

The Discount Rate and Market Interest Rates: What's the Connection?

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DISCOUNT rate changes invariably send newspaper reporters to the phone to call their favorite economist to ask the inevitable question: What will this do to market interest rates? The impact of discount rate changes on market interest rates apparently is the source of much public confusion and misunderstanding.

This confusion arises from a variety of factors. First, the discount rate is an administered rate set by the Federal Reserve. Second, high interest rates often occur when the discount rate is high, while low interest rates often occur when the discount rate is low. Finally, discount rate changes often are associated with changes in other interest rates in the same direction. These factors have led to a misunderstanding about the pre-eminence of the discount rate in credit markets.¹

The idea of the pre-eminence of the discount rate stems, in part, from a failure to understand the mechanism through which changes in the discount rate are transmitted to market interest rates. The purpose of this article is to analyze the theoretical basis of the link between the discount rate and market interest rates, and to review the recently observed relationship between these rates in light of the theoretical discussion.

THE THEORETICAL CONNECTION BETWEEN THE DISCOUNT RATE AND MARKET INTEREST RATES

The discount rate is the interest rate at which Federal Reserve banks lend reserves to depository institutions, primarily to enable these institutions to meet their reserve requirements.² The relationship

¹For a recent statement on the importance of the discount rate, see Saul H. Hymans, et al., "The U.S. Outlook for 1982," *Economic Outlook USA* (Winter 1982), p. 3. For a statement about the discount rate as a pivotal rate in the market, see George McKenney, *The Federal Reserve Discount Window* (Rutgers University Press, 1960), p. 6.

²As a result of the Monetary Control Act of 1980, enacted on March 31, 1980, all depository institutions will have the same reserve

between the discount rate and market interest rates can be illustrated using a simple, static model of interest rates called the *loanable funds theory*. According to the loanable funds theory, interest rates are determined by the intersection of the demand for and supply of credit, as illustrated in figure 1. The demand for credit consists of investment demand, government demand (deficits) and changes in the demand for money.³ The supply of credit is composed of public and private savings and changes in the supply of money. Changes in the discount rate affect market interest rates only to the extent that they alter the demand for or the supply of credit.

The Discount Rate and the Supply of Credit

Changes in the discount rate directly affect the supply of credit through their impact on the money supply. To illustrate this, consider the simple model of the money supply given by:

$$(1) M^S = m \cdot B.$$

The supply of nominal money (M^S) is determined by the product of the monetary base (B) and the money multiplier (m). The monetary base consists of the total reserves of depository institutions plus currency held by the nonbank public. The money multiplier summarizes the effect of all other factors on the money supply and, for the purpose of our analysis, is

requirements. The uniform reserve requirements will be phased in over a number of years. For more details, see "The Federal Reserve Requirements" (Board of Governors of the Federal Reserve System, 1981). The Monetary Control Act also has given thrift institutions access to the discount window through "extended credit borrowing." For more details, see "The Federal Reserve Discount Window" (Board of Governors of the Federal Reserve System, 1980).

³The supply curve is sloped positively on the assumption that higher interest rates encourage more savings and because the money supply may be positively related to the interest rate (see footnote 4 below). The demand for loanable funds is downward sloping due to the downward sloping marginal efficiency of investment and the inverse relationship between the demand for money and interest rates.

assumed to be constant and independent of market interest rates.⁴

Total reserves supplied by the Federal Reserve can be broken down into those supplied at the discount window, called borrowed reserves (BR), and those supplied through open market operations, called nonborrowed reserves (NBR). The monetary base, therefore, can be written as the sum of BR, NBR and currency held by the nonbank public (C). Thus, equation 1 can be rewritten as:

$$(2) M^S = m \cdot (BR + NBR + C).$$

Changes in the discount rate affect market interest rates through their impact on borrowing from the Federal Reserve. For example, an *increase* in the discount rate will *reduce* the level of borrowing, *ceteris paribus*, reducing both the monetary base and the money supply. As a result, the supply-of-credit schedule in figure 1 will shift to the left and market interest rates will rise. Reducing the discount rate will have the opposite effect.

Discount Rate Changes and Depository Institution Borrowing

The crucial link between the discount rate and market interest rates is the connection between the discount rate and borrowing from the Federal Reserve. When the discount mechanism originally was formulated, it was assumed that banks would be reluctant to be in debt to the Federal Reserve and would endeavor to repay their indebtedness as soon as possible.⁵ It was thought that the Federal Reserve could control the level of bank borrowing by reinforcing banks' reluctance to borrow, through the administration of the discount window, and by alter-

ing the discount rate.⁶ Given the nonpecuniary costs associated with discount window administration, an increase in the discount rate would reduce the level of borrowing; reductions in the discount rate would have the opposite effect.

Later, it was recognized that the relationship between the discount rate and borrowing at the discount window was not quite so simple. Borrowing from the Federal Reserve is only one of several methods depository institutions use to adjust their reserve positions. They can borrow from the Federal Reserve, buy federal funds in the federal funds market, or sell earning assets, such as short-term Treasury securities.⁷ It is not simply the level of the discount rate that influences a depository institution's decision to borrow, but the level of the discount rate *relative* to rates on alternative adjustment assets. A financial institution confronted with a reserve deficiency will adjust its reserve position in the least costly manner. Thus, the important variable in the decision to borrow is the so-called least-cost spread between the rate on the next best reserve adjustment asset and the discount rate.

In the aggregate, borrowing is usually represented by an equation like (3) below, in which (i_d) denotes the discount rate and (i_a) denotes the interest rate on next best reserve adjustment asset.⁸

$$(3) BR = a_0 + a_1 (i_a - i_d), a_0 \geq 0, a_1 > 0$$

In this equation, a_0 denotes a "frictional" level of

⁴It is sometimes argued that the money supply is positively related to interest rates due to changes in the public's desire to hold various assets in response to interest rate changes. For an analysis of the monetary base approach to the money supply process, see Jerry L. Jordan, "Elements of the Money Stock Determination," this *Review* (October 1969), pp. 10-19.

⁵Winfield Riefler noted that "the reluctance of member banks to borrow is not based solely upon the philosophy of reserve banks, however. Indeed, that philosophy merely expresses the desire of the great majority of the member banks themselves to remain out of debt . . . and a feeling on their part that borrowing for profit is unsound. . . . Long before the establishment of the reserve system, it was one of the fundamental traditions of sound banking practice in this country, that a bank's operations should be confined to the resources which it derives from its stockholders and depositors and interbank borrowing was at all times limited." Winfield Riefler, *Money Rates and Money Markets in the United States* (Harper and Bros., 1930), p. 29.

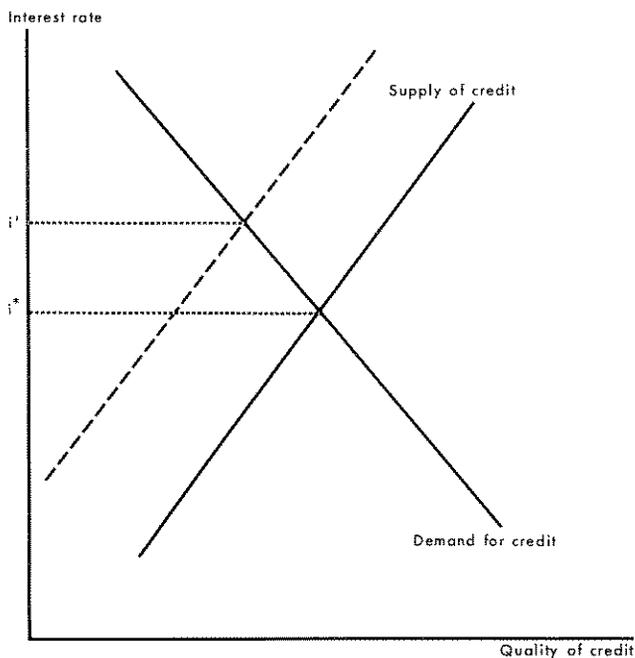
⁶It is still thought that depository institutions are reluctant to borrow from the Federal Reserve; however, it has been a long-standing question whether the reluctance is inherent or induced. The use of nonprice rationing at the discount window began as early as 1918. See Clay Andersen, *A Half-Century of Federal Reserve Policymaking: 1914-1964* (Federal Reserve Bank of Philadelphia, 1965).

⁷Prior to September 1968, depository institutions could adjust their reserve position by reducing the level of their deposits and, hence, required reserves. In September 1968, the Federal Reserve introduced lagged reserve accounting, in which required reserves in the current week are based on deposit levels of two weeks previous.

At the same time, the Federal Reserve changed Regulation D to permit a reserve deficiency carryover equal to 2 percent of required reserves. Depository institutions can also adjust their reserve position by carrying over the deficiency into the next reserve week. Carryovers in excess of 2 percent of required reserves are charged a rate 2 percentage points above the lowest discount rate in effect on the first day of the calendar month in which the deficiency occurs. It should be noted that only borrowing from the Federal Reserve adds reserves to the system as a whole.

⁸The borrowing equation usually includes variables to measure the degree of reserve pressure of depository institutions, such as the level of or the change in nonborrowed reserves. Because they have no significance for our purpose, they were ignored here.

Figure 1
Credit Market Equilibrium



borrowing (i.e., borrowing that occurs even if the discount rate is not the least costly alternative).⁹

Given equations 2 and 3, the connection between the discount rate and market interest rates is apparent. Increases in the discount rate reduce the least-cost spread, which reduces borrowing and

For a discussion of the various theories of depository institutions' borrowing, see Riefler, *Money Rates and Money Markets in the United States*; Lauchlin Currie, *The Supply and Control of Money* (Harvard University Press, 1934); Robert Turner, *Member-Bank Borrowing* (Ohio State University Press, 1938); Murray E. Polakoff "Reluctance Elasticity, Least-Cost, and Member Bank Borrowing: A Suggested Integration," *Journal of Finance* (March 1960), pp. 1-18; Murray Polakoff and William Silber, "Reluctance and Member-Bank Borrowing: Additional Evidence," *Journal of Finance* (March 1967), pp. 88-92; and Stephen Goldfeld and Edward Kane, "The Determinants of Member Bank Borrowing: An Econometric Study," *Journal of Finance* (September 1966), pp. 499-514.

⁹The fact that there is usually some level of borrowing even when the discount rate is above most other short-term market interest rates is usually construed as prima facie evidence of the inadequacy of the alternative mechanisms in providing the reserve adjustment needs of all depository institutions. At the other extreme, borrowing takes the form of a subsidy if the discount rate is substantially below market rates. See R. Alton Gilbert, "Benefits of Borrowing from the Federal Reserve when the Discount Rate is Below Market Interest Rates," this *Review* (March 1979), pp. 25-32.

thus the monetary base. As a result, the supply of credit schedule shifts to the left and market interest rates rise until the least-cost spread is restored. Thus, increasing the discount rate will, ceteris paribus, cause market rates to increase.

The extent of the increase in the market interest rate is determined by the sensitivity of borrowing to the least-cost spread (a_1) and by the interest sensitivity of the demand for credit. The more borrowing is interest-sensitive to the least-cost spread (i.e., the larger a_1), the greater will be the shift in the supply of credit for any change in the discount rate. The larger the shift in the supply of credit, the greater the change in the market interest rate, for any given credit demand curve. Also, the less interest-sensitive the demand for credit (i.e., the steeper the demand curve), the greater the change in the market interest rate for any given shift in the supply schedule resulting from a change in the discount rate.

The Discount Rate, Interest Rates and Monetary Policy

Unfortunately, the above analysis is overly simple in that it ignores the role of monetary policy in influencing the link between the discount rate and market interest rates. Specifically, the relationship between the discount rate and market interest rates depends on other monetary policy actions and, in particular, on the operating procedure of the Federal Reserve. For example, if the Federal Reserve were to pursue a policy of controlling the level of interest rates, changes in the discount rate would have *no independent impact* on market rates. The reason for this is straightforward. Under an interest rate targeting procedure, the Trading Desk of the Federal Reserve Bank of New York would offset any movement in market rates by changing the level of nonborrowed reserves through open market operations; that is, the leftward shift in the credit supply schedule due to an increase in the discount rate would be offset by a rightward shift resulting from Federal Reserve open market operations. The impact of the change in the discount rate on the market rate would be nil.¹⁰

A similar result would hold if the Federal Reserve chose to control the level or growth of the money

¹⁰It should be noted that the Federal Reserve cannot "peg" interest rates in an inflationary environment without continually accelerating the growth rate of money. See Milton Friedman, "The Role of Monetary Policy," *American Economic Review* (March 1968), pp. 1-17.

supply, and if it effected its control through monetary base (or total reserve) targeting. In this instance, an increase in the discount rate would lower the level of borrowing and, hence, the monetary base. If this change caused the base to deviate from its desired path, given a money growth objective, the Federal Reserve would increase nonborrowed reserves via open-market operations in order to return the monetary base to its desired path. Changes in the discount rate would have no independent effect on either the money supply or market interest rates.

The effect of a discount rate change on market rates could be significant when the Federal Reserve targets on nonborrowed reserves as it currently does. In this instance, changes in the discount rate alter aggregate borrowing, the monetary base and the money supply as before. The movement in the base would not necessarily be offset through open market operations. As long as nonborrowed reserves are on path, the Federal Reserve might choose not to offset changes in borrowings associated with changes in the discount rate.¹¹ Under the present system of lagged reserve accounting (LRA), however, the effect of a discount rate change on aggregate borrowing, the monetary base and the money supply will be much smaller.

The Role of Lagged Reserve Accounting

The present system of lagged reserve accounting, which was introduced in September 1968, has made depository institutions' demand for reserves less responsive to interest rate changes.¹² Thus, any change in the supply of reserves, either through changes in NBR or the discount rate, produces a larger change in the rates on reserve adjustment assets, such as federal funds and Treasury bills.

¹¹The reader might legitimately inquire as to why the Federal Reserve would not offset all changes in aggregate borrowing if it did not desire a change in the money supply. Unfortunately, there is no simple answer to this question. Recently the Federal Reserve has attempted to offset changes in borrowing *only* if they are viewed to be permanent in some sense. See David E. Lindsey, "Nonborrowed Reserve Targeting and Monetary Control" in *Improving Money Stock Control: Problems, Solutions and Consequences*, conference cosponsored by the Federal Reserve Bank of St. Louis and the Center for the Study of American Business, Washington University, October 30-31, 1981 (forthcoming).

It should be noted, however, that if the Federal Reserve were to offset all changes in borrowings that move them off their nonborrowed reserve path, they would essentially be targeting on total reserves or the base.

¹²Since this article was completed, the Federal Reserve Board adopted a resolution to return to contemporaneous reserve accounting.

In order to see this point, consider the following simple model of the market for reserves. Reserves are supplied by the Federal Reserve either through open market operations or at the discount window. NBR are determined solely by Federal Reserve actions and are independent of market interest rates. In contrast, BR are related to interest rates via equation 3. Depository institutions' demand for reserves is composed of their demand for required reserves (as determined by their deposit levels) and their demand for excess reserves. Under a system of contemporaneous reserve accounting (CRA), both required reserves and excess reserves are assumed to be negatively related to the rate on reserve adjustment assets.¹³ This equilibrium is illustrated in figure 2a by the intersection of R_s and R_d^c .

Under a system of LRA, current required reserves are determined by depository institutions' deposits of the prior two weeks. The demand for *current required reserves* is completely insensitive to the interest rates on reserve adjustment assets. The interest responsiveness of the demand for reserves is determined solely by the demand for excess reserves. Thus, demand for reserves under LRA is less interest-sensitive (steeper), as illustrated by R_d^l in figure 2b.¹⁴

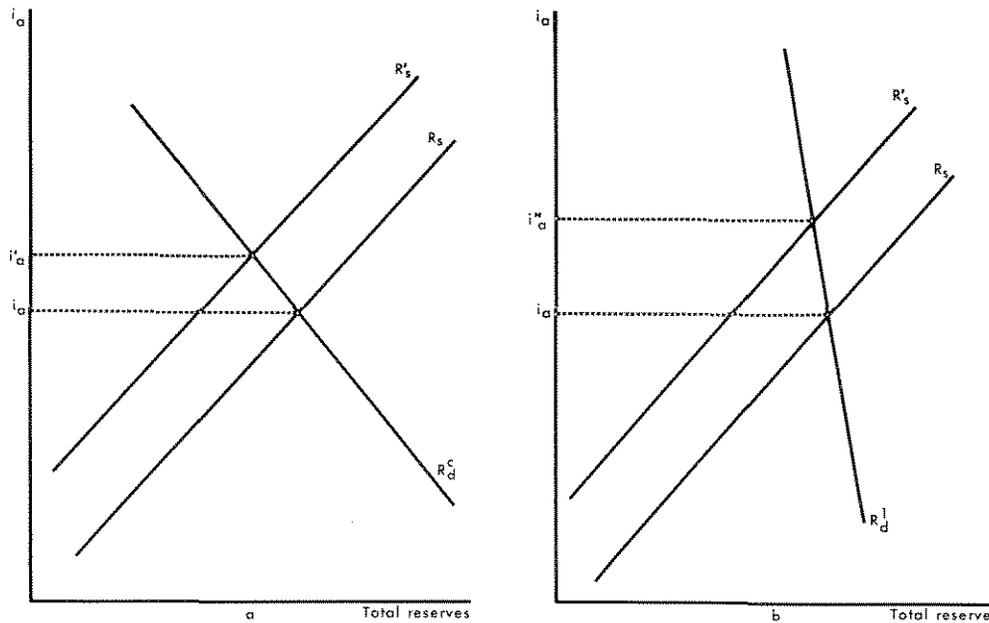
The impact of a change in the discount rate under CRA and LRA is illustrated in figure 2. An increase in the discount rate reduces the amount of reserves supplied at each market rate, shifting the reserve supply curve to R'_s . Given that the demand for

¹³Under CRA, depository institutions must weigh the marginal costs of having to adjust their reserve position either at the discount window or in the market with the marginal gain from making additional loans and investment and, thereby, creating additional deposits. Thus, when either the discount rate or the rates on alternative adjustment assets increase relative to depository institutions' lending rates, they respond by curtailing their lending and investment activities, which reduces their deposit liabilities and their demand for required reserves. Thus, the demand for required reserves would be interest-sensitive under CRA. Under LRA, the demand for required reserves is determined by deposit levels two weeks previous and, hence, is independent of current interest rates.

Excess reserves are thought to be held as a source of liquidity for the depository institution. As such, the opportunity cost of holding excess reserves is income forgone by not investing them in some income-generating asset, like federal funds. Thus, the demand for excess reserves is thought to be responsive to changes in market interest rates. The demand for excess reserves, however, is generally not thought to be responsive to interest rates.

¹⁴The equilibrium market rate is shown the same for both CRA and LRA for ease of illustration. This accommodation to convenience does not affect the conclusions.

Figure 2
The Effect of Discount Rate Change Under Contemporaneous and Lagged Reserve Accounting



reserves is less interest-sensitive under LRA, interest rates must rise by more in order to restore market equilibrium. Thus, a change in the discount rate will result in a larger change in the interest rates on reserve adjustment assets, and a smaller change in aggregate borrowing, the monetary base and the money supply.

The Effect on Other Market Rates

A change in the discount rate has its initial effect on the market interest rate of reserve adjustment assets. The extent to which a change in the market rates of these assets spills over to other market interest rates depends on the substitutability of assets in the portfolios of financial intermediaries and the public. To illustrate this point, assume for simplicity that depository institutions use only one asset as an alternative to borrowing from the Federal Reserve, and that this asset is not held in the portfolios of the rest of the private sector of the economy (e.g., federal funds). Thus, there are no close substitutes for this asset in the portfolios of nondepository institutions. In this case, the initial impact of a change in the discount rate would be reflected primarily in the market rate of this asset. The effect on other market interest rates would materialize only as depository institutions modified their lending and investment activities in light of the higher marginal cost of reserve adjustment funds.

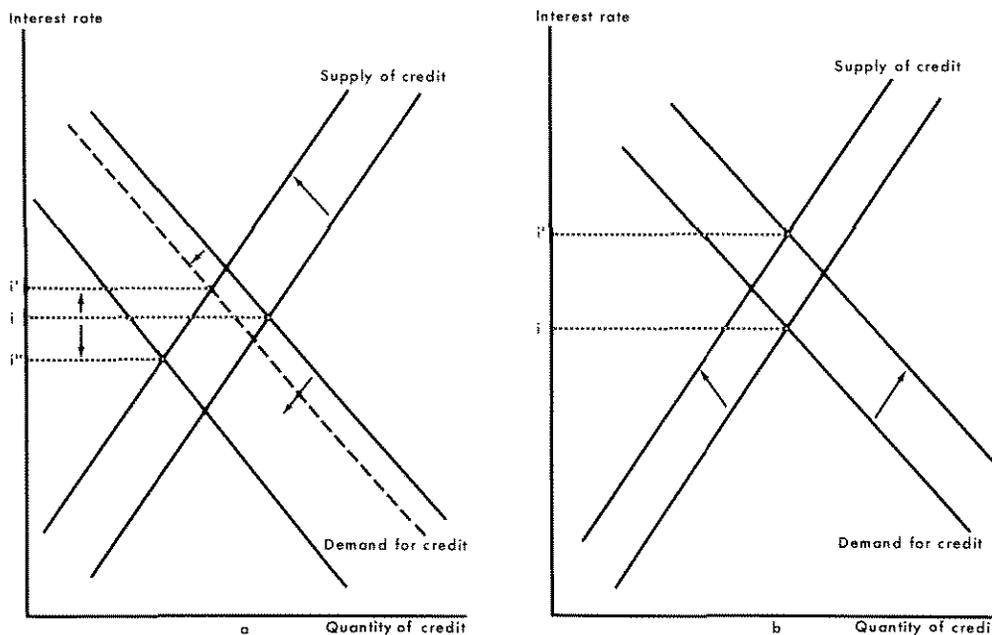
The Discount Rate and the Demand for Credit

The discount rate also affects market interest rates via the demand for credit through the so-called announcement effect. According to this view, the business and financial communities regard discount rate changes as *signals* of the future direction of monetary policy. Discount rate changes are thus said to alter expectations about the future of business profits and the direction of interest rates.

Unfortunately, the impact of the announcement effect depends on the exact nature of these expectation effects.¹⁵ To illustrate this, consider the following: If the Federal Reserve increased the discount rate, individuals might interpret this action as an indication that a slower rate of monetary growth, a lower rate of inflation and, hence, lower interest rates will soon follow. If this were the case, they might

¹⁵Warren Smith has argued that the exact impact of the announcement effect depends on the market perception of the efficacy of monetary policy, the elasticity of interest rate expectations and the distributions of these expectations among borrowers and lenders in the market. See Warren Smith, "Instruments of General Monetary Control," *National Banking Review* (September 1963), pp. 47-76; "The Discount Rate as a Credit Control Weapon," *Journal of Political Economy* (April 1958), pp. 171-77; and "On the Effectiveness of Monetary Policy," *American Economic Review* (September 1956), pp. 588-606.

Figure 3
Discount Rate Change and Expectations Effects



reduce their current demand for credit in anticipation of lower future interest rates. The demand for credit would shift to the left and, ceteris paribus, current interest rates would fall. The combined effects of a discount rate increase on the supply of and the demand for credit in this instance, under nonborrowed reserve targeting, are illustrated in figure 3a. An increase in the discount rate shifts both the supply-of-credit and the demand-for-credit schedules to the left. Market interest rates would rise or fall depending on whether the shift in the demand curve is small or large, relative to the shift in the supply curve.

Conversely, individuals might interpret the discount rate increase as an indication that market interest rates will temporarily rise. In this case, the current demand for credit would increase. Under these circumstances, an increase in the discount rate would shift the supply of credit to the left and the demand for credit to the right as illustrated in figure 3b. Market interest rates would then have risen in response to a discount rate change.¹⁶

¹⁶Warren Smith has commented that, rather than changing the demand for credit in the short run, a discount rate increase may merely induce market participants to shift to different term assets in response to expectations of higher or lower future interest rates. If this were the case, the yield curve would shift with changes in the discount rate. See Smith, "The Discount Rate as a Credit Control Weapon."

It should be noted, however, that there are those who question whether there should be any significant expectational effect associated with a discount rate change. They argue that a discount rate change is only one of a myriad of signals that individuals receive concerning the direction of economic activity and interest rates; therefore, it is doubtful that changes in the discount rate alone have any significant impact on the demand for credit.

Furthermore, it has been noted that changes in the discount rate are sometimes merely *technical adjustments*, designed to bring the discount rate in line with changes in market interest rates. Thus, if discount rate changes are commonly interpreted as signals of policy change, they may be misinterpreted. It has even been suggested that, given the Federal Reserve Banks' tendency to make these technical adjustments, a failure to change the discount rate when market rates are changing could be construed as a change in Federal Reserve policy.¹⁷

¹⁷For a recent interpretation of discount rate changes as technical adjustments, see Hymans, et. al., "The U.S. Economic Outlook for 1982." For an interesting look at various interpretations of a discount rate change, see Charles Walker, "Discount Policy in Light of Recent Experience," *Journal of Finance* (May 1957), pp. 223-37; Milton Friedman, *A Program for Monetary Stability* (Fordham University Press, 1959); and Ralph A. Young, "Tools and Processes of Monetary Policy," in Neil H. Jacoby, ed., *United States Monetary Policy* (Fredrick A. Proeger, 1964), pp. 24-72.

The Discount Rate and the Level of Market Interest Rates

Up to this point, the discussion has been solely in terms of the effect of *changes* in the discount rate on market interest rates. Nothing has been said about the relationship between the *level* of the discount rate and the *level* of market interest rates. Thus, one additional point must be made before proceeding to the empirical analysis. The point is that there are numerous factors that affect the supply of and the demand for credit besides the discount rate. Thus, there is no one level of market interest rates that necessarily corresponds to any given level of the discount rate. It would not be surprising, then, to find that other factors dominate movements in market interest rates in the longer run. This is especially true when one recognizes that the discount rate is an administered rate that is changed infrequently.

THE DISCOUNT RATE AND MARKET INTEREST RATES: THE RECENT EXPERIENCE

Now consider the empirical evidence on the relationship between the discount rate and market interest rates. The data analyzed is from January 1978 to April 1982, a period chosen because it is timely and because it is characterized by markedly different Federal Reserve operating procedures. Until October 6, 1979, the Federal Reserve followed a procedure of federal funds rate targeting; that is, it conducted open market operations in such a way as to keep the federal funds rate in a narrow range established by the Federal Open Market Committee (FOMC). Also, the Federal Reserve followed a policy of changing the discount rate frequently to maintain a fairly constant federal funds rate/discount rate differential.

Since October 1979, the Federal Reserve has pursued a policy of controlling the monetary aggregates through a nonborrowed reserve targeting procedure.¹⁸ Thus, the announced federal funds

rate range has been much wider since October 6, and the federal funds rate has exhibited more day-to-day variability. Moreover, the average daily spread between this rate and the discount rate has been much wider.¹⁹

Establishing the precise relationship between the discount rate and market interest rates is extremely difficult. Ideally, sets of equations representing the demand for credit, the supply of credit and a market-clearing condition should be specified. In this way, one could not only estimate the extent of the impact of a discount rate change on various market interest rates, but also identify the most significant source of the change (i.e., its effect through the supply of or the demand for credit).²⁰ In practice, however, this is difficult. As a result, the impact of a discount rate change on market interest rates is usually estimated with a reduced-form model, which

¹⁹For a discussion of the relationship between the federal funds rate and the FOMC's announced federal funds rate range, see Lang, "The FOMC in 1979: Introducing Reserve Targeting"; and Gilbert and Trebing, "The FOMC in 1980: A Year of Reserve Targeting."

²⁰One possible way to identify a separate announcement effect is to specify a general model of the supply of and the demand for money. This could be done by simply including the discount rate as a separate variable in the demand for money and supply of money functions, and testing to see whether it has a significant effect on either or both. However, the correspondence between the discount rate and market interest rates, due to the fact that discount rate changes tend to *follow* market interest rate changes, biases this test toward the rejection of the announcement effect unless one has precise knowledge of the Federal Reserve's discount rate reaction function. This problem could be overcome by simply estimating a reduced-form, equilibrium money stock equation. This equation would have the money stock a function of the exogenous variables of the system: aggregate income, the monetary base and the discount rate.

A significant discount rate effect would be clear evidence of an announcement effect, since the impact of a discount rate change on the money supply would be incorporated in the base. Unfortunately, an insignificant discount rate will not necessarily imply the absence of an announcement effect; this result could also be obtained if the money supply is relatively interest-inelastic. Thus, one would have to show both that the money supply schedule is interest-elastic *and* an insignificant discount rate in such a reduced-form equation to argue convincingly that there is *no* announcement effect. Regrettably, practical problems make this virtually impossible.

¹⁸For a discussion of the Federal Reserve's operating procedure since October 6, 1979, see 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; R. Alton Gilbert and Michael E. Trebing, "The FOMC in 1980: A Year of Reserve Targeting," this *Review* (August/September 1981), pp. 2-22; Richard W. Lang, "The FOMC in 1979: Introducing Reserve Targeting," this *Review* (March 1980), pp. 2-25; and Lindsey, "Nonborrowed Reserve Targeting and Monetary Control."

It is possible to show that the discount rate is insignificant in a reduced-form equation, *employing seasonally adjusted data*, for the 10/1979 — 10/1981 period. The money supply equation exhibits some interest elasticity, however, only if *seasonally unadjusted data* is used. Because personal income (the only available monthly income series) is available only on a seasonally adjusted basis, it is impossible to estimate the reduced-form equation using seasonally unadjusted data. Thus, the insignificant discount rate variable in the seasonally adjusted, reduced-form equation is *not* conclusive evidence against an announcement effect.

does not permit one to differentiate between supply-side and demand-side effects.²¹

The Discount Rate and Market Rates

To determine the effect of discount rate changes on market interest rates, the following equation was estimated using both the federal funds and the 3-month Treasury bills to represent alternative adjustment assets:

$$(4) \Delta i_{at} = \delta_0 + \sum_{j=1}^{10} \delta_j \Delta i_{at-j} + \delta_2 \Delta DR_t + \epsilon_t$$

This equation was estimated using daily data for the period from January 10, 1978, to April 13, 1982, and for subperiods of federal funds rate targeting and NBR targeting.²² The 10-day distributed lag of the market rate was included to capture the effect of other factors on the market rate before the discount rate change.

Table 1 presents estimates of equation 4.²³ The change in the discount rate, denoted by ΔDR , equals the change only on the day that it became effective. The ΔDR variable was partitioned into technical changes— ΔDRT —and nontechnical changes— $\Delta DRNT$ —to test whether there is a different effect if discount rate changes are made solely for technical reasons (i.e., to keep the discount rate in line with market interest rates [see insert, page 12]).²⁴

Also, a discount rate surcharge variable, ΔSC , was included in some of the regressions in the NBR targeting period to capture any effect of the Federal Reserve's surcharge on large, frequent borrowers.²⁵

The results for the entire period indicate that a discount rate change has a significant positive effect on both the federal funds and the Treasury bill rates. When the equation is estimated for subperiods of federal funds rate and NBR targeting, however, the results change. The coefficient on ΔDR is not significantly different from zero for the Treasury bill rate during the period of federal funds rate targeting. In contrast, the coefficient on ΔDR is significant for both market rates during the period of NBR targeting. Furthermore, the coefficient estimates on ΔDR are larger during the latter period.

The preceding section noted that discount rate changes would not affect market interest rates if the Federal Reserve targeted on them, but would affect market rates under NBR targeting. The results for the Treasury bill rate equation correspond with this analysis, but the results from the federal funds rate equation do not. If depository institutions primarily rely on the federal funds market to adjust their reserve positions, however, it is conceivable that most of the impact of a discount rate change could be absorbed by the federal funds rate with virtually no spillover to other market rates. This even seems likely when one recognizes that the Federal Reserve has never followed a policy of rigidly pegging the level of the federal funds rate.

In addition, discount rate changes generally were made in order to keep the rate spread between the discount rate and the federal funds rate in a fairly narrow band during the funds rate targeting period.²⁶ Thus, during this period, discount rate changes may have been anticipated and fully reflected in market rates before the discount rate change. The Federal Reserve allowed the spread between the discount and the federal funds rates to be much larger and variable during the NBR target-

²¹Among the studies that have attempted to test for an announcement effect using a reduced-form model are: H. Kent Baker and James M. Meyer, "Impact of Discount Rate Changes on Treasury Bills," *Journal of Economics and Business* (Fall 1980), pp. 43-48; Douglas R. Mudd, "Did Discount Rate Changes Affect the Foreign Exchange Value of the Dollar During 1978?" this *Review* (April 1979), pp. 20-26; Rodger Waud, "Public Interpretation of Federal Reserve Discount Rate Changes: Evidence on the 'Announcement Effect,'" *Econometrica* (March 1970), pp. 231-50; and Raymond Lombra and Raymond Torto, "Discount Rate Changes and Announcement Effects," *Quarterly Journal of Economics* (February 1977), pp. 171-76.

²²The data were partitioned on September 19, 1979, the effective date of the last discount rate change prior to the implementation of the new operating procedures on October 6, 1979.

²³The equations were estimated with ordinary least squares (OLS) and with a maximum likelihood procedure that adjusts for first-order autocorrelation. OLS results are reported if the estimate of the coefficient of autocorrelation was not significantly different from zero. The results, however, were essentially invariant to the estimation technique.

²⁴Discount rate changes were made for purely technical reasons on May 11 and July 3, 1978, and on May 30, June 13, July 28, 1980, and December 4, 1981.

²⁵The Federal Reserve first introduced a surcharge of 3 percent to the basic discount rate for large and frequent borrowers on March 17, 1980. The effective surcharges and dates are: 3 percent on March 17, 1980, removed May 7, 1980; 2 percent on November 17, 1980; 3 percent on December 5, 1980; 4 percent on May 5, 1981; 3 percent on September 22, 1981; 2 percent on October 13, 1981, removed November 17, 1981.

²⁶The average spread between the discount and the federal funds rates between discount rate changes ranged from 50 to 100 basis points.

Table 1
Estimates of Equation 4

Period	Constant	ΔDR	$\Delta DRNT$	ΔDRT	ΔSC	Sum of lags	ρ	R^2/SEE
Federal Funds Rate								
1/10/78-	.007*	.487				-.536	-.26	.117
4/13/82	(.476)	(2.831)					(8.84)	.648
	.003*		.736	-.134*		-.253	-.41	.121
	(.185)		(3.678)	(.462)			(14.76)	.646
1/10/78-	.023	.312				-1.462	-.61	.323
9/19/79	(2.892)	(2.247)					(16.00)	.252
	.023		.431	-.583*		1.378	-.68	.332
	(2.963)		(3.023)	(1.564)			(19.28)	.250
9/20/79-	.006*	.553				-.326	-.19	.110
4/13/82	(.217)	(2.300)					(4.92)	.803
	.001*		.884	-.092*		-.283	-.32	.114
	(0.057)		(3.006)	(.239)			(8.58)	.800
	.001*	.414*			.423	-.453	-.14	.119
	(.105)	(1.679)			(2.823)		(3.59)	.792
	.007*		.687	-.038*	.375	-.426	-.22	.120
	(.237)		(2.206)	(.098)	(2.501)		(5.73)	.797
Treasury Bill Rate								
1/10/78-	.002*	.357				.261	N.A.	.046
4/13/82	(.307)	(5.655)						.230
	.000*		.473	.104*		.308	-.08	.051
	(.028)		(6.234)	(.942)			(2.64)	.228
1/10/78-	.010	.028*				-.226	N.A.	.067
9/19/79	(2.103)	(.454)						.095
	.010		.054*	-.167*		-.384	N.A.	.068
	(2.13)		(.839)	(.970)				.095
9/20/79-	.002*	.434				.286	N.A.	.050
4/13/82	(.181)	(4.979)						.286
	-.002*		.613	.110*		.349	-.12	.059
	(.157)		(5.687)	(.778)			(3.07)	.282
	.003*	.396			.094*	.124	.13	.053
	(.199)	(4.546)			(1.762)		(3.33)	.283
	.001*		.573	.139*	.064*	.262	N.A.	.059
	(.067)		(5.056)	(.967)	(1.153)			.285

The absolute value of the "t-ratios" are in parentheses below each coefficient.

*Indicates the coefficient is not significant at the .05 level.

N.A. indicates the equation was estimated with ordinary least squares.

ing period. Hence, discount rate changes may not have been anticipated as well during this period, resulting in a more significant announcement effect on the demand side.

Furthermore, the absolute value of discount rate changes were larger in the latter period. The nine discount rate changes in the early period averaged 50 basis points, while each of the 11 changes in the

latter period were 100 basis points in absolute value. Thus, one could argue that only larger discount rate changes have a significant effect on market interest rates.

To further investigate the relationship between discount rate changes and market interest rates, the equations were re-estimated using both $\Delta DRNT$ and ΔDRT , which reflect nontechnical and technical

Reasons for Changes in the Discount Rate

Date	Change	Reason
May 11, 1978	6½ to 7%	Action taken to bring discount rate in closer alignment with short-term interest rates.
July 3, 1978	7 to 7¼%	Essentially the same as above.
August 21, 1978	7¼ to 7¾%	Action taken in view of recent disorderly conditions in foreign exchange markets, as well as the continuation of serious domestic inflation.
September 22, 1978	7¾ to 8%	Action taken to bring discount rate in closer alignment with short-term interest rates, and as a further step to strengthen the dollar.
October 16, 1978	8 to 8½%	Action taken to bring the discount rate in closer alignment with short-term interest rates, and in recognition of the continued high inflation rate and of the current international financial condition.
November 1, 1978	8½ to 9½%	Action taken to strengthen the dollar and to counter continuing domestic inflationary pressures.
July 20, 1979	9½ to 10%	Action taken in view of the recent rapid expansion of the monetary aggregates, to strengthen the dollar on foreign exchange markets and to bring the discount rate into alignment with short-term interest rates.
August 17, 1979	10 to 10½%	Action taken in view of the continuing strong inflationary forces and the relatively rapid expansion in the monetary aggregates.
September 19, 1979	10½ to 11%	Action taken to bring the discount rate into alignment with short-term interest rates, and to discourage excessive borrowing from the discount window.
October 9, 1979	11 to 12%	Action taken to bring discount rate into closer alignment with short-term rates, and to discourage excessive borrowing.
February 15, 1980	12 to 13%	Concern about the increased price of imported oil adding to inflationary pressures underscored the need to raise the discount rate and maintain firm control over the growth of money and credit.
May 30, 1980	13 to 12%	Action taken entirely in recognition of recent substantial declines in short-term market interest rates to levels below the discount rate.
June 13, 1980	12 to 11%	Essentially the same as above.
July 28, 1980	11 to 10%	Essentially the same as above.
September 26, 1980	10 to 11%	Action taken as part of a continuing policy to discourage excessive growth in the monetary aggregates.
November 17, 1980	11 to 12%	Action taken in view of the current level of short-term interest rates and the recent rapid growth in the monetary aggregates and bank credit.
December 5, 1980	12 to 13%	Action taken in light of the level of market rates and consistent with the existing policy to restrain excessive growth in money and credit.
May 5, 1981	13 to 14%	Action taken in light of the current levels in short-term market interest rates and the need to maintain restraint in the monetary and credit aggregates.
November 2, 1981	14 to 13%	Action taken against the background of recent declines in short-term interest rates and the reduced level of adjustment borrowing at the discount window. It is consistent with a pattern of continued restraint on the growth of money and credit.
December 4, 1981	13 to 12%	Action taken to bring the discount rate into better alignment with short-term interest rates that were prevailing recently in the market.

Source: *Federal Reserve Bulletins* released the month of or one month after the announced change in the discount rate.

changes in the discount rate, respectively. Discount rate changes that are made purely for technical reasons might have less of an impact on market rates in that either (1) the Federal Reserve offsets their effect on the supply of credit through open market operations because they were not intended as a change in policy, or (2) the announcement effect was weaker because market participants do not view such changes as indications of a change in Federal

Reserve policy.²⁷ If either of these is true, the coefficient on $\Delta DRNT$ will be larger than the coefficient on ΔDR , and the coefficient in ΔDRT will not be statistically significant. Table 1 shows that these

²⁷Under LRA a change in the discount rate produces a much smaller change in aggregate borrowing than under contemporaneous reserve accounting. Thus, the level of open market operations required to offset the effect of this change on money is much smaller.

results were obtained in every instance. Thus, it appears that only discount rate changes that are made for nontechnical reasons have a significant impact on market interest rates. The coefficient on $\Delta DRNT$ in the Treasury bill rate equation, however, was not significant during the early period. Discount rate changes appear to have had no impact on the 3-month Treasury bill rate under interest rate targeting, regardless of the reason for the change.²⁸

The Effects of the Surcharge

The effects of the discount rate surcharge on market interest rates during the NBR targeting period are mixed. When the discount rate surcharge variable is added to the federal funds rate equation, the coefficients on the discount rate variables become smaller. Furthermore, the coefficients on the surcharge variables are statistically significant. These results indicate a significant positive surcharge effect on the federal funds rate. In addition, they indicate that the estimates of the discount rate effect alone are unduly large when the surcharge variable is ignored. This is likely because of the interaction of discount rate and surcharge effects.²⁹

When the surcharge variable is included in the Treasury bill rate equation, the coefficients on the discount rate variables are essentially unaffected. The coefficients on the ΔSC variable are insignificant and small. Thus, it appears that the surcharge has no appreciable impact on the Treasury bill rate.

The Levels of the Discount Rate and Market Rates

The fact that discount rate changes have a significant immediate effect on market interest rates does not mean that there is a significant relationship between the *level* of the discount rates and the *level* of market rates. One would anticipate that any effect of a discount rate change on market interest rates

would be reflected in market rates rather quickly, so that movement in these rates between discount rate changes would be dominated by other factors.³⁰ This is borne out in a casual observation of the relationship between the discount rate and market rates over this period as shown in chart 1.

It is clear from this chart that market interest rates varied from levels substantially above the discount rate to levels substantially below it over this period. This merely reflects the previously noted fact that *there is no level of market interest rates that necessarily corresponds to a given level of the discount rate.*

Furthermore, there were at least three occasions when discount rate changes were closely followed by movements in the 3-month Treasury bill rate in the opposite direction (June 13, 1980, December 5, 1980, and May 5, 1981). In the last instance, the federal funds rate and the Treasury bill rates moved in opposite directions. The federal funds rate rose from early May to mid-July 1981, then declined. In contrast, the bill rate fell from early May to early July, then rose until late August. Thus, it is difficult to find any consistent longer-term relationship between the level of the discount rate and the level of market interest rates.

CONCLUSIONS

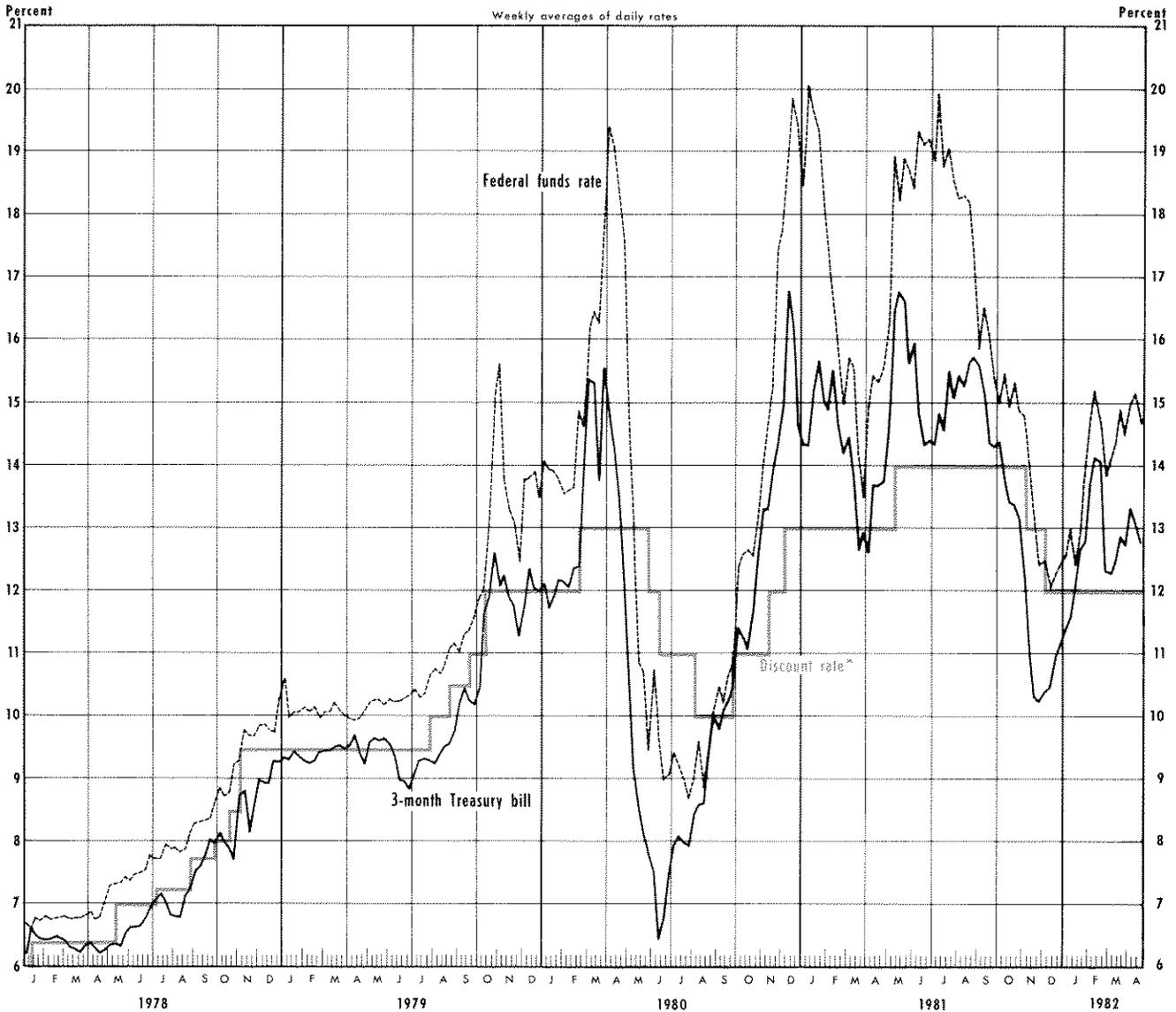
Market interest rates are influenced by numerous factors that affect the supply of and demand for credit. *One* of these factors is the discount rate. The impact of the discount rate on market rates varies with the Federal Reserve's operating procedures. If the Federal Reserve is controlling interest rates, the monetary base or total reserves, changes in the discount rate have no effect on interest rates independent of the general tenor of monetary policy; the Federal Reserve simply would offset the effect of discount rate changes through open market operations. If the Federal Reserve is targeting on non-borrowed reserves, changes in the discount rate are more likely to have an impact on market rates, especially under lagged reserve accounting.

²⁸The results presented in this section appear to be robust. They are essentially unchanged if the equation is estimated in level form, although the \bar{R}^2 s are much larger. Also, essentially the same results are obtained by a statistical comparison of the one-day percentage changes in the market rates on the day the discount rate change became effective with the 10-day and 20-day growth rates prior to the discount rate change.

²⁹It is important to include the surcharge variable in the latter period because some of the changes in the discount rate and the surcharge overlap. The overlapping dates are: November 17, 1980, December 5, 1980, and May 5, 1981. Failure to include the surcharge could result in a spurious estimate of the discount rate effect.

³⁰In an effort to uncover a possible lagged response of the federal funds rate to discount rate changes, equation 4 was estimated with a 20-day distributed lag of the ΔDR variable. None of the lagged variables, however, was significant except for the seventh day. It is interesting to note that, since most of the discount rate changes became effective on a Monday, the seventh-day lag would be Wednesday, the close of the "reserve week." This result, however, is perhaps too tentative to assign any significance to it.

Chart 1
Selected Interest Rates



*Rate changes when one of the twelve Reserve Banks has the approval of the Federal Reserve Board to change its discount rate

Data indicate that *changes* in the discount rate have produced a significant, albeit varied, immediate impact on both the federal funds rate and the 3-month Treasury bill rate since January 1978. The effect of a discount rate change on the federal funds rate was significant for periods of both federal funds rate targeting and nonborrowed reserve targeting. Discount rate changes significantly affected the Treasury bill rate, however, only in the period of nonborrowed reserve targeting. Furthermore, changes in the discount rate that were made for purely technical reasons had no effect on either market interest rate, while changes in the Federal

Reserve's surcharge on large, frequent borrowers during the nonborrowed reserve targeting period had a significant effect only on the federal funds rate.

There is virtually no evidence, however, that discount rate changes have had a significant, independent effect on market rates in the longer run. Therefore, while changes in the discount rate do produce changes in market interest rates in the short run, they do not appear to be the most significant factor affecting the level of market interest rates in the longer run.