Operating procedures and the reserve market with a non-penalty discount rate: Section 9.4 from the second edition of *Monetary Theory and Policy*[*]

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1 Operating Procedures and Policy Measures

Understanding a central bank's operating procedures is important for two reasons. First, it is important in empirical work to distinguish between endogenous responses to developments in the economy and exogenous shifts in policy. Whether movements in a monetary aggregate or a short-term interest rate are predominantly endogenous responses to disturbances unrelated to policy shifts or are exogenous shifts in policy will depend on the nature of the procedures used to implement policy. Thus, some understanding of operating procedures is required for empirical investigations of the impact of monetary policy.

Second, operating procedures, by affecting the automatic adjustment of interest rates and monetary aggregates to economic disturbances, can have implications for the macro equilibrium. For example, operating procedures that lead the monetary authority to smooth interest-rate movements can introduce a unit root into the price level,[1] and in the models examined in chapters 2 and 3, the economy's response to productivity shocks was shown to depend on how the money supply was adjusted (although the effects were small).

Analyses of operating procedures are based on the market for bank reserves. In the United States, this is the federal funds market. While the focus in this section will be on the United States and the behavior of the Federal Reserve, similar issues arise in the analysis of monetary policy in other countries, although institutional details can vary considerably. Discussions of operating procedures in major OECD countries can be found in Batten, Blackwell, Kim, Nocera, and Ozeki (1990), Bernanke and Mishkin (1992), Morton and Wood (1993), Kasman (1993), and Borio (1997) .

[*]References can be found in either the 2nd or 3rd editions.

[1]See Goodfriend (1987) and Van Hoose (1989)..

1.1 Money Multipliers

Theoretical models of monetary economies often provide little guidance to how the quantity of money appearing in the theory should be related to empirical measures of the money supply. If m is viewed as the quantity of the means of payment used in the conduct of exchange, then cash, demand deposits, and other checkable deposits should be included in the empirical correspondence.[2] If m is viewed as a variable set by the policy authority, then an aggregate such as the monetary base, which represents the liabilities of the central bank and so can be directly controlled, would be more appropriate. The *monetary base* is equal to the sum of the reserve holdings of the banking sector and the currency held by the nonbank public.[3] These are liabilities of the central bank and can be affected by open market operations. Most policy discussions, however, focus on broader monetary aggregates, but these are not the direct instruments of monetary policy. A traditional approach to understanding the linkages between a potential instrument such as the monetary base and the various measures of the money supply is to express broader measures of money as the product of the monetary base and a money multiplier. Changes in the money supply can then be decomposed into those resulting from changes in the base and those resulting from changes in the multiplier. The multiplier is developed using definitional relationships, combined with some simple behavioral assumptions.

A central bank can control the monetary base through open market operations. By purchasing securities, the central bank can increase the supply of bank reserves and the base. Securities sales reduce the base.[4] Denoting total reserves by TR and currency by C, the monetary base MB is given by

$$MB = TR + C.$$

In the United States, currency represents close to 90% of the base. Aggregates such as the monetary base and total reserves are of interest because of their close connection to the actual instruments central banks can control and because of their relationship to broader measures of the money supply.

In the United States, the monetary aggregate $M1$ is equal to currency in the hands of the public plus demand deposits and other checkable deposits. If the deposit component is denoted D and there is a reserve requirement ratio of rr against all such deposits, we can write

$$MB = RR + ER + C = (rr + ex + c)D,$$

[2] Whether these difference components of money should simply be added together, as they are in monetary aggregates such as $M1$ and $M2$, or whether the components should be weighted to reflect their differing degree of liquidity is a separate issue. Barnett (1980) has argued for the use of divisia indices of monetary aggregates. See also Spindt (1985).

[3] There are two commonly used data series on the U.S. monetary base–one produced by the Board of Governors of the Federal Reserve System and one by the Federal Reserve Bank of St. Louis. The two series treat vault cash and the adjustment for changes in reserve requirements differently.

[4] In the United States, daily Fed interventions are chiefly designed to smooth temporary fluctuations and are conducted mainly through repurchase and sale-purchase agreements rather than outright purchases or sales.

where total reserves have been divided into required reserves (RR) and excess reserves (ER), and where $ex = ER/D$ is the ratio of excess reserves to deposits that banks choose to hold and $c = C/D$ is the currency-to-deposit ratio. This relationship allows us to write

$$M1 = D + C = (1 + c)D = \left(\frac{1 + c}{rr + ex + c}\right) MB. \tag{1}$$

Equation (1) is a very simple example of money-multiplier analysis; a broad monetary aggregate such as $M1$ is expressed as a multiplier, in this case $(1 + c)/(rr + ex + c)$, times the monetary base. Changes in the monetary base translate into changes in broader measures of the money supply, given the ratios rr, ex, and c. Of course, the ratios rr, ex, and c need not remain constant as MB changes. The ratio ex is determined by bank decisions and the Fed's policies on discount lending, while c is determined by the decisions of the public concerning the level of cash they wish to hold relative to deposits. The usefulness of this money-multiplier framework was illustrated by M. Friedman and Schwartz (1963b), who employed it to organize their study of the causes of changes in the money supply.

In terms of an analysis of the market for bank reserves and operating procedures, the most important of the ratios appearing in (1) is ex, the excess reserve ratio. Since reserves earn no interest[5], banks face an opportunity cost in holding excess reserves. As market interest rates rise, banks will tend to hold a lower average level of excess reserves. This drop in ex will work to increase $M1$. This implies that, holding the base constant, fluctuations in market interest rates will induce movements in the money supply

1.2 The Reserve Market

In the United States, the Federal Reserve engages in open-market operations that affect the supply of reserves in the banking system and the federal funds rate, the interest rate banks in need of reserves pay to borrow reserves from banks with surplus reserves. Variations in the total quantity of bank reserves are associated with movements in broader monetary aggregates such as measures of the money supply ($M1$, $M2$, etc.). Similarly, movements in the funds rate influence other market interest rates. It is by intervening in the reserve market that the Fed attempts to affect the money supply, market interest rates, and, ultimately, economic activity and inflation.[6] The way reserve market variables (various reserve aggregates and the funds rate) respond to disturbances depends on the operating procedure being followed by the Fed. One objective in developing a model of the reserve market is to disentangle movements in reserves and the funds rate that are due to nonpolicy sources from those caused by exogenous policy actions.

[5] This statement is not true of all countries. For example, in New Zealand, reserves earn an interest rate set 300 basis points below the seven-day market rate.

[6] In the United States, the development of the modern reserves market dates from the mid-1960s. See Meulendyke (1998).

Models of the reserve market generally have a very simple structure; reserve demand and reserve supply interact to determine the funds rate. Reserve demand arises primarily from the requirement that banks hold reserves equal to a specified fraction of their deposit liabilities; consequently, variations in the public's demand for bank liabilities will alter the banking sector's demand for reserves. The focus of these models is on the way reserves and interest rates react to shocks under alternative operating procedures. Hamilton (1996) provides a model that emphaiszes the microstructure of the reserve market, while Bartolini, Bertolam, and Prati (2002) develop a model designed to capture the day-to-day operations of the reserves market when the central bank targets the funds rate.

In the United States, banks are required to maintain an average reserve level equal to a fraction of their deposit liabilities; the fraction is set by the Federal Reserve.[7] These required reserves represent the bulk of reserve holdings, but the banking system does hold, on average, a level of reserves slightly greater than its level of required reserves. These excess reserves holdings are needed to meet the daily unpredictable net inflow or outflow of funds that each bank faces.[8] Excess reserves, when added to required reserves, yield total reserve holdings: $TR = RR + ER$. To give some sense of the magnitudes involved, in June 2002, seasonally adjusted total reserves of U.S. depository institutions averaged \$39.3 billion, of which \$38.0 billion were required reserves. By contrast, $M1$ averaged \$1.2 trillion in June 2002 and $M2$ averaged \$5.6 trillion. An economic expansion that increases the demand for money on the part of the public will lead to an increase in the banking sector's demand for reserves as required reserves rise with the growth of deposits.

The demand for reserves will also depend on the costs of reserves and on any factors that influence money demand–aggregate income, for example. In order to focus on the very short-run determination of reserve aggregates and the funds rate, factors such as aggregate income and prices are simply treated as part of the error term in the total reserve demand relationship, allowing us to write

$$TR^d = -ai^f + v^d, \tag{2}$$

where TR^d represents total reserve demand, i^f is the funds rate (the rate at which a bank can borrow reserves in the private market), and v^d is a demand disturbance. This disturbance will reflect variations in income or other factors that produce fluctuations in deposit demand. One interpretation of (2) is that it represents a relationship between the innovations in total reserve demand and the funds rate after the lagged effects of all other factors have been removed.

[7] The actual precedure in the United States involves maintaining an average reserve level over a two-week maintenance period based on the average level of deposit balances two weeks earlier. For a discussion of these points, see Hamilton (1996).

[8] Models of excess reserve holdings are generally based on inventory-theoretic models. Banks hold an inventory of reserves to balance stochastic payment flows. There is a cost asssociated with holding excess reserve balances that are too large (reserves don't pay interest) and with holding balances that are too small (the cost of borrowing reserves to offset a deficit position).

For example, Bernanke and Mihov (1998) attempt to identify policy shocks by focusing on the relationships among the innovations to reserve demand, reserve supply, and the funds rate obtained as the residuals from a VAR model of reserve market variables. They characterize alternative operating procedures in terms of the parameters linking these innovations.[9]

The total supply of reserves held by the banking system can be expressed as the sum of the reserves that banks have borrowed from the Federal Reserve System plus nonborrowed reserves:

$$TR_t^s = BR_t + NBR_t.$$

The Federal Reserve can control the stock of nonborrowed reserves through open market operations; by buying or selling government securities, the Fed affects the stock of nonborrowed reserves. For example, a purchase of government debt by the Fed raises the stock of nonborrowed reserves when the Fed pays for its purchase by crediting the reserve account of the seller's bank with the amount of the purchase. Open market sales of government debt by the Fed reduce the stock of nonborrowed reserves. So the Fed can, even over relatively short time horizons, exercise close control over the stock of nonborrowed reserves.

The stock of borrowed reserves depends on the behavior of private banks and on their decisions about borrowing from the Fed (borrowing from the discount window). Bank demand for borrowed reserves will depend on the opportunity cost of borrowing from the Fed (the discount rate) and the cost of borrowing reserves in the federal funds market (the federal funds rate). An increase in the funds rate relative to the discount rate makes borrowing from the Fed more attractive and leads to an increase in bank borrowing. The elasticity of borrowing with respect to the spread between the funds rate and the discount rate will depend on the Fed's management of the discount window. Traditionally, the Fed has maintained the discount rate below the federal funds rate. This creates an incentive for banks to borrow reserves at the discount rate and then lend these reserves at the higher market interest rates. To prevent banks from exploiting this arbitrage opportunity, the Fed used nonprice methods to ration bank borrowing. This nonprice rationing affects the degree to which banks turn to the discount window to borrow as the incentive to do so, the spread between the funds rate and the discount rate, widens. Banks must weight the benefits of borrowing reserves in a particular week against the possible cost in terms of reduced future access to the discount window. Banks reduce their current borrowing if they expect the funds rate to be higher in the future because they prefer to preserve their future access to the discount window, timing their borrowing for periods when the funds rate is high. Therefore, borrowing decisions depend on the expected future funds rate as well as the current funds rate:

$$BR_t = b_1\left(i_t^f - i_t^d\right) - b_2 \mathrm{E}_t\left(i_{t+1}^f - i_{t+1}^d\right) + v_t^b, \tag{3}$$

[9] Kasa and Popper (1995) employ a similar approach to study monetary policy in Japan. Leeper, Sims, and Zha (1996) develop a more general formulation of the links between reserve market variables in an identified VAR framework.

where i^d is the discount rate (a policy variable) and v^b is a borrowing disturbance.

In 2002, the Fed proposed changing the way it administers the discount window. Under the new proposals, the discount rate would be set above the federal funds rate. Banks that qualify for *primary credit* could borrow at a rate 1% above the funds rate; *secondary credit* would be available at a rate 1.5% above the funds rate. By converting the discount rate into a penalty rate, the arbitrage opportunity created when the discount rate is below the funds rate will be eliminated. With a penalty rate, the need for nonprice rationing at the discount window is reduced. Because empirical work on the U.S. reserve market relies on data from periods when the discount rate was kept below the funds rate, our model of the reserve market will assume that $i^f > i^{\ d}$.

The simplest versions of a reserve market model often postulate a borrowing function of the form

$$BR_t = b(i_t^f - i_t^d) + v_t^b. \tag{4}$$

The manner in which an innovation in the funds rate affects borrowings, given by the coefficient b in (4), will vary, depending on how such a funds rate innovation affects expectations of future funds rate levels. Suppose, for example, that borrowings are actually given by (3) and that policy results in the funds rate following the process $i_t^f = \rho i_{t-1}^f + \xi_t$. Then $\mathrm{E}_t i_{t+1}^f = \rho i_t^f$ and, from (3), $BR_t = b i_t^f$, where $b = b_1 - \rho b_2$.[10] A change in operating procedures that leads the funds rate to be more highly serially correlated (increases ρ) will reduce the response of borrowings to the funds rate-discount rate spread.[11] While relationships such as (4) can help us to understand the linkages that affect the correlations among reserve market variables for a given operating procedure, we should not expect the parameter values to remain constant across operating procedures.

To complete the reserve market model, we need to specify the Fed's behavior in setting nonborrowed reserves. To consider a variety of different operating procedures, assume the Fed can respond contemporaneously to the various disturbances to the reserve market, so that nonborrowed reserves are given by

$$NBR_t = \phi^d v_t^d + \phi^b v_t^b + v_t^s, \tag{5}$$

where v^s is a *monetary policy shock*. Different operating procedures will be characterized by alternative values of the parameters ϕ^d and ϕ^b.[12]

Equilibrium in the reserve market requires that total reserve demand equal total reserve supply. This condition is stated as

$$TR_t^d = BR_t + NBR_t. \tag{6}$$

[10] For simplicity, this ignores the discount rate i^d for the moment.

[11] Goodfriend (1983) provides a formal model of borrowed reserves; see also Waller (1990). For a discussion of how alternative operating procedures affect the the relationship between the funds rate and reserve aggregates, see Walsh (1982). Attempts to estimate the borrowings function can be found in Peristiani (1991) and Pearce (1993).

[12] Note that ϕ^d and ϕ^b correspond to ϕ in (1.9) of chapter 1 since they reflect the impact of nonpolicy originating disturbances on the policy variable NBR.

If a month is the unit of observation, reserve market disturbances are likely to have no contemporaneous effect on real output or the aggregate price level.[13] Using this identifying restriction, Bernanke and Mihov (1998) obtain estimates of the innovations to TR, BR, i^f, and NBR from a VAR system that also includes GDP, the GDP deflator, and an index of commodity prices but in which the reserve market variables are ordered last.[14] Whether any of these VAR residuals can be interpreted directly as a measure of the policy shock v^s will depend on the particular operating procedure being used. For example, if $\phi^d = \phi^b = 0$, (5) implies that $NBR = v^s$; this corresponds to a situation in which the Fed does not allow nonborrowed reserves to be affected by disturbances to total reserve demand or to borrowed reserves, so the innovation to nonborrowed reserves can be interpreted directly as a policy shock. Under such an operating procedure, using nonborrowed reserve innovations (i.e., NBR) as the measure of monetary policy, as Christiano and Eichenbaum (1992a) do, is correct. However, if either ϕ^d or ϕ^b differs from zero, NBR will reflect nonpolicy shocks as well as policy shocks.

Substituting (2), (4), and (5) into the equilibrium condition (6) and solving for the innovation in the funds rate yields

$$i_t^f = \left(\frac{b}{a+b}\right) i_t^d - \left(\frac{1}{a+b}\right)\left[v_t^s + (1+\phi^b)v_t^b - (1-\phi^d)v_t^d\right]. \tag{7}$$

The reduced-form expressions for the innovations to borrowed and total reserves are then found to be

$$BR_t = -\left(\frac{ab}{a+b}\right) i_t^d - \left(\frac{1}{a+b}\right)\left[bv_t^s - (a-b\phi^b)v_t^b - b(1-\phi^d)v_t^d\right] \tag{8}$$

$$TR_t = -\left(\frac{ab}{a+b}\right) i_t^d + \left(\frac{1}{a+b}\right)\left[av_t^s + a(1+\phi^b)v_t^b + (b+a\phi^d)v_t^d\right]. \tag{9}$$

How does the Fed's operating procedure affect the interpretation of movements in nonborrowed reserves, borrowed reserves, and the federal funds rate as measures of monetary policy shocks? Under a federal funds rate operating procedure, the Fed offsets total reserve demand and borrowing demand disturbances so that they do not affect the funds rate. According to (7), this policy requires that $\phi^b = -1$ and $\phi^d = 1$. In other words, a shock to borrowed reserves leads to an equal but opposite movement in nonborrowed reserves to keep the funds rate (and total reserves) unchanged (see 5), while a shock to total reserve demand leads to an equal change in reserve supply through the adjustment of nonborrowed reserves. The innovation in nonborrowed reserves is equal to $v^s - v^b + v^d$ and so does not reflect solely exogenous policy shocks.

[13] Referring back to the discussion in section 1.3.4, this assumption corresponds to the use of the assumption that $\theta = 0$ to identify VAR innovations.

[14] The commodity price index is included to eliminate the price puzzle discussed in chapter 1. This creates a potential problem for Bernanke and Mihov's identification scheme, since forward-looking variables such as asset prices, interest rates, and commodity prices may respond immediately to policy shocks. See the discussion of this issue in Leeper, Sims, and Zha (1996), who distinguish between policy, banking sector, production, and information variables.

Under a nonborrowed reserve procedure, $\phi^b = 0$ and $\phi^d = 0$ as innovations to nonborrowed reserves reflect policy shocks. In this case, (7) becomes

$$i_t^f = \left(\frac{b}{a+b}\right) i_t^d - \left(\frac{1}{a+b}\right)\left(v_t^s + v_t^b - v_t^d\right), \tag{10}$$

so innovations in the funds rate reflect both policy changes and disturbances to reserve demand and the demand for borrowed reserves. In fact, if v^d arises from shocks to money demand that lead to increases in measured monetary aggregates, innovations to the funds rate can be positively correlated with innovations to broader monetary aggregates. Positive innovations in an aggregate such as $M1$ would then appear to increase the funds rate, a phenomenon found in the VAR evidence reported in chapter 1.

From (8), a borrowed reserves policy corresponds to $\phi^d = 1$ and $\phi^b = a/b$, since adjusting nonborrowed reserves in this manner insulates borrowed reserves from nonpolicy shocks. That is, nonborrowed reserves are fully adjusted to accommodate fluctuations in total reserve demand. Under a borrowed reserves procedure, innovations to the funds rate are, from (7),

$$i_t^f = \left(\frac{b}{a+b}\right) i_t^d - \left(\frac{1}{a+b}\right)\left[v_t^s + \left(1 + \frac{a}{b}\right) v_t^b\right]$$

so the funds rate reflects both policy and borrowing disturbances.

Table 9.1 summarizes the values of ϕ^d and ϕ^b that correspond to different operating procedures.

Table 9.1
Parameters Under Alternative Operating Procedures

	Operating Procedure			
	Funds Rate	Nonborrowed	Borrowed	Total
ϕ^d	1	0	1	$-\frac{b}{a}$
ϕ^b	-1	0	$\frac{a}{b}$	-1

In general, the innovations in the observed variables can be written (ignoring discount rate innovations) as

$$\begin{bmatrix} i_t^f \\ BR_t \\ NBR_t \end{bmatrix} \equiv u_t = \begin{bmatrix} -\frac{1}{a+b} & -\frac{1+\phi^b}{a+b} & \frac{1-\phi^d}{a+b} \\ -\frac{b}{a+b} & \frac{a-b\phi^b}{a+b} & \frac{b(1-\phi^d)}{a+b} \\ 1 & \phi^b & \phi^d \end{bmatrix} \begin{bmatrix} v_t^s \\ v_t^b \\ v_t^d \end{bmatrix} \equiv A v_t. \tag{11}$$

By inverting the matrix A, we can solve for the underlying shocks, the vector v, in terms of the observed innovations u: $v = A^{-1}u$. This operation produces

$$\begin{bmatrix} v_t^s \\ v_t^b \\ v_t^d \end{bmatrix} = \begin{bmatrix} b\phi^b - a\phi^d & -(\phi^d + \phi^b) & 1 - \phi^d \\ -b & 1 & 0 \\ a & 1 & 1 \end{bmatrix} \begin{bmatrix} i_t^f \\ BR_t \\ NBR_t \end{bmatrix}.$$

Hence,

$$v_t^s = (b\phi^b - a\phi^d)i_t^f - (\phi^d + \phi^b)BR_t + (1 - \phi^d)NBR_t, \tag{12}$$

so that the policy shock can be recovered as a specific linear combination of the innovations to the funds rate, borrowed reserves, and nonborrowed reserves. From the parameter values in table 9.1, we have the following relationship between the policy shock and the VAR residuals:

$$\begin{aligned} \text{Funds Rate Procedure} &: \quad v_t^s = -(b + a)i_t^f \\ \text{Nonborrowed Procedure} &: \quad v_t^s = NBR_t \\ \text{Borrowed Reserves Procedure} &: \quad v_t^s = -\left(1 + \frac{a}{b}\right) BR_t \\ \text{Total Reserves Procedure} &: \quad v_t^s = \left(1 + \frac{a}{b}\right) TR_t \end{aligned}$$

Policy shock cannot generally be identified with innovations in any one of the reserve market variables. Only for specific values of the parameters ϕ^d and ϕ^b, that is, for specific operating procedures, might the policy shock be recoverable from the innovation to just one of the reserve market variables.

1.3 Reserve Market Responses

This section will use the basic reserve market model to discuss how various disturbances affect reserve quantities and the funds rate under alternative operating procedures. Figure 1 illustrates reserve market equilibrium between total reserve demand and supply. For values of the funds rate less than the discount rate, reserve supply is vertical and equal to nonborrowed reserves. With the discount rate serving as a penalty rate, borrowed reserves fall to zero in this range, so that total reserve supply is just NBR. As the funds rate increases above the discount rate, borrowings become positive (see 4) and the total supply of reserves increases. Total reserve demand is decreasing in the funds rate according to (2).

Consider first a positive realization of the policy shock v^s. The effects on i^f, BR, and NBR can be found from the first column of the matrix A in (11). The policy shock increases nonborrowed reserves (we could think of it as initiating an open market purchase that increases banking sector reserve assets). In figure 1, the reserve supply curve shifts to the right horizontally by the amount of the increase in NBR. Given the borrowed reserves and total reserve demand functions, this increase in reserve supply causes the funds rate to fall. Bank borrowing from the Fed decreases because the relative cost of borrowed reserves

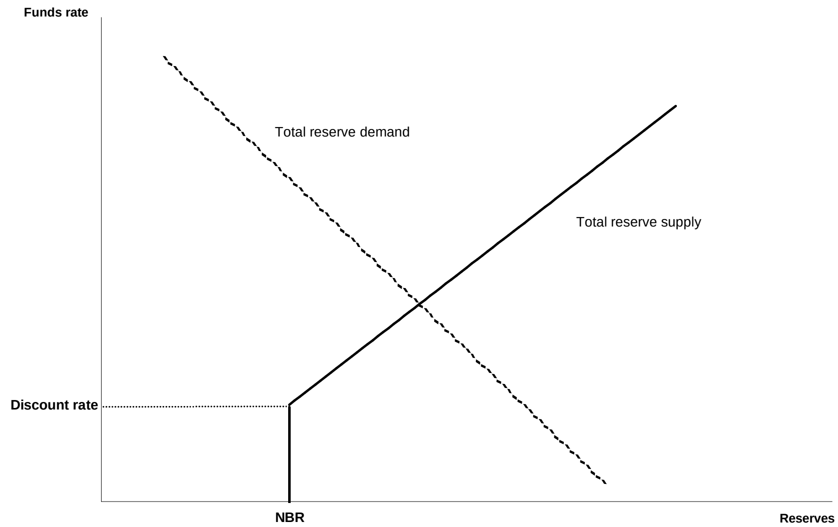

Figure 1: The Reserves Market

$(i^d - i^f)$ has risen, partially offsetting some of the increase in total reserve supply.[15] A policy shock is associated with an increase in total reserves, a fall in the funds rate, and a fall in borrowed reserves.

It is the response to nonpolicy disturbances that will differ, depending on the operating procedures (see the second and third columns of A; the elements of these columns depend on the ϕ^j parameters). Suppose there is a positive disturbance to total reserve demand, $v^d > 0$. This shifts total reserve demand to the right from RD to $R\prime D\prime$, as shown in figure 2. In the absence of any policy response (i.e., if $\phi^d = 0$), the funds rate increases (shown as the move from point A to point B in figure 2). This increase reduces total reserve demand (if $a > 0$), offsetting to some degree the initial increase in reserve demand. The rise in the funds rate induces an increase in reserve supply as banks increase their borrowing from the Fed. Under a funds rate operating procedure, however, $\phi^d = 1$; the Fed lets nonborrowed reserves rise by the full amount of the rise in reserve demand to prevent the funds rate from rising. Both reserve demand and reserve supply shift to the right by the amount of the disturbance to reserve demand, and the new equilibrium is at point C with an unchanged funds rate. Thus, total reserve demand shocks are completely accommodated under a funds rate procedure. If the positive reserve demand shock originated from an increase in the demand for bank deposits as a result of an economic expansion, a funds

[15] This analysis assumes that the discount rate has not changed; the Fed could, for example, change the discount rate to keep $i^f - i^d$ constant and keep borrowed reserves unchanged. Since the total supply of reserves has increased, the funds rate must fall, so this would require a cut in the discount rate.

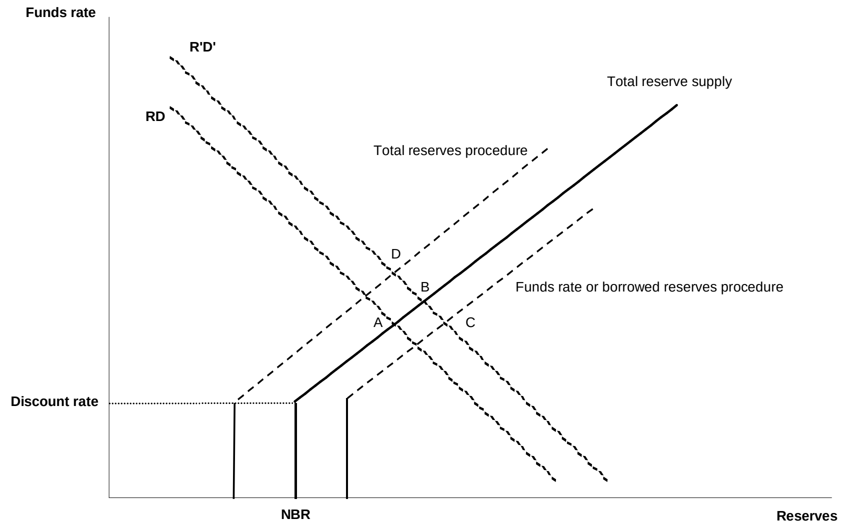

Figure 2: The Reserves Market Response to a Reserve Demand Increase

rate procedure automatically accommodates the increase in money demand and has the potential to produce procyclical movements of money and output.[16]

In contrast, under a total reserves operating procedure, the Fed would adjust nonborrowed reserves to prevent v^d from affecting total reserves. From (9), this requires that $\phi^d = -b/a$; nonborrowed reserves must be reduced in response to a positive realization of v^d. It is not sufficient to just hold nonborrowed reserves constant; the rise in the funds rate caused by the rise in total reserve demand will induce an endogenous rise in reserve supply as banks increase their borrowing from the Fed. To offset this, nonborrowed reserves are reduced. Equilibrium under a total reserves procedure is at point D in figure 2. Thus, while a funds rate procedure offsets none of the impact of a reserve demand shock on total reserves, a total reserves procedure offsets all of it.

Under a nonborrowed reserve procedure, $\phi^d = 0$; hence, a positive shock to reserve demand raises the funds rate and borrowed reserves. Total reserves rise by $-ai^f + v^d = [b/(a+b)]\, v^d < v^d$. So reserves do rise (in contrast to the case under a total reserves procedure) but by less than under a funds rate procedure.

Finally, under a borrowed reserves procedure, a positive shock to total reserve demand will, by increasing the funds rate, also tend to increase bank

[16] Since we have defined operating procedures in terms of the innovations to reserves and the funds rate, we have not said anything about the extent to which the funds rate might be adjusted in subsequent periods to offset movements in reserve demand induced by output or inflation.

borrowing. To hold borrowed reserves constant, the Fed must prevent the funds rate from rising (i.e., it must keep $i^f = 0$; see 4). This objective requires letting nonborrowed reserves rise. So in the face of shocks to total reserve demand, a funds rate operating procedure and a borrowed reserves procedure lead to the same response. In terms of figure 2, both a funds rate procedure and a borrowed reserves procedure result in a new equilibrium at point C. As (10) shows, however, a borrowed reserves operating procedure is an inefficient procedure for controlling the funds rate in that it allows disturbances to the borrowings function (i.e., v^b shocks) to affect the finds rate. These results are summarized in table 9.2.

Table 9.2
Response to a Positive Reserve Demand Shock

	Operating Procedure			
	FF	BR	NBR	TR
Funds rate	0	0	+	+
Total reserves	+	+	+	0
Nonborrowed reserves	+	+	0	−
Borrowed reserves	0	0	+	+

Now suppose there is a positive shock to bank borrowing; $v^b > 0$. The increase in borrowed reserves, by increasing total reserves, will lower the funds rate. Under a funds rate procedure, the Fed prevents this outcome by reducing nonborrowed reserves ($\phi^b = -1$) to fully neutralize the effect of v^b on the total reserve supply. The same response would occur under a total reserves operating procedure. In contrast, under a nonborrowed reserves procedure, $\phi^b = 0$, so the increase in borrowed reserves also increases total reserve supply, and the funds rate must decline to clear the reserve market. These results are summarized in table 9.3.

Table 9.3
Response to a Positive Shock to Borrowed Reserves

	Operating Procedure			
	FF	BR	NBR	TR
Funds rate	0	−	−	0
Total reserves	0	+	+	0
Nonborrowed reserves	−	+	0	−
Borrowed reserves	+	0	+	+

While the focus has been on the reserve market, it is important to keep in mind that the purpose of reserve-market intervention by the Fed is not to affect the funds rate or reserve measures themselves. The Fed's objective is to influence its policy-goal variables such as the rate of inflation. The simple money-multiplier framework that was discussed earlier provides a link between the reserve market and other factors affecting the supply of money. The observed quantities of the broader monetary aggregates then reflect the interaction of the supply of and demand for money. Movements in the funds rate are linked to longer-term interest rates through the term structure, a topic discussed in chapter 10.