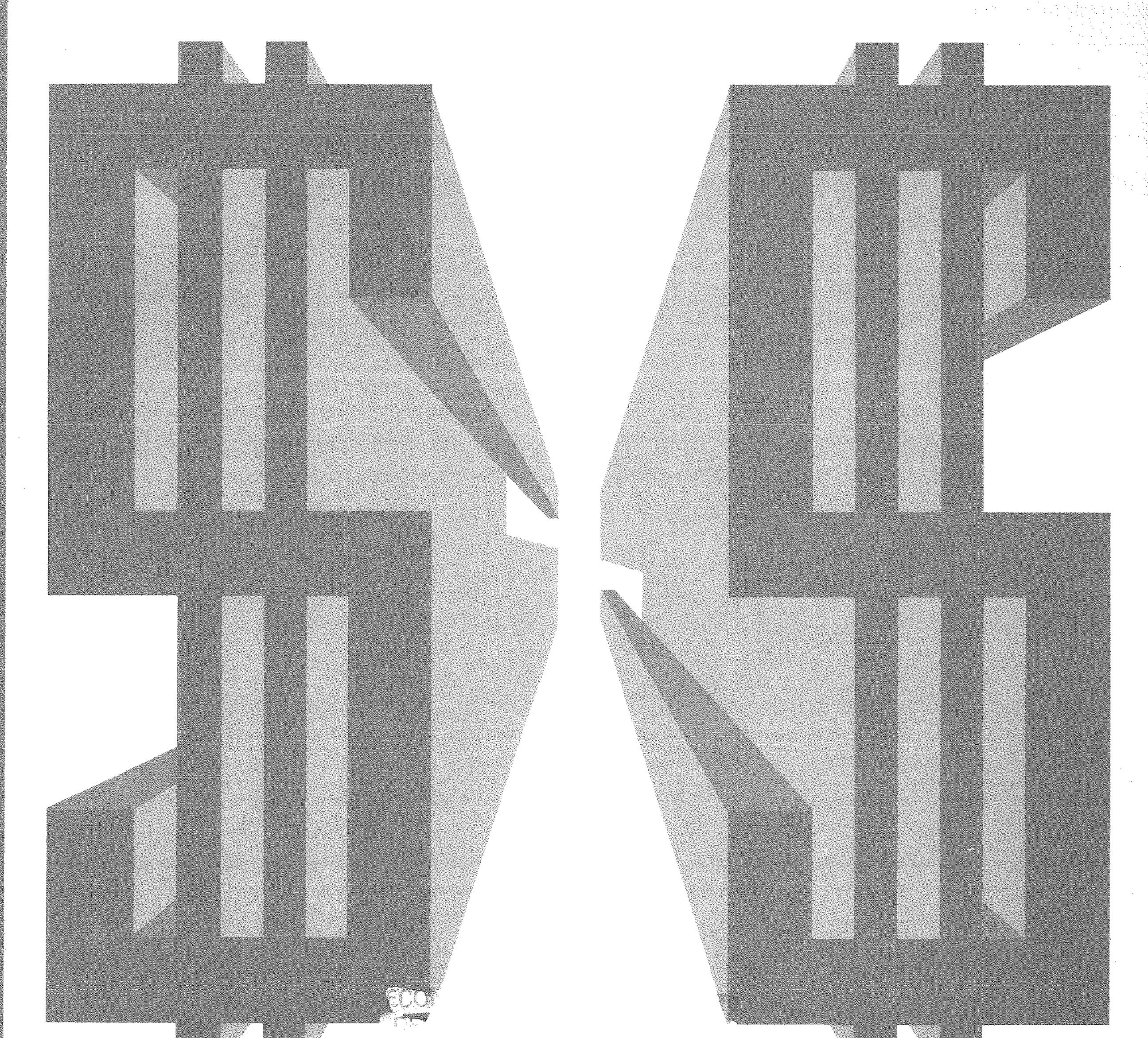
FEDERAL RESERVE BANK OF SAN FRANCISCO ECONOMIC REVIEW SUMMER 1981



MONETARY POLICY AND INTEREST RATES

Liability Management, Bank Loans, And Deposit "Market" Disequilibrium

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High rates of inflation during the past decade have increasingly focused the attention of policy makers and the general public on the importance of bringing the monetary aggregates under control. The Federal Reserve System now has an official goal of slowly reducing growth rates in the monetary aggregates over the next few years in order to lower rates of inflation gradually. Since October 1979, the Fed has attempted to improve monetary control by focusing its short-run operations on achieving targets for bank reserves, and by letting the Federal-funds rate vary more widely than previously had been the case.[1]

Despite these procedural changes, the monetary aggregates gyrated widely in 1980, and were significantly above or below the Fed's longer-run targets at various times during the year. This paper discusses a monthly money-market model which provides an explanation for the surprisingly high variability of money in 1980. The model shows how certain types of financial-market disturbances, such as sharp changes in bank loans, can affect the money supply and thus cause problems of monetary control. The evidence indicates that large swings in bank loans, induced primarily by the Special Credit Control Program, were the major source of money's variability in 1980.

This explanation has no role in conventional models, which view the supply of deposits as being determined by the public's demand, given short-term rates of interest, income and prices.[2] With a conventional model, unexpected movements in the monetary aggregates often reflect changes in the past relationship between the public's demand for money and its determinants – that is, reflect a "shift" in the demand function for money. There is little doubt, in retrospect, that such a downward shift occurred in 1975-76, when historically high interest rates induced the public to economize on money balances.[3] In far greater doubt, however, are assumed subsequent "shifts" of shorter duration, such as the one in the second quarter of 1980. The present paper argues that the rapid monetary deceleration in the second quarter of 1980 (as well as the rapid growth in the first and third quarters) was caused, not by a money-**demand** shift, but by a money-**supply** "shock" induced by changes in bank loans. This is a crucial distinction for policymakers. A downward shift in the demand for money makes a given money supply more expansionary. Thus the appropriate policy is to lower the money supply. On the other hand, a downward money-supply "shock" for a given demand for money makes policy more contractionary. Thus the appropriate policy response is to offset the money-supply "shock" through faster growth in bank reserves.

Whereas conventional models emphasize the demand for money, the model in this paper emphasizes the supply of money, with banks playing an important role in determining that supply. In particular, it explicitly incorporates bank loans and banks' management of non-deposit liabilities into the determination of transaction deposits.[4] In this approach, banks maximize profits by satisfying the public's

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demand for loans with funds raised with the least costly mix of managed liabilities (such as large certificates of deposit and repurchase agreements). The outcome of this process is an aggregate "supply" of transaction deposits, which varies inversely with the Federal-funds rate and directly with the commercial-paper rate and with bank loans.

The model treats money as a buffer stock in the public's portfolio. Loan-induced increases in the money supply thus exert an especially powerful impact on the monetary aggregates in the model. When the public demands additional bank loans, it temporarily absorbs the deposits that are created in the process without significant interest-rate changes in the short-run: i.e., money-supply shocks induced by bank-loan movements can put the market for money into temporary disequilibrium. This means that changes in bank loans have a large short-run effect on the public's money holdings and a relatively small effect on interest rates.

The model therefore provides a theoretical rationale to explain why changes in the **supply** of money can dominate short-run movements in the monetary aggregates. The empirical section provides three pieces of evidence consistent with this hypothesis. They involve the speed with which banks adjust reserves when interest rates change, with the contribution that bank-loan changes make to explaining movements in money, and with the extent to which money-supply shocks temporarily shift the public's demand curve for money.

Section I of the paper describes the theoretical model. Here we show how the model determines the stock of transaction deposits, total reserves, and the Federal-funds and commercial-paper rates. Section II reports the results of estimating the model on lunar-monthly data (four-week blocks) for the sample period July 1976 to September 1979. This section also considers the results of simulating the model both over the sample period and out of sample over the post-October 1979 period — the period marked by the Federal Reserve's adoption of a new reserve-operating procedure. Section III uses the simulation results to assess the cause of the volatility in the monetary aggregates in 1980. Section IV summarizes the conclusions and the policy implications of the model.

I. Theoretical Model

The model is designed to analyze the behavior of the commercial banks, nonbank public and Federal Reserve in the markets for transaction deposits and bank reserves. Thus the primary variables determined by the model include the stock of transaction deposits and the commercial-paper rate in the deposit market, and the stock of reserves and the Federal-funds rate in the reserves market. The underlying characteristics of the model are described in three distinct stages, which are summarized in Table 1. Each stage includes the preceding stage(s), so that by stage 3, the model is complete. A formal specification of the model is presented in Appendix A.

Stage 1 analyses the markets in which commercial banks sell nondeposit liabilities (such as large certificates of deposit and repurchase agreements) to the nonbank public. As shown below, demands for and supplies of these instruments — expressed as functions of own and substitute yields as well as the sizes of the banks' and public's portfolios — are sufficient to determine the banking system's mix of liabilities between deposits and nondeposits. The level of deposits implied by this mix constitutes the banking system's "supply" of transaction deposits. Note that in Stage 1, the "supply" of deposits is defined as a function of the Federal-funds rate, and therefore abstracts of conditions in the market for reserves.

Stage 2 introduces the Federal Reserve by adding to the analysis the market for bank reserves. The banking system's desired mix between nondeposit liabilities and deposits determined in Stage 1, together with the reserve-requirement ratios on these categories of bank liabilities, define the banking system's demand for total reserves. The supply of reserves comes from 1) the amount of borrowing from the Federal Reserve, and 2) the amount of nonborrowed reserves supplied by the Fed. The addition of the supply of reserves allows the reserves market to clear at equilibrium values of the funds rate and total reserves. In Stage 2, both the reserves and nondeposit-liabilities markets clear. Hence the supply of deposits at this stage is consistent not only with the banks' preference among liabilities, but also with the banks' and the Fed's desired level and composition of reserves.

Stage 3 introduces the public's demand for transaction deposits. The interaction of this demand with the supply of deposits determined in Stage 2 completes the solution of the model. Here it is not strictly accurate to speak of market equilibrium because the market for deposits allows for short-run disequilibrium. Nevertheless, since the model defines the source and size of that disequilibrium, the deposit market can determine the stock of deposits and the commercial-paper rate. The remainder of this section describes each stage in more detail.

Stage 1: Nondeposit Liabilities

The analysis begins with the description of the portfolio behavior of an individual bank (Figure 1). A minimum of seven categories of bank assets and liabilities is necessary to preserve the model's usefulness as a foundation for empirical research. These categories are total reserves, R; bank loans, BL; private transaction deposits (including demand, ATS and NOW accounts), DB; other deposits (primarily small time and savings), TB; managed liabilities less security holdings, IMB;[5] member-bank borrowing, RB; and net Federal funds purchased and repurchase agreements, FF/RP. The last three items together constitute what we call nondeposit liabilities.

The short-run problem of a representative bank involves financing a given stock of loans. Banks consider loans to be exogenous on a monthly basis, because the short-run demand is relatively interest inelastic — and because banks often respond sluggishly in altering their loan rates when their marginal costs of funds change, waiting for signs that such cost changes are not transitory.

Part of the bank's loan portfolio is financed by transaction and other deposits, which it

Table 1

Stages of the Model

	Markets	Behavioral Relations	Variables or Relations Solved For	Variables Affecting Solution
Stage 1	Banks' nondeposit liabilities	1. Banks' supplies of nondeposit liabilities 2. Public's demand for nondeposit liabilities	a. **Supply of deposits-1** b. Banks demand for total reserves c. CD Rate	i) Funds rate ii) Commercial paper rate iii) Discount rate iv) Bank loans
Stage 2	Bank reserves	1. Banks' demand for total reserves 2. Federal Reserve's supply of reserves	a. **Supply of deposits-2** b. Funds Rate c. Total Reserves	i) Nonborrowed reserves target ii) Commercial paper rate iii) Discount rate iv) Bank loans
Stage 3	Transaction deposits	1. **Supply of deposits-2** 2. Public's demand for deposits	a. Stock of deposits b. Commercial paper rate	i) Nonborrowed reserves target ii) Discount rate iii) Bank loans iv) Personal income

regards as exogenous in the short run. The bank adjusts implicit deposit rates sluggishly — as it does the loan rate — viewing the quantity of deposits in the short run as being essentially determined by the public's demand. Banks must finance the excess of loans over deposits by selling nondeposit liabilities to the public. The **individual** bank's short-run portfolio choice involves choosing the structure of nondeposit liabilities — among IMB, FF/RP and RB.

The bank's portfolio choices are the outcomes of maximizing expected profits subject to the balance-sheet constraint. In the very short run, only IMB, FF/RP and RB can be adjusted. The factors influencing expected profits include, among other things, the explicit interest costs of each of three liability items — the rate on longer-term managed liabilities (such as CDs), denoted by i_0; the discount rate, i_B; and the Fed-funds rate, i_F. As well, expected profits depend on the risk and liquidity characteristics of assets and liabilities, so that the marginal returns or costs of each portfolio item include a marginal non-interest element in addition to the explicit interest cost.[6] For example, banks' borrowings from the Federal Reserve depend not only on the discount rate, but also on banks' traditional "reluctance to borrow" from the Fed. Given these variables — as well as the (exogenous) size of the portfolio to be financed, (BL + R - DB - TB) — individual banks sell optimal quantities of IMB, FF/RP and RB to the noncommercial-bank sectors.

The quantities of these instruments actually observed depend on the interaction of the banks' supplies of various types of nondeposit liabilities with the nonbank public's demands for them. The latter depends upon relative yields and other characteristics (e.g., risk) of the bank and nonbank assets in the public's portfolio, together with the overall size of that portfolio.[7]

The interaction between the banks and the nonbank public in the markets for banks' nondeposit liabilities is critical to the model, because equilibrium in these markets determines the "supply" of deposits created by the banking system. Equilibrium is depicted in Figure 2 by the curve EQ. This curve represents all combinations of the funds rate and bank nondeposit liabilities (IMB + FF/RP) which are consistent with equilibrium between the banks' supplies of and the public's demands for IMB and FF/RP (for expositional purposes we assume that RB = 0).

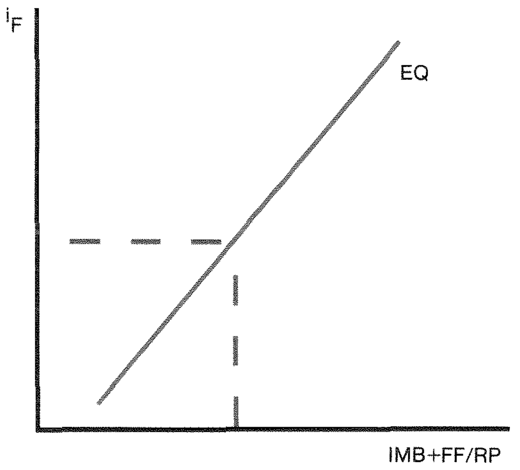
Movements along EQ are determined in the following manner. Assume that the funds rate rises. Since banks consider FF/RP a substitute for IMB as a source of funds, they will respond by raising their offer rates on IMB.[8] Since rates on **both** IMB and FF/RP have risen, the public's demand for the total of those instruments would also have risen, with the net inflow of funds having been drawn from nonbank instruments (such as commercial paper), whose rates had not increased. Thus an increase in the funds rate induces an increase in i_O, which results on balance in a rise in banks' total nondeposit funds.

The increased purchases of IMB + FF/RP extinguish demand deposits as the public draws down its checking accounts to pay for them. This process ensures that the banks' balance sheets will be in equilibrium. If banks attract more nondeposit funds, their need for deposits decreases, given the size of the loan portfolio to be financed. The destruction of deposits that accompanies the inflow of non-

Figure 1
Representative Bank Balance Sheet

Assets		**Deposits and Nondeposit Liabilities**	
Reserves:	R	Transaction deposits	DB
		Other deposits	TB
Loans:	BL	Managed liabilities less security holdings	IMB
		Net Fed funds purchased plus repurchase agreements	FF/RP
		Member bank borrowing	RB

Figure 2
Equilibrium in the Markets for Banks' Nondeposit Liabilities



deposits ensures that the new mix of liabilities is consistent with the banking system's portfolio needs. Thus the combination of EQ — which describes the nondeposit funds supplied by the public for each level of the funds rate — and the bank's portfolio constraint implicitly defines the stock of deposits which is consistent with both the banks' and public's preferences for nondeposits.

The combinations of i_F and DB that satisfy both EQ and the bank's portfolio constraint constitute the Stage 1 supply of deposits (DB^s-1). A higher funds rate leads to fewer deposits being supplied. This occurs because the inflow of nondeposit funds to banks resulting from the funds-rate increase causes banks to extinguish deposits as their need for them declines. DB^s - 1 is also a function of the nonfinancial commercial-paper rate (representing the rate on the public's nonbank instruments) and the banking system's portfolio scale variable, BL + R - TB (referred to as SCALE below).

DB^s-1 is positively related to the nonfinancial commercial-paper rate, which means that its curve shifts to the right when i_{cp} rises. The public regards commercial paper as a substitute for bank liabilities like RPs and large CDs. Hence a rise in the paper rate will reduce the public's demand for bank nondeposit liabilities as they shift funds into commercial paper. Banks will respond by raising offer rates on nondeposit liabilities, but this will be insufficient to stem completely the exodus of funds. As a result, banks will end up supplying more transaction deposits, which they create as they buy back managed liabilities from the nonbank public.

A rise in SCALE also shifts DB^s-1 to the right. A rise in bank loans, for example, increases the size of the portfolio banks must finance, with a consequent increase in SCALE. For given i_F and i_O, the amount of nondeposit liabilities is fixed by the public's demand for these liabilities. Consequently, the supply of bank deposits must increase by the increase in loans if rates are not to change. These deposits constitute the proceeds of loans, which are spent by the initial borrower and flow into the accounts of his suppliers, employees and the like.

Stage 2: Reserves

The deposit-supply function of Stage 1 was defined as a function of the funds rate. In Stage 2, we add the reserves market; this determines the funds rate along with a more comprehensive definition of the supply of deposits, denoted DB^s-2, which includes the influence of the Federal Reserve's conduct of monetary policy.

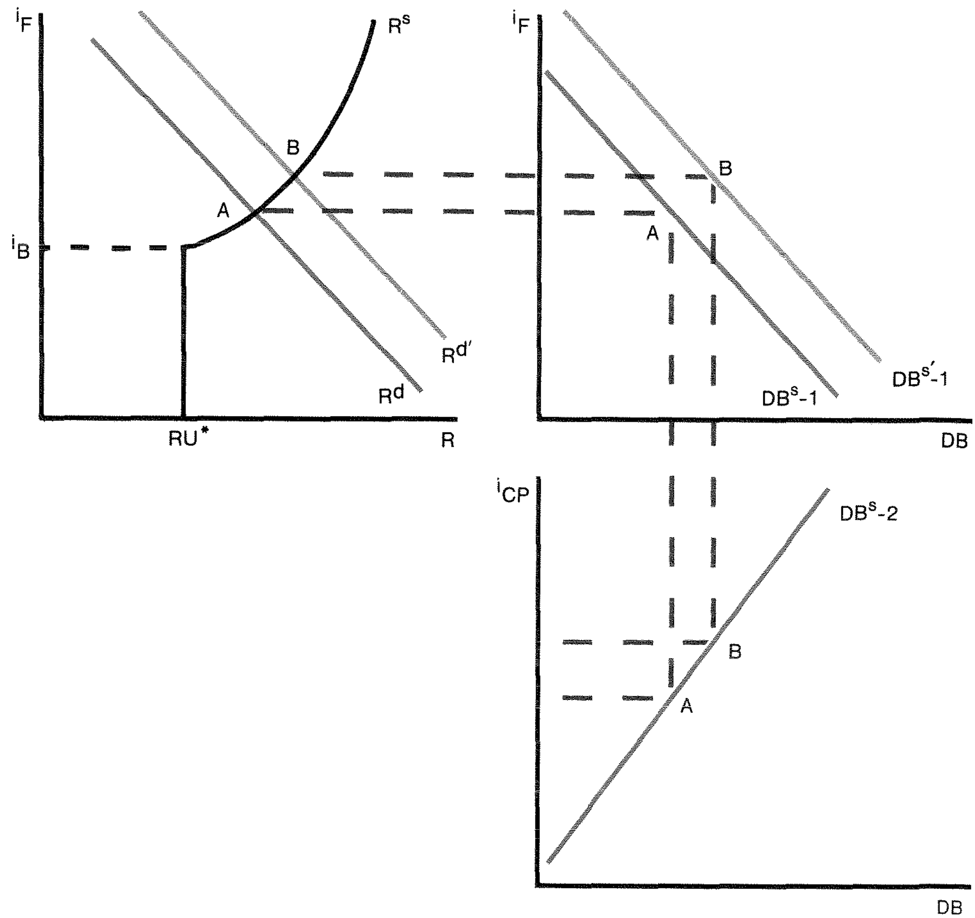
The right-hand diagram of Figure 3 shows DB^s-1 from Stage 1. In the left-hand diagram, R^d plots the amounts of required reserves the banking system would need to hold for each point on DB^s-1. This will depend upon the required-reserve ratio for transaction deposits. (For expositional purposes, only transaction deposits are considered reservable.) The higher the level of transaction deposits supplied, the larger are required reserves. Hence lower funds rates, which are consistent with a larger quantity of deposits supplied, are in turn associated with a greater need or "demand" for reserves. The graph of all such combinations of funds rates and required reserves therefore can be thought of as defining the banking system's demand function for reserves, depicted in Figure 3 as R^d.

The description of the factors determining the total amount of reserves available — the supply of reserves — is conditional on the Federal Reserve's choice of operating procedure. We assume the current procedure, whereby the Federal Reserve determines a target for nonborrowed reserves; in Figure 3 one such target is illustrated by the vertical line RU*.

Total reserves available can be larger than RU*. Banks may borrow reserves from the Federal Reserve on a temporary basis, instead of borrowing in the Federal-funds market. Consequently, a higher funds rate leads banks to switch from the Fed-funds market to the Federal Reserve's discount window, adding to the aggregate stock of reserves in the system. The amount borrowed will also depend on the discount rate (i_B), the rate charged by the Fed for such borrowing. At funds rates below the discount rate, banks have little incentive to borrow, so that total reserves are roughly equal to nonborrowed reserves (this accounts for the vertical portion of R^s below the "kink" at $i_F = i_B$). But as the funds rate rises above the discount rate, banks respond to a profit incentive and expand their borrowing from the Fed. However, the amount of this borrowing is limited by the banks' reluctance to borrow, which effectively determines the slope of R^S at funds rates above the kink. Since the reluctance to borrow tends to rise as the level of

Figure 3

Derivation of Stage 2 Deposit Supply



borrowing rises, R^s becomes more steeply sloped at higher funds rates.[9] In Figure 3, discount-window borrowing as a function of the funds rate is added to the nonborrowed-reserves target to obtain total reserves available, or what we call reserves supply, R^s.

The interaction of reserves supply, reserves demand and DB^s-1 determine market-clearing levels for the funds rate, total reserves and the Stage 2 supply of deposits (DB^s-2). As noted earlier, DB^s-1 is defined for different funds rates, whereas DB^s-2 is co-determined with the funds rate for any given level of the Federal Reserve's monetary-control instrument. Point A in the upper two graphs of Figure 3 illustrates the determination of DB at stage 2 for the case in which the Fed uses nonborrowed reserves as its instrument.[10]

The movement from A to B shows the effect on Stage 2 DB of an increase in the commercial-paper rate. As seen from the discussion of Stage 1, a rise in the commercial-paper rate shifts DB^s-1 to the right. This shift, shown in the NE diagram of Figure 3, is associated with an increase in the demand for reserves in the NW diagram. The increased demand for reserves puts upward pressure on the funds rate. Hence the increase in i_{CP} causes both i_F and DB to rise from A to B. Levels of Stage 2 deposits are plotted against the commercial-paper rate in the SE diagram, and denoted by DB^s-2.

An increase in the Federal Reserve's nonborrowed-reserves operating instrument causes DB^s-2 to rise. For example, a larger stock of nonborrowed reserves puts downward pressure on the funds rate. As a result, borrowed reserves fall, offsetting part of the increase in RU. In addition, the lower funds rate induces banks to cut the rates they pay on other nondeposit liabilities, so that the public reduces its holdings of these instruments, causing banks to create more deposits. The net effect in the reserves market is a movement down along the R^d curve, with a lower funds rate and a higher level of total reserves. In the deposit market, the Stage 2 supply curve shifts to the right. For any given commercial-paper rate, a lower funds rate induces a lower equilibrium quantity of IMB + FF/RP, and thus a larger supply of deposits.

An increase in bank loans also has a positive effect on DB^s-2. When bank loans rise, banks' managed liabilities **and** deposits rise at unchanged interest rates: i.e., both R^d and DB^s-2 shift to the right. The increased demand for reserves causes the funds rate to rise, as banks are "forced" to the discount window for a larger quantity of reserves when nonborrowed reserves are held constant. The higher funds rate eliminates part of the increase in banks' reserves demand and deposit supply, but on balance both quantities rise.

Note that the influence of bank loans on deposit supply depends heavily on the behavior of the Federal Reserve. If, for example, the Fed held the funds rate constant in the face of an increase in bank loans, the partial offset of the increase in DB^s-2 could not occur. As a consequence, the impact of a bank-loan increase would be larger than in the case where the Fed held nonborrowed reserves constant and allowed the funds rate to rise. By an analogous argument, the Fed could reduce nonborrowed reserves to such an extent that a change in bank loans would have no influence on the quantity of deposits supplied.

Stage 3: Transaction Deposits

Only in the last stage is the public's demand for transaction deposits introduced. This demand is used in conjunction with the Stage 2 deposit supply to solve for the commercial-paper rate and the stock of transaction deposits. The model allows for the possibility of market disequilibrium by distinguishing two concepts of deposit demand. The first — short-run **equilibrium** demand — is the conventional relationship in which deposit demand is a function of short-term interest rates, income and lagged deposits. We include lagged deposits in this function to allow for incomplete adjustment of the public's demand in the short-run to changes in interest rates and income.

Conventional practice treats this short-run equilibrium demand as equal to the actual stock of deposits: i.e., it views the public as always being on its demand function. The present model, however, allows for temporary disequilibrium in the deposit market, in which the commercial paper rate does **not** adjust to make the actual stock equal to the short-run equilibrium demand at each moment of time.[11]

Actual deposits are therefore identified with the second concept of short-run demand — the **disequilibrium** demand for deposits. This differs from its equilibrium counterpart to the extent that market disturbances originating in certain types of shifts in the Stage 2 money supply temporarily force the public off the equilibrium demand curve. This approach makes an important distinction between the demand for money and the demand for credit. Changes in the quantity of bank loans, for example, are assumed to be in accordance with equilibrium in the bank-loan market. However, these loan changes have an important by-product: the creation or destruction of deposits. Since changes in credit demand are not necessarily associated with equal changes in deposit demand, the public ends up temporarily holding deposits it does not want: i.e., it only accepts the deposits because this is a necessary part of accepting the credit it does want.

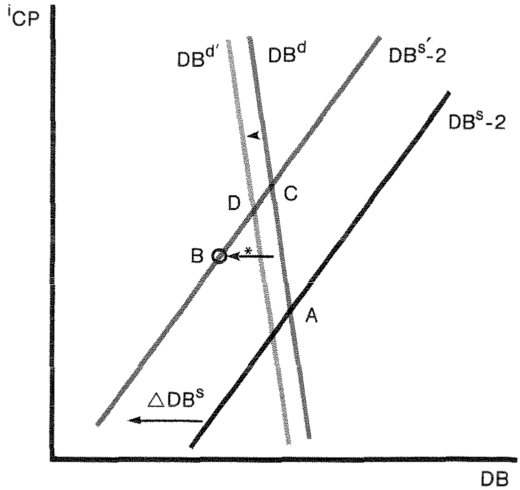
The important question is whether the public remains in disequilibrium for a long enough time to permit this effect to show up in monthly observations. The persistence of disequilibrium will depend, in part, upon the size of transaction costs involved in adjusting money balances to desired levels, and will vary among classes of depositors. Transaction costs may be relatively small for large businesses, who have at their disposal a number of highly liquid financial instruments (e.g., repurchase agreements) with which to adjust deposit holdings. In contrast, households and others could face relatively large transaction costs. Inflows of "unwanted" deposit balances do not lead them to make immediate portfolio adjustments by the full amount necessary to restore equilibrium.

Disequilibrium in the deposit market could persist longer than it takes an individual depositor to adjust to desired balances. One depositor's equilibrium may be another depositor's disequilibrium. To the extent that depositors reduce their unwanted balances by purchasing goods and services and securities from other members of the public, the latter's deposit balances may exceed desired levels. This process of spending and respending persists until the unwanted deposits are "sold" back to banks for nondeposit liabilities (reducing deposit supply) and/or income and prices rise enough (raising deposit demand) to restore equilibrium to the deposit market.

Finally, the actions of the Federal Reserve can significantly influence disequilibrium in the deposit market. If the Fed moves RU so as to peg the funds rate, for example, it would in effect allow the full impact of bank-loan changes on deposit supply to be felt in the deposit market. If, on the other hand, the Fed hits its nonborrowed reserves targets and lets the funds rate vary, the impact of bank loans on deposit-market disequilibrium will be muted. Furthermore, under such a reserves-control procedure, the Fed could be an important source of disequilibrium itself. Assume, for example, that the Fed exogenously increased total reserves in excess of required reserves. Banks might lend out these excess reserves by purchasing Treasury securities

Figure 4

Effect of Deposit Supply "Shock" on Observed Deposits



Note: $\overset{*}{\leftarrow} = \lambda \Delta DB^s$

from the public. The Treasury-bill rate would fall enough to induce the public to sell bills, but the associated increase in deposits (i.e., the proceeds of the bill sales) would not necessarily be demanded in the equilibrium sense in the short-run. The deposit market would be in (temporary) disequilibrium to the extent that this occurs.

The process by which bank loans influence the deposit market is illustrated in Figure 4. The curve DB^d denotes the short-run equilibrium demand for deposits as a function of the commercial-paper rate, i_{CP}, with nominal income, Y, held constant. A decrease in bank loans is illustrated by a leftward shift in the deposit-supply function by the horizontal distance, ΔDB^s. This disturbance causes the public to end up holding fewer deposits than the equilibrium-demand curve would indicate. In the short-run, i_{CP} and DB^d move from point A to point B rather than to the point C indicated by the equilibrium-demand function. At point B, DB^s differs from DB^d by some fraction λ of the initial DB^s "shock". This disequilibrium reduces interest-rate variability in response to deposit-supply disturbances such as changes in bank loans. (The same may also be true for changes in nonborrowed reserves when they are a source of deposit-market disturbances.) Graphically, the process of the move back to equilibrium can be thought of as made up of 1) movements along DB^s as interest rates adjust, and 2) leftward shifts in DB^d (shown by $DB^{d'}$) as income and prices change until equilibrium is reached at D.

The theoretical model is completed with the addition of descriptions of the public's demands for currency (C) and other deposits (TB) as functions of income, the commercial-paper rate and other variables. These equations will be described in more detail in the next section.

II. Empirical Model

We summarize the empirical version of the theoretical model in Table 2, and report the corresponding estimation results in Table 3. (Appendix B contains a glossary of variable names.) The empirical version of the model recapitulates, with modifications, the theoretical model, but it also includes additions to explain other components of M1B besides demand deposits, and to account for the other important uses of reserves besides those held against demand deposits and nondeposit funds. (A fuller accounting for the uses of reserves, along with a more complete description of some of the modifications discussed below, can be found in Appendix C). But more importantly, the empirical model includes modifications to the core equations dictated by the fairly complex structure of reserve requirements in the real world.

Two of the equations from the theoretical model carry over with minor changes. They are the banks' aggregate demand for reserves against demand deposits and nondeposit funds, denoted RA and described in equation (2.1), and the banks' demand for borrowed reserves described in equation (2.3). Reserves demand now includes the discount rate, i_B, which had previously been assumed to be constant, and the reserve ratio against nondeposit liabilities, r_l, which had been assumed to be zero. Equations (2.1), (2.3), the specification of the Federal Reserve's supply of nonborrowed reserves (equation (2.11)) and the supply of deposits (2.12) together constitute the empirical version of Stage 2 of the model, which is used to solve for the funds rate, the quantity of reserves, and DB^s-2.

The empirical counterpart of Stage 3 is used to solve for the commercial-paper rate and the quantity of demand deposits. This version consists of the public's demand for demand deposits, equation (2.5), and the corresponding supply of demand deposits (DB^s-2). The latter relationship is where the empirical version departs most significantly from the theoretical model.

In the theoretical discussion, the derivation of deposit supply in Stage 2 was trivial: the

Table 2
Empirical Model

Behavioral Relations

	Description	Banks, Thrifts and Public	Estimated Equation (see Table 3)
(2.1)	Banks' demand for reserves	$RA = RA(\overset{-}{i_F}, \overset{+}{i_{CP}}, \overset{-}{i_B}, \overset{+}{SCALE}, \overset{+}{r_D}, \overset{+}{r_l})$	(3.1)
(2.2)	Banks' demand for reserves (two week lag)	$RA_{t+1/2} = RA'(\overset{-}{i_F}, \overset{+}{i_{CP}}, \overset{-}{i_B}, \overset{+}{SCALE}, \overset{+}{r_D}, \overset{+}{r_l})$	(3.2)
(2.3)	Borrowing from Federal Reserve	$RB = RB(\overset{+}{i_F}, \overset{-}{i_B}, \overset{-}{\Delta RU}, \overset{+}{RB_{t-1}})$	(3.3)
(2.4)	Multiplier	$DB/RA_{t+1/2} = MULT(\overset{-}{r_D}, \overset{-}{r_l}, \overset{?}{SCALE}, \overset{-}{(LTB/DB)}_{t-1})$	(3.4)
(2.5)	Public's demand for demand deposits	$DB^d = DB^d(\overset{-}{\Sigma i_{CP}}, \overset{+}{\Sigma Y}, \overset{+}{\Delta BL})$	(3.5)
(2.6)	Public's demand for savings deposits	$SB = SB(\overset{-}{i_{CP}}, \overset{+}{Y}, DUM(.), \overset{+}{SB_{t-1}})$	(3.6)
(2.7)	Public's demand for small time deposits	$STB = STB(\overset{-}{i_{CP}}, \overset{+}{Y}, DUM(.), \overset{+}{STB_{t-1}})$	(3.7)
(2.8)	Public's demand for currency	$C^d = C^d(\overset{+}{\Sigma Y})$	(3.8)
(2.9)	Public's demand for checkable deposits at banks	$OCDB = OCDB(OCDB_{t-1}, OCDB_{t-2})$	(3.9)
(2.10)	Public's demand for other checkable deposits at banks and thrifts	$OCD = OCD(OCD_{t-1}, OCD_{t-2}, OCD_{t-3})$	(3.10)

Federal Reserve
Supply of Nonborrowed Reserves

(2.11a)	Funds rate operating procedure	$RU = RU(i_F{}^*, R^d)$
(2.11b)	Reserves operating procedures	$RU = RU^*$

Identities

(2.12)	Supply of demand deposits	$DB = MULT \bullet RA_{t+1/2} = (1/(r_D + r_l(LTB/DB)))RA_{t+1/2}$
(2.13)	Total reserves	$R = RA + r_D DBG_{t-1/2} + r_T(SB_{t-1/2} + STB_{t-1/2} + OCDB_{t-1/2}) + RTH + RE$
(2.14)	M-1A	$M1A = DB + C$
(2.15)	M-1B	$M1B = M1A + OCD$
(2.16)	Excess reserves	$RE = \overline{RE}$
(2.17)	Reserves against thrift deposits	$RTH = \overline{RTH}$
(2.18)	Treasury deposits at commercial banks	$DBG = \overline{DBG}$

reserves-demand function was simply multiplied by the inverse of the required-reserve ratio against demand deposits. This approach implicitly assumed that changes in deposits were fully reflected contemporaneously in reserves, and that only demand deposits were reservable. In the real world, neither is true.

With lagged reserve accounting, changes in deposits do not show up in reserves demand until two weeks later.[12] Even with monthly data, reserves of the current month only **partly** reflect contemporaneous deposit changes. The full effect of deposits shows up in reserves centered two weeks later: i.e., in the average of the last two weeks of this month and the first two weeks of **next** month. Clearly, if we want to predict deposits from reserves, we must use this measure of reserves, i.e., reserves shifted forward half a month.

Hence, two estimates of reserves demand are needed for the empirical model. The first, RA or contemporaneous reserves, is used to explain the funds rate, and is described by equation (2.1). The second, $RA_{t+1/2}$, or reserves shifted forward half a month, is used to predict the supply of deposits for Stage 2, and is described by equation (2.2). To make a uniform two-week lag from deposits to reserves, we must respecify all of the data in the model in lunar months of four weeks each.

Predicting the multiplier is also no longer trivial. The complication arises not because nondeposit funds are reservable, but because the requirement is not uniform across all types of such funds. Consequently, the average reserve-requirement ratio is a function not only of the split between demand deposits and nondeposit funds, but also of the allocation of the latter among reservable and nonreservable categories. As a result, the arguments of RA, which explain the split only, are not necessarily suited to predicting the average reserve-requirement ratio and hence its inverse, the multiplier. Preliminary estimation indicated that the SCALE variable of RA (a measure of the aggregate size of banks' portfolios) helped to explain the multiplier, but that the interest-rate arguments of RA (the funds rate, the commercial-paper rate and the discount rate) did not. Since large CDs (LTB) accounted for almost all of the reserve requirements against nondeposit funds, we used the lagged ratio of large CDs to demand deposits to help predict the multiplier, as shown in equation (2.4). We then multiplied this prediction by $RA_{t+1/2}$ to obtain the deposit-supply function for Stage 2.

Estimation Results

All equations were estimated in seasonally-adjusted lunar-monthly observations (four-week periods) from 1976:Lunar 8 (begins July 21, 1976) through 1979:Lunar 10 (ends October 3, 1979). The ending date coincided with the Federal Reserve's adoption of a monetary-control procedure which focuses primarily on reserves in day-to-day operations. We chose the beginning date to avoid entangling the estimation of the model with the bias inherent in the (mid-1974 to mid-1976) shift in money demand. (Now that the model has been estimated over a fairly "clean" sample period, we are working to extend the sample back to 1973.)

We aggregated seasonally-adjusted weekly figures (where available) to give lunar-month observations, or interpolated where only calendar-month data were available. Both the funds rate and commercial-paper rate are endogenous in the model, so that we used two-stage least squares wherever these rates appeared as explanatory variables in a regression equation. Even though the funds rate was a policy variable under the Fed's pre-October 1979 operating regime, it was not strictly exogenous. The Fed adjusted the rate when money deviated from target,[13] and because money is one of the endogenous variables in the model, this practice effectively made the funds rate endogenous as well. We corrected for first-order serial correlation where the autocorrelation coefficient was significant at the 10-percent level.

The results of estimating the reserves-market equations and the demand-deposit multiplier are reported in Table 3 as equations (3.1) to (3.4). Recall that reserves demand is viewed as reflecting primarily the behavior of deposit supply. The latter in turn is regarded as

Table 3
Estimated Equations

Equation

(3.1) $\ln RA^d_t = \underset{(9.27)}{3.8} - \underset{(1.93)}{.36}(\ln i_{F,t} - \ln i_{CP,t}) - \underset{(1.83)}{.07}\ln i_{B,t-1} + \underset{(4.62)}{.23}\ln SCALE_t$

$+ \underset{(5.49)}{1.04}\ln r_{D,t} - \underset{(1.67)}{.23}\ln r_{1,t} + \underset{(4.06)}{.53}U_{t-1}$

$\bar{R}^2 = .98$
SEE = .0069
DW = 1.89

(3.2) $\ln RA^d_{t+1/2} = \underset{(6.2)}{3.1} - \underset{(2.6)}{.51}(\ln i_{F,t} - \ln i_{CP,t})$

$-\underset{(3.0)}{.12}\ln i_{B,t-1} + \underset{(4.9)}{.30}\ln SCALE_t + \underset{(3.1)}{.70}\ln r_{D,t+1/2} - \underset{(1.0)}{.13}\ln r_{1,t+1/2} + \underset{(2.5)}{.36}U_{t-1/2}$

$\bar{R}^2 = .96$
SEE = .0087
DW = 1.85

(3.3) $RB_t = \underset{(0.19)}{.008} + \underset{(4.61)}{.64}(i_{F,t} - i_{B,t})^{1/2}Z1 - \underset{(7.44)}{.54}\Delta RU_t \cdot Z1 + \underset{(6.14)}{.59}RB_{t-1}$

$Z1 = 1$ when $i_{F,t} > i_{B,t}$

$\quad 0$ when $i_{F,t} \leq i_{B,t}$

$\bar{R}^2 = .92$
SEE = .14
DW = 1.84

(3.4) $\ln MULT_t = \underset{(0.6)}{.01} - \underset{(3.1)}{.075}\ln(LTB_{t-1}/DB_{t-1}) - \underset{(2.6)}{.04}\ln SCALE_t$

$- \underset{(12.1)}{.80}\ln r_{D,t} - \underset{(2.7)}{.13}\ln r_{1,t} + \underset{(7.0)}{.73}U_{t-1}$

$\bar{R}^2 = .97$
SEE = .0026
DW = 1.99

(3.5) $\ln DB_t - .8\ln DB_{t-1} = \underset{(1.42)}{.17} + \underset{(2.16)}{.66}\Delta\ln BL_t + \sum_{i=0}^{6} a_i \ln i_{CP_{t-i}}$

$- .8\sum_{i=0}^{6} a_i \ln i_{CP,t-1-i} + \sum_{i=0}^{3} b_i \ln Y_{t-i} - .8\sum_{i=0}^{3} b_i \ln Y_{t-1-i}$

where

$a_0 = -.016$ (1.24)	$b_0 = .33$ (1.67)
$a_1 = -.015$ (2.02)	$b_1 = .19$ (4.36)
$a_2 = -.014$ (2.75)	$b_2 = .10$ (1.57)
$a_3 = -.012$ (2.39)	$b_3 = .02$ (0.31)
$a_4 = -.010$ (1.81)	
$a_5 = -.008$ (1.46)	
$a_6 = -.006$ (1.22)	
$\Sigma = -.081$ (2.75)	$\Sigma = .64$ (7.47)

$\bar{R}^2 = .88$
SEE = .0038
DW = 1.74

Table 3 (continued)

(3.6) $\ln SB_t = .44 + .11\,(1/i_{CP,t}) + .13 \ln Y_t + .65 \ln SB_{t-1}$
(3.07) (2.44) (4.07) (11.03)

$- .02 MMCDUM_t - .13 BUSDUM_t - .02 ATSDUM_t + .56 U_{t-1}$
(2.63) (2.78) (5.21) (4.36)

$\bar{R}^2 = .998$
SEE = .0024
SW = 1.76

(3.7) $\ln STB_t = -0.05 + .16(1/i_{CP,t}) - .15(1/i_{CP,t}) MMCDUM_t + .16 \ln Y_t$
(.20) (1.54) (2.63) (2.52)

$+ .77 \ln STB_{t-1} + .03 MMCDUM_t + .008 ATSDUM_t + .007 SPRDUM_t + .19 U_{t-1}$
(13.93) (2.92) (4.69) (3.02) (1.29)

$\bar{R}^2 = .999$
SEE = .0029
DW = 2.19

(3.8) $\ln C_t = -1.64 + \sum_{i=0}^{8} a_i \ln Y_{t-i} + .87 U_{t-1}$
(12.2) (11.5)

where

a_0 = .12 (1.62)	a_5 = .09 (3.20)
a_1 = .12 (2.95)	a_6 = .07 (2.42)
a_2 = .12 (8.07)	a_7 = .05 (2.01)
a_3 = .11 (17.92)	a_8 = .04 (1.75)
a_4 = .11 (5.14)	
	Σ = .83 (46.34)

$\bar{R}^2 = .999$
SEE = .0016
DW = 1.57

(3.9) $OCDB_t = .03 + 1.00\, OCDB_{t-1} + .55\, \Delta OCDB_{t-1}$
(1.43) (60.83) (3.96)

$\bar{R}^2 = .989$
SEE = .254
DW = 1.99

(3.10) $OCD_t + .80 + 1.57\, OCD_{t-1} - .73\, OCD_{t-2} + .12\, OCD_{t-3}$
(2.02) (5.32) (1.39) (0.40)

$\bar{R}^2 = .986$
SEE = .473
DW = 2.11

NOTE:
t-statistics are in parentheses.
Estimation method is two-stage least squares with Cochrane-Orcutt adjustment where indicated by the variable U_{t-1}. Instrumental variables used for i_F and i_{CP}. Sample period was 1976: Lunar 8 - 1979: Lunar 10. Distributed lags in (3.5) and (3.8) are second-degree Almon with the tail tied to zero.

being determined by the aggregate size of banks' portfolios, measured by SCALE, and by the fraction financed by nondeposits, which is a function of i_{CP}, i_F, and i_B. Hence RA^d depends on the same variables and is influenced in the same direction by them. In particular, higher i_F and i_B would be expected to lower RA^d, while increases in SCALE and i_{CP} would raise it. Also, increases in the required-reserve ratios, r_D and r_l, should raise RA^d.

The first two lines report the results for the two estimates of reserves demand. Both equations fit the data quite well. All the estimated coefficients have the right signs, and all pass a test of significance at the 95-percent confidence level, except for the coefficients on r_l. Both measures of RA^d are relatively elastic with respect to the funds rate, especially $RA_{t+1/2}$, which determines the elasticity of demand-deposit supply. The RA_t measure of reserves demand should be less responsive to its arguments than is $RA_{t+1/2}$, which in fact is true. The reason is that RA_t reflects only a partial response of demand deposits to changes in the funds rate and the other arguments, because it excludes the requirements against deposits created in the last half of the month. $RA_{t+1/2}$ on the other hand includes reserves against all deposits of the current month, and therefore more accurately measures their response to interest rates and SCALE.

The two versions of reserve demand adjust rapidly to their explanatory variables, with full adjustment occurring in one month. Although we tried a number of distributed-lag specifications, lagged effects of the explanatory variables were consistently insignificant. These findings — rapid speeds of adjustment and relatively large interest elasticities — are consistent with one of our central hypotheses: the supply of deposits results from the interaction of banks and the public in various credit markets, where participants actively maximize profits on a day-by-day and hour-by-hour basis. As noted earlier, this part of the model differs from conventional models, which view deposit supply as accommodating the public's demand for deposits. Since many deposit holders inactively manage their balances, conventional models produce the result that deposits (and thus reserves) respond to interest rates with long lags and low elasticities.

Next, we present the model's representation of the supply of total reserves. Under the funds-rate regime of the estimation period, total reserves supply is simply equal to banks' demand for total reserves, R^d. The only remaining issue concerns what part of this demand is supplied through borrowed and what part through nonborrowed reserves. The estimated member-bank borrowing function is reported in Table 3 equation (3.3). Its arguments are the square root of the differential of the funds rate over the discount rate (defined to be zero when the funds rate is below the discount rate), changes in nonborrowed reserves, and lagged borrowing. It was observed that, when the funds rate fell below the discount rate, member-bank borrowing shrank to a small frictional amount. Thus, we hypothesized that banks borrow from the Federal Reserve primarily when there is sufficient incentive in the form of a positive funds rate/discount rate differential. Tests of this hypothesis were strongly confirmed. As a consequence, we imposed the constraint on the estimated equation that borrowing responds only to positive differentials.

We used the square root of the differential to reflect the increasing administrative pressure and/or reluctance to borrow accompanying a rise in the spread (and therefore in RB). With the square root, the RB equation has the property that RB's responsiveness to a given change in the spread declines as the level of the spread rises.

We also hypothesized that because of lagged reserve accounting, changes in nonborrowed reserves would have a transitory effect on borrowing. Under lagged accounting, required reserves this week are fixed, being determined by deposits of two weeks ago. A reduction in nonborrowed reserves therefore forces banks in the short-run to replace them with borrowed reserves, because the total demand for reserves is unchanged. Thus we should observe a negative relationship between changes in nonborrowed and borrowed reserves.

In the borrowing equation, first, all explanatory variables have the expected signs and are highly significant. Second, the speed of adjustment is again relatively fast — the mean lag is 1.4 lunar months. However, even this relatively quick adjustment seems surprisingly slow when compared to the even faster adjustment in the reserves-demand equations noted earlier. Third, the implied contemporaneous response of borrowing to the funds rate is very large, especially when the spread is very low. Thus a 10-basis-point rise in the funds rate increases borrowing by $64 million when the spread is 25 basis points. When the spread rises to 50, 100 or 200 basis points, a 10-basis-point increase in the funds rate produces $45, $32 and $22 million of additional borrowing, respectively. The long-run responses are about 2½ times larger.

To complete the banking side of the model, we need a prediction of the supply of deposits. This we obtain by multiplying the equation for $RA_{t+1/2}$ (equation (3.2)) by the estimate of the multiplier in equation (3.4). The multiplier is simply a weighted average of the reserve-requirement ratios on demand deposits and nondeposit funds. For reasons explained in Appendix C, large certificates of deposit (LTB) are the only significant reservable "nondeposit" liability. Hence, the multiplier can be written as $1/(r_D + r_l(LTB/DB))$. For reasons discussed above, the ratio LTB/DB is approximated as a function of its lagged value and SCALE. Hence we estimated the multiplier as a function of these two variables and the required-reserve ratios. The coefficients on the latter had the correct negative signs. The coefficient on SCALE was also negative, indicating perhaps that as banks' portfolios increased, they raised nondeposit rates to attract more funds, causing the ratio of CDs to demand deposits to rise.

The demand for demand deposits can be viewed as a disequilibrium process in which deposit-supply shocks move the public away from its equilibrium demand. Over the sample period of this study, bank loans were found to be the major source of money-supply shocks.[14] Changes in bank loans therefore can proxy for money-supply shocks. Disequilibrium caused by past shocks is worked off at a rate of $(1-\rho)$ per month, so that a fraction ρ of last month's disequilibrium persists into the current period. At the same time, the fraction λ of this month's shock is held temporarily, and thus adds to the measure of current disequilibrium. Observed deposits therefore can be written,

$$\ln DB_t = \ln DB_t^d + \rho\,(\ln DB_{t-1} - \ln DB_{t-1}^d) + \lambda \Delta \ln BL_t \qquad (1)$$

The short-run equilibrium demand function for deposits, DB^d, is a function of i_{CP} and nominal income (Y) — which determine the long-run equilibrium demand for deposits — and lagged values of DB^d represent partial adjustment of money demand in the short-run to the long-run equilibrium level. Since we cannot directly observe DB^d — it does not equal DB when there is disequilibrium — we solve for it in terms of interest rates and income by successive substitution, i.e.,

$$\ln DB_t^d = \Sigma a_i \ln i_{cp,t-i} + \Sigma b_i \ln Y_{t-i} \qquad (2)$$

Substituting this result into (1) and rearranging we have[15]

$$\begin{aligned}\ln DB_t = {} & \Sigma a_i \ln i_{cp,t-i} - \rho \Sigma a_i \ln i_{cp,t-1-i} \\ & + \Sigma b_i \ln Y_{t-i} - \rho \Sigma b_i \ln Y_{t-1-i} \\ & + \rho \ln DB_{t-1} + \lambda \Delta \ln BL_t \qquad (3)\end{aligned}$$

Estimates of the demand-deposit demand equation are shown in (3.5). The long-run elasticities on income and the commercial-paper rate are highly significant, and their values are in the "normal" range for traditional money-demand equations. Second, the change in the bank-loan variable is significant, with the expected positive sign. Third, the coefficient on $\Delta \ln BL$ is relatively large. For example, the decline in BL in May 1980 is estimated to have held observed demand deposits to a 1/2-percent growth rate, compared to the 13-percent growth which would have otherwise occurred. Fourth, the estimate of ρ at .8

indicates that deposit-market disequilibrium induced by bank loans persists with a mean lag of four months.

Equation (3.8) presents the public's demand for currency as a function of a distributed lag on nominal GNP. The commercial-paper rate could theoretically enter this equation, but did not do so significantly during the sample period. The combination of DB and C^d provides the model with the stock of M1A.

In order to determine M1B, we must explain M1A plus total other checkable deposits (OCD). The latter includes deposits both at banks and thrifts, although thrift deposits were relatively small, being confined to NOW accounts at institutions in Northeastern states. The major component of OCD during the sample period was commercial-bank ATS (automatic transfer from savings) accounts. These deposits were introduced in November 1978; hence the growth in OCD represents almost entirely the public's accumulation of desired stocks of ATS accounts. This stock adjustment in the public's demand was modelled most effectively as a function of past OCD. (3.10)

The model includes three more demands by the public for bank liabilities: banks' other checkable deposits, equation (3.9); small time deposits, equation (3.7); and passbook savings deposits, equation (3.6). These variables enter the model because banks are required to hold reserves against them. Other checkable deposits at banks (OCDB), like OCD, is modelled as a time series. For savings (SB) and small time deposits (STB), the public's demands determine their quantities. The arguments of these functions include personal income, the commercial-paper rate, and a number of (dummy) variables capturing the effects of various regulatory changes during the sample period (see Appendix B for definitions).

Simulation Results

While Table 3 shows how the estimated equations perform individually, it does not indicate how well all of the model's equations and identities simultaneously predict the endogenous variables of the system. Consequently, we made a full-model static simulation of the sample period, using actual values for lagged dependent variables and applying autocorrelation corrections to preceding month's errors. Table 4 presents the results of this simulation for the four major variables of the model (M1A, M1B, R, i_{cp}).

The model fits the in-sample data for the monetary and reserve aggregates quite well, producing root-mean-squared errors (RMSE) ranging from 0.21 to 0.30 percent of the average levels of M1A, M1B, and R. As is typi-

Table 4
Model Simulations
Root Mean Squared Errors

	In-Sample[1] 1976/L8 - 1979/L10 (Static)	Out-of-Sample[2] 1979/L11 - 1980/L11 (Dynamic)
M1A	$883 million (0.21 percent)	$2,238 million (0.60 percent)
M1B	$1,016 million (0.30 percent)	$2,166 million (0.55 percent)
Total reserves	$108 million (0.24 percent)	$169 million (0.45 percent)
Commercial paper rate	14 basis points (1.7 percent)	195 basis points (15.9 percent)

[1]Federal-funds rate exogenous. All exogenous variables set at actual values.

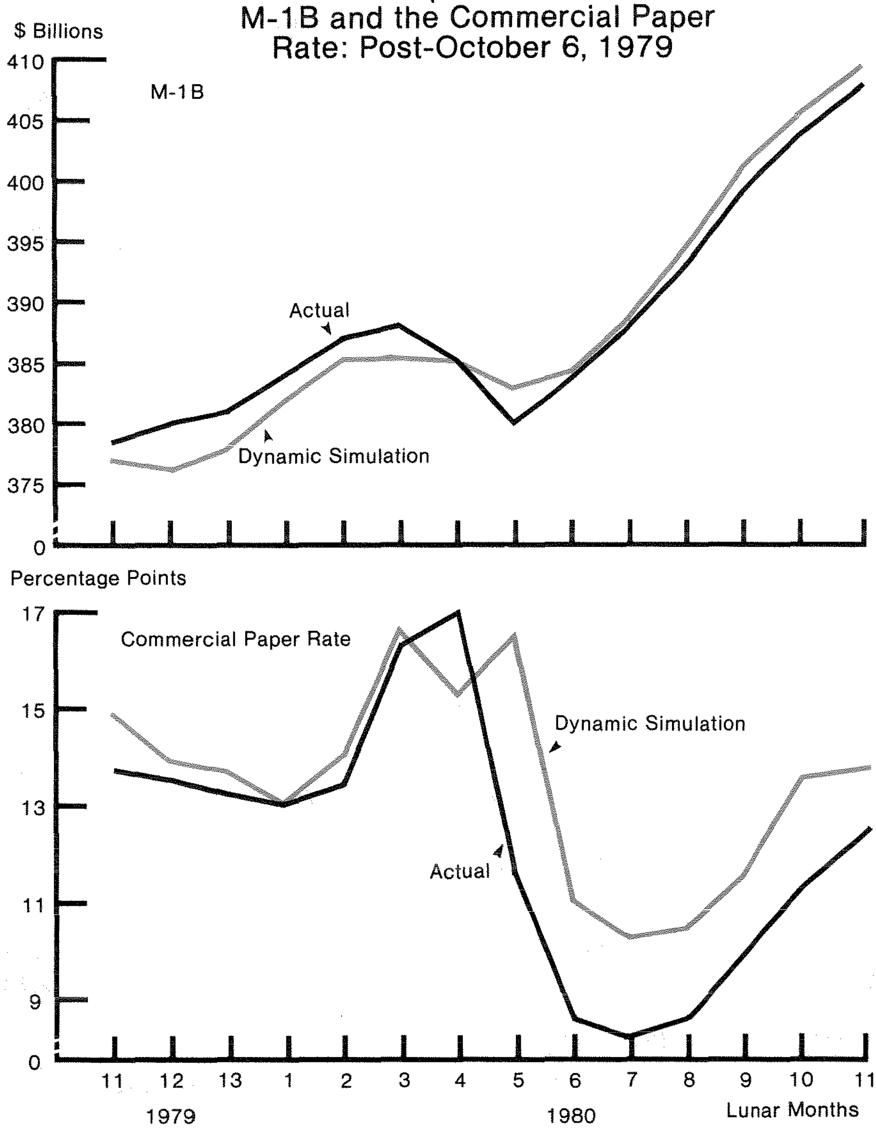
[2]Nonborrowed reserves exogenous in 1979/L11-1980/L5, and 1980/L10-1980/L11. Federal-funds rate exogenous in 1980/L6-1980/L9. All exogenous variables set at actual values.

cal of money-market models, the interest-rate forecasts are less accurate than the monetary and reserve-aggregate forecasts. The RMSE for the commercial-paper rate is 1.7 percent, which amounts to 14 basis points.

The right-hand column of Table 4 shows RMSEs for the same four variables from a dynamic out-of-sample simulation over 1979/L11 - 1980/L11. In this simulation, lagged dependent variables took on values predicted by the model in previous periods, and serial correlation adjustments were applied only to the error in the final in-sample month. Not surprisingly, the RMSEs from this experiment are larger than the in-sample results — for the aggregates, they range from 0.45 to 0.60 percent, while for the commercial-paper rate the RMSE is 15.9 percent. In view of the extreme volatility of the post-October 1979 period compared to the earlier estimation period, we may

Figure 5

Out-of-Sample Predictions of M-1B and the Commercial Paper Rate: Post-October 6, 1979



take the out-of-sample results as a measure of the model's success.

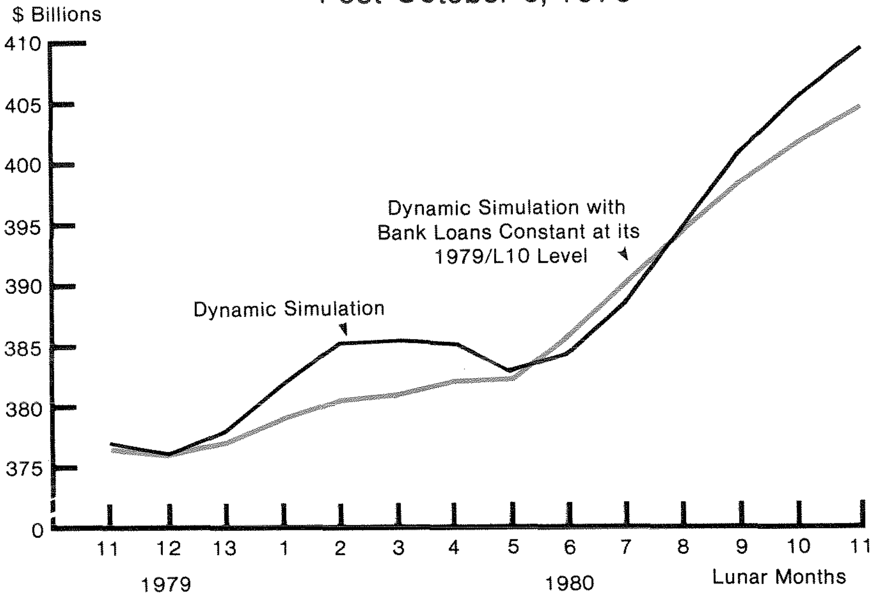
Even more encouraging is the success of the model at predicting the turning points during the period. As shown in Figure 5, the model was able to simulate the rather wild gyrations of M1B, whereas a wide variety of more traditional models missed these turning points.[16] The model did not do quite as well on i_{CP}, specifically missing the large drop in 1980/L5. In other months, however, the simulation tracked reasonably well.

III. Why Were the Aggregates So Volatile in 1980?

Analysis of the model's exogenous variables indicates that changes in bank loans were by far the most important contributor to M1B's rapid growth in the first and third quarters of 1980 — and also to its rapid second-quarter decline. Evidence for this conclusion is presented in Figure 6, which compares two dynamic simulations of M1B. The solid line is a full dynamic simulation — i.e., the same one shown in Figure 5. The dashed line is a simulation with bank loans constant, but identical in every other respect to the full simulation. This experiment indicates that without the post-1979 volatility in bank loans, M1B would not have gyrated as it did.

What accounts for the erratic pattern of bank-loan movements in 1980? The most plausible explanation is the Special Credit Control Program of March 1980, which put binding constraints on bank-credit growth. In the first quarter of 1980, the financial press had reported that businesses were anticipating credit controls. This probably contributed to the rapid growth of loans in that quarter, as

Figure 6
Simulation of the Effect of Bank Loans on M-1B: Post-October 6, 1979



firms attempted to obtain bank credit while it was still available. In the second quarter, loans declined absolutely in response to the binding constraints of the credit controls. Finally, loans spurted in the summer period as firms attempted to make up for the lack of loans in the preceding quarter.

IV. Conclusions

Conventional money-market models reflect the view that the monetary aggregates are determined primarily by the public's demand for money. The money-market model presented in this paper reflects an alternative view — that the monetary aggregates are determined in the short run primarily by the supply of money, which arises out of the behavior of banks and the public in established financial markets. Several pieces of evidence support this hypothesis. First, the money supply responds to its financial-market determinants with very short lags, consistent with the typical speed of adjustment in financial markets, but not with the typical sluggishness of money demand. Second, bank loans can have — and in 1980, did have — a potent influence on the monetary aggregates. Third, the market for money is often characterized by disequilibrium in the short-run. Money-supply "shocks" temporarily push the public off its short-run money-demand curve, which allows the money supply to exert a large short-run influence on the stock of money observed in the economy.

These results have important implications for Federal Reserve monetary policy. First, policy makers should pay close attention to financial-market developments, which can influence the growth of money in a quick and potent fashion. Second, policy makers should be especially careful to evaluate financial-market developments when signs appear of a shift in the conventional money-demand function. A good case in point is the second quarter of 1980, when conventional models severely overpredicted the money stock. Evidence of a downward shift in the money-demand relationship would imply that money supply should be allowed to fall commensurately to avoid an overly expansionary monetary policy. On the other hand, the model in this paper explains the decline in money as a supply shock, induced by the decline in bank loans that followed from the Special Credit Control Program of 1980. Such a conclusion implies that monetary-control efforts should be directed toward more rapid money-supply growth to avoid an overly contractionary policy.

Appendix A
Formal Representation of the Model

The model describes the portfolio behavior of the Federal Reserve, commercial banks and the nonbank public over monthly observations. The balance sheets of commercial banks and the nonbank public are shown below. See Appendix B for definitions of variables.

Commercial Banks		Nonbank Public	
Assets	**Liabilities**	**Assets**	**Liabilities**
R	DB	DB	NW
BL	TB	TB-DBG	BL
	IMB	IMB	OL
	FF/RP	FF/RP	
	RB	OA	
		C	

The Federal Reserve is assumed to control $RU = R - RB$ and i_B, making them exogenous. In addition, the model takes as exogenous BL and Y. BL is exogenous because the public's demand for loans is unresponsive to the contemporaneous (monthly) loan rate, while Y is exogenous because the lag between monetary policy and Y is greater than one month. In addition, individual banks take deposits (DB and TB) as determined entirely by the public's demand for deposits. Since the yields banks pay on these assets are legally held below market-clearing levels, individual banks will supply any quantity demanded by the public. Finally, it is assumed that any quantity of currency demanded by the public will be supplied. Given these assumptions and the profit-maximizing behavior described in Section I of the text, the following structural model may be specified.

$$IMB^s = IMB^s(i_O, i_F, i_B, BL - DB - TB + R) \quad (1)$$
$$IMB^d = IMB^d(i_O, i_F, i_{CP}, Y) \quad (2)$$
$$FF/RP^s = FF^s(i_O, i_F, i_B, BL - DB - TB + R) \quad (3)$$
$$FF/RP^d = FF^d(i_O, i_F, i_{CP}, Y) \quad (4)$$
$$RB^d = RB(i_F, i_B) \quad (5)$$
$$OA^d(i_O, i_F, i_{CP}, Y) - OL^s(i_O, i_F, i_{CP}, Y) = 0 \quad (6)$$
$$DB^d = DB^d(i_{CP}, Y) \quad (7)$$
$$DB - DB^d = DBSH(\Delta DB^s) \quad (8)$$
$$TB^d = TB^d(i_O, i_F, i_{CP}, Y) \quad (9)$$
$$C^d = C^d(i_O, i_F, i_{CP}, Y) \quad (10)$$
$$R^d - RB^d = RU^s \quad (11)$$
$$R^d = r_D DB \quad (12)$$
$$NW = DB + TB - DBG - BL + C + IMB + FF/RP + OA - OL \quad (13)$$

Only twelve of these thirteen equations are independent, and thus any one of them can be dropped from the solution of the model's reduced form. We chose to drop equation 6. The remaining twelve equations can be solved for the following twelve unknowns: IMB, FF/RP, DB, DB^d, TB, C, R, RB, NW, i_O, i_F, i_{CP}.

In Section I of the text, the model is solved in three stages as follows. In Stage 1, equations 1, 2, 3, 4, 5 and 12 are solved for IMB, FF/RP, RB, i_O, DB and R as functions of i_F, i_{CP}, i_B, (BL − TB), Y and other variables. The **sum** of the equations for IMB, FF/RB, and RB provides the EQ equation of the text. The equations for DB and R are the Stage 1 deposit-supply and reserves-demand equations.

In Stage 2, equation 11 is added to the Stage 1 equations, to provide solutions for IMB, FF/RP, RB, i_O, DB, R **and** i_F, as functions of i_{CP}, and i_B, (BL − TB), Y and other variables. The equation for DB is the Stage 2 deposit-supply equation.

In Stage 3, equations 7 and 8 are added to the Stage 2 equations, providing solutions for IMB, FF/RP, RB,i_O, DB, R, i_F , and DB^d and i_{CP}, as functions of i_B, (BL − TB), Y and other variables. Finally, the model can be completed by using equations 9, 10, and 13 to provide solutions for C, TB, and NW.

Appendix B
Glossary of Symbols

ATSDUM	Dummy variable for the introduction of ATS accounts at commercial banks: ln1, ln2, ln3, . . . , ln13, during 1978/L11-1979/L10.
BUSDUM	Dummy variable for the introduction of business and state-and-local government saving deposits at banks: ln20, ln21, ln22, . . . , ln26, during 1976/L7-1976/L12, and ln26 during 1976/L13-1979/L10.
C	Currency in the hands of the public
DB	Private demand deposits at commercial banks.
DBG	U.S. Treasury demand deposits at commercial banks.
DUM(.)	Institutional changes affecting the public's demand for SB and STB; includes ATSDUM, BUSDUM, MMCDUM and SPRDUM.

FF/RP	Net federal funds purchased plus security repurchase agreements at commercial banks.
IMB	Total nondeposit funds plus time deposits in denominations of $100,000 or more, less total holdings of securities at commercial banks, less FF/RP.
LTB	Time deposits in denominations of $100,000 or more.
i_B	Federal Reserve discount rate.
i_{CP}	Three-month nonfinancial commercial-paper rate.
i_F	Federal-funds rate.
i_O	Ninety-day large negotiable certificate-of-deposit rate.
i_{SB}	Passbook-savings rate at commercial banks.
BL	Total loans at commercial banks.
MMCDUM	Dummy variable for the introduction of six-month money market certificates at commercial banks: 1 during 1978/L7-1979/L10; 0 elsewhere.
M1B	C + DB + OCD.
MULT	$DB/RA_{t+1/2}$.
NW	Net worth of the nonbank public = DB + TB − DBG − BL + C + IMB + FF/RP + OA − OL.
OCD	Other checkable deposits at commercial banks and thrift institutions.
OCDB	Other checkable deposits at commercial banks.
OA	Other assets of the nonbank public.
OL	Other liabilities of the nonbank public.
R	Total member-bank reserves, adjusted for Regulations D and M.
RA	Reserve requirements against demand deposits and managed liabilities, adjusted for Regulations D and M.
RB	Borrowed reserves from the Federal Reserve.
RE	Member bank excess reserves.
RR	Member bank required reserves, adjusted for Regulations D and M.
RU	Member bank nonborrowed reserves, adjusted for Regulations D and M.
r_D	Reserve-requirement ratio against demand deposits.
r_l	Reserve-requirement ratio against time deposits in denominations of $100,000 or more.
r_O	Reserve-requirement ratio against IMB.
r_T	Reserve-requirement ratio against SB, STB and OCDB.
SB	Passbook-savings deposits at commercial banks.
SCALE	IMB + FF/RP + RB + DB − RA = BL − TB + (R−RA).
SPRDUM	Dummy variable for the elimination of the 25-basis-point spread between yields on money-market certificates at thrift institutions over commercial banks: 1n1, 1n2, . . . , 1n7 during 1979/L4-1979/L10.
STB	Time deposits in denominations of less than $100,000 at commercial banks.
TB	Other deposits = DBG + OCDB + SB + STB.
Y	Personal income in current dollars.
Z1	Zero when funds rate below or at discount rate. Unity when funds rate above discount rate.

Appendix C
Other Reserve Requirements

The theoretical model focuses on the way that portfolio decisions of banks and the public affect the stock of demand deposits, and through them, the demand for reserves. In reality, other items besides demand deposits are reservable. Small time and savings deposits (SB and STB), government deposits (DBG), other checkable deposits (OCDB), and certain nondeposits also have reserve requirements, and therefore affect the amount of required reserves.[17] In addition, required reserves contain the reserves that thrift institutions must hold (RTH) with the phasing in of the universal reserve requirements mandated by the Monetary Control Act.[18] And finally, measured reserves also include the small amount of excess reserves (RE) that banks hold.

The behavioral relationship underlying reserves demand is framed in terms of demand deposits and nondeposit liabilities only. Hence the other components of reserve requirements must first be stripped away before reserves demand can be estimated. This refined version is called adjusted reserves, RA; its relation to total reserves, R, is shown in the reserves identity (equation 2.13 of Table 2 in the text.)

The other components of total reserves must still be accounted for. This is done in two ways. Excess reserves and requirements against thrift deposits and Treasury deposits are treated as constants over the sample period (equations 2.16, 2.17, and 2.18), since they are small and exhibit only slight variation. The others are treated by estimating the quantities of corresponding deposits and multiplying them by the appropriate reserve ratio. For small time and savings deposits, the public's demands are viewed as determining their quantities, because the banks' scope for altering rates is constrained by interest-rate ceilings. Thus the public's demands for SB and STB are estimated as functions of interest rates, income, and a number of variables representing institutional changes (DUM(.)).[19] The resulting estimates are multiplied by the corresponding reserve ratio to predict the amount of reserves held against them. Estimates of the public's demand for other checkable deposits at banks (equation 2.9) are used in the same way to estimate the reserves held against them.

Recognizing that both demand deposits and some non-deposit liabilities are reservable makes the analysis of the multiplier somewhat more complicated than our theoretical discussion would indicate. In that discussion, we could think of demand deposits alone as having reserve requirements, which meant that the multiplier — the ratio of demand deposits to reserves — was simply the reciprocal of the demand-deposit required-reserve ratio, r_D. With managed funds also reservable, we must also take account of the fact that part of RA will not be available to support demand deposits. The larger the amount of reserves absorbed in requirements against nondeposit liabilities, the smaller will be the amount of demand deposits outstanding per dollar of RA, i.e. the smaller will be the multiplier.

Not all nondeposit liabilities are reservable. For all intents and purposes, large time deposits (LTB) are the only significant ones that are. This is because the model uses a reserve series that abstracts from changes in Regulations D and M, which define reserve requirements. That is, the measure removes discontinuities in the reserves numbers caused by **changes** in required-reserve ratios. If a liability item has incurred reserve requirements only part of the time, its reserves will not show up in the smoothed series because its benchmark ratio is zero. Most reserve requirements on nondeposits have been on-again, off-again (on Eurodollar borrowing, for example) and therefore are not included in our reserve series. The important exception is reserves against LTB, which are included because these large CDs have always been covered by reserve requirements.

Hence our adjusted reserves series, RA, is essentially composed of required reserves against demand deposits and large time deposits. The multiplier therefore depends not only on r_D but as well on LTB (relative to DB) and its reserve ratio, r_L. In the empirical model, the multiplier is estimated as a function of these variables.

FOOTNOTES

1. John P. Judd and John L. Scadding, "Conducting Effective Monetary Policy: The Role of Operating Instruments," **Economic Review,** Federal Reserve Bank of San Francisco, Fall 1979, pp. 23-37.

2. See Thomas D. Thomson, James L. Pierce and Robert T. Parry, "A Monthly Money Market Model," **Journal of Money, Credit and Banking,** November 1975, pp. 411-431.

3. Richard D. Porter, Thomas D. Simpson, and Eileen Mauskopf, "Financial Innovation and the Monetary Aggregates," **Brookings Papers on Economic Activity,** I:1979, pp. 213-224.

4. The money-supply part of the present model is in the spirit of the model in Franco Modigliani, Robert Rasche, and J. Philip Cooper, "Central Bank Policy, the Money Supply, and the Short Term Rate of Interest," **Journal of Money, Credit and Banking,** May, 1970, pp. 166-217.

5. Managed liabilities and security holdings are combined because they serve basically the same function in banks' balance sheets — they provide liquidity. See Jack Beebe, "A Perspective on Liability Management and Bank Risk," **Economic Review,** Federal Reserve Bank of San Francisco, Winter 1977, pp. 12-25.

6. Ernst Baltensperger, "Alternative Approaches to the Theory of the Banking Firm," **Journal of Monetary Economics,** January 1980, pp. 1-38. He distinguishes the following non-interest costs: for liabilities, their associated costs of liquidity management (e.g., differences in withdrawal risk) and costs of producing and maintaining deposit contracts; on the asset side, risks of default, and information and transaction costs associated with extending different types of credit. Baltensperger also includes differences in the cost of acquiring or disposing of an asset or liability.

7. The nonbank public's balance-sheet constraint is derived from the following balance sheet.

Assets		**Liabilities**	
Currency	C	Loans from Banks	BL
Demand Deposits	DB	Other Liabilities	OL
Other Deposits	TB-DBG	Net Worth	NW
Managed liabilities of bank (net of bank securities holdings)	IMB		
Net Federal Funds lent plus repurchase agreements	FF/RP		
Other assets	OA		

8. Thomas D. Simpson, "The Market for Federal Funds and Repurchase Agreements," Board of Governors of the Federal Reserve System, **Staff Studies,** Number 106, July 1979, has detailed the growing importance of Federal funds and repurchase agreements as alternatives to managed liabilities.

9. See Murray E. Polakoff and William L. Silber, "Reluctance and Member Bank Borrowing: Additional Evidence," **Journal of Finance,** March 1967, pp. 88-92.

10. Until October 6, 1979, the Fed used the funds rate as its operating instrument. To achieve its targets, the Fed set RU so that the funds rate which cleared the reserves market equalled the funds-rate target. This procedure makes DB^s-1 and DB^s-2 empirically indistinguishable. However, the theoretical distinction noted above still applies: DB^s-2 includes Fed behavior, whereas DB^s-1 remains the same no matter what the Fed's operating procedures are.

11. This approach is in the tradition of the following research: Jack Carr and Michael R. Darby, "The Role of Money Supply Shocks in the Short-Run Demand for Money," U.C.L.A. Discussion Paper, No. 98, September 1978 (forthcoming, **Journal of Monetary Economics);** Warren L. Coats, "Modeling the Short-Run Demand for Money with Exogenous Supply," unpublished paper, Board of Governors of the Federal Reserve System, 1979; Michael R. Darby, "The Allocation of Transitory Income Among Consumers' Assets," **American Economic Review,** December 1972, pp. 928-941; Dennis R. Starleaf, "The Specification of Money Demand/Supply Models Which Involve the Use of Distributed Lags," **Journal of Finance,** September 1970, pp. 743-760; and D. Tucker, "Macroeconomic Models and the Demand for Money Under Market Disequilibrium," **Journal of Money, Credit and Banking,** February 1971, pp. 57-83. For a discussion of the conventional approach see Gregory C. Chow "On the Long-Run and Short-Run Demand for Money", **Journal of Political Economy,** April 1966, pp. 111-131.

12. See Warren L. Coats, "Lagged Reserve Accounting and the Money Supply Process," **Journal of Money, Credit and Banking,** May 1976, pp. 239-246, and Daniel E. Laufenberg, "Contemporaneous Versus Lagged Reserve Accounting," **Journal of Money, Credit and Banking,** May 1976, pp. 239-246.

13. See Paul DeRosa and Gary H. Stern, "Monetary Control and the Federal Funds Rate," **Journal of Monetary Economics,** April 1977, pp. 217-230.

14. There is no theoretical reason why this must be so. Rather, the importance of bank loans presumably reflects in part the fact that the Federal Reserve used a Federal-funds instrument to try to control money during the sample period. As discussed in the theoretical section, this procedure allowed bank

loans the fullest scope to affect the supply of money. But during the simulation period (1980) — despite the Fed's reserves-control procedure — bank loans remained an important source of disequilibrium because of the very large impact of the Special Credit Control Program.

15. Equation 3 resembles an autoregressive transformation of a conventional short-run deposit-demand function, in which actual deposits are identified with short-run equilibrium demand. This transformation is frequently used in conventional estimates of short-run money-demand functions because of evidence of significant serial correlation in the residuals. The disequilibrium specification (1) suggests that there is a structural explanation for this serial correlation: namely, the process by which equilibrium is restored in the money market. As well, however, the disequilibrium specification differs from the conventional by a term which measures the effect on money demand of current money-supply disturbances.

16. See David Lindsey and others, "Monetary Control Experience Under the New Operating Procedures," Federal Reserve Staff Study - Volume II, **New Monetary Control Procedures,** February 1981.

17. Reserve-requirement ratios include the effects of the proportion of each deposit type held at member banks: i.e., $r_D = r_m(DM/DB)$, where r_m is the average ratio imposed on member banks, DM is member-bank demand deposits subject to reserve requirements, and DB is all bank demand deposits. Weekly data are available for DM/DB. Member-to-total bank ratios of .70 and .63 were used for SB and STB throughout the sample period. The member-to-total bank series for LTB was calculated for each month as the residual from the above data and assumptions, and from currently available reserve-requirement data.

18. J. A. Cacy and Scott Winningham, "Reserve Requirements Under the Depository Institutions Deregulation and Monetary Control Act of 1980," **Economic Review,** Federal Reserve Bank of Kansas City, September - October 1980, pp. 3-16.

19. These consist of the following: the introduction of business and state and local government passbook-savings deposits; the introduction of six-month MMCs at banks; the introduction of ATS accounts; and the removal of the 25-basis-point thrift differential on MMCs.