The Impact of Discount Rate Changes on Market Interest Rates

By V. Vance Roley and Rick Troll

The Federal Reserve's discount rate — the rate charged to depository institutions borrowing from Federal Reserve banks — was more important in the implementation of monetary policy in the three years after the Federal Reserve changed its monetary control procedures in October 1979.[1] Until then, the Federal Reserve had focused on short-term market interest rates in attempting to achieve monetary growth objectives. In the three years after the change, however, the Federal Reserve focused mainly on the availability of reserves to depository institutions. As a result, borrowing at the discount window — a component of total reserves of depository institutions — took on more significance, as did the cost of borrowing represented by the discount rate.

This article analyzes the economic significance of discount rate changes by comparing market interest rates just before an announced discount rate change with market interest rates immediately after. Unlike other studies on this subject, the analysis examines the responses of both short and long-term interest rates.[2] By considering the response of the whole term structure of interest rates, possible effects associated with both short and long-run monetary policy objectives can be investigated. Of particular interest is the notion that long-term yields may fall (rise) in response to an

[1] For the descriptions of the operating procedures adopted by the Federal Reserve on October 6, 1979 and comparisons with the previous approach, see J. A. Cacy, "Monetary Policy in 1980 and 1981," Economic Review, Federal Reserve Bank of Kansas City, December 1980, pp. 18-25; and Stephen Axilrod and David E. Lindsey, "Federal Reserve System Implementation of Monetary Policy: Analytical Foundations of the New Approach," American Economic Review, May 1981, pp. 246-52.

V. Vance Roley is an associate professor of finance at the University of Washington and a visiting scholar at the Federal Reserve Bank of Kansas City. Rick Troll was an assistant economist at the Bank. The views expressed here are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Kansas City or the Federal Reserve System.

[2] While other research has not examined the impact on the entire term structure of interest rates, the impact on a variety of markets has been studied. See, for example, Roger Waud, "Public Interpretation of Federal Reserve Discount Rate Changes: Evidence on the 'Announcement Effect'," Econometrica, March 1970, pp. 231-50; Raymond E. Lombra and Raymond G. Torto, "Discount Rate Changes and Announcement Effects," Quarterly Journal of Economics, February 1977, pp. 171-76; Douglas R. Mudd, "Did Discount Rate Changes Affect the Foreign Exchange Value of the Dollar During 1978?" Review, Federal Reserve Bank of St. Louis, April 1979, pp. 20-6; H. Kent Baker and James M. Meyer, "Impact of Discount Rate Changes on Treasury Bills," Journal of Economics and Business, Fall 1980, pp. 43-8; Kathleen Hope Brown, "Effect of Changes in the Discount Rate on the Foreign Exchange Value of the Dollar: 1973 to 1978," Quarterly Journal of Economics, August 1981, pp. 551-58; Daniel

increase (decrease) in the discount rate if such an increase reflects a policy objective of lower long-run monetary growth and, hence, lower inflation. As is argued here, however, the opposite response may be seen if discount rate changes instead reflect changes in only short-run monetary growth objectives.

The first section examines the response of market interest rates to new monetary policy information in a simple analytical model. Also considered is the potential role of discount rate changes in conveying new monetary policy information. The effect of discount rate changes under other operating procedures is analyzed in the second section. The third section empirically examines the response of the term structure of interest rates before October 1979 and since that time. The main conclusions of the article are summarized in the final section.

New monetary policy information and interest rates

If announced changes in the discount rate affect market interest rates, they do so primarily by providing the public new information about monetary policy objectives. In other words, changes in the discount rate may have "announcement effects" regarding a change in monetary policy.[3] The precise nature of the announcement effects cannot be readily discerned in other studies. In this section, an analytical framework is provided for identifying the possible sources of announcement effects.[4] Then, the impact of new information about monetary policy objectives on market interest rates is analyzed.

Model of interest rate determination

Market interest rates can be influenced significantly by changes in both short and long-run monetary policy objectives. To characterize long-run monetary objectives, it is assumed that the Federal Reserve focuses on a single monetary aggregate. A long-run path, represented by the line LR in Figure 1, is then assumed to be set from a base level that was observed some in weeks previously (m^B_{t-n}).[5] This long-run path represents trend monetary growth well into the future. In contrast, actual long-run targets specified by the Federal Reserve are in terms of annual ranges. It may nevertheless be reasonable to expect market

L. Thornton, "The Discount Rate and Market Interest Rates: What's the Connection?" Review, Federal Reserve Bank of St. Louis, June-July 1982, pp. 3-14; and Gordon H. Sellon, Jr. and Diane Seibert, "The Discount Rate. Experience Under Reserves Targeting," Economic Review, Federal Reserve Bank of Kansas City, September-October 1982, pp 3-18.

[3] See, for example, Warren Smith, "Instruments of General Monetary Control," National Banking Review, September 1963, pp. 47-76, and Roger Waud, "Public Interpretation of Federal Reserve Discount Rate Changes: Evidence on the 'Announcement Effect'," Econometrica, March 1970, pp. 231-50

[4] The model in this and the following sections is a simplified version of that presented in V. Vance Roley and Carl E. Walsh, "Monetary Policy Regimes, Expected Inflation, and the Response of Interest Rates to Money Announcements," Working Paper No. 1181, National Bureau of Economic Research, August 1983. Also see Thomas J. Urich, "The Information Content of Weekly Money Supply Announcements," Journal of Monetary Economics, July 1982, pp. 73-88, and Peter A. Tinsley, Peter von zur Muehlen, Warren Trepeta, and Gerhard Fries, "Money Market Impacts of Alternative Operating Procedures," in New Monetary Control Procedures, Federal Reserve Staff Study — Volume II, Board of Governors of the Federal Reserve System, February 1981.

[5] Long-run target values of the money stock may be represented as

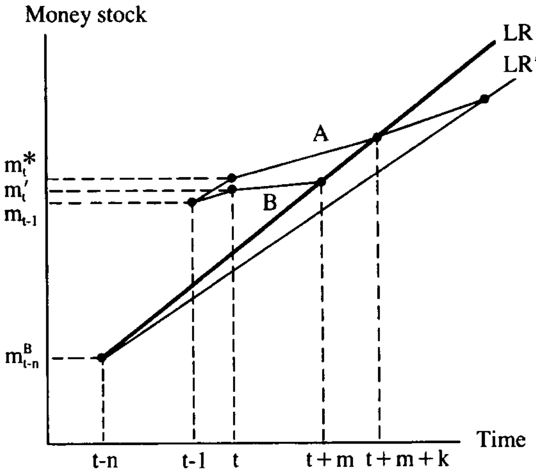
$$M^T_{t+j} = (1+g)^{n+j} M^B_{t-n}, \quad (1)$$

where M^T_{t+j} is the target level of the money stock in week t+j, M^B_{t-n} is the base level of the money stock in week t-n, and g is the weekly growth rate implied by the annual target rate. For the derivations that follow in this article, it is useful to take logarithms of both sides of(1) to yield

$$m^T_{t+j} = (n+j)g + m^B_{t-n}, \quad (2)$$

where m^T_{t+j} is log (M^T_{t+j}), and m^T_{t-n}, is log (M^B_{t-n}).

FIGURE 1
Short and long-run monetary paths



participants to infer a long-run money path extending beyond one year based on past Federal Reserve actions and statements related to trend money growth.

A variety of unanticipated disturbances in the financial and nonfinancial sectors of the economy can cause short-run money growth to deviate substantially from its desired long-run rate. Suppose at the beginning of the current week (t), for example, the Federal Reserve estimates that money in the previous week (t-1) increased faster than the desired trend. In the model, it is assumed that the Federal Reserve then specifies a short-run money path consistent with eventually obtaining the long-run path, as represented by either line A or B in the figure.[6] In the figure, short-run path A implies slower adjustment back to the long-run path than path B. Consequently, the level of the money stock is higher under path A for a number of weeks (m + k).

The assumptions underlying the short-run paths again depart from actual Federal Reserve policymaking behavior. The model assumes that new short-run money paths are specified every week, so that they represent the best forecast of actual money stock behavior. In contrast, short-run paths specified by the Federal Reserve are typically set only at FOMC meetings and are, therefore, not adjusted weekly to reflect actual money growth. The counterfactual assumptions concerning monetary targets are presented merely for expositional and analytical ease and do not significantly change any of the main results. In the remainder of the article, monetary policy objectives are discussed in terms of this analytical framework.

The alternative short-run paths in Figure 1 have different implications for the level of interest rates. To see this, the demand for money must be considered. In Figure 2, the demand for money in week t (m_t^D) is graphed as a negative function of the federal funds rate.[7] The relationship reflects the desire of households and businesses to economize on their money holdings as interest rates rise. Money demand depends on other factors — such as income, wealth, and prices — that would cause the relationship in the figure to shift if their values changed.

From the short-run path for money in Figure 1, the target levels of money from the current

---

[6] The short-run path may be represented as

$$m_{t+j} = (n+j)g + m_{t-n}^B + (1-\lambda)^j [m_{t-1} - (n-1)g - m_{t-n}^B], \qquad (3)$$

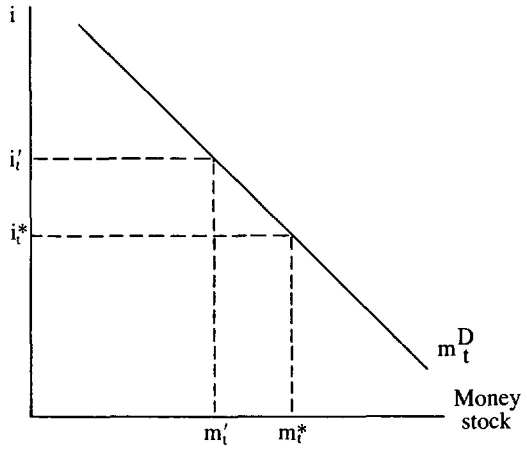
where $m_{t,j}$ is the short-run target level of the money stock in week t + j as of week t, and is the rate at which the deviation of money from its long-run target is offset.

[7] Other short-term interest rates may more appropriately represent the opportunity cost of holding money. To simplify the analysis, however, the federal funds rate is assumed to be a representative short-term yield. Analytically, the money demand function considered hence may be represented as

$$m_t = a_0 - a \cdot i_t + u_t, \qquad (4)$$

where a_0 and a are positive parameters and u_t is a random error term. Because of lagged reserve requirements it is assumed

FIGURE 2
Money market



week (t) through a number of subsequent weeks may be determined. Also, given the target level of money in week t (m_t^*, for example), the federal funds rate consistent with this level (i_t^*) may be determined from the money demand function in Figure 2. Because the money path in Figure 1 embodies levels of the money stock for a number of subsequent weeks, future levels of the federal funds rate are also implicit in the model. For example, the money stock target for the next week can be inferred from Figure 1, and, in turn, an implied level of next week's federal funds rate can be obtained from the money demand function. Levels of the federal funds rate in subsequent weeks can be derived the same way, again conditional on the information available in the current week (t). As a result, the current path for money has implications for both the federal funds rate and longer term interest rates if longer term rates reflect expected future levels of the federal funds rate.[8] In the case of a one-month yield, for example, it may be expected to be an average of the current week's federal funds rate plus the levels of the federal funds rate over the next three weeks. Thus, any change in policy affecting either the current week's federal funds rate or its level in the future would be expected to affect this yield.

Change in short-run monetary policy objectives

If new information about short-run monetary policy objectives becomes available, market interest rates may move from their previous level. In examining this case, suppose that in the current week (t), both the Federal Reserve and the public observe that available data on the money stock indicate higher than desired money growth, as in Figure 1. Based on past Federal Reserve behavior, financial market participants may expect a short-run money path corresponding to path A in the figure. This path has implications, as previously discussed, for the levels of current and future short-term interest rates. Now suppose that new information available to the public suggests the Federal Reserve's implied short-run money path has moved from path A to path B in Figure 1. As a result, the current week's target as assessed by the public has decreased from m_t^* to m_t' in Figures 1 and 2. In an effort to achieve this reduced level of the money stock, the federal funds rate is expected to rise from i_t^* to i_t'.

---

that only the demand for needs to be considred in any given week to determine the desired level of the federal funds rate. This property is discussed in detail below.

[8] Analytically, this term structure relationship is

$$r_{m,t} = (1/m)\, i_t + (1/m) \sum_{j=1}^{m-1} E_t\,(i_{t+j}), \qquad (5)$$

where $r_{m,t}$ is the yield on an m-week security in week t, and $E_t(\ )$ is the expectations operator conditional on information available in week t.

Long-term interest rates also can be affected by changes in short-run monetary policy objectives. If the anticipated short-run path is again moved from path A to path B in Figure 1, expected levels of the money stock are less than those previously expected for m + k weeks. From Figure 2, this reduction implies higher expected levels for the federal funds rate over this period. If long-term yields reflect these expected future levels of short-term interest rates, long-term yields also would rise.

Change in long-run monetary policy objectives

New information about long-run monetary policy objectives also may affect market interest rates. In examining this case, it is convenient to assume that the public's assessment of the short-run path is unchanged. Suppose, for example, the current short-run path is path A and the current long-run path is LR, as both are represented in Figure 1. Now assume that the public receives new information suggesting that the long-run path has moved from LR to LR′. In this instance, the current federal funds rate would remain unchanged since the assessed target for money in the current week is unchanged. This result follows because short-run money growth is still expected to follow path A. Thus, because expected levels of the money stock are unchanged for m + k weeks into the future, expected levels of the federal funds rate for the current and m + k future weeks should be unchanged.

After m + k weeks, expected levels of the money stock are uniformly lower than before. These lower future levels of the money stock imply higher future short-term interest rates after m + k weeks, as in Figure 2. However, a permanent reduction in the growth of the money stock would reduce expected inflation, which would lower future expected short-term interest rates.[9] This latter effect would be more likely to dominate the longer the maturity of the security. Thus, long-term interest rates may decline immediately if trend monetary growth is reduced and the current short-run money path is maintained.

Impact of discount rate changes under alternative operating procedures

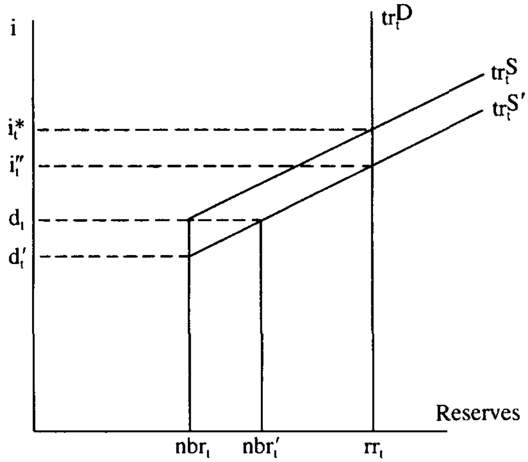
The potential role of changes in the discount rate in revealing information about either short or long-run monetary policy objectives depends on the type of operating procedure the Federal Reserve uses. This section examines the effect of discount rate changes under federal funds rate and nonborrowed reserves operating procedures. To consider these different operating procedures, a model of the reserves market is presented first.

Model of the reserves market

The determination of the federal funds rate consistent with the desired level (i_t*) implied by Figures 1 and 2 may be represented in the market for reserves. The demand for and supply of reserves are represented graphically in Figure 3. The demand for total reserves is comprised of required reserves and excess reserves. For simplicity, it is assumed that excess reserves equal zero and that uniform reserve requirements are imposed on all components of the money stock. Because of

[9] Note that nominal money demand in the future would decrease, leading to a lower implied level of the federal funds rate. To analyze this effect properly, the nonfinancial economy and an adjustment mechanism describing movements in prices should be added to the model. It is assumed throughout this article that prices are not flexible in the short run. In particular, it is assumed that inflationary expectations are unaffected unless the long-run target path is changed.

FIGURE 3
Reserves market



lagged reserve requirements, however, the current demand for required reserves (rr_t) depends on the deposits of financial institutions in the statement week before last. Since the demand for reserves depends only on a previous level of the money stock, and not current short-term interest rates, it can be represented by the vertical line (tr_t^D) in the figure.[10]

The supply of reserves to depository institutions (tr_t^S) also consists of two components: borrowed reserves from the Federal Reserve's discount window and nonborrowed reserves. Nonborrowed reserves (nbr) can be closely controlled by the Federal Reserve through open-market operations — temporary or outright purchases and sales of securities. In the absence of policy considerations, the supply of nonborrowed reserves is also insensitive to interest rates. So, as before, it can also be represented in the figure by a vertical line.

The other component, borrowed reserves, depends mainly on the spread between the federal funds rate and the discount rate.[11] The federal funds rate — the daily rate charged on reserves borrowed from other financial institutions — represents a cost of obtaining reserves in the short run. For depository institutions to borrow from the Federal Reserve, the federal funds rate must be sufficiently higher than the discount rate to compensate for any nonpecuniary costs associated with discount window borrowing.[12] For analytical convenience, it is assumed that discount window borrowing equals zero when the federal funds rate is at or below the discount rate and that discount window borrowing increases as the positive spread between the federal funds rate and the discount rate widens. Given these assumptions, the supply of total reserves simply equals nonborrowed reserves for levels of the federal funds rate (i_t) below the discount rate (d_t), and equals the sum of nonborrowed and borrowed reserves for higher levels of the federal funds rate.[13] In this framework, the level

[10] Analytically, the demand for total reserves (TR^D) may be represented as

$$TR_t^D + RR_t^D + ER_t^D. \quad (6)$$

Since it is assumed that the demand for excess reserves equals zero ($ER^D = 0$), and that required reserves are proportional to the lagged money stock ($RR^D = kM_{t-2}$), the logarithm of the demand for total reserves may be expressed as

$$tr_t^D = rr_t^D + k + m_{t-2}. \quad (7)$$

[11] For detailed analyses of depository institutions' short-run reserves adjustments, see Stephen M. Goldfeld and Edward J. Kane, "The Determinants of Member Bank Borrowing: An Econometric Study," Journal of Finance, September 1966, pp 499-514; Peter A. Frost and Thomas J. Sargent, "Money Market Rates, the Discount Rate, and Borrowing from the Federal Reserve," Journal of Money, Credit, and Banking, February 1970, pp. 56-82; and Marvin Goodfriend, "Discount Window Borrowing, Monetary Control, and the Post-October 6, 1979 Federal Reserve Operating Procedure," Working Paper No. 81-1, Federal Reserve Bank of Richmond, January 1981.

[12] The costs reflect a possible administrative burden due to the guidelines governing access to the discount window, the reluctance of institutions to use their limited borrowing privilege, and a traditional unwillingness of some banks to borrow from the Federal Reserve at all.

of the federal funds rate (i_t^*) consistent with Figure 2 is determined by the intersection of the demand for and supply of reserves in Figure 3.[14]

Federal funds rate operating procedure

Under the pre-October 1979 monetary control procedure, the Federal Reserve adjusted the supply of nonborrowed reserves to maintain the federal funds rate within a narrow band. If the desired level of the federal funds rate is i_t'', for example, the supply of nonborrowed reserves could be increased from nbr_t to nbr_t' to achieve this rate. In this case, the supply of total reserves shifts from tr_t^S to $tr_t^{S'}$, as illustrated in the figure.

Taken by themselves, discount rate changes would not reflect any new information about monetary policy objectives under a federal funds rate operating procedure. If the discount rate is d_t' and the current week's federal funds rate is i_t'', for example, an increase in the discount rate to d_t would result in nonborrowed reserves increasing from nbr_t to nbr_t' in Figure 3. In this case, the assessed target for the current week's money stock would remain the same as before. In contrast, if the federal funds rate changed from its previous level, this change would reveal new information about current and future levels of the money stock. An increase in the federal funds rate, for example, implies that the current week's expected money stock is less than before, as shown in Figure 2. Discount rate changes would not convey any new information since they are not needed to change the level of the federal funds rate. Thus, under a federal funds rate operating procedure, discount rate changes would not be expected to affect market interest rates.

Nonborrowed reserves operating procedure

Under the post-October 1979 operating procedure, the Federal Reserve maintained a target path for nonborrowed reserves, thereby allowing larger fluctuations in the federal funds rate. For a given level of required reserves (rr_t, for example), if borrowing demand was higher than expected, the total supply of reserves would shift from tr_t^S to $tr_t^{S'}$ in the figure. With a fixed supply of nonborrowed reserves, the federal funds rate would drop from i_t^* to i_t''.

Under a nonborrowed reserves operating procedure, a discount rate change would be expected to affect interest rates without any

---

[13] The supply of total reserves (TR_t^S) can be expressed as

$$TR_t^S = RR_t = NBR_t + BR_t \tag{8}$$

where NBR_t and BR_t are the levels of nonborrowed and borrowed reserves, respectively. Rearranging (8) and taking logarithms yields

$$rr_t = nbr_t + \ln(1 + BR_t/NBR_t), \tag{9}$$

where rr_t and nbr_t are the logarithms of RR_t and NBR_t, respectively. To represent the discount-window borrowing behavior of depository institutions, it is assumed that

$$\ln(1 + BR_t/NBR_t) = b_0 + b(i_t - d_t) + v_t \tag{10}$$

for it d_j, and zero otherwise, where b_0 and b are positive parameters, and v_t is a stochastic error term. From (9) and (10), the supply of reserves therefore equals

$$rr_t = nbr_t + b_0 + b(i_t - d_t) + v_t. \tag{11}$$

[14] Because of lagged reserve requirements, it is assumed that there is not a direct link between the demand for reserves and the current level of the money stock in any given week in the model. For other analyses emphasizing this property, see Stephen F. LeRoy, "Monetary Control Under Lagged Reserve Accounting," Southern Economic Journal, October 1979, pp. 460-470; David S. Jones, "Contemporaneous vs. Lagged Reserve Accounting: Implications for Monetary Control," Economic Review, Federal Reserve Bank of Kansas City, November 1981, pp. 3-19; and Robert L. Hetzel, "The October 1979 Regime of Monetary Control and the Behavior of the Money Supply in 1980," Journal of Money, Credit, and Banking, May 1982, pp. 234-251. For an analysis of money stock determination under contemporaneous reserve requirements, also see Howard L. Roth and Diane Seibert, "The Effect of Alternative Discount Rate Mechanisms on Monetary Control," Economic Review, Federal Reserve Bank of Kansas City, March 1983, pp. 16-29.

further overt policy actions. In particular, if nonborrowed reserves are fixed in week t, a decrease in the discount rate from d_t to d_t' in Figure 3, for example, causes the federal funds rate to fall from i_t^* to i_t''. In this case, the shift in the supply of reserves reflects the increased willingness of banks to borrow at any given federal funds rate. The subsequent fall in the federal funds rate causes market participants to revise their estimate of the current week's money stock upward. The public may further infer a change in the entire short-run money stock path, causing the discount rate change to affect both short and long-term interest rates. Thus, under a nonborrowed reserves operating procedure, changes in the discount rate reflect changes in at least the short-run money path.[15] Discount rate changes also may reflect simultaneous changes in both short and long-run monetary policy objectives, making their impact on long-term interest rates ambiguous.

Response of interest rates to discount rate announcements: empirical results

This section empirically examines the response of the term structure of interest rates to announced changes in the discount rate and analyzes the results in the context of the previous two sections. The model used in the empirical work is discussed next, followed by the presentation of the estimation results.

The model

An efficient markets model was used to examine the relationship between discount rate announcements and changes in market interest rates. The model assumes that market participants use all the information available to the public efficiently in determining interest rates in the money and capital markets. Yields on all Treasury securities should reflect the expectations of investors regarding the discount rate and other pertinent announcements.

The primary implication of this application of the model is that daily changes in interest rates should depend only on new information received between closing quotations at the end of successive business days. As a result, the market's best forecast of the next day's close is the observed yield at the close of the current business day. Thus, any unexpected announcement of a change in the discount rate or new information obtained from an economic release may affect the yield on Treasury securities immediately. Since other empirical work has indicated that economic releases not directly related to monetary policy did not significantly affect Treasury bill yields, the only other announcements included in the model are money stock releases.[16]

Because only new information should affect

[15] The public and the Federal Reserve also are implicitly assumed to have the same information about the position of the demand for money schedule in Figure 2. Thus, changes in the discount rate are not assumed to represent new public information about money demand. For similar interpretations, see Peter Keir, "The Impact of Discount Policy Procedures on the Effectiveness of Reserve Targeting," in New Monetary Control Procedures, Federal Reserve Staff Study — Volume I, Board of Governors of the Federal Reserve System, February 1981, and Fred J. Levin and Paul Meek, "Implementing the New Operating Procedures: The View from the Trading Desk," in New Monetary Control Procedures, Federal Reserve Staff Study — Volume I, Board of Governors of the Federal Reserve System, February 1981.

[16] See V. Vance Roley and Rick Troll, "The Impact of New Economic Information on the Volatility of Short-Term Interest Rates," Economic Review, Federal Reserve Bank of Kansas City, February 1983, pp. 3-15. Money stock announcements were included to avoid biasing results when a discount rate announcement and a money announcement occur on the same day. There were nine such occurrences in the sample period under consideration.

market interest rates, the unexpected component of a discount rate change should be used to determine its effect. Discount rate changes, however, have sometimes been interpreted as merely reflecting past movements in short-term market interest rates.[17] In such instances, the motive for changing the discount rate is to realign it with the federal funds rate. As illustrated in Figure 3, the larger the spread between these two rates, the higher the level of borrowing. Thus, the discount rate may be increased, for example, if discount window borrowing is thought to be excessive because of recent increases in the federal funds rate.

If discount rate changes can be predicted from past movements in the federal funds rate, an announced change should not affect market interest rates. Even if the announced change coincided with a recent change in short-run monetary policy objectives, the change would already be incorporated into market yields. This result follows under either operating procedure, since no new information is provided by the announcement.

The relationship between past movements in the federal funds rate and discount rate changes is examined in Table 1. The empirical relationship related daily movements in the discount rate — which are zero unless a discount rate change is announced — to the cumulative change in the federal funds rate since the last discount rate announcement. This specification implies that changes in the discount rate result from cumulative increases or decreases in the spread between the federal funds rate and the discount rate. The model further allowed for possible differential effects of positive and negative movements in the funds rate and positive movements larger than one percentage point.

With this model, cumulative changes in the federal funds rate were found to be related to announced discount rate changes. However, increases in the federal funds rate of less than one percentage point were not significantly related to discount rate changes. This result possibly indicates a reluctance by the Federal Reserve to adjust the discount rate often to dampen volatility in short-term interest rates. The predictive power of the equation is somewhat higher in the second period than in the first. In both periods, however, only a small part of the variation in discount rate changes is explained. As a result of this low explanatory power, the entire change in the discount rate is assumed to be unanticipated.[18]

Response of Treasury security yields to discount rate announcements

The efficient markets model was used to investigate the response of the term structure of interest rates to discount rate announcements both before and after the Federal Reserve changed its operating procedures. Unexpected changes in the money stock were constructed by taking the difference in the actual announced change in the narrow monetary aggregate and the median of market survey.[19] The announced changes in the discount rate were used, since no survey measure incor-

[17] See, for example, Raymond E. Lombra and Raymond G. Torto, "Discount Rate Changes and Announcement Effects," Quarterly Journal of Economics, February 1977, pp. 171-176.

[18] These results do not necessarily mean that changes in the discount rate are mostly unanticipated. These results may instead reflect the difficulty in predicting the exact timing of a discount rate announcement. In addition, other factors, including statements by Federal Reserve officials and trends in open market operations may also provide information about the timing of discount rate changes not captured in the equations investigated here.

[19] See V. Vance Roley, "Weekly Money Supply Announcements and the Volatility of Short-Term Interest Rates," Economic Review, Federal Reserve Bank of Kansas City, April 1982, pp. 3-15.

TABLE 1
Discount rate announcements and past changes in the federal funds rate

Estimation Period	Constant	ΔRFF⁻	ΔRFF⁺	ΔRFF⁺⁺	$\bar{R}^2$	DW
9/29/77- 10/05/79	0.0051 (0.0049)	0.0090 (0.0238)	0.0173 (0.0176)	0.0317* (0.0110)	.012	2.01
10/08/79- 10/15/82	-0.0089 (0.0086)	0.0049 (0.0038)	0.0104 (0.0223)	0.0104* (0.0045)	.014	1.92

*Significant at the 5 percent level. Estimated standard errors in parenthesis.
Note: The equations were estimated in the following form:
where

$\Delta RD_t = b_0 + b_1 \cdot \Delta RFF_t^- + b_2 \cdot \Delta RFF_t^+ + b_3 \cdot \Delta RFF_t^{++} + e_t$, where

ΔRD_t = announced change in discount rate

ΔRFF_t^- = decline in federal funds rate since last discount rate announcement, 0 otherwise

ΔRFF_t^+ = rise in federal funds rate since last discount rate announcement between 0 and 1 percentage point, 0 otherwise

ΔRFF_t^{++} = rise in federal funds rate since last discount rate announcement greater than 1 percentage point, 0 otherwise

e_t = random error term

$\bar{R}^2$ = multiple correlation coefficient corrected for degrees of freedom

DW = Durbin-Watson statistics

b_0, b_1, b_2, b_3 = coefficients

porating both the timing and magnitude of the discount rate changes was available, and empirical equations had marginal explanatory power.

The estimates in Table 2 measure the daily response in security yields to money stock and discount rate announcements. Focusing on the discount rate response, the corresponding coefficient measures the market's reaction to an announcement of a one percentage point change in the discount rate. For example, during the period from September 29, 1977 to October 5, 1979, announcements of a discount rate change did not significantly alter yields on any maturity of Treasury securities tested.[20] Thus, changes in the discount rate in the first period contained little new information and were not interpreted as signaling a change in Federal Reserve policy.

The response in the post-October 1979 period was markedly different. Announced changes in the discount rate affected interest rates across the entire maturity spectrum. For example, the estimated response of 3-month Treasury bills to a one percentage point

[20] The November 1, 1978, discount rate announcement was dropped from the sample. In this case, the change in the discount rate was announced as part of a broad program designed to help stabilize the exchange value of the dollar. It was thought that the effect of the other measures taken at that time could not be adequately explained within the empirical framework used in this study. It has been noted by other authors (for example, Albert J. Wojnilower, "The Central Role of Credit Crunches in Recent Financial History," Brookings Papers on Economic Activity, 2:1980, pp. 277-326) that long-term rates declined dramatically on this date, contrary to expectation. Indeed, inclusion of this date alters the empirical results. While short-term rates still exhibit no response to discount rate announcements, long-term rates are found to move significantly in the opposite direction of the discount rate changes.

TABLE 2
Discount rate announcements and the term structure of interest rates

September 29, 1977 - October 5, 1979

Dependent Variable	Constant	ΔRD	UM1	$\bar{R}^2$	SE	DW
				Summary Statistics		
ΔR3M	0.0251*	0.0974	0.0167*	.058	.106	1.873
	(0.0107)	(0.0677)	(0.0067)			
ΔR1Y	0.0215*	0.0659	0.0160*	.088	.077	1.843
	(0.0078)	(0.0580)	(0.0049)			
ΔR5Y	(0.0078)	0.0574	0.0082*	.092	.043	1.883
	(0.0044)	(0.0324)	(0.0027)			
ΔR10Y	0.0072	0.0056	0.0029	-.003	.037	1.672
	(0.0038)	(0.0282)	(0.0024)			
ΔR20Y	0.0056*	0.0233	0.0023	.009	.029	1.936
	(0.0029)	(0.0217)	(0.0018)			

October 8, 1979 - October 15, 1982

Dependent Variable	Constant	ΔRD	UM1	$\bar{R}^2$	SE	DW
				Summary Statistics		
ΔR3M	0.0691*	0.5550*	0.1026*	.290	.381	1.941
	(0.0292)	(0.1090)	(0.0149)			
ΔR1Y	0.0382	0.4495*	0.0967*	.349	.300	2.079
	(0.0230)	(0.0858)	(0.1173)			
ΔR5Y	0.0418*	0.2296*	0.0558*	.258	.207	2.136
	(0.0158)	(0.0590)	(0.0081)			
ΔR10Y	0.0366*	0.1376*	0.0396*	.173	.181	2.070
	(0.0138)	(0.0517)	(0.0071)			
ΔR20Y	0.0332*	0.1461*	0.0356*	.151	.181	2.065
	(0.0139)	(0.0519)	(0.0071)			

*Significant at the 5 percent level. Estimated standard errors in parentheses.
Note: The equations are estimated in the following form:
Dependent variable$_t$ = $b_0 + b_1 \cdot \Delta RD_t + b_2 \cdot UM1_t + e_t$
where the U's indicate that only the unanticipated component of the announcement are included.

R3M = yield on 3-month Treasury bill
R1Y = yield on 1-year Treasury constant maturity
R5Y = yield on 5-year Treasury constant maturity
R10Y = yield on 10-year Treasury constant maturity
R20Y = yield on 20-year Treasury constant maturity
RD = discount rate
UM1 = unanticipated announced change in the narrowly defined money stock
e = random error term
$\bar{R}^2$ = multiple correlation coefficient corrected for degrees of freedom
SE = standard error
DW = Durbin-Watson statistic

change in the discount rate was 56 basis points, while the response for 20-year Treasury bonds was 15 basis points. Even though the response of Treasury securities generally decreased as maturity increased, the response of long-term rates was still substantial and more than might be expected from comparisons with the response of short-term rates. Thus, the results suggest that market participants revised not only their assessments of current short-term rates but also their expectations about future short-term rates.[21]

These results can be interpreted in a manner consistent with the analytical model presented in the first section. Before October 1979, market participants did not associate any change in expected money growth with changes in the discount rate. As a result, there was no significant movement in security yields associated with discount rate announcements. After the change in operating procedures, however, market participants began attaching policy significance to discount rate changes. Consistent with the estimated response, investors may have interpreted discount changes as signaling changes in the short-run path for money. Therefore, if an increase in the discount rate was seen as a move by the Federal Reserve to return more rapidly to the long-run path for money, not only would current short-term rates change but also expected levels of future short-term rates. Such a response could produce a change in the term structure of interest rates similar to that seen.

As suggested earlier, a change in the term structure of interest rates in response to a discount rate announcement may be due to a perceived change in both the short and long-run paths for money. For a discount rate increase, current short-term rates may rise while expected future short-term rates fall if a reduction in expected long-run money growth causes a decline in expected inflation. This possibility was tested in Table 3, where the impact of discount rate changes on forward rates was examined. The second row of the table, for example, estimates the impact on the expected four-year yield one year in the future.[22] Similarly, the last row corresponds to the change in the expected 10-year yield ten years in the future. If an increase in the discount rate lowers expected inflation, this latter expected yield, as well as others in the table, would be expected to decline. However, as shown in the table, the estimated response is never significantly below zero. Thus, the

---

[21] Under the expectations theory of the term structure of interest rates, if only current short-term rates are affected by discount rate announcements then the response of the long-term rates should be only a small fraction of the short-term rate response. Consider the following example:

$$R20Y = \frac{1}{80}(R3M + R3M_{+3} + R3M_{+6} + \ldots + R3M_{+240})$$

where

$R20Y$ = 20-year bond rate

$R3M_{+i}$ = expected 3-month Treasury bill rate in period i

$R3M$ = current 3-month Treasury bill rate.

If expectations of future short-term rates were unaffected by discount rate announcements, then the change in the 20-year bond rate would be (1/80) times the 3-month response. Using the estimated response of 55 basis points for 3-month Treasury bills, this implies a 0.61 basis point response of the 20-year Treasury bonds. To the extent that the expectations hypothesis about the term structure of interest rates is valid, the estimated response of 15 basis points for 20-year Treasury bonds must be the result of revisions of expectations of future short-term rates. Using the analytic model presented in this paper, it can be shown that the response of the 20-year yield relative to the 3-month yield is explained by the model for a value of λ around 0.25.

[22] The 1-year ahead 4-year forward rate may be approximated by $F(1Y,4Y)_t = 5/4\, R5Y_t - 1/4\, R1Y_t$

where

$R1Y$ = 1-year constant maturity rate

$R5Y$ = 5-year constant maturity rate.

A more accurate approximation is actually used in this article, as reported in Robert J. Shiller, John Y. Campbell, and Kermit L. Schoenholtz, "Forward Rates and Future Policy: Interpreting the Term Structure of Interest Rates," mimeo, Yale University, 1983.

TABLE 3
Discount rate announcements and forward rates in the post-October 1979 period

Dependent Variable	Constant	ΔRD	UM1	Summary Statistics $\bar{R}^2$	SE	DW
ΔF(3M,9M)	0.0280	0.4144*	0.0947*	.334	.299	2.11
	(0.0228)	(0.0854)	(0.0117)			
ΔF(1Y,4Y)	0.0429*	0.1559*	0.0421*	.178	.191	2.12
	(0.0146)	(0.0547)	(0.0075)			
ΔF(5Y,5Y)	0.0271	-0.0303	0.0100	.001	.185	1.96
	(0.0142)	(0.0529)	(0.0072)			
ΔF(10Y,10Y)	0.0219	0.1745*	0.0221*	.035	.286	2.17
	(0.0219)	(0.0819)	(0.0112)			

*Significant at the 5 percent level. Estimated standard errors in parentheses.
Note: The equations are estimated in the following form:
Dependent variable$_t$ = $b_0 + b_1 \cdot \Delta RD_t + b_2 \cdot \Delta UM1_t + e_t$.
F(3M,9M) = 3-month ahead 9-month forward rate
F(1Y,4Y) = 1-year ahead 4-year forward rate
F(5Y,5Y) = 5-year ahead 5-year forward rate
F(10Y,10Y) = 10-year ahead 10-year forward rate
RD = discount rate
UM1 = unanticipated announced change in the narrowly defined money stock
e = random error term
$\bar{R}^2$ = multiple correlation coefficient corrected for degrees of freedom
SE = standard error
DW = Durbin-Watson statistic

empirical evidence presented here does not support the hypothesis that increases in the discount rate lower interest rates by reducing investors' expectations of future inflation.

Conclusions

The results of this study reinforce the view that the discount rate played a significantly larger role in the implementation of monetary policy after the Federal Reserve switched to a reserves-based approach in controlling money. Before October 1979, market yields did not change significantly in response to a discount rate announcement. After the change in operating procedures, interest rates across the maturity spectrum responded to such announcements. Also, the response of long-term rates was found to be quite large. Thus, Federal Reserve actions concerning the discount rate can have an immediate and significant impact on the level of long-term interest rates.

The results provide little to suggest that investors revise expectations of inflation when discount rate changes are announced. The results do suggest, however, that significant new information is provided by discount rate changes. In particular, the evidence generally supports the view that changes in the discount rate represent changes in the expected short-run path of money.