# The Effect of Alternative Discount Rate Mechanisms on Monetary Control

*By Howard L. Roth and Diane Seibert*

When the Federal Reserve changed its operating procedure in October 1979 from an interest rate to a reserve aggregate operating variable, discount window borrowing—depository institution borrowing from the Federal Reserve District Banks—became an important factor in the Federal Reserve's efforts to control monetary growth. Under the new regime, administration of the discount window also has had important implications for short-term market interest rates. Partially in recognition of the importance of discount window borrowing on its monetary control efforts, the Federal Reserve on occasion has imposed a discount rate surcharge on large and frequent borrowers. In addition, other proposals have been advanced for administering the discount window.

In view of the increased importance of discount window policy, this article analyzes the effects of alternative discount window policies on monetary control. The first section of the article describes the reserves and money markets and their interrelationship. The second section analyzes alternative discount window policies and illustrates their effects on the money supply function. The third section points out how unexpected changes in money supply or money demand complicate monetary control and examines the implications of alternative discount window policies for monetary control and interest rate volatility. Empirical evidence on the effects of alternative discount window mechanisms is presented in the last section.

The analysis presented in the article suggests that discount window mechanisms can dampen the effects of disturbances on monetary growth and interest rates without involving direct action on the part of the monetary authority. However, the degree of such automatic control of a monetary disturbance depends on the kind of discount window policy employed and the source of the disturbance. As a result, no single policy provides maximum control for all situations. Furthermore, the adoption of a frequently advocated policy, a penalty discount rate policy, could dramatically increase short-term interest rate volatility.

## THE RESERVES AND MONEY MARKETS

The ability of the Federal Reserve to influence key economic variables derives from its influence on the availability of reserves to depository institutions. Reserve availability, in turn, affects interest rates as well as the growth of money and credit. The authority of the Federal Reserve to require depository institutions

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to hold a fraction of their deposits as reserves provides the link between reserves and monetary aggregates. Thus, analysis of the effects of discount window policy on monetary control must begin with an analysis of the demand for and supply of reserves.

## The reserves market

The demand for reserves is the sum of financial institutions' demands for required reserves and excess reserves, the latter being reserves that depository institutions hold in addition to their required reserves. To simplify the analysis in this section, it is assumed that reserve accounting is contemporaneous, that a uniform reserve requirement is imposed on transactions accounts, and that no reserves are required for other deposits.[1] Accordingly, the demand for required reserves is assumed to be a fraction of total transactions deposits.[2] Since transactions deposits generally earn less than a market rate of return, the demand for transactions deposits and thus the demand for required reserves are inversely related to market interest rates.

The demand for excess reserves constitutes the second component of the demand for total reserves.[3] Because depository institutions earn no income on reserve balances, they would be expected to reduce their holdings of excess reserves as short-term market rates rose. However, this interest elasticity of the demand for excess reserves has been difficult to identify empirically. As a result, the demand for excess reserves is assumed in this article to be interest insensitive.[4]

The demand for total reserves—the sum of the demands for required reserves (RR) and excess reserves (ER)—is graphically represented in Figure 1 by $TR^d$. The quantity demanded is inversely related to the federal funds rate, rF, reflecting the assumed negative relationship between market interest rates and the demand for transactions account balances from which the demand for required reserves derives.[5]

The supply of reserves to depository institutions also consists of two components, reserves borrowed from the Federal Reserve at the discount window, BR, and nonborrowed reserves

1 Over the past few decades, the Federal Reserve has used two accounting methods in determining required reserves. Prior to September 12, 1968, a contemporaneous reserve accounting system was used, in which a financial institution's current required reserves are based on its current deposit liabilities. Since then, a lagged reserve accounting system has been used. Under this system, an institution's required reserves are computed as a fraction of deposits held two weeks before. In an effort to improve control over monetary aggregates, the Federal Reserve will return to contemporaneous reserve accounting in February 1984. In a separate development, the Depository Institutions Deregulation and Monetary Control Act of 1980 (DIDMCA) has broadened the range of institutions subject to Federal Reserve System reserve requirements and instituted a transition to primarily exclusive reservability of transactions accounts. With a few exceptions, only member banks of the Federal Reserve System were subject to Federal Reserve requirements prior to DIDMCA. Now, all depository institutions are required to maintain reserves.

2 Under these assumptions, depository institutions have the following demand for required reserves,

$$(1)\ RR^d = \Upsilon \cdot D,$$

where D is the demand for transactions account balances, $RR^d$ is the demand for required reserves, and $\Upsilon$ is the required reserve ratio.

3 For various reasons, financial institutions may hold more reserves than required. Uncertainty about levels of reservable deposits and, hence, required reserves may induce institutions to hold excess reserves to reduce the likelihood of having to make undesired adjustments at the end of an accounting period. Institutions also may increase their holdings of excess reserves when the money markets are unstable. Furthermore, institutions may adjust their levels of excess reserves in anticipation of interest rate movements.

4 Algebraically, the demand for excess reserves, $ER^d$, is given by

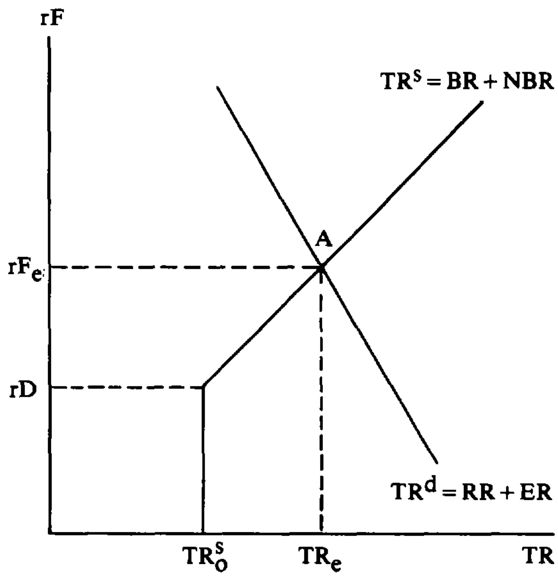
$$(2)\ ER^d = \overline{ER}.$$

5 The interest sensitivity of the demand for transactions account balances is discussed in the description of the money market below.

obtained from other sources, NBR. The Federal Reserve influences nonborrowed reserves through open market operations.[6] A purchase of securities in the open market increases nonborrowed reserves, and an open market sale of securities reduces nonborrowed reserves. When the Federal Reserve uses nonborrowed reserves as an operating target, as it has since October 1979, the supply of nonborrowed reserves can be represented as an interest-insensitive level determined by the Federal Reserve.[7]

Depository institutions also can obtain reserves by borrowing from their District Federal Reserve Bank at the discount rate. For the most part, discount window borrowing is intended to help depository institutions make short-run adjustments in meeting their reserve requirements. Instead of borrowing from the Federal Reserve to meet its reserve requirements, a financial institution can borrow reserves from other financial institutions in the federal funds market or take other actions that redistribute reserves among financial institutions without altering the aggregate level of reserves. The federal funds market is such an important alternative to borrowing from the Federal Reserve that the demand for borrowed reserves is determined primarily by the spread (difference) between the federal funds rate and the discount rate. When the federal funds rate is at or below the discount rate, i.e., for nonpositive spreads, borrowing tends to be at a minimal level which is interest insensitive. But when the spread is positive, borrowing from the Federal Reserve becomes more attractive and increasingly so as the spread increases. The sensitivity of borrowing to positive spreads reflects Federal Reserve 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.[8]

**Figure 1**




[6] When the Federal Reserve buys securities, it credits the account of the security dealer's depository institution, injecting reserves into the financial system. A sale of securities by the Federal Reserve removes reserves from the system. Nonborrowed reserves are also affected by technical market factors such as unexpected flows into or out of Treasury deposits at Federal Reserve Banks and changes in float.

[7] An approximation of the supply of nonborrowed reserves is given by

$$\text{(3) } NBR = NBR^*$$

where NBR* is the level set by the Federal Reserve. This formulation ignores technical factors that might affect the level of nonborrowed reserves (footnote 6).

[8] A simple model of discount window borrowing is

$$\text{(4) } BR = \begin{cases} \overline{BR}, \text{ for } rF \le rD \\ \overline{BR} + b\cdot(rF - rD), \text{ for } rF > rD \end{cases}$$

where $\overline{BR}$ is the interest-insensitive level of borrowing, rF is the federal funds rate, rD is the discount rate, and b is the slope of the borrowing function for positive spreads (note, $b > 0$).

Adding the supply of nonborrowed reserves, NBR, to the supply of borrowed reserves, BR, yields the supply of total reserves, $TR^S$, shown graphically in Figure 1. The federal funds rate and the discount rate are denoted rF and rD, respectively. For nonpositive spreads (i.e., for values of rF which are less than or equal to rD), the supply of total reserves consists of nonborrowed reserves and interest-insensitive borrowings. Since nonborrowed reserves also are interest insensitive, the supply of total reserves is interest insensitive for nonpositive spreads, as indicated by the vertical segment of the $TR^S$ curve in Figure 1. In addition to these components, the sum of which is indicated by $TR_0^S$ in Figure 1, interest-induced borrowing contributes to the supply of total reserves when the spread is positive (i.e., when the funds rate is above the discount rate). The tendency of this borrowing to increase with the spread is reflected in the upward-sloping segment of $TR^S$.[9]

The reserve market is in equilibrium when the demand for total reserves equals the supply of total reserves. This equilibrium, point A in Figure 1, determines the level of the federal funds rate, $rF_e$, and the level of total reserves, $TR_e$.[10]

## The money market

The demand for money derives from its role as a medium of exchange.[11] As transactions deposits typically earn a lower rate of return than other assets, the nonbank public tends to reduce its transactions balances as rates of return on other assets rise and to increase its holdings of assets with higher yields. This behavior can be represented simply by specifying that the demand for money is inversely related to a market rate of interest, such as the federal funds rate.[12] The demand for transactions balances also is positively related to income because increases in income cause an increase in transactions that must be financed by the means of payment. The

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9 The graph of $TR^S$ is simply the graph of BR shifted rightward by $NBR^*$.

10 The reserve market equilibrium condition is obtained by equating the sum of equations 1 and 2 with the sum of equations 3 and 4

$$\overline{BR} + b\cdot(rF - rD) + NBR^* = \Upsilon\cdot D + \overline{ER}, \text{ for } rF > rD$$

$$\overline{BR} + NBR^* = \Upsilon\cdot D + \overline{ER}, \text{ for } rF \leq rD.$$

The expression for positive spreads can be solved for the equilibrium funds rate

$$rF_e = rD + \frac{\Upsilon}{b}\cdot D + \frac{1}{b}\cdot(\overline{ER} - \overline{BR} - NBR^*), \text{ for } rF > rD.$$

The value of the equilibrium federal funds rate depends on the contemporaneous level of transactions account balances. Alternatively, for both positive and nonpositive spreads, the reserve market equilibrium condition can be solved for D.

$$(5)\ D = \begin{cases} \frac{1}{\Upsilon}\cdot(\overline{BR} + NBR^* - \overline{ER}) + \frac{b}{\Upsilon}\cdot(rF - rD), & \text{for } rF > rD \\ \frac{1}{\Upsilon}\cdot(\overline{BR} + NBR^* - \overline{ER}), & \text{for } rF \leq rD. \end{cases}$$

11 Transactions balances are held primarily as currency and transactions account balances. To simplify the analysis in this section, a currency-less economy is assumed. With this assumption, transactions balances, hereafter called money, are held entirely in transactions accounts at depository institutions. In the empirical analysis in the last section of this article, currency is not assumed away.

12 Because the nonbank public participates little in the federal funds market, use of the funds rate as a measure of the opportunity cost of holding transactions balances may not seem appropriate. Its use simplifies the analysis, however, and can be justified theoretically.

The demand for transactions balances could depend on the rates of return of a number of assets to which transactions balances could be transferred. Empirical evidence suggests, however, that the demand for transactions balances is affected significantly only by the returns on liquid financial assets. Since short-term rates of return characteristically move together, their effect on the demand for transactions balances can be summarized quite well by including a single short-term rate in the demand function. In practice, the federal funds rate performs well in this role and its use simplifies the analysis in this article. Had another rate been used—for example, a 90-day commercial paper rate—the relationship between that rate and the federal funds rate would have had to be specified before the effects of alternative discount window policies could have been analyzed.

demand for money, $M^d$, for a fixed level of income is depicted in Figure 2.

The reserve market equilibrium condition (demand for total reserves equal to supply of total reserves) can be used to obtain a money supply function. The following equation gives the reserve market equilibrium condition.

$$RR + ER = NBR + BR.$$

If the average reserve requirement is given by $\Upsilon$, the ratio of the money stock to required reserves is $1/\Upsilon$, which can be thought of as the money-required reserves multiplier.[13] Substituting $\Upsilon \cdot M$ for required reserves in the reserve market equilibrium condition and solving for M yields the following money supply relationship,[14]

$$M^S = \frac{1}{\Upsilon} \cdot (NBR + BR - ER).$$

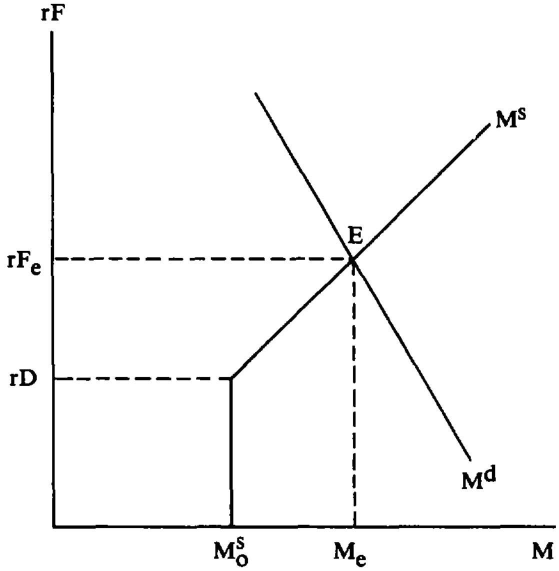
The money supply function shows that the amount of money supplied to the public by depository institutions depends positively on the incentive for these institutions to borrow from the Federal Reserve and on the availability of nonborrowed reserves, and negatively on the demand for excess reserves by these institutions.

Because of the linkage between the money supply and discount window borrowing, the supply of money depends positively on the federal funds rate for positive spreads. An increase in the federal funds rate encourages financial institutions to undertake more discount window borrowing, thereby increasing the amount of reserves available to support expansion of the money supply.

13 As a currency-less economy is assumed, transactions deposits and money are equivalent.

14 For the algebraic model, this relationship is given by equation (5) in footnote 10. To reflect the no-currency assumption, "D" should be replaced by "M" in this equation.

**Figure 2**




If the demand for excess reserves is insensitive to short-term interest rates, the relationship between $M^S$ and the federal funds rate merely reflects the relationship of discount window borrowing to the federal funds rate.[15] Consequently, a change in discount window policy that affects the interest sensitivity of the supply of borrowed reserves correspondingly changes the slope of the money supply curve.[16] The slope of the money supply function is

15 Recall that the supply of nonborrowed reserves is interest insensitive.

16 For example, if the Federal Reserve wanted to discourage borrowing, it could reduce the frequency with which depository institutions are allowed to borrow. Institutions, trying to avoid the possibility of being refused when their needs were more urgent, would then become more reluctant to borrow from the Federal Reserve. At any value of the spread, borrowing would be less than without the change in administration of the discount window. That is, BR would be steeper. As a result, the supply of money would be less responsive to a change in the federal funds rate.

proportional to that of the supply of borrowed reserves.[17] In addition, the money supply function has an interest-insensitive level corresponding to the interest-insensitive level of the supply of total reserves.[18] Consequently, $M^S$ shifts to the right with either an increase in the supply of nonborrowed reserves or interest-insensitive borrowings, or with a decrease in the demand for excess reserves.[19]

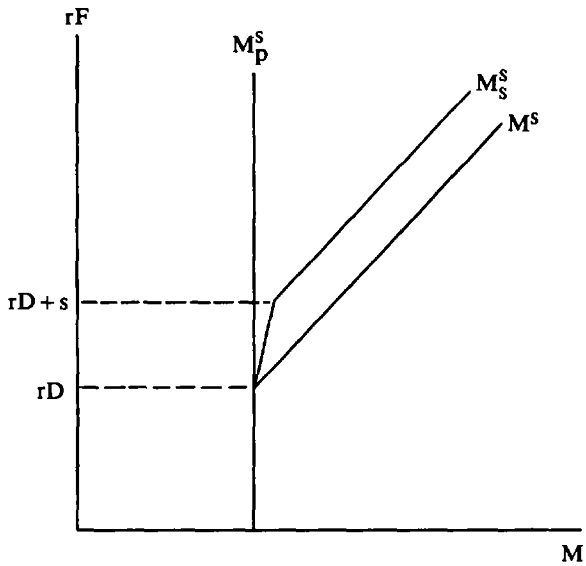
Equilibrium in the money market, point E in Figure 2, determines the federal funds rate, $rF_e$, and the money stock, $M_e$. The federal funds rate is identical to that obtained in equilibrium of the reserves market.

## ALTERNATIVE DISCOUNT WINDOW POLICIES AND THE MONEY SUPPLY FUNCTION

This section describes alternative discount window policies and explores their implications for the money supply function. As reasoned in the preceding section, changes in discount window policy that affect the supply of borrowed reserves are reflected in the money supply function. The succeeding section shows that the slope of the money supply function is an important factor in the control of the money stock. Consequently, the current section establishes the critical link between discount window policy and monetary control.

Two alternative discount window policies, a penalty rate policy and a surcharge policy, are examined here. Current discount window policy, described in the preceding section, serves as a reference.

**Figure 3**




### A penalty rate

Under the reserve-targeting approach to monetary control adopted by the Federal Reserve in October 1979, there has been considerable short-run variability in the growth of both money and reserves. This variability has led some observers to conclude that for the Federal Reserve to achieve its monetary objectives it needs to obtain closer short-run control over reserves. Convinced that interest rate-induced changes in discount borrowing are the main source of reserve variability, they argue that the Federal Reserve's control over total reserves and money could be improved if discount window borrowing were insensitive to changes in the spread between the federal funds rate and the discount rate.

Because borrowing is highly interest insensitive for negative spreads, keeping the discount rate above the federal funds rate would greatly reduce the interest sensitivity of borrowing. Un-

[17] The constant of proportionality is $1/\Upsilon$, which reflects the ability of a given amount of reserves to support a larger amount of deposits ($0 < \Upsilon < 1$).

[18] This level is equal to $\frac{1}{\Upsilon} \cdot (NBR^* + BR - ER)$.

[19] The horizontal shift is equal to $1/\Upsilon$ times the change in nonborrowed reserves, interest-insensitive borrowings, or excess reserves.

der such a policy, a financial institution could always obtain reserves in the federal funds market at less cost than borrowing from the Federal Reserve. Consequently, a discount rate higher than the federal funds rate is commonly called a penalty rate. When the discount rate is a penalty rate, borrowed reserves and, therefore, total reserves are little affected by a change in the federal funds rate. The preceding section explained that the money supply function has the same shape as the supply of total reserves. In particular, the money supply function possesses an interest-insensitive segment corresponding to that of the supply of total reserves. Thus, with a penalty discount rate, the entire money supply function is highly insensitive to the federal funds rate, as shown by $M^S_p$ in Figure 3. As a reference, the money supply function implied by current discount window policy, $M^S$, is reproduced from Figure 2.

### A surcharge rate

A less extreme discount window policy is to charge frequent users of the discount window a penalty discount rate while simultaneously charging occasional borrowers a nonpenalty rate. In fact, the Federal Reserve has used such a policy on two occasions within the past three years. In March 1980, a discount rate surcharge was imposed on large banks that borrowed frequently at the window.[20] The surcharge, designed to "discourage frequent use of the discount window and to encourage banks with access to money markets to adjust their loans and investments more promptly to changing market conditions," was intended "to facilitate the ability of the Federal Reserve to attain longer-run bank credit and money supply objectives."[21] The surcharge was removed after two months, but was reimposed in November 1980 and remained in effect a year. During the time the surcharge was in effect, it ranged from 2 to 4 percent.

Borrowing behavior of large banks potentially subject to the surcharge depends on the federal funds rate relative to the sum of the basic discount rate and the surcharge. When the price of reserves borrowed at the discount window is higher than the price of reserves obtained in the federal funds market (i.e., when the basic discount rate plus the surcharge is more than the federal funds rate), large banks potentially subject to the surcharge have an incentive to avoid the discount window. When the federal funds rate is more than the basic rate plus the surcharge, large banks tend to resume discount window borrowing.

The money supply curve in a surcharge rate environment is shown as $M^S_S$ in Figure 3. When the federal funds rate is between the discount rate and the discount plus surcharge rate, the money supply curve is steeper than it is under the current discount window policy, as demonstrated by a comparison of $M^S_S$ with $M^S$ in Figure 3. Over this range of interest rates, with only small banks borrowing, borrowed reserves are less sensitive to the interest rate. As a result, the supply of total reserves and, therefore, the supply of money are less interest sensitive. When the federal funds rate exceeds the discount plus surcharge rate, large banks resume borrowing and the original interest sensitivities of the supply of reserves and the supply of money are restored.[22]

20 Banks with deposits over $500 million that borrowed for two consecutive weeks or for more than four weeks in a calendar quarter were required to pay the surcharge in addition to the basic discount rate. On October 1, 1981, the formula for applying the surcharge was changed from a calendar quarter to a moving 13-week period.

21 Federal Reserve press release, March 14, 1980.

22 For a more detailed explanation of the effect of a surcharge on the demand for borrowed reserves, see Gordon H. Sellon, Jr., and Diane Seibert, "The Discount Rate: Experience Under Reserve Targeting," *Economic Review,*

## ALTERNATIVE DISCOUNT WINDOW POLICIES AND MONETARY CONTROL

A general discussion of monetary control issues is presented in this section along with an examination of the implications of alternative discount window policies for monetary control and interest rate volatility.

### Monetary control

Since the money stock responds to changes in nonborrowed reserves, achieving a desired money stock would seem straightforward. The Federal Reserve would determine the level of nonborrowed reserves consistent with the desired money stock and then buy or sell government securities until that level was reached. This description of monetary control, however, overlooks several details. The Federal Reserve would have to be able to accurately predict money demand, borrowed reserves, excess reserves, and other economic variables. In practice, changes in these variables prevent perfec control of the money stock. Another complication is that factors unrelated to open market operations can affect nonborrowed reserves. These factors include float and Treasury deposits at the Federal Reserve, both of which can and do change quite unpredictably.

Within the framework of Figure 2, an unexpected change in nonborrowed reserves, excess reserves, or the level of interest-insensitive borrowings causes the money supply curve to shift horizontally, i.e., either to the left or to the right. Such changes are collectively referred to as money supply disturbances. In general, a money supply disturbance affects the money stock. As will be seen below, the change in the money stock depends on the slopes of the money demand and money supply curves and typically is less than the horizontal movement in the money supply curve. That is, the effect of a money supply disturbance on the money stock is dampened without direct action by the Federal Reserve. In the absence of other considerations, this automatic control of money supply disturbances is desirable. However, open market operations, like money supply disturbances, shift the money supply curve. Thus, if money supply disturbances have little effect on the money stock, open market operations also have relatively little effect on the money stock. That is, a tradeoff exists between the Federal Reserve's discretionary control of the money stock and the automatic control of money supply disturbances.[23]

The money demand curve also can shift because of unanticipated changes in economic variables. For example, shifts in money de-

Federal Reserve Bank of Kansas City, September-October 1982.

A third alternative, more general than either the penalty rate or the surcharge, is a graduated rate policy that specifies a rising cost of borrowing. Under this policy, low levels of borrowing could be allowed at a base discount rate below the federal funds rate. Successively higher borrowing levels would be allowed at successively higher rates. With this policy, the shape of the borrowings function could be tailored by adjusting the width of the borrowing steps over which the borrowing rate is constant or by adjusting the changes in the borrowing rate between adjacent levels. In this way, any degree of interest sensitivity in the money supply curve could be achieved.

Proponents maintain that the adoption of such a policy would enhance the predictability of borrowed reserves, particularly if the cost schedule were relied on to limit the borrowing of individual institutions and administrative pressure were eliminated. It seems likely, however, that far more institutions would use the discount window under such a policy. If that were the case, the cost of operating the discount window could increase considerably. For further discussion of graduated rate policies, see Perry D. Quick, "Discount Window Policies Without Administrative Pressures," Federal Reserve Board staff memo, May 22, 1980.

23 Discretionary control is important to the extent that open market operations entail costs. If discretionary control were low, major security dealers' inventories might be insufficient, on occasion, for the Federal Reserve to effect a desired change in the money stock.

**Figure 4a**

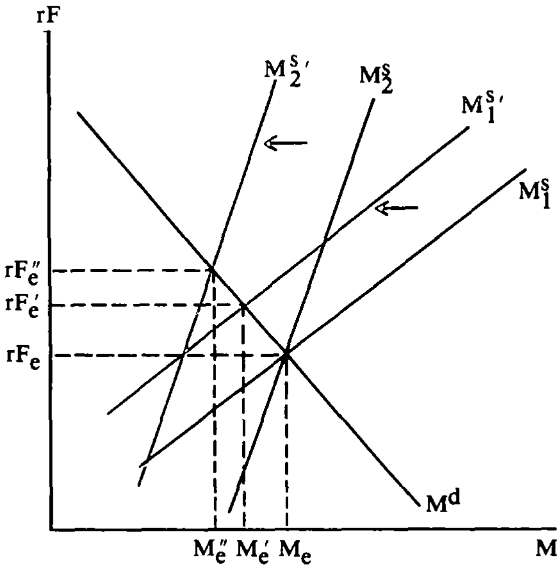
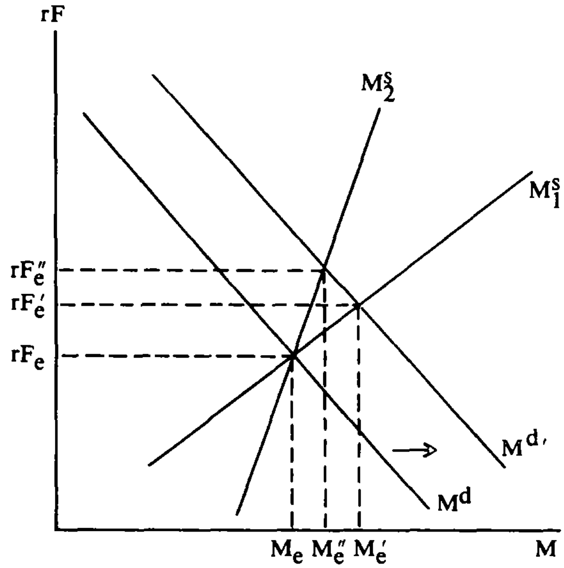



**Figure 4b**




mand can result from unanticipated changes in income and unanticipated changes in liquidity preference. An unanticipated money demand shift is called a money demand disturbance.

As with money supply disturbances, the effect of a money demand disturbance on the money stock can be dampened without direct action by the Federal Reserve. The extent of automatic control is again determined by the slopes of the money demand and money supply curves. An additional complication is that in some instances the Federal Reserve may consider the automatic control of a money demand disturbance undesirable. For example, it might want to accommodate an increase in money demand if it thought uncertainty was responsible for an increase in demand for liquidity.

Whereas the Federal Reserve may be concerned primarily with achieving its money stock targets, it also has to be aware of the implications of monetary policy for interest rate volatility. Indeed, interest rate volatility can differ considerably under alternative discount window policies.

As was demonstrated in the previous section, discount window policy affects the slope of the money supply function. Consequently, the choice of discount window policy has implications for each of the issues considered above—automatic control of money supply disturbances, the Federal Reserve's discretionary control of the money stock, automatic control of money demand disturbances, and interest rate volatility.

The automatic control of a money supply disturbance is graphically illustrated in Figure 4a.[24] Two money supply curves of differing interest sensitivity are shown. The interest sensitivity of borrowings underlying $M^S_1$ is greater

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[24] This discussion is adapted from Gordon H. Sellon, Jr., "The Role of the Discount Rate in Monetary Policy: A Theoretical Analysis," *Economic Review*, Federal Reserve Bank of Kansas City, June 1980.

than that of $M_2^S$. In response to a negative money supply disturbance, due perhaps to an increase in excess reserves, the two money supply curves are shown to shift an equal distance leftward—$M_1^S$ to $M_1^{S\prime}$ and $M_2^S$ to $M_2^{S\prime}$. The decrease in the equilibrium money stock to $M_e'$ under the more interest-sensitive money supply curve is smaller than the decrease to $M_e''$ under the less interest-sensitive money supply curve. In addition, the increase in the federal funds rate to $rF_e'$ under the interest-sensitive money supply curve is smaller than the increase to $rF_e''$ under the less interest-sensitive money supply curve.

Thus, interest sensitivity in the money supply function increases automatic control of money supply disturbances and dampens interest rate volatility. On the other hand, if the shifts in the money supply curves were caused by a sale of securities by the Federal Reserve, the larger change in the money stock under the less interest-sensitive money supply curve would represent greater discretionary control. Thus, interest sensitivity in the money supply function reduces the Federal Reserve's discretionary control of the money stock.

The automatic control of a money demand disturbance, due perhaps to an unexpected increase in personal income, is depicted in Figure 4b. Unlike the result obtained for a money supply disturbance, the change in the money stock is greater when the money supply curve is more interest sensitive. That is, interest sensitivity in the money supply function reduces automatic control of money demand disturbances. However, the change in the federal funds rate is smaller under the more interest-sensitive money supply curve, as was the case for a money supply disturbance.

[25] The equal leftward shifts are evidenced by the intersection of $M_1^{S\prime}$ and $M_2^{S\prime}$ at $rF = rF_e$.

In summary, the desirability of borrowing function interest sensitivity cannot be specified without reference to the source of money disturbances, the desirability of accommodating money demand disturbances, the importance of discretionary control, and the implications for interest rate volatility.

## Implications for the alternative discount window policies

Of the three discount window policies considered in this article, the money supply curve associated with the current policy is the most interest sensitive. The money supply curve associated with the surcharge policy is less interest sensitive and the curve associated with the penalty rate policy is the least interest sensitive. Thus, of the three, the current policy provides the greatest automatic control of money supply disturbances, the least automatic control of money demand disturbances, and the least discretionary control. Interest rates also are least volatile under this policy.

At the other extreme, the penalty discount rate provides the least automatic control of money supply disturbances, the greatest automatic control of money demand disturbances, and the most discretionary control. Interest rate volatility is greatest with the penalty discount rate policy.[26] For each of these criteria, the surcharge policy scores between the current policy and the penalty rate policy.

The desirability of automatic control of money demand disturbances depends on the nature of the disturbances. If money demand disturbances are predominantly the kind the Federal Reserve needs to accommodate, a high degree of automatic control of these disturbances is not desirable.

[26] For discussion of the penalty rate alternative, see J. A. Cacy, Bryon Higgins, and Gordon H. Sellon, Jr., "Should the Discount Rate be a Penalty Rate?" *Economic Review,* Federal Reserve Bank of Kansas City, January 1981.

## EMPIRICAL ANALYSIS OF ALTERNATIVE DISCOUNT MECHANISMS

Empirical evidence on the implications of alternative discount window policies for monetary control was obtained from the estimation and simulation of a money market model. The effects of a money demand disturbance and a money supply shock were examined under alternative discount window policies.[27] This section describes the money market model and discusses the design of the simulations and the conclusions that can be drawn from them.

### The model

A monthly money market model was used in assessing the effects of discount window policy on monetary control. The model consists of three behavioral equations that explain the demand for currency, the demand for transactions accounts, and the supply of borrowed reserves, plus an equation that expresses required reserves as a function of transactions accounts, and two equations that define equilibria in the reserves and money markets. Table 1 summarizes characteristics of the model.

The demand for currency and the demand for transactions account balances are functions of nominal personal income and the federal funds rate. Demands for both are positively related to income and negatively related to interest rates. An increase in personal income was found to increase the demands for the two assets in the current and the following five months. An increase in the federal funds rate was found to reduce the demands for the two assets over the same period.

The estimated supply of borrowed reserves function has the characteristics described in the preceding section. Borrowed reserves are interest insensitive when the discount rate is greater than the federal funds rate. They are positively related to the spread, however, when the funds rate is greater than the discount rate.

**Table 1**
**A SIMPLE MONEY MARKET MODEL**

**Equations**

(1) BR = BR(rF − rD,s,RR,D1,D2,D3)
(2) CURR = CURR(Y,rF)
(3) TRANS = TRANS(Y,rF,DUMNOW)
(4) RR = .12·TRANS
(5) NBR + BR = RR + ER
(6) M1 = CURR + TRANS

**Endogenous Variables**

| | |
|---|---|
| BR: | borrowed reserves, excludes nonseasonal extended credit |
| RR: | required reserves |
| CURR: | currency |
| TRANS: | transactions deposits (includes demand deposits and other checkable deposits, such as NOW accounts) |
| M1: | currency plus transactions deposits |
| rF: | federal funds rate |

**Exogenous and Dummy Variables**

| | |
|---|---|
| rD: | Federal Reserve discount rate |
| s: | surcharge rate |
| Y: | nominal personal income |
| DUMNOW: | dummy variable to account for deposit shifts into NOW accounts |
| ER: | excess reserves |
| NBR: | nonborrowed reserves, includes nonseasonal extended credit |
| D1,D2,D3: | dummy variables based on relationship between discount rate, federal funds rate, and surcharge rate |

Note: Equations 1-3 are behavioral equations and equations 4-6 are identities or definitions. All data except interest rates and dummy variables were in billions of dollars, seasonally adjusted. Reserve series were adjusted for changes in reserve requirements. In equations 2 and 3, natural logarithms of all variables except DUMNOW were used. Equations 2 and 3 were estimated using data for the period January 1977 to September 1982. Equation 1 was estimated using data for the period October 1979 to September 1982.

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[27] Money supply shock is interpreted as a shift in the money supply curve caused by either a money supply disturbance or an open market operation.

The interest sensitivity of borrowed reserves is reduced considerably when a surcharge is in effect and the federal funds rate is between the basic rate and the basic rate plus the surcharge. The demand for required reserves is a fraction of transactions deposits in the same month.

## Simulations with the model

To examine the implications of alternative discount window policies, simulations were made with the estimated model. Of primary interest was the extent to which monetary control is determined by the interest sensitivity of the borrowings function. Three versions of the model were simulated corresponding to three levels of interest sensitivity—the zero interest sensitivity of a penalty rate policy, an intermediate sensitivity associated with a surcharge policy, and the higher sensitivity of the current policy. All three versions were simulated under three sets of assumptions regarding disturbances or shocks to the money demand and money supply functions. Each simulation covered a four-month period.

The first simulations, the results of which are reported in the top panel of Table 2, assume no unexpected changes in either money demand or money supply. These reference simulations correspond to a situation in which the Federal Reserve's initial estimates of money demand and money supply relationships are exactly correct. Thus, the desired rate of monetary growth, assumed to be 4.5 percent, is achieved precisely, regardless of the type of discount window administration. Moreover, the federal funds rate is the same for all three versions of the model, reflecting that there is a unique level of the federal funds rate consistent with the desired rate of monetary growth. If, as assumed, the Federal Reserve correctly estimates income and the other determinants of money demand, the choice of nonborrowed reserve path and discount rate that determine the position of the money supply function must result in an interest rate consistent with the monetary growth target regardless of the type of discount window policy.

The results of the second set of simulations are reported in the middle panel of Table 2. In these simulations, a positive money demand disturbance is modeled by assuming that growth of personal income is higher than the Federal Reserve initially expected.[28] For the two discount window policies other than the penalty rate policy, the unexpected increase in money demand causes growth in the money stock to exceed the Federal Reserve's 4.5 percent target. Compared to the current policy, the surcharge policy provides slightly more automatic control of the money demand disturbance at the cost of a slight increase in interest rate volatility, as evidenced by the smaller increase in monetary growth and the wider range for the federal funds rate under the surcharge policy. With a penalty rate policy, automatic control of the money demand disturbance is complete and the monetary growth target of 4.5 percent is achieved. Interest rate volatility is greater, however, for the penalty rate policy than for the other two policies.

The third set of simulations assumes that demand for excess reserves is $500 million more than the Federal Reserve expected. This negative money supply shock causes money stock growth to fall short of the 4.5 percent target regardless of discount window policy. The shortfall is most extreme with the penalty rate policy, as an annualized money growth rate of only 0.2 percent is reached. There is also extreme interest rate volatility with this policy; during the period of the money supply distur-

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28 The annualized growth rate of personal income in the reference simulations is 4.9 percent. For the money demand simulations, this growth rate is 6.4 percent.

**Table 2**
**THE EFFECTS OF DISCOUNT WINDOW POLICY ON MONEY AND THE FEDERAL FUNDS RATE**

| Discount Window Policy | Annualized Growth Rate of Money | Average Federal Funds Rate | Range of Federal Funds Rate |
|---|---|---|---|
| | | **Reference Simulations (No Disturbances)** | |
| No Surcharge | 4.5% | 10.25% | 10.25-10.25% |
| Surcharge | 4.5 | 10.25 | 10.25-10.25 |
| Penalty Rate | 4.5 | 10.25 | 10.25-10.25 |
| | | **Money Demand Disturbance (Positive)** | |
| No Surcharge | 5.4 | 10.40 | 10.25-10.50 |
| Surcharge | 5.3 | 10.47 | 10.25-10.61 |
| Penalty Rate | 4.5 | 10.97 | 10.25-11.38 |
| | | **Money Supply Shock (Negative)** | |
| No Surcharge | 3.3 | 11.02 | 10.25-11.38 |
| Surcharge | 2.8 | 11.38 | 10.25-12.01 |
| Penalty Rate | 0.2 | 14.67 | 10.25-25.00 |

bance, the federal funds rate jumps to 25 percent. Automatic control of the money supply disturbance is considerably greater and interest rate volatility is markedly less with a surcharge policy than with the penalty rate policy. And, by either criterion, current policy is a slight improvement over the surcharge policy.[29]

The results of this third set of simulations have to be interpreted differently if the money supply shock is taken to be a reduction of nonborrowed reserves brought on by a Federal Reserve sale of securities. If the monetary growth under the penalty rate policy, 0.2 percent, is taken to be the Federal Reserve's target for monetary growth, the higher growth rates under the other two policies represent less discretionary control.

29 Although the results in Table 2 are based on contemporaneous reserve accounting (CRA), the same model simulations were conducted for lagged reserve accounting (LRA). The results were essentially the same. The only significant difference was with a money supply shock and a penalty discount rate. In this situation, the model resulted in extreme interest rate volatility under CRA and would not simulate under LRA. The penalty rate is not tenable under LRA.

## SUMMARY

Under the reserves operating procedure adopted by the Federal Reserve in October 1979, discount window policy has become a more important factor in the Federal Reserve's efforts to control monetary aggregates. The choice of discount window policy also has more potential for affecting short-term interest rates. For these reasons, analytical and empirical investigations were made of the effects of alternative discount window policies on monetary aggregates and short-term interest rates.

Graphical analysis of a simple money market model showed the interest sensitivity of the money supply function is a critical factor in both controlling the money stock and determining short-term interest rates. The interest sensitivity of this function is directly related to the interest sensitivity of the borrowed reserves function. The latter varies widely over the discount window options considered here—current policy, a surcharge policy, and a penalty rate policy.

It was shown graphically that interest sensitivity in the borrowings function and, hence, the money supply function, improves automatic control of money supply disturbances. On the other hand, interest sensitivity in these functions reduces the Federal Reserve's discretionary control of the money stock and the automatic control of money demand disturbances. Consequently, for the discount window policies considered in this article, the degree of automatic control of money supply disturbances should theoretically be least with a penalty rate policy, greater with a surcharge policy, and greatest with the current discount window policy. For automatic control of money demand disturbances and the potency of discretionary policy, the rankings are reversed. The potential for short-term interest rate volatility is greatest under a penalty rate policy, less under a surcharge policy, and the least under the current policy.

The empirical investigation confirmed the theoretical analysis. The tradeoff between automatic control of money supply and money demand disturbances was evident. The relative usefulness of the discount rate options depended on the source of the money disturbance. Furthermore, the extreme volatility of short-term interest rates experienced in the penalty discount rate simulations would appear to be a strong indictment against that discount rate policy.