ending the Wednesday after the survey is mailed to the week average ending on Wednesday that includes the last day of the next quarter.

Table III

The Accuracy of Federal Funds Rate Expectations Across Policy Regimes as Measured by the Goldsmith-Nagan Survey

The dependent variable is the quarterly change in the statement week average federal funds rate, and the independent variable is the expected quarterly change in the statement week average federal funds rate, as measured by the median response to the survey near the end of each quarter. The equations are estimated with quarterly data from 1972:Q1 to 1987:QIV using OLS with corrections for heteroskedasticity.^{*}

$RFF_{t+1} - RFF_t = b_0 + b_1[E_t(RFF)_{t+1} - RFF_t] + u_{t+1}$				
Time Period				
Coefficient ^a	1972:Q1-1987:QIV	1972:Q1-1979:QIII	1979:QIV-1982:QIV	1983:Q1-1987:QIV
$\hat{b}_0$	.42 (.24)	.36 (.19)	2.0 (1.5)	-.05 (.28)
$\hat{b}_1$	1.01** (.23)	.84* (.39)	1.58** (.42)	-.10 (.51)
$\bar{R}^2$	.17	.17	.21	-.05
SEE	2.2	1.1	4.3	1.3
D.W.	2.2	1.4	2.3	2.2

^a Standard errors are in parentheses. One and two asterisks indicate coefficients that are significantly different from zero at the 95% and 99% confidence levels, respectively.

regression is run for the entire sample and for the same subsamples as in the previous section, with corrections for heteroskedasticity with the methods used in the previous section.

The survey forecasts are consistent with the finding that the Treasury bill-federal funds rate spread most accurately forecasts future levels of federal funds rates during the nonborrowed reserves regime, although the survey forecasts are not consistent with the lack of predictive power during the federal funds rate pegging regime or with the finding of some predictive ability during the borrowed reserves regime. Table III indicates that, from 1979:QIV to 1982:QIV, unbiasedness cannot be rejected and the coefficient on the expected change in the federal funds rate is significantly greater than zero at a one percent level and is not different from one. The results also indicate that expectations are unbiased over the federal funds targeting regime, with a coefficient on the expected change that is significantly greater than zero at the five percent level; however, the survey has no predictive power from 1983:Q1 to 1987:QIV.¹⁵ Thus, the survey results are consistent with the view that the increased accuracy of term structure forecasts during the nonborrowed reserves period results from the increased accuracy of expectations.

V. Conclusion

This paper models 3-month Treasury bill rates as a function of current and expected future levels of the federal funds rate and a time-varying risk premium,

¹⁵ Using Goldsmith-Nagan survey data, Friedman (1980) finds that expectations of one- and two-quarter ahead federal funds rates are unbiased from 1969 through 1976. However, he shows that the forecasts are not consistent with rationality because they do not efficiently incorporate readily available information.

proxied by a market-based indicator of credit risk in the banking system. The finding that the Treasury bill-federal funds rate spread most accurately forecasts changes in the federal funds rate during the nonborrowed reserves regime, despite the substantial increase in volatility, may be somewhat surprising but is consistent with survey data indicating that expectations of federal funds rate changes were unbiased over that period. The increased reliance of monetary policy on rules rather than on discretion during the nonborrowed reserves period, as well as the emphasis of the rules on M1 growth, which are observed by market participants on a weekly basis, apparently allowed market participants to gauge more accurately future changes in the federal funds rate. During this period, change in the federal funds rate were determined to a large extent endogenously by market factors, rather than by discrete policy moves. When M1 overshot its growth target, market participants could infer that the federal funds rate would rise in the near-term because the resulting increased demand for required reserves would not be offset by an increased supply of nonborrowed reserves.

By contrast, during the federal funds rate targeting regime and to a lesser extent during the borrowed reserves operating regime, federal funds rate changes were smoother because the federal funds rate was more of a managed rate, with the impact of shocks on the federal funds rate offset to a greater extent by changes in the supply of nonborrowed reserves. Because changes in the federal funds rate were based to a greater extent on discretion rather than on a well-defined rule, federal funds rate changes may have been more difficult to forecast. During the borrowed reserves regime, involving an intermediate degree of interest rate smoothing, the Treasury bill-federal funds rate spread has some predictive power when a time-varying risk premium term is included, but it has none during the federal funds targeting regime.

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