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ALTERNATIVE RESERVE CONCEPTS AS OPERATING TARGETS IN MONETARY POLICY IMPLEMENTATION: SPECIFICATION OF THE STRUCTURAL MODEL*

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I

Introduction

Monetary policy is concerned both with the ultimate goals of price stability, full employment, and economic growth, and with the short-run stability of financial markets. Financial markets are important not only for their own sake, but also as the mechanism through which the Federal Reserve affects the economy generally. Since the ultimate goals of economic policy are remote in time and causal connection from the everyday conduct of open market operations, the Federal Reserve finds it useful to direct its attention toward intermediate variables, or operating targets, closer in time and under more positive control than ultimate goals.

Recent papers concerning optimal monetary policy have concentrated on that aspect of the policy process involving the linkage of a single intermediate target with ultimate goals such as real income, price stability and unemployment. Poole [21], for example, uses the LM/IS model to demonstrate that whether the money supply or the interest rate is the optimal intermediate target depends upon the relative stability of the LM or IS curve. Similarly, Holbrook and Shaprio [20] use the Theil [22] approach and a small analytical model to demonstrate that preference for a money supply strategy rests on the stability of demand in the monetary sector relative to commodity demand. These studies assume positive central bank control over the intermediate target, and thus ignore the monetary policy process (i.e., the adjustment of reserves and short-term interest rates to open market operations, the discount rate, and reserve requirement policy) altogether.

Waud [23] has recently considered this aspect of the problem and shown that (1) in the absence of knowledge of the parameters of the system, predictable control over intermediate targets such as interest rates is questionable, and (2) even with knowledge of these parameters, monetary policy may very well work in a direction adverse to the attainment of given targets. These conclusions rest on the basic proposition that the monetary authority is not able to distinguish between a stochastic disturbance and a fundamental parameter shift on a current, ongoing basis. Waud concludes that intermediate targeting to achieve ultimate goals such as a desirable level of employment may be "fraught with ambiguity at best and . . . very likely to be inconsistent with the ultimate goal for which they are assumed to be a surrogate." [13, p. 3] It would be preferable, therefore, for the monetary authority to concentrate directly on the ultimate goals.

These papers assume that the monetary authority concentrates on a single intermediate target. In practice, monetary policy is conducted on a "multiple target--range of tolerance" basis. Following a single operating target to enhance control over a longer-run aggregate may be justifiable when (1) there is a stable multiplier relationship between the operating target and the aggregate and (2) the noncontrollable factors influencing the operating target are predictable with a reasonable degree of accuracy [15]. Given uncertainty regarding these factors, a system of multiple targets with ranges of tolerance for each may be appropriate. Ranges of tolerance allow for trade-offs among conflicting short-run targets, provide for possible shifts in the multiplier, and allow the monetary authority to "look through" the short-run indicators to the behavior of intermediate monetary aggregates when necessary.

The present paper presents the results of the first phase of a long-term study designed to evaluate a number of alternative intermediate targeting strategies that could be used by the Federal Reserve for monetary control. The project involves the use of linear quadratic optimal control, using the solution derived by Pindyck [13]. In linear quadratic optimal control, the policy maker is assumed to formulate his preferences for various targets as terms in a quadratic preference function. He then conducts policy so as to maximize this preference function subject to the constraints of the economic structure, represented by a linear (or linearized) model of the economy. Often the model is a reduced form of some structural model.

In the present paper, a monthly econometric model of the financial sector is developed that can be formulated in terms of alternative intermediate operating strategies. Simulation in an optimal control framework over a policy planning period under alternative strategies produces data that can be analyzed to determine which strategy performs best in controlling the money stock.

Within this general context, the results being reported here concern the specification and estimation of the structural model of the financial sector to be used in these studies. From this structural model alternative reduced form models will be derived later for the optimal control analysis. The results of the optimal control analysis will be contained in subsequent study papers.

Current Policy Procedures

In order to make the requirements of the model more specific, current policy procedures will be described briefly. The spectrum of Federal Reserve operating targets currently includes the Federal funds rate (RFF), the money supply (M_1) and (M_2), bank credit, and reserves available to support private nonbank deposits (RPD). The FOMC specifies a tolerance range for the growth of RPD's and the monetary aggregates and a corresponding tolerance range for RFF. Given an RPD path for a two-month period assumed to be consistent with desired M_1 growth, the Desk provides sufficient nonborrowed reserves to keep RPD growth within the acceptable range. If RPD growth appears likely to exceed this range, the Desk provides nonborrowed reserves with greater reluctance, so long as RFF does not rise beyond an acceptable level. This would cause borrowed reserves to rise, put upward pressure on RFF, and set in motion the portfolio adjustments that would eventually tend to dampen growth of demand deposits and the monetary aggregates [10]. Thus, the intent of the RPD approach is to bridge the gap between open market operations and the monetary aggregates. Because information lags and random weekly fluctuations in the aggregates provide unreliable signals concerning long-run behavior, an intermediate operating target for open market operations is necessary.

While RPD's are the first reserve measure used as an operating target, there are several reserve concepts other than RPD's that are a priori more suitable for this role. Richard Davis [4] suggests that the following variables may be feasible as operating targets for the Open Market Account Manager during the period between Federal Open Market Committee meetings: unborrowed reserves (RU), unborrowed monetary base (BU), unborrowed reserves less reserves against Treasury deposits (RU - TRR), unborrowed monetary base less reserves against Treasury deposits (BU - TRR), and free reserves (RF). Unborrowed RPD's may be added to this list, since they can be obtained by subtracting reserves against interbank deposits from (RU - TRR). Total RPD's, however, are not included because of the interdependence of borrowed reserves and excess reserves.

Given the above operating target candidates, an econometric model of the financial sector may be specified that is conformable to inclusion of these targets. Such a model is specified in the section below.

II

The Model

The financial sector is a complex of interrelated markets for financial assets and debts. It is an important link between monetary policy actions and those long-term interest rates that are important determinants of economic activity in other sectors of the economy. To establish the financial sector, we concentrate on the process by which major participants in the financial sector adjust their balance sheets to policy- and market-induced changes.

The mechanism that links monetary policy actions and real output is a substitution process--the continual readjustment of actual asset portfolios to desired portfolio compositions. Consider, for example, the impact of a Federal Reserve purchase of Government securities. If the securities are purchased from commercial banks, an immediate rise in the monetary base and free reserves occurs, creating discrepancies between the banks' actual and desired earning assets to reserves ratios. Similarly, if the purchase is made from the public, its asset allocation is upset in the direction of excess liquidity. Both commercial banks and the public subsequently attempt to readjust their portfolios by purchasing financial assets similar to those that were sold. There follows a chain of adjustments by participants in financial and real sector markets that eventually affects real economic activity.

In order to specify a financial sector, we begin by considering the balance sheets of two important money market participants, commercial banks and the nonbank public. A third participant, the central bank, is represented by its influence over nonborrowed reserves and the discount rate, and jointly with the Treasury, by its influence over the total quantity of publicly-held Treasury bills.

The public's assets are assumed to include demand deposits (DD), time deposits (TD), certificates of deposit (CD), currency (C), Treasury bills (QTBP), and other assets (OA). Commercial loans (CL), which are assumed to be the major liability of the public, and other liabilities (OL), constitute the liability side of the public's balance sheet, which can be represented as:

Public

DD	CL
TD	OL
CD	
C	
QTBP	
OA	NW

The appropriate balance sheet constraint for the public is:

$$DD + TD + CD + QTBP + C - CL - (OA - OL) = NW$$

where NW is public net worth. All of the variables on the left-hand side, with the exception of (OA - OL) are explicitly determined in the model. Net worth is assumed to be determined in the real sector and is thus exogenous to the model. Rather than attempting to measure household net worth on a monthly basis, we assume that personal income (PI) is a (stable) function of net worth and use personal income as a net worth proxy. We assume following Brainard and Tobin [2], that the public's demand for assets and liabilities are homogeneous in wealth, so that the public's demand for the various balance sheet components can be written in the form:

$$\frac{Ai^P}{PI} = A_i^P(r^P,\ I)$$

where r^P is the public's relevant rate vector and I is a vector of impact variables.

This type of demand function is a general expression of the linear asset demand function developed by Gramlich and Kalchbrenner [7]. Maximization of a simple quadratic utility function, with utility and balance sheet components normalized on exogenous wealth, would yield linear demand functions of the type presented above.

Commercial banks' assets are assumed to include reserves, Treasury bills (QTBB), commercial loans (CL), and other assets. Reserves may be classified by source--borrowed (RB) or unborrowed (RU)--and by use--required (RR) or excess (ER). Commercial bank liabilities include demand deposits, time deposits, and certificates of deposit. The major elements of the consolidated commercial bank balance sheet can thus be shown as:

Commercial Banks

RR	DD
ER	TD
CL	CD
QTBB	OL
OA	

For the banking system as a whole, the following balance sheet identity holds:

$$RR + ER + CL + QTBB + (OA - OL) = DD + TD + CD$$

Required reserves are predetermined by virtue of the Federal Reserve System's lagged accounting procedures; the remaining variables on the left-hand side of the above equation are determined explicitly in the model, as of course are deposit levels. With these deposits assumed to constitute the banks' constraint on the demand for assets, we write the banks' asset demand functions in the form:

$$\frac{A_i^B}{D} = A_i^B(r^B, I)$$

where D is total deposits, r^B is the relevant vector of own and competing interest rates, and I is a vector of impact variables that cause portfolio positions to diverge in the short run from desired levels. While only a limited number of assets and liabilities are included in the model, we specify demand and supply determinants in those markets that appear to be most important in the financial sector. But, as Tobin has pointed out [2], such a model implicitly determines the behavior of the net composite assets of both the commercial banks and the nonbank public. At this point, we have not investigated the implied behavior of these balance sheet components.

The financial sector to be developed below is driven by the policy decisions of the central bank and Government as reflected in the determination of unborrowed reserves, the discount rate, and the volume of Treasury bills outstanding. The model is related to the real sector through the behavior of a number of predetermined variables reflecting various aspects of business and household activity, which will be described in the process of developing the theoretical model.

The Market For Bank Reserves

The equilibrium level of short-term interest rates is assumed in most financial sector models to be determined ultimately by the interaction of the Federal Reserve's supply of reserves with the commercial banks' demand for them [5]. Since the volume of unborrowed reserves ($\overline{RU}$) is assumed to be closely related to Federal Reserve open market operations, the true policy instrument, the banks' demand for total reserves (TR) in essence is reflected in the demand for borrowed reserves. That is, since total reserves equal borrowed plus unborrowed reserves:

$$TR = \overline{RU} + RB \tag{1}$$

and $\overline{RU}$ is controlled by the monetary authority, bank borrowing determines the demand for total reserves. Total reserves can also be described by its uses, i.e.

$$TR = ER + RR \tag{2}$$

Since lagged reserve accounting procedures are used by the Federal Reserve, required reserves are assumed to depend on the deposit levels of the previous period:

$$RR = (K_D DD + K_T TD)_{-1} \tag{3}$$

Since required reserves are predetermined, the demand for borrowing, which determines the demand for total reserves, can also be interpreted as the demand for excess reserves by the banking system. The interaction of these supply and demand forces can be seen to determine free reserves. By equating the right-hand sides of identities (1) and (2),

$$\overline{RU} + RB = ER + RR,$$

and transposing borrowed and required reserves, we obtain expressions for free reserves:

(4) $$FR = ER - RB \text{ or } \overline{RU} - RR.$$

The demand equation for borrowed reserves at the discount window involves two hypotheses: First, the desired (equilibrium) level of borrowed reserves is assumed to be a positive function of the implicit equilibrium rate of return on reserves and a negative function of direct cost of reserves [9]. The Treasury bill rate (RTB) is assumed to reflect the return on reserves, in essence being a proxy for the weighted average of rates of return on the banks' portfolio of assets. The discount rate (RDIS) is the cost of borrowed reserves. The Federal funds rate (RFF), representing the cost of reserves from alternative sources is assumed to be positively related to banks' desired demand for borrowed reserves [12]:

$$RB^D = RB^D(RTB^*, RDIS^*, RFF^*)$$

Fundamental changes in the equilibrium relationships between return on and cost of reserves would alter the desired level of bank borrowing. Such changes can be expected to occur only as banks adjust their estimates of this relationship. The starred variables RTB* and RFF* thus represent the best current estimate of equilibrium rates based on available information concerning past and current financial conditions (more specifically vectors of current and lagged variables).

Secondly, the actual level of bank reserve borrowing in the short run will differ from the desired level because of the influence of certain impact variables. Banks consider their business customers to be valuable sources of deposits, and are reluctant to deny reasonable requests for loans. If an unanticipated upsurge in commercial loan demand occurs, banks are likely to accommodate these demands and finance the additional loans by temporarily borrowing additional reserves or by drawing down excess reserves. Similarly, short-term disequilibrium in the reserve market can be caused by changes in unborrowed reserves resulting from open market operations, reserve requirement changes, changes in float, etc. Immediate adjustments to these changes can likewise be expected to occur through changes in borrowing or excess reserve positions. Given additional time, these factors may affect other bank liabilities and assets, such as CD's and Treasury bills. Ultimately, desired borrowings might change as these factors affect market interest rates through the financial markets. In other words, borrowed reserves also serve as a buffer stock to accommodate unanticipated changes in the impact variables such as commercial loans (ΔCL), unborrowed reserves, and required reserves. Thus the actual level of borrowings is a function of both desired borrowings (RB^D) and disequilibrium conditions:

$$(5'') \qquad RB = RB(RB^D, \Delta CL, \Delta\overline{RU}, \Delta RR) = RB(RTB^*, RDIS^*, RFF^*, \Delta CL, \Delta\overline{RU}, \Delta RR)$$

using bank deposits as a proxy for the banks' wealth constraint and scaling RB by deposits, we obtain the borrowings function:

$$(5) \qquad \frac{RB}{D} = RB(RTB^*, RDIS^*, RFF^*, \frac{\Delta CL}{D}, \frac{\Delta\overline{RU}}{D}, \frac{\Delta RR}{D})$$

To complete the specification of the market for bank reserves, it is desirable to take explicit account of the Federal funds market. The Federal funds rate equation is derived by Modigliani, Rasche and Cooper as a reduced form function of free reserves and the discount rate [12]. It is shown that the loanable funds available to the Federal funds market depends upon the surplus of excess reserves available over reserve borrowing by banks (free reserves) and the return from lending excess reserves (the Federal funds rate). Similarly, the demand for borrowing Federal funds depends upon free reserves and the spread between the return from lending and the cost of borrowing reserves (the Federal funds rate less the discount rate). Equating supply and demand and solving for the funds rate, a reduced form equation for the funds rate is obtained:

$$\text{RFF} = \text{RFF}(\text{FR*},\overline{\text{RDIS*}}) \tag{6}$$

where the stars again indicate vectors of current and lagged values. In general, we assume that the market for bank reserves adjusts rapidly to changing conditions, so that the explanatory vectors include short lags, if any at all.

<u>The Banking Sector</u>

The remaining assets in the banks' balance sheet are holdings of Treasury bills and commercial loans. The desired proportion of Treasury bills in the portfolio of commercial banks is assumed to be a positive function of the Treasury bill rate and a negative function of the opportunity cost of holding assets in this form. In the case of Treasury bills, the opportunity cost is measured by the rate on Federal funds, the closest substitute source of income on reserve funds and perhaps by the rate on commercial loans (RCL). Since banks ordinarily make short-term adjustments by borrowing reserves, rather than by selling assets, no impact variables need be assumed in the demand for bank holdings of Treasury bills. Accordingly,

$$\frac{\text{QTBB}}{\text{D}} = \text{QTBB}(\text{RTB*},\text{RFF*RCL*}) \tag{7'}$$

The other bank asset considered in the model is commercial and industrial loans. The volume of commercial loans outstanding is specified in the public sector of the model, below, as a public demand equation. The supply, or rate setting, equation involves the presumption that banks attempt to accommodate customer demands for loans whenever possible, and adjust this loan rate in accordance with changes in the cost of loanable funds or in the opportunity cost of lending. The rate on certificates of deposit (RCD) serves as a measure of the cost of loanable funds. The opportunity cost of lending is measured by the Treasury bill rate. The ratio of commercial loans to total deposits serves as a portfolio balance variable [8, p. 12]. Both the portfolio variable and the interest rate variables are assumed to be positively related to the commercial loan rate:

$$RCL = RCL(RTB^*, RCD^*, \frac{CL}{D}) \tag{8}$$

In addition to the supply equation on commercial loans, a bank asset, a number of rate setting equations must be specified for bank liabilities. The implicit rate paid by banks for demand deposits (the value of services provided to holders of these accounts) is assumed to change sufficiently slowly so that a rate equation need not be specified. The rate on time deposits, excluding CD's, is assumed to be exogenous.

The banking sector is closed by the banks' supply function of CD's. The rate banks desire to pay for CD funds can be expected to be positively related to loan demand and to rates on competing instruments. Banks are assumed to view security sales as increasingly undesirable as market (bill) rates rise, and to seek funds more aggressively through the

CD market. This process can continue so long as the CD rates remain below Regulation Q ceiling levels. At that point, banks can no longer pay the rate that they would otherwise be willing to pay given market condition and loan demand. Nevertheless, trading continues in the secondary market, and we choose to represent the banks desired rate on CDs by the secondary market rate. Since banks cannot pay the desired rate, the public will of course tend to run down their holdings of CDs as they mature; we will incorporate the CD runoff phenomenon in the public's demand for CDs. Accordingly, the secondary rate on CD's is a positive function of the commercial loan to deposit ratio and of the Treasury bill rate:

$$\text{(9)} \qquad RCD = RCD(RTB^{*}, \frac{CL^{*}}{D})$$

The remaining bank liabilities are discussed as publicly held assets in the section below.

The Public Sector

The balance sheet of the public sector, as discussed earlier, contains deposits and currency as assets and commercial loans as the single specified liability. The public's demand for deposits interacts with the banking system's ability to supply deposits, as constrained by the policy-determined level of unborrowed reserves, to simultaneously determine the deposit quantities and the rate on CD's. The supply of currency is assumed to be completely elastic and thus determined by the public's demand for currency.

While demand deposits and currency together constitute the money stock, their demand equations will be specified separately. Demand deposits are determined in the process of bank adjustment to changing reserve and market forces; currency is basically demanded by the public for transactions purposes. In each case, the basic form of the equation is $M = k(r)Y$, where M is the quantity of money demanded; k is the Cambridge cash balance or money/income ratio, expressed as a function of a vector of interest rates on short-term financial assets; and Y is the level of income [12].

Again incorporating starred notation to indicate the adjustment process, the demand for currency is assumed to be related to the rate on Treasury bills, serving as a proxy for other competing types of short-term liquid assets. The wealth constraint is incorporated by expressing asset demand as a proportion of the wealth proxy, income. Thus the currency equation can be expressed as:

$$\frac{C}{PI} = C(RTB^*) \tag{10}$$

Similarly, the demand for checking account balances is written as:

$$\frac{DD}{PI} = DD(RTB^*, RTD^*) \tag{11}$$

The demand for time deposits (excluding CD's) at commercial banks is assumed to depend upon a vector of own and competing rates. In addition to the rates in the two preceding functions, the CD rate is also included in the demand for time deposits:

$$\frac{TD}{PI} = TD(RTB^*, RTD^*, RCD^*) \tag{12}$$

The growing importance of liability management as a source of bank funds requires specification of demand and supply functions for the chief instrument used--certificates of deposit. The banks' supply of CD's was discussed earlier as the secondary market rate setting equation. The public's demand for CD's is a typical asset demand function, being a positive function of the CD rate and a negative function of the rates on competing short-term financial assets. In addition, the occasional rise of the CD rate above the Regulation Q ceiling requires that we account for the resulting runoff in the volume of CD's. This phenomenon, presently only of historical importance, since the Regulation Q ceilings on CD's have been removed, is explained by the introduction of a dummy variable QT. Normally Q = 0, but when RCD is above the ceiling $\bar{R}$CD, Q = 1. Then T is initialized to 1.0 and increases in index fashion as long as the runoff continues. This enables us to capture historical runoffs as a demand phenomenon in the same equation with the normal structure of the public's demand for CD's. Note, however, that the other explanatory variables continues to offset CD demand. At any time, the prevailing CD rate is actually an average of rates paid by banks. Thus there will be some banks that can issue CDs at less than the average rate. In addition, there is probably a lag in the public's recognition of the rate discrepancy between CDs and other similar instruments. Consequently, market factors continue to act on the public's CD demand, with the offsetting report of the Q ceiling growing stronger over time. The competing rate vector is assumed to include the Treasury bill rate and the rate on commercial paper, and personal income serves as a wealth proxy:

(13) $$\frac{CD}{PI} = CD(RCD, RTB, RCP, QT)$$

The total quantity of publicly held Treasury bills is assumed to be a joint fiscal-monetary policy decision, with the distribution of this total determined by the interaction of bank and public demand for bills:

(14) $$\overline{QTBT} = QTBB + QTBP$$

The quantity of Treasury bills desired by the public is considered to be a positive function of wealth and the bill rate, and a negative function of the opportunity cost of bill holdings, i.e., the return on competing short-term assets. The rates on commercial paper and CD's serve as competing rates, and again personal income serves as the wealth proxy:

$$(15) \qquad \frac{QTBP}{PI} = QTBP(RTB^*, RCP^*, RCD^*)$$

In our simultaneous equation environment, either equation (7') or (15) may be renormalized to provide a rate setting equation for Treasury bills. We choose to renormalize equation (7'):

$$(7) \qquad RTB = RTB(\frac{QTBB^*}{D}, RFF^*, RCL^*)$$

The identity (14) may then be employed to determined the quantity of Treasury bills held by banks.

In order to complete the public sector, it is necessary to specify the public's demand for commercial loans. The demand for loans is related to a vector of competing rates on alternative sources of funds, to the cost of commercial loans, and to a shift variable representing the impact of real economic activity on the demand for funds, in this case inventory accumulation (ΔH). The inventory variable is included to reflect the proposition that, at the margin, all inventory investment is financed by borrowing from commercial banks [5, Appendix, p. A3]. The competing rate vector includes the commercial paper rate and the corporate bond rate. The commercial loan demand function is written as:

$$(16) \qquad \frac{CL}{PI} = CL(RCL^*, RCP^*, RCB^*, \Delta H^*)$$

The final behavioral relation in the model is a reduced form equation for the commercial paper rate. The supply of commercial paper, presumably by the corporate sector, is a function of a loan demand variable, the paper rate, and rates on competing financing methods:

$$(17') \qquad CP^{s} = CP^{s}(RCP, RCB, RCL)$$

The demand for paper is a function of rates on competing short-term assets and the paper rate:

$$(17'') \qquad CP^{D} = CP^{D}(RCP, RTB, RTD)$$

Since net commercial paper holdings are assumed to be zero for the nonbank public, it is not necessary to specify a quantity equation. The resulting reduced form rate equation can be expressed as

$$(17) \qquad RCP = RCP(RTB^{*}, RTD^{*}, RCB^{*}, RCL^{*})$$

The model contains 18 endogenous variables and thus far only 17 equations have been specified. The model may be closed by the definitional identity expressing total bank deposits as the sum of certificates of deposit, demand deposits and time deposits.

$$(18') \qquad D = DD + TD + CD$$

As specified above, the model contains 18 equations. There are commercial bank demand equations for borrowed reserves, required reserves, and loanable funds through the CD market (the supply of CD's). Public asset demand equations are included for demand deposits, time deposits (excluding CD's), currency, Treasury bills, and commercial loans. Supply equations include the public's supply of loanable funds through the CD market (the demand for CD's). Reduced form rate setting equations explain the Federal funds rate and the commercial paper rate. The Treasury bill rate equation is a renormalized bank demand for Treasury bills. The sector is closed by six identities, with all policy and real sector variables being considered exogenous.

III

Estimating the Model

The model is estimated using monthly data over the twelve-year period 1962-1973. The various sources of the data are described in the Appendix.

Both seasonally adjusted and unadjusted data were used in the estimation of the model. In the case of the deposit equations, total private deposits at all commercial banks were felt to be the appropriate dependent variables. These data are seasonally adjusted. In addition, a breakdown of time deposit data into CD's and time deposits other than CD's is estimated only for all commercial banks on a monthly basis. The only monthly data available on member bank time deposits is inclusive of CD's.

In computing member bank reserves, it was felt desirable to use unadjusted data, since bank reserve requirements are based on actual (unadjusted) deposit levels. Furthermore, monetary authorities generally deal with unadjusted reserve data in making short-term policy decisions; thus it was desirable to formulate the reserve equations on an unadjusted basis. Consequently, two equations were estimated to allow transformations between seasonally adjusted commercial bank deposit data and unadjusted member bank data.

The regression equation in Table II-1, using 0-1 seasonal dummies, relates unadjusted member bank total time deposits, including CD's, to total adjusted commercial bank time deposits.

A similar equation, shown in Table II-2, is estimated to obtain private nonbank member bank demand deposits, seasonally unadjusted from private, adjusted demand deposits at all commercial banks. Once member

II - 1

Time Deposit Transformation

$$
\begin{aligned}
TTD_{MB} = {} & \underset{(7.5520)}{8.9145} + \underset{(129.9105)}{.7486}\ TTD^{SA}_{CB} - \underset{(.5519)}{.5604}\ S_1 \\
& - \underset{(.4529)}{.4608}\ S_2 \\
& + \underset{(3.2595)}{3.3121}\ S_3 \\
& - \underset{(.0408)}{.0415}\ S_4 \\
& - \underset{(.0294)}{.0299}\ S_5 \\
& - \underset{(.3624)}{.3682}\ S_6 \\
& - \underset{(.3703)}{.3762}\ S_7 \\
& + \underset{(.2929)}{.2976}\ S_8 \\
& + \underset{(.1417)}{.1440}\ S_9 \\
& + \underset{(.0582)}{.0591}\ S_{10} \\
& - \underset{(.9311)}{.9466}\ S_{11} \\
& - \underset{(1.0117)}{1.0292}\ S_{12}
\end{aligned}
$$

$R^2 = .9957$

$SE = 3.6559$

$DW = 2.1260$

$\rho = .2851$

II - 2

Demand Deposit Transformation

$$
\begin{aligned}
DD_{MB}^{PNB} = \underset{(18.9537)}{22.0542} + \underset{(84.0514)}{.6238}\, DD_{CB}^{SA} & + \underset{(17.1105)}{4.5497}\; S_1 \\
& - \underset{(2.8895)}{.7715}\; S_2 \\
& - \underset{(2.1098)}{.5603}\; S_3 \\
& + \underset{(3.8934)}{1.0330}\; S_4 \\
& - \underset{(9.6878)}{2.5697}\; S_5 \\
& - \underset{(5.0997)}{1.3528}\; S_6 \\
& - \underset{(4.6241)}{1.2271}\; S_7 \\
& - \underset{(8.9063)}{2.3642}\; S_8 \\
& - \underset{(3.9201)}{1.0409}\; S_9 \\
& - \underset{(1.2404)}{.3295}\; S_{10} \\
& + \underset{(1.7316)}{.4603}\; S_{11} \\
& + \underset{(15.6886)}{4.1730}\; S_{12}
\end{aligned}
$$

$R^2 = .9973$

$SE = .8904$

$DW = 2.3084$

$\rho = .6326$

bank deposits are known, Government demand deposits and net interbank demand deposits are added to obtain total demand deposits subject to reserve requirements:

$$DD_{MB}^{NSA,\ T} = DD_{MB}^{NSA,\ P} + DD_{MB}^{NSA,\ G} + DD_{MB}^{NSA,\ IB}$$

In the simulations of the model, commercial bank deposits DD_{CB}, TD_{CB}, and CD_{CB} would be determined by their respective demand equations. The corresponding unadjusted member bank deposit components would then be determined from the equations in Tables II-1 and II-2 to obtain private nonbank deposits subject to reserve requirements. Government deposits and interbank deposits at member banks are then included to obtain total deposits subject to reserve requirements.

Finally, the commercial loan demand equation is estimated using seasonally adjusted data, although it enters the borrowings equation unadjusted. In simulating the model, therefore, the seasonal adjustment equation shown in Table II-3 is used.

Estimating the Distributed Lags

In developing the theoretical model, the behavioral relationships are generally expressed in terms of vectors of current and lagged independent variables. Such lags permit desired portfolio adjustments to occur over time in response to changing market conditions. Empirical estimation of such lags is complicated by the presence of high correlations among explanatory variables, as well as by the correlations among the various lagged values of a given explanatory variable. Ordinary least squares analysis of lag coefficients under such conditions will yield unbiased parameter estimates, but the sampling variances obtained are

II - 3

Commercial Loan Seasonal Adjustment

$$
\begin{aligned}
CL_{CB}^{NSA} = & - \underset{(.1387)}{.0130} + \underset{(998.1836)}{1.0003}\, CL_{CB}^{SA} - \underset{(9.0912)}{.9964}\, S_1 \\
& - \underset{(7.9894)}{.8771}\, S_2 \\
& + \underset{(.7818)}{.0857}\, S_3 \\
& + \underset{(.7821)}{.0857}\, S_4 \\
& - \underset{(2.3373)}{.2562}\, S_5 \\
& + \underset{(12.7896)}{1.4019}\, S_6 \\
& - \underset{(.2893)}{.0317}\, S_7 \\
& - \underset{(8.1979)}{.8986}\, S_8 \\
& - \underset{(.1414)}{.0155}\, S_9 \\
& - \underset{(4.7036)}{.5157}\, S_{10} \\
& - \underset{(2.6531)}{.2909}\, S_{11} \\
& + \underset{(21.0512)}{2.3088}\, S_{12}
\end{aligned}
$$

$R^2 = .9998$

$SE = .3926$

$DW = 1.9573$

$\rho = -\ .0798$

likely to have an upward bias, and could lead to inappropriate rejection of hypotheses.

In our model, specification of the structural equations indicates the need for distributed lags, possibly relatively lengthy, on several interest rate vectors. In order to increase the efficiency of estimation in our analysis, we have taken the common approach of using Almon polynomial lags to estimate the distributed lag coefficients.

Almon distributions were estimated using either second or third degree polynomials. No end point constraints are imposed. In the absence of *a priori* information warranting such constraints, their imposition could result in misspecification. Thus it is desirable to leave the end points unconstrained and allow the data to determine the end point coefficients.

Specification of the Structural Equations

The choice of optimal lag specifications for the explanatory variables is a decision problem for which no systematic statistical procedure is available. The problem is particularly serious in the case of a structural model, since specification errors are transmitted throughout the system. The use of polynomial lags further complicates the task of estimating the structural equations, since misspecification of the lag parameters (length, degree of polynomial) can lead to serious bias in the estimates of the distributed lag weights.

In the case of fixed independent variables, Theil [17, pp. 211-215] has suggested the use of the minimum standard error as a reasonable criterion for selecting from among a set of specifications most likely to include the correct specification. A strict application of this procedure in selecting the lag specifications in this model, however, did not yield a set of equations that satisfied *a priori* sign requirements. Moreover, several equations selected in this manner were characterized by unexpectedly long lags that were apparently responsible for unreasonable simulation results.

The empirical equations presented in this study were consequently obtained in the following manner. Each structural equation was estimated over the entire lag space from 0 to 9 periods. This requires beginning the estimation at the lag length equal to the degree of the polynomial, which is an OLS estimate and allows for the possibility of no lag [16, p. 13]. Then the minimum standard error criterion was applied to those specifications that _generally satisfied reasonable a priori requirements_ in order to obtain the behavioral equations. In those equations for which the lags were expected to be quite short, straight OLS estimates were obtained directly.

In several equations, distributed lag effects, although properly signed, appear with rather large standard errors. Polynomial lag techniques cannot, of course, entirely eliminate the multicollinearity problem, and the relatively large sampling variances no doubt reflect to some degree the remaining influence of the collinear independent variables. However, no attempt was made to remove these seemingly insignificant explanatory variables from the equations, since they did not appear to adversely affect the simulation of the model. Moreover, specification error could occur if independent variables are omitted on the basis of upward biased standard errors resulting from collinearity among the independent variables.

Empirical Results

Bank reserves and the Federal funds market.--In these two equations, it was assumed that bank borrowings at the discount window and in the Federal funds market adjust rapidly to changing market conditions. Thus only contemporaneous values of the explanatory variables are included in the OLS estimate of these equations.

The regression results for bank borrowings are presented in Table II-4. All of the coefficients have the expected signs, and with the exception of the change in commercial loans and the discount rate, relatively small standard errors. The Durbin-Watson statistic is rather low, however, and indicates that the sampling variances could be subject to downward bias. Experimentation with various lagged specifications of the borrowings equation failed to alter the estimates. The approximately equal coefficients on ΔRU and ΔRR indicate that free reserves could be used as the explanatory reserve impact variable in the borrowing function.

Table II-5 presents the results for the Federal funds rate as specified by Modigliani _et al_. The reduced-form model performs very well; in fact the strong relationship between RFF and the discount rate is somewhat surprising in view of the rather weak relationship between RDIS and member bank borrowing. This result probably indicates that RDIS should not be included in the equation for member bank borrowings along with RFF.

Experimentation with lagged specifications of these two equations failed to produce any indication that the bank borrowing does not adjust rapidly to changing market conditions.

Deposits.--The public's demand for the various deposit categories are expressed as a proportion of the wealth proxy, personal income (PI). The initial formulation of the demand and time deposit equations also included retail sales as a transactions variable. However, estimation

II - 4

Member Bank Demand for Borrowed Reserves

$$
\begin{aligned}
\frac{RB_{MB}}{D_{CB}} = & - \underset{(.4057)}{.0246} && - \underset{(1.3417)}{.0106}\; S_1 \\
& + \underset{(3.0973)}{.0261}\; RFF_t && - \underset{(1.2756)}{.0102}\; S_2 \\
& + \underset{(.9055)}{.0079}\left(\frac{\Delta CL}{D_{CB}}\right)_t && + \underset{(.0299)}{.0002}\; S_3 \\
& - \underset{(.6105)}{.0104}\; RDIS_t && - \underset{(.1791)}{.0012}\; S_4 \\
& - \underset{(8.3864)}{.3941}\left(\frac{\Delta RU_{MB}}{D_{CB}}\right)_t && + \underset{(.6254)}{.0044}\; S_5 \\
& + \underset{(8.7790)}{.4003}\left(\frac{\Delta RR_{MB}}{D_{CB}}\right)_t && + \underset{(1.0159)}{.0081}\; S_6 \\
& + \underset{(2.1242)}{.0182}\; RTB_t && + \underset{(2.4725)}{.0193}\; S_7 \\
& && + \underset{(2.3151)}{.0171}\; S_8 \\
& && + \underset{(.3138)}{.0023}\; S_9 \\
& && - \underset{(1.5916)}{.0113}\; S_{10} \\
& && - \underset{(.8896)}{.0062}\; S_{11} \\
& && - \underset{(1.2465)}{.0119}\; S_{12}
\end{aligned}
$$

R^2 = .9445

SE = .0228

DW = 1.4156

ρ = .9087

II - 5

Federal Funds Rate

$$RFF = -\underset{(2.8477)}{1.7970} - \underset{(4.7647)}{.7206}\, FR_t + \underset{(12.0466)}{1.4678}\, RDIS_t$$

R^2 = .9852

SE = .2456

DW = 1.9607

ρ = .9119

of the equations produced coefficients on retail sales that were not different from zero. It appears that the wealth proxy PI is also capturing the effect of transactions demand on deposits, and these demand functions were re-estimated without the retail sales variable. The regression results of the two deposit equations are presented in Tables II-6 and II-7.

A priori, it would appear plausible that the impact of the time deposit rate on demand deposits would be distributed over time. However, distributed lags on RTD produced no significant relationship. Since it was felt that savings deposits were a close and important substitute for demand deposits, a nonlagged version of the demand deposit equation was estimated in order to allow for this substitution effect.

The time deposit equation itself reflects a fairly lengthy adjustment period of up to eight months. The coefficients are of proper sign, but in the case of the bill rate RTB and the own rate RTD, the relatively large standard errors of the lagged relationships again suggest the influence of the collinearity remaining among the explanatory variables.

In both equations, and particularly in that for demand deposits, the strength of the constant term indicates a strong relationship between deposits and the wealth proxy PI.

Currency.--As in the case of the two deposit equations, retail sales were initially included in the currency equation, Table II-8, but it appears that the income variable is picking up the effect of the transactions demand for currency, as indicated again by the strength of the constant term. The only other variable included in the equation is the Treasury bill rate. Although currency obviously cannot be considered as a close substitute for Treasury bills, it is necessary to include

Public Demand for Demand Deposits

$$\frac{DD^P_{CB}}{PI} = \underset{(29.2092)}{25.9038} + \underset{(2.0063)}{.0954}\ RTB_t - \underset{(4.0852)}{.7714}\ RTD_t - \underset{(.5642)}{.0305}\ RTB_{t-1}$$

$$- \underset{(2.3540)}{.0937}\ RTB_{t-2}$$

$$- \underset{(2.4903)}{.1077}\ RTB_{t-3}$$

$$- \underset{(1.5699)}{.0861}\ RTB_{t-4}$$

$$- \underset{(.8404)}{.0423}\ RTB_{t-5}$$

$$\Sigma = \underset{(2.6829)}{-.2650}$$

R^2 = .9955

SE = .1499

DW = 1.7974

ρ = .9500

II - 7

Public Demand for Time Deposits

time period	$\frac{TD_{CB}}{PI}$ =		RTB	RCD	RTD
		30.0224 (5.4397)	$-$ .0068 RTB_t (.1135)	$-$ .0292 RCD_t (.5076)	+ .1882 RTD_t (.7732)
t-1			$-$ .0284 (.4136)	$-$ .0308 (.7356)	+ .5652 (1.7349)
t-2			$-$ .0515 (.6670)	$-$ .0330 (.8236)	+ .3767 (1.3541)
t-3			$-$ .0718 (1.0468)	$-$ .0356 (1.1237)	$-$ .0580 (.2197)
t-4			$-$ .0851 (1.4137)	$-$ .0386 (1.8882)	$-$ .4197 (1.2264)
t-5			$-$ .0870 (1.3242)	$-$ .0419 (2.2223)	$-$ .3890 (1.1881)
t-6			$-$ .0732 (1.0047)	$-$ .0455 (1.9633)	+ .3533 (.5318)
t-7			$-$ .0396 (.5980)	$-$ .0491 (2.2826)	
t-8			+ .0181 (.2517)	$-$ .0528 (1.3981)	
		Σ =	$-$ .4253 (1.0276)	$-$ .3566 (2.3570)	+ .6166 (.5960)

R^2 = .9954

SE = .1431

DW = 1.9091

ρ = .9887

II - 8

Public Demand for Currency

$$
\begin{aligned}
\frac{C}{PI} = \underset{(58.5834)}{6.2295} &+ \underset{(.1198)}{.0013}\ RTB_t \\
&- \underset{(.5660)}{.0067}\ RTB_{t-1} \\
&- \underset{(1.1762)}{.0150}\ RTB_{t-2} \\
&- \underset{(.7041)}{.0087}\ RTB_{t-3}
\end{aligned}
$$

$$\Sigma = \underset{(1.8298)}{-.0291}$$

R^2 = .9899

SE = .0372

DW = 2.1393

ρ = .9500

a variable that represents the rate on competing assets yielding a positive return. If a change in market rates causes the public, for example, to increase its total proportion of interest-bearing assets, there should be an indirect effect on the public's desire to hold currency. In fact, the bill rate does display a negative three-month lagged impact on currency holdings, although the impact is small relative to the bill rate's impact on other assets.

Treasury bills.--In this model the bill rate and the distribution of bill holdings between commercial banks and the public are determined by two demand equations and the identity equating total bill holdings to the bank and public holdings.

Commercial bank demand for Treasury bills is assumed to be a function of the bill rate, the Federal funds rate, and the rate on commercial loans. The equation was estimated as a rate equation, and the results are shown in Table II-9. The quantity variable has the expected positive sign with a relatively small standard error, indicating that bank holdings are sensitive to changes in the bill rate. The commercial loan rate also displays a positive distributed lag relationship, over three months, with the bill rate. It is reasonable to assume that as commercial loan rates rise, Treasury bill rates will have to rise also to encourage banks to maintain their holdings of Treasury bills. Finally, the bill rate displays a very strong positive relationship with the lagged Federal funds rate. It thus appears that banks interpret movements in the funds rate over time as an indicator of monetary policy

II - 9

Bank Demand Equation
Rate on Treasury Bills

time period					
t	RTB =	− .3402 (.5787)	+ 17.8764 $\left(\frac{QTBB}{D}\right)_t$ (3.0017)	+ .3654 RFF_t (5.4914)	+ .3614 RCL_t (3.2505)
$t-1$				+ .3321 (4.5960)	+ .1842 (1.6590)
$t-2$				+ .1452 (2.9425)	− .3562 (3.3794)
$t-3$				− .0719 (.9672)	+ .1806 (1.6709)
$t-4$				− .1959 (2.8885)	
			Σ =	+ .5749 (4.8338)	+ .3700 (2.4713)

R^2 = .9770

SE = .2126

DW = 1.8988

ρ = .7859

direction, and adjust their portfolios accordingly. It is of interest to note that a relatively long distributed lag on Federal funds was obtained in the monthly financial sector model developed by Pierce and Thomson [18, p. 26].

The public's demand for bills, as shown in Table II-10, behaves as expected. The commercial paper and CD rates have a negative impact distributed over five months, although the standard error on the distributed lag impact of the CD rate suggests that the collinear interrelationships among the rates are blurring the separate impact of the CD rate on public bill holdings.

Certificates of deposit.--Because of Regulation Q ceilings imposed on CD deposit rates by the Federal Reserve Board in the past, the empirical estimation of the CD market required some method to account for the CD runoffs that occurred in 1966, 1968, and 1969, when secondary market CD rates rose above the Q ceilings. Our approach is to assume that banks have a desired CD rate, which reflects overall loan demand and the rate on competing money market instruments, proxied by RTB. This desired rate is assumed to be reflected in the secondary market rate on CD's since it is the rate banks did in fact pay when Regulation Q ceilings were not binding. We assume further that given bill rates and loan demand, the secondary rate is the rate that would have been paid in those periods when Q ceilings were in effect.

The secondary CD rate is presented in Table II-11 as a function of the bill rate and the commercial loan variable $\frac{CL}{D}$. The lag space search was carried out for this equation using a second degree polynomial; thus the estimates in the table are OLS estimates. A third degree poly-

II - 10

Public Demand for Treasury Bills

time period			constant	RTB	RCP	RCD
t	$\left(\frac{QTBP}{PI}\right)$	=	+ .0800 (7.6751)	+ .0045 RTB_t (3.0277)	- .0079 RCP_t (3.9065)	+ .0021 RCD_t (1.2033)
t-1				+ .0047 (2.5820)	- .0051 (2.8912)	+ .0010 (.5537)
t-2				+ .0039 (2.6090)	- .0031 (1.8005)	- .0003 (.1435)
t-3				+ .0034 (1.8744)	- .0014 (.8588)	- .0013 (.7917)
t-4				+ .0043 (2.5348)	+ .0008 (.4683)	- .0019 (1.1831)
t-5					+ .0043 (1.8187)	- .0017 (1.2903)
t-6						- .0004 (.4375)
	Σ	=		+ .0208 (3.8317)	- .0124 (1.7224)	- .0025 (.3332)

R^2 = .9158

SE = .0032

DW = 2.3851

ρ = .9446

II - 11

Bank Supply Equation

Rate on Certificates of Deposit

$$
\begin{array}{llll}
RCD = & \underset{(1.9103)}{-1.2245} & + \underset{(10.3013)}{.6663}\ RTB_t & \underset{(.3371)}{-1.2436}\ \left(\frac{CL}{D}\right)_t \\
 & & + \underset{(7.2575)}{.5576}\ RTB_{t-1} & \underset{(1.72226)}{+6.1496}\ \left(\frac{CL}{D}\right)_{t-1} \\
 & & - \underset{(.3136)}{.0208}\ RTB_{t-2} & \underset{(.3047)}{-1.1130}\ \left(\frac{CL}{D}\right)_{t-2} \\
\Sigma = & & \underset{(22.1257)}{1.2031} & \underset{(1.1296)}{3.7931}
\end{array}
$$

R^2 = .9866
SE = .2058
DW = 2.1407
ρ = .6055

nomial was originally applied in the lag search but no reasonable results were obtained.

The impact of Q ceilings are explicitly introduced in the public's demand for negotiable certificates of deposit. It is assumed that the CD runoff is essentially a demand phenomenon. Over time, public awareness of the differential between allowable CD rates and rates on other instruments will reduce their desire to hold CD's at below market rates. Thus, the variable QT is introduced in the demand function; Q = 1 when the secondary CD rate is above the Q ceiling; Q = 0 otherwise. T is reset at 1 each time Q switches from 0 to 1, and is indexed through the runoff period.

The public's CD demand function is presented in Table II-12. The interest rate variables both have significant distributed lag effects with the expected sign. In addition, the runoff variable QT also appears with a relatively small standard error, and seems to support the hypothesized behavioral relationship. The Durbin-Watson statistic is quite low, 1.1266, so it is quite possible that substantial specification error exists in this equation, which could be producing gratuitously large t- statistics.

Commercial loans.--The bank supply function for commercial loans was estimated as a rate equation, as shown in Table II-13. It was assumed that banks generally accommodate, to the extent possible, customer demand for loans and adjust the loan rate according to variations in the cost of financing those loans and to the opportunity cost of competing assets, in this case Treasury bills. The estimation results bear this out as the only significant distributed lag effects are obtained for the CD rate; although the Treasury bill distributed lag coefficient is negative, it has a relatively large standard error. While some positive relationship

II - 12

Public Demand for Certificates

of Deposit

time period							
t	$\frac{CD}{PI}$ =	7.3335 (6.4070)	− .0171 QT (2.3879)		+ .0889 RCD_t (1.5476)		− .0742 RCP_t (1.1276)
t-1					+ .1536 (2.4217)		− .1021 (1.2183)
t-2					+ .1864 (2.8622)		− .2152 (2.6211)
t-3					+ .0171 (.2910)		− .1468 (1.7122)
				Σ =	.4460 (2.6289)		− .5384 (2.9544)

R^2 = .9894

SE = .1220

DW = 1.1266

ρ = .9900

II - 13

Bank Supply of Commercial Loans
Rate Setting Equation

time period					
t	RCL =	2.0760 (2.9713)	+ .8742 $\left(\frac{CL}{D}\right)_t$ (.2679)	+ .2261 RTB_t (3.1875)	+ .0181 RCD_t (.2610)
t-1				- .0374 (.4319)	+ .1794 (3.3564)
t-2				- .1425 (1.5675)	+ .2156 (4.1482)
t-3				- .0299 (.3408)	+ .1709 (4.5253)
t-4					+ .0893 (3.5986)
t-5					+ .0151 (.5549)
t-6					- .0077 (.3087)
t-7					+ .0652 (1.4776)
			Σ =	+ .0162 (.0775)	+ .7460 (4.6243)

R^2 = .9837

SE = .1682

DW = 2.2401

ρ = .8396

between the banks' loan portfolio variable $\frac{CL}{D}$ and the loan rate might be expected, the lagged value (and contemporary value in another space search) entered the equation with a quite large standard error. This suggests a supply function that is completely elastic with respect to the loan rate, so that the loan rate is completely determined by the cost of funds.

The public's demand for commercial loans is presented in Table II-14. The results indicate that the demand for commercial bank loans can be explained by inventory accumulation and the rate on commercial paper, an important source of nonbank financing. Although the RCL effect shows up properly signed, it has a large standard error. The corporate bond rate however appears improperly signed.

The overall picture is a loan market in which the commercial bank loan supply function is perfectly elastic, with the loan rate determined primarily by the cost of loanable funds at the margin, in this case the rate on CD's. Thus commercial loans are essentially demand determined. The public's demand is apparently inelastic, and reflects mainly the behavior of the real shift variable ΔH and the alternative cost of funds in the commercial paper market. If in fact banks do accommodate loan demand by issuing CD's, this would explain the absence of a significant Treasury bill relationship in the supply equation, since no substitution on a relative cost basis would be involved.

It is necessary to point out, however, the tentative nature of these results. The commercial loan rate is a manufactured variable that reflects mainly the behavior of the prime rate. The failure of the equations to indicate a significant relationship between CL and RCL may simply reflect the fact that the prime rate until relatively recently did not accurately reflect the true cost of commercial loans.

II - 14

Public Demand for Commercial Loans

time period				
t	$\frac{CL_{CB}^{SA}}{PI}$ =	14.1404 (15.6799)	− .0894 RCB_t (.9420)	
t		+ .0243 RCL_t (.4390)	+ .1208 RCP_t (2.8228)	+ .0025 ΔH_t (.1623)
t-1		+ .0227 (.3724)	+ .0091 (.2671)	+ .0210 (1.1009)
t-2		− .0752 (1.2265)	− .0174 (.7337)	+ .0283 (1.3722)
t-3		− .0869 (1.2398)	+ .0094 (.2563)	+ .0304 (1.4611)
t-4			+ .0575 (1.1685)	+ .0330 (1.6795)
t-5				+ .0418 (2.5627)
	Σ =	− .0971 (.6584)	+ .1794 (1.7800)	+ .1570 (1.7548)

R^2 = .9924

SE = .0996

DW = 1.9517

ρ = .9834

Commercial paper rate.--The reduced-form commercial paper rate equation, estimated using a second degree polynomial, is presented in Table II-15. The equation indicates that commercial paper rate movements will closely reflect movements in rates on competing short-term instruments and the commercial loan rate. In addition, it is quite sensitive in the short run to changes in the bond rate.

Reduced Form Commercial Paper Rate Equation

time period				
	RCP =	− .4355 (1.7713)	+ .3130 RCB_t (3.0785)	− .2938 RCB_{t-1} (2.9606)
t		+ .3760 RTB_t (7.2302)	+ .4021 RCD_t (8.1394)	+ .0140 RCL_t (.2325)
t-1		+ .0615 (1.3936)	+ .1659 (3.9202)	+ .1257 (3.3604)
t-2		− .0719 (1.3765)	− .0267 (.6167)	+ .1404 (3.2219)
t-3		− .0242 (.5099)	− .1756 (3.6026)	+ .0581 (1.8999)
t-4		+ .2047 (3.4071)		− .1212 (2.1484)
Σ		.5460 (3.2744)	.3657 (2.9118)	.2171 (2.1653)

R^2 = .9952

SE = .1170

DW = 1.7381

ρ = .6919

IV

Some Simulation Results

In order to indicate the tracking ability of the model and any remaining problems in its specification, an in-period simulation is reported in this section. This simulation, which covers the period 1972-1 to 1973-12, uses actual values in the lag structure, rather than computed values, in order to demonstrate the model's single period estimating characteristics. While the results reported in Tables IV-1 to IV-11 cover the entire simulation period, the first six periods are used to get the model "on track," and should not be evaluated too closely. The first period, for example, represents only one iteration, not a convergent solution, and is used merely to initiate the Cochrane-Orcutt autoregressive correction scheme.

One equation, the ratio of Treasury bills held by the public to personal income, generally over estimates in the simulation period. Rather than use an intercept adjustment, we chose to leave the variable exogenous and examine the tracking characteristics of the remaining equations.

Reserves borrowed by commercial banks, Table IV-1, exhibit a relatively large root mean squared error (RMSE). Two instances of negative borrowing occur. The first, in 72-5, results from an abnormally large fall-off in the solution values for commercial loans (Table IV-4). The second results from a large fall in required reserves in 72-11. Each of these variables enter into the borrowings equation as impact variables, and the impact, in these cases, is too severe to keep borrowings positive. This equation needs more work to prevent negative borrowings.

The fall-off in required reserves in 72-11 is reflected in a number of interest rate variables in the model. As shown in Tables IV-2, 3, 5, 6 and 7, these rates fall substantially in this period. The chain of causation appears to flow from required reserves to borrowings to free reserves to the Federal funds rate to the Treasury bill rate, and on to the other rates. The chain continues through the commercial paper rate to commercial loans, as shown in Table IV-4. In the following period, the Cochrane-Orcutt correction scheme brings the model back "on track." A similar pattern, again caused by fluctuating required reserves, appears in 73-11 and 12. In the remainder of the period, these equations track reasonably well.

The remaining variables presented in these tables are monetary aggregates. Both time and demand deposits at member banks appear to track very well. Both the M_1 and M_2 equations are also performing well.

Conclusion

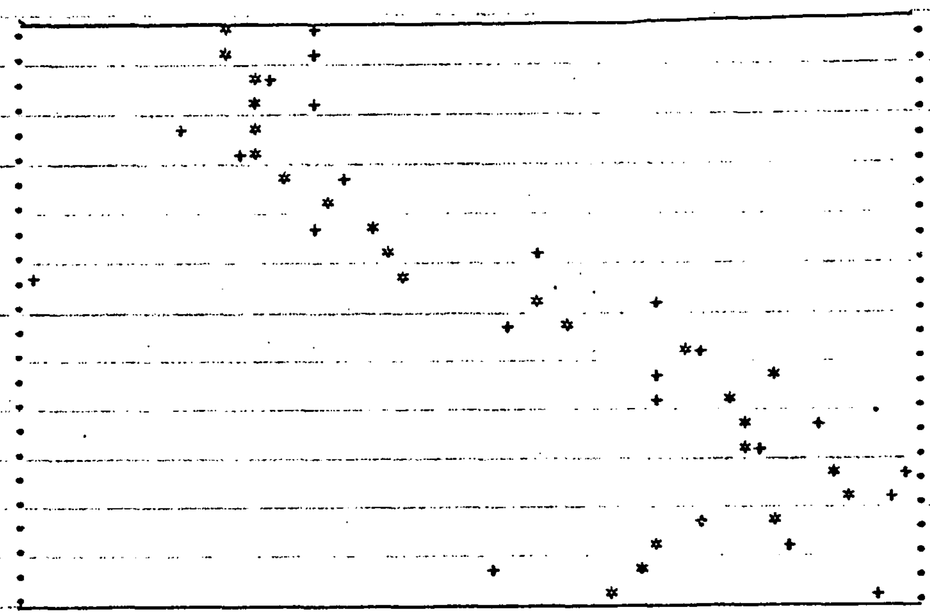
The model, as specified and estimated here, represents the first step in an optimal control study of monetary policy. Further development of this model to specify the Federal Funds market, to linearize the model and to run the optimal control experiments will be presented in forthcoming papers.

MEMBER BANK BORROWINGS AT THE DISCOUNT WINDOW

Actuals = * Predicted = +

RANGE -0.627 TO 2.322

PRED.	ACTUAL	ERROR	PERCENT	TIME
0.300	0.020	0.280	1400.366	1
0.309	0.030	0.279	930.180	2
0.195	0.100	0.095	95.284	3
0.326	0.120	0.206	171.392	4
-0.119	0.110	-0.229	-208.057	5
0.096	0.100	-0.004	-3.839	6
0.411	0.230	0.181	78.537	7
0.361	0.390	-0.029	-7.395	8
0.344	0.540	-0.196	-36.328	9
1.079	0.550	0.529	96.210	10
-0.627	0.610	-1.237	-202.708	11
1.461	1.050	0.411	39.097	12
0.976	1.165	-0.189	-16.223	13
1.633	1.593	0.040	2.542	14
1.473	1.858	-0.385	-20.699	15
1.469	1.721	-0.252	-14.622	16
2.015	1.786	0.229	12.848	17
1.826	1.789	0.037	2.062	18
2.322	2.051	0.271	13.225	19
2.280	2.143	0.137	6.378	20
1.628	1.861	-0.233	-12.494	21
1.899	1.467	0.432	29.443	22
0.921	1.399	-0.478	-34.187	23
2.197	1.298	0.899	69.284	24



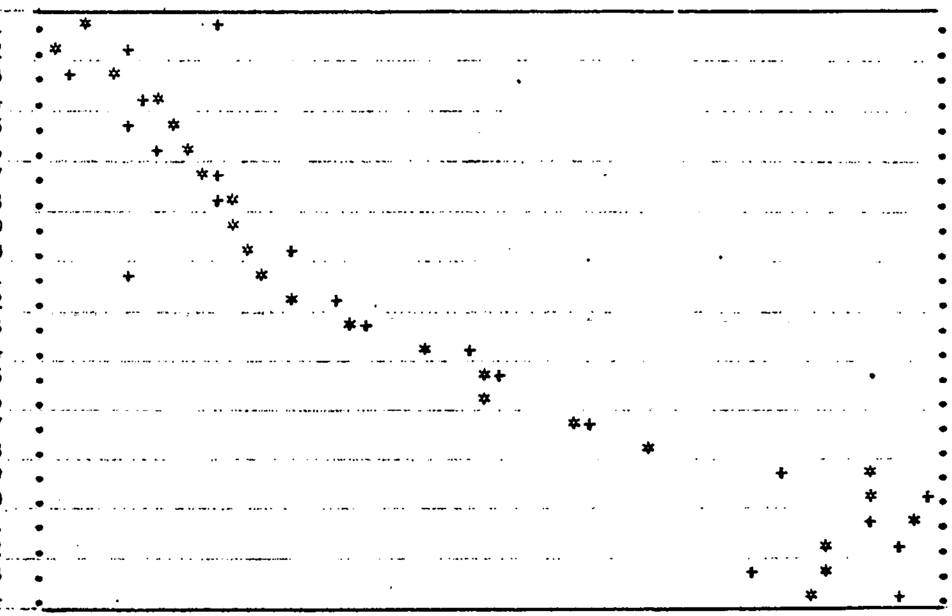
SUM OF THE SQUARES = 3.982530
NUMBER OF OBSERVATIONS = 24
ROOT MEAN SQUARE DEVIATION = 0.407356

THE FEDERAL FUNDS RATE

Actuals = *   Predicted = +

PRED.	ACTUAL	ERROR	PERCENT	TIME
4.671	3.500	1.171	33.462	1
3.905	3.290	0.615	18.708	2
3.401	3.830	-0.429	-11.191	3
4.016	4.170	-0.154	-3.686	4
3.939	4.270	-0.331	-7.753	5
4.195	4.460	-0.265	-5.938	6
4.717	4.550	0.167	3.666	7
4.782	4.800	-0.018	-0.370	8
4.810	4.870	-0.060	-1.237	9
5.385	5.040	0.345	6.839	10
3.914	5.060	-1.146	-22.654	11
5.723	5.330	0.393	7.373	12
6.045	5.940	0.105	1.765	13
6.924	6.580	0.344	5.234	14
7.150	7.090	0.060	0.839	15
7.011	7.120	-0.109	-1.537	16
7.908	7.840	0.068	0.863	17
8.455	8.490	-0.035	-0.417	18
9.670	10.400	-0.730	-7.023	19
10.961	10.500	0.461	4.394	20
10.415	10.780	-0.365	-3.384	21
10.750	10.010	0.740	7.395	22
9.344	10.030	-0.686	-6.840	23
10.645	9.950	0.695	6.980	24

RANGE 3.290 TO 10.961



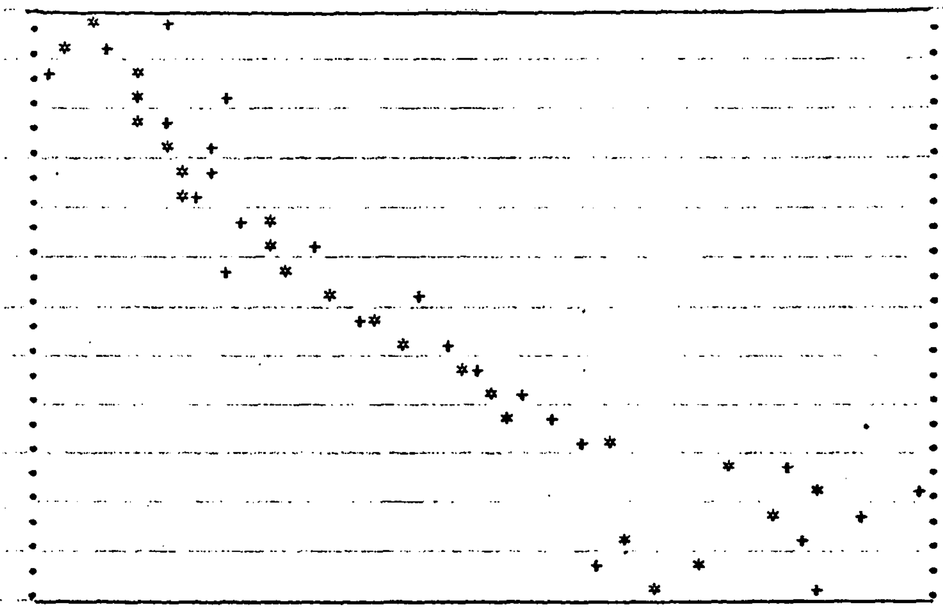
SUM OF THE SQUARES = 6.287992
NUMBER OF OBSERVATIONS = 24
ROOT MEAN SQUARE DEVIATION = 0.511859

THE TREASURY BILL RATE

Actuals = *   Predicted = +

RANGE 3.058 TO 9.402

PRED.	ACTUAL	ERROR	PERCENT	TIME
3.879	3.400	0.479	14.102	1
3.516	3.200	0.316	9.888	2
3.058	3.700	-0.642	-17.356	3
4.314	3.700	0.614	16.592	4
3.941	3.700	0.241	6.500	5
4.254	3.900	0.354	9.084	6
4.217	4.000	0.217	5.434	7
4.162	4.000	0.162	4.038	8
4.413	4.700	-0.287	-6.097	9
5.002	4.700	0.302	6.427	10
4.363	4.800	-0.437	-9.095	11
5.755	5.100	0.655	12.850	12
5.294	5.400	-0.106	-1.967	13
6.011	5.600	0.411	7.348	14
6.207	6.090	0.117	1.921	15
6.500	6.260	0.240	3.841	16
6.732	6.360	0.372	5.848	17
6.965	7.190	-0.225	-3.133	18
8.397	8.010	0.387	4.828	19
9.402	8.670	0.732	8.447	20
8.988	8.290	0.698	8.422	21
8.548	7.220	1.328	18.389	22
7.009	7.830	-0.821	-10.489	23
8.646	7.450	1.196	16.055	24



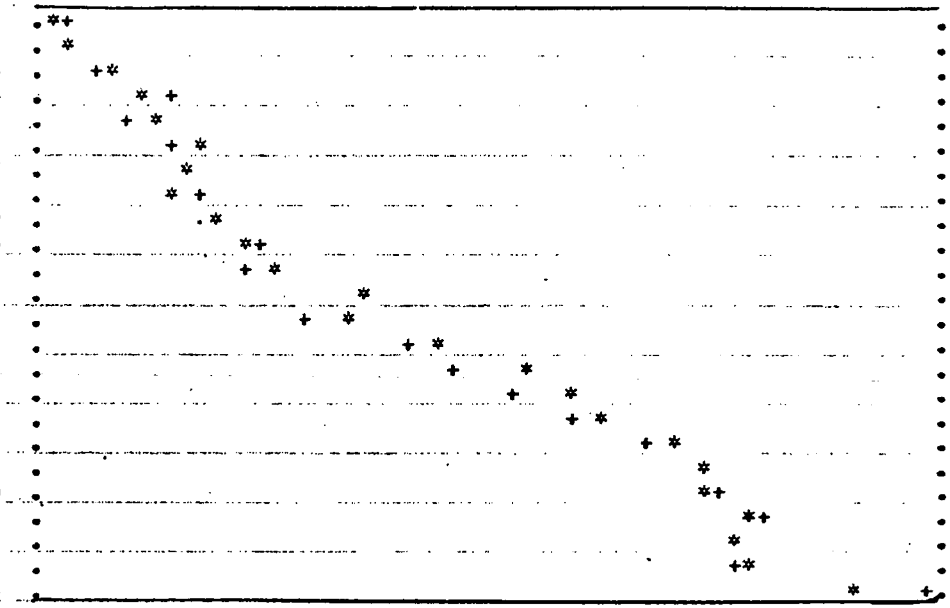
SUM OF THE SQUARES = 7.651735
NUMBER OF OBSERVATIONS = 24
ROOT MEAN SQUARE DEVIATION = 0.564644

COMMERCIAL AND INDUSTRIAL LOAND AT COMERCIAL BANKS

Actual = * Predicted = +

RANGE 115.200 TO 164.331

PRED.	ACTUAL	ERROR	PERCENT	TIME
115.626	115.200	0.426	0.369	1
116.129	116.100	0.029	0.025	2
117.467	118.400	-0.933	-0.788	3
121.816	120.100	1.716	1.429	4
119.487	120.800	-1.313	-1.087	5
122.252	123.200	-0.948	-0.770	6
122.927	122.300	0.627	0.512	7
123.505	122.200	1.305	1.068	8
124.713	124.200	0.513	0.413	9
126.574	125.800	0.774	0.615	10
125.810	127.600	-1.790	-1.403	11
132.272	132.700	-0.428	-0.323	12
129.460	132.000	-2.540	-1.925	13
134.979	136.600	-1.621	-1.187	14
137.620	141.700	-4.080	-2.880	15
141.326	144.400	-3.074	-2.129	16
144.631	146.400	-1.769	-1.208	17
148.542	150.400	-1.858	-1.235	18
151.711	151.800	-0.089	-0.058	19
152.795	152.200	0.595	0.391	20
154.809	154.100	0.709	0.460	21
153.529	153.300	0.229	0.149	22
153.161	154.600	-1.439	-0.931	23
164.331	159.900	4.431	2.771	24



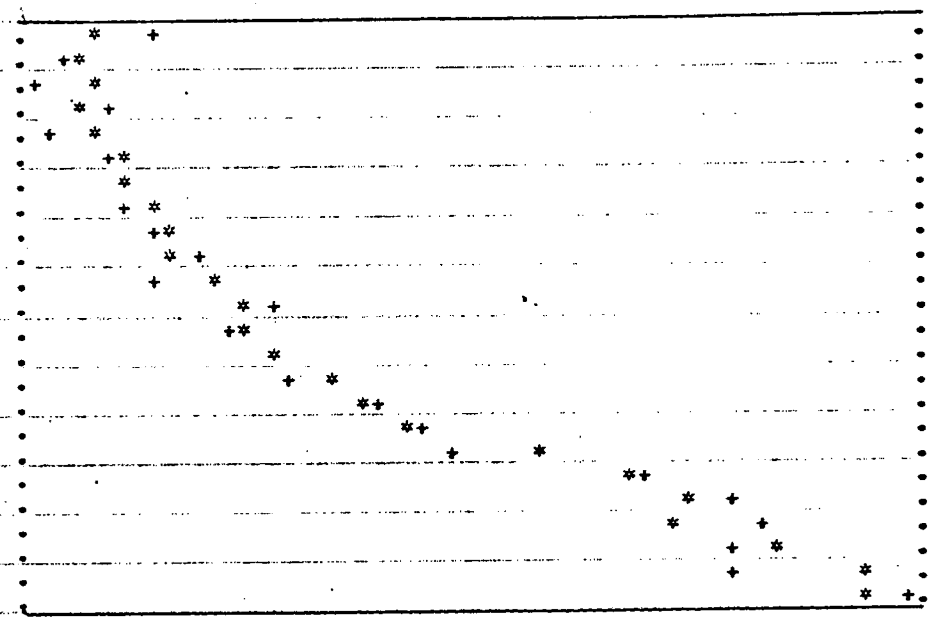
SUM OF THE SQUARES = 77.343506
NUMBER OF OBSERVATIONS = 24
ROOT MEAN SQUARE DEVIATION = 1.795173

THE RATE ON COMMERCIAL LOANS

Actuals = * Predicted = +

PRED.	ACTUAL	ERROR	PERCENT	TIME
6.139	5.810	0.329	5.668	1
5.603	5.700	-0.097	-1.709	2
5.437	5.780	-0.343	-5.936	3
5.862	5.680	0.182	3.199	4
5.514	5.730	-0.216	-3.769	5
5.828	5.910	-0.082	-1.381	6
5.945	5.910	0.035	0.594	7
5.929	6.120	-0.191	-3.124	8
6.140	6.150	-0.010	-0.161	9
6.345	6.220	0.125	2.015	10
6.109	6.450	-0.341	-5.284	11
6.782	6.630	0.152	2.290	12
6.502	6.580	-0.078	-1.179	13
6.781	6.760	0.021	0.314	14
6.891	7.080	-0.189	-2.673	15
7.334	7.300	0.034	0.471	16
7.593	7.480	0.113	1.511	17
7.794	8.260	-0.466	-5.638	18
8.821	8.800	0.021	0.241	19
9.355	9.120	0.235	2.578	20
9.543	9.000	0.543	6.030	21
9.353	9.590	-0.237	-2.466	22
9.365	10.060	-0.695	-6.913	23
10.340	10.060	0.280	2.783	24

RANGE 5.437 TO 10.340



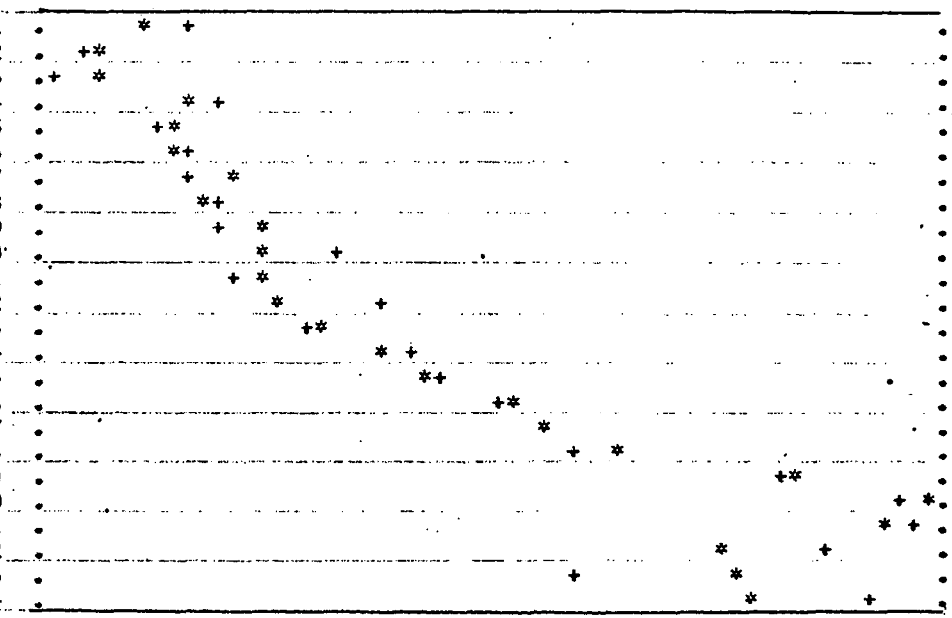
SUM OF THE SQUARES = 1.756155
NUMBER OF OBSERVATIONS = 24
ROOT MEAN SQUARE DEVIATION = 0.270505

SECONDARY MARKET RATE ON CERTIFICATES OF DEPOSIT

Actuals = * Predicted = +

RANGE 3.394 TO 10.800

PRED.	ACTUAL	ERROR	PERCENT	TIME
4.492	4.200	0.292	6.950	1
3.688	3.750	-0.062	-1.649	2
3.394	3.800	-0.406	-10.697	3
4.793	4.500	0.293	6.508	4
4.290	4.400	-0.110	-2.499	5
4.564	4.400	0.164	3.717	6
4.569	4.850	-0.281	-5.802	7
4.751	4.650	0.101	2.164	8
4.806	5.150	-0.344	-6.688	9
5.800	5.200	0.600	11.539	10
4.918	5.200	-0.282	-5.417	11
6.155	5.250	0.905	17.245	12
5.499	5.600	-0.101	-1.807	13
6.370	6.200	0.170	2.739	14
6.641	6.550	0.091	1.385	15
7.180	7.300	-0.120	-1.647	16
7.573	7.500	0.073	0.977	17
7.751	8.210	-0.459	-5.590	18
9.502	9.610	-0.108	-1.125	19
10.586	10.800	-0.214	-1.985	20
10.700	10.440	0.260	2.488	21
9.943	9.090	0.853	9.378	22
7.788	9.210	-1.422	-15.439	23
10.307	9.330	0.977	10.476	24



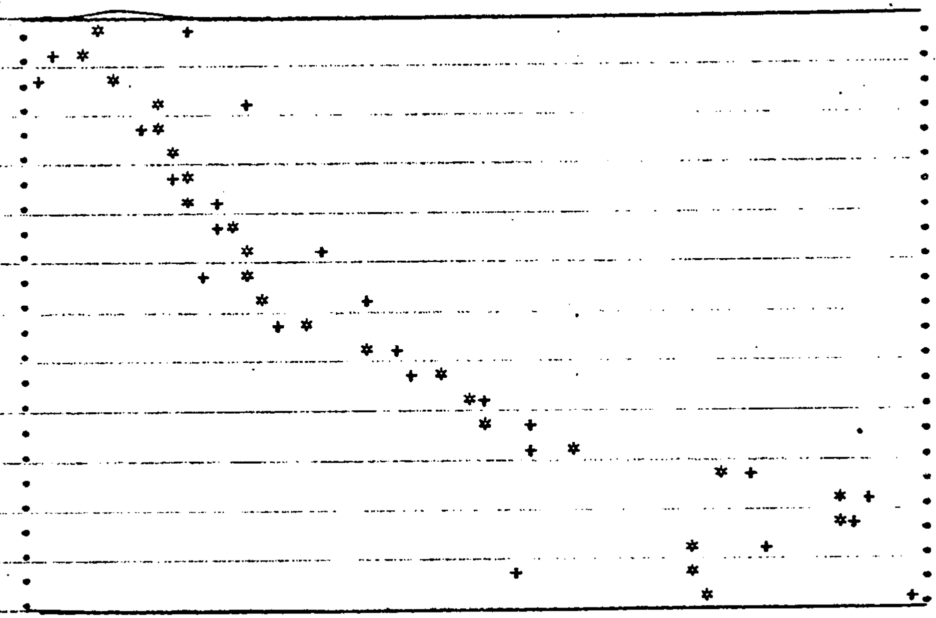
SUM OF THE SQUARES = 5.952572
NUMBER OF OBSERVATIONS = 24
ROOT MEAN SQUARE DEVIATION = 0.498020

THE RATE ON COMMERCIAL PAPER

Actuals = * Predicted = +

RANGE 3.561 TO 10.803

PRED.	ACTUAL	ERROR	PERCENT	TIME
4.814	4.080	0.734	17.980	1
3.714	3.930	-0.216	-5.503	2
3.561	4.170	-0.609	-14.594	3
5.305	4.580	0.725	15.835	4
4.401	4.510	-0.109	-2.423	5
4.694	4.640	0.054	1.174	6
4.712	4.850	-0.138	-2.855	7
5.024	4.820	0.204	4.232	8
4.990	5.140	-0.150	-2.916	9
5.851	5.300	0.551	10.392	10
4.869	5.250	-0.381	-7.249	11
6.208	5.450	0.758	13.902	12
5.484	5.780	-0.296	-5.122	13
6.550	6.220	0.330	5.304	14
6.639	6.850	-0.211	-3.085	15
7.283	7.140	0.143	2.005	16
7.608	7.270	0.338	4.656	17
7.626	7.990	-0.364	-4.552	18
9.460	9.180	0.280	3.055	19
10.495	10.210	0.285	2.787	20
10.321	10.230	0.091	0.890	21
9.599	8.920	0.679	7.614	22
7.504	8.940	-1.436	-16.059	23
10.803	9.080	1.723	18.973	24



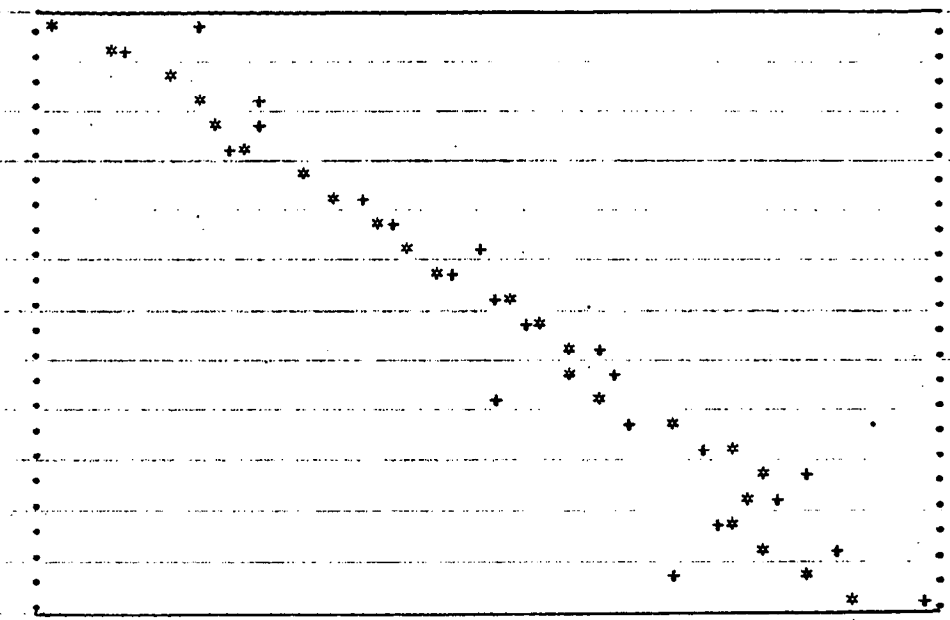
SUM OF THE SQUARES = 8.768171
NUMBER OF OBSERVATIONS = 24
ROOT MEAN SQUARE DEVIATION = 0.604434

THE MONEY SUPPLY M1

Actuals = * Predicted = +

PRED.	ACTUAL	ERROR	PERCENT	TIME
241.732	235.500	6.232	2.646	1
239.052	238.200	0.852	0.358	2
240.666	240.500	0.166	0.069	3
244.483	242.000	2.483	1.026	4
244.559	242.800	1.759	0.724	5
243.248	244.200	-0.952	-0.390	6
246.353	246.600	-0.247	-0.100	7
248.964	247.900	1.064	0.429	8
250.075	249.500	0.575	0.230	9
254.036	251.300	2.736	1.089	10
253.244	252.600	0.644	0.255	11
255.196	255.700	-0.504	-0.197	12
256.258	256.700	-0.442	-0.172	13
259.199	257.900	1.299	0.504	14
260.351	258.100	2.251	0.872	15
255.236	259.400	-4.164	-1.605	16
260.805	262.400	-1.595	-0.608	17
263.938	265.500	-1.562	-0.588	18
268.586	266.400	2.187	0.821	19
267.219	266.200	1.019	0.383	20
264.698	265.500	-0.802	-0.302	21
269.578	266.500	3.078	1.155	22
262.948	268.800	-5.853	-2.177	23
273.691	270.400	3.291	1.217	24

RANGE 235.500 TO 273.691



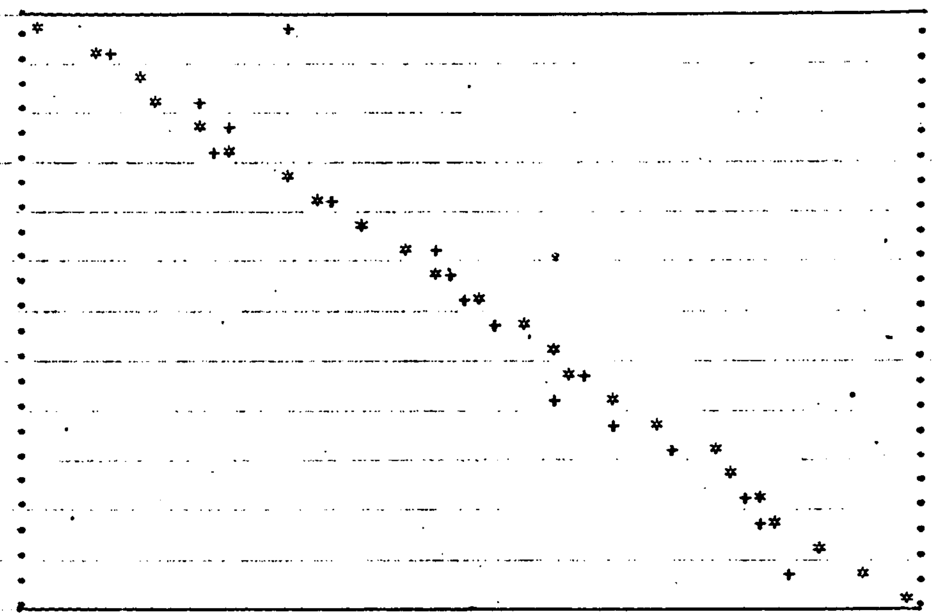
SUM OF THE SQUARES = 149.722122
NUMBER OF OBSERVATIONS = 24
ROOT MEAN SQUARE DEVIATION = 2.497684

THE MONEY SUPPLY M2

Actuals = * Predicted = +

RANGE 477.300 TO 570.700

PRED.	ACTUAL	ERROR	PERCENT	TIME
504.249	477.300	26.949	5.646	1
484.883	482.900	1.983	0.411	2
488.835	487.600	1.235	0.253	3
494.540	490.600	3.940	0.803	4
497.194	494.100	3.094	0.626	5
495.590	498.400	-2.810	-0.564	6
503.871	503.700	0.171	0.034	7
508.800	507.800	1.000	0.197	8
511.737	511.900	-0.163	-0.032	9
519.750	516.600	3.150	0.610	10
520.896	520.100	0.796	0.153	11
522.787	525.500	-2.713	-0.516	12
526.959	529.600	-2.641	-0.499	13
532.799	532.300	0.499	0.094	14
535.865	534.600	1.265	0.237	15
532.413	538.300	-5.887	-1.094	16
539.737	543.600	-3.864	-0.711	17
545.410	549.400	-3.990	-0.726	18
551.821	552.000	-0.179	-0.033	19
552.900	554.900	-2.000	-0.360	20
554.349	556.600	-2.251	-0.404	21
561.206	561.600	-0.395	-0.070	22
557.616	566.700	-9.084	-1.603	23
570.090	570.700	-0.610	-0.107	24



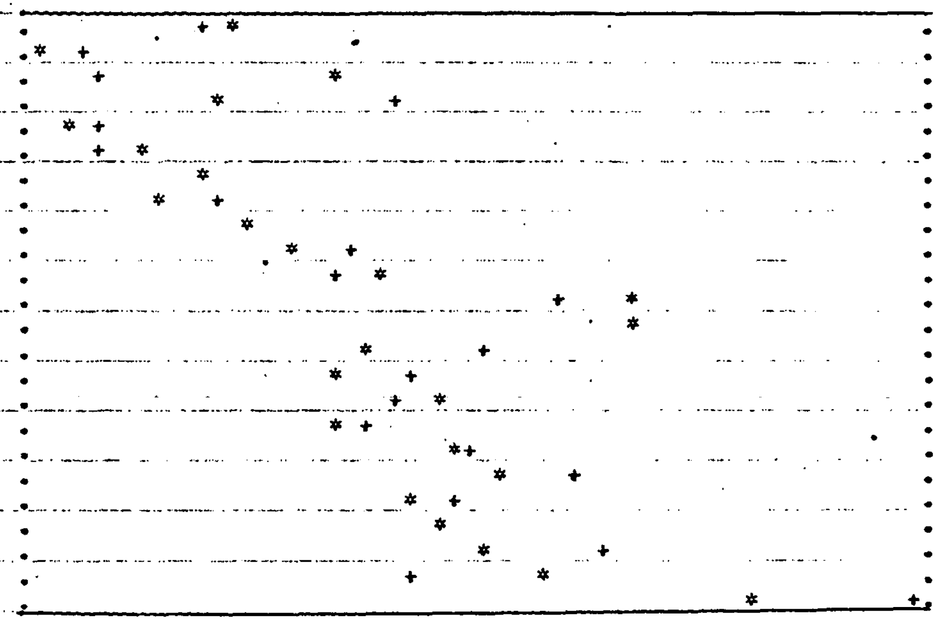
SUM OF THE SQUARES = 950.130859
NUMBER OF OBSERVATIONS = 24
ROOT MEAN SQUARE DEVIATION = 6.291962

PRIVATE NONBANK DEMAND DEPOSITS AT MEMBER BANKS

Actuals = * Predicted = +

RANGE 136.100 TO 159.083

PRED.	ACTUAL	ERROR	PERCENT	TIME
140.510	141.200	-0.690	-0.489	1
137.351	136.100	1.251	0.919	2
137.569	143.700	-6.131	-4.267	3
145.363	140.800	4.563	3.241	4
137.506	136.700	0.806	0.590	5
137.752	138.700	-0.948	-0.683	6
140.266	140.400	-0.134	-0.095	7
140.622	139.400	1.222	0.876	8
141.744	141.400	0.344	0.243	9
144.389	142.800	1.589	1.113	10
143.866	145.000	-1.134	-0.782	11
149.798	151.500	-1.702	-1.124	12
151.679	151.700	-0.021	-0.014	13
147.592	144.600	2.992	2.069	14
145.897	144.000	1.897	1.317	15
145.337	146.800	-1.463	-0.997	16
144.827	143.700	1.127	0.784	17
147.270	147.000	0.270	0.184	18
150.134	148.200	1.934	1.305	19
147.126	145.700	1.426	0.979	20
146.503	146.600	-0.097	-0.066	21
150.762	147.800	2.962	2.004	22
145.718	149.500	-3.782	-2.530	23
159.083	154.900	4.183	2.701	24



SUM OF THE SQUARES = 132.730667
NUMBER OF OBSERVATIONS = 24
ROOT MEAN SQUARE DEVIATION = 2.351689

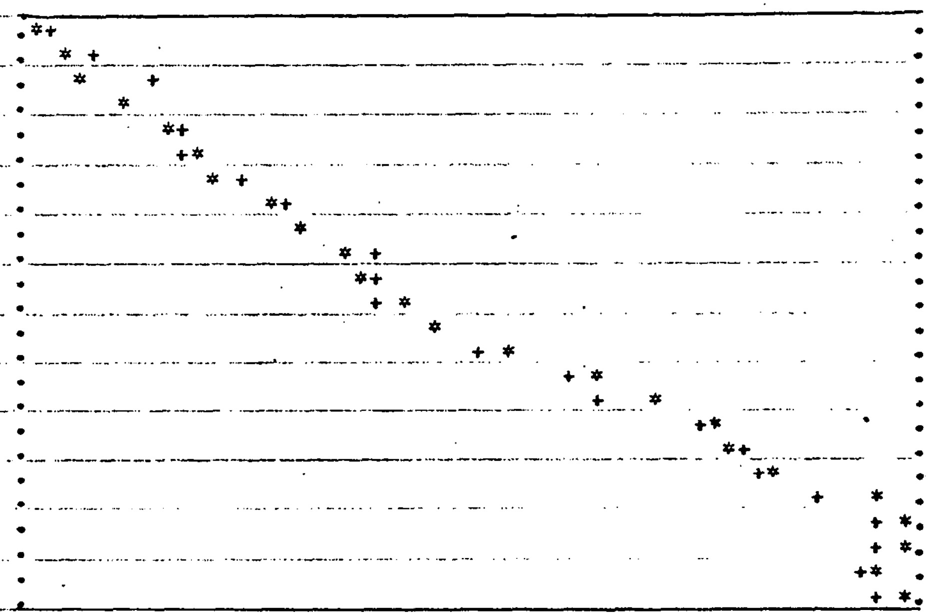
END OF COMPUTATION

TIME AND SAVINGS DEPOSITS AT MEMBER BANKS

Actuals = * Predicted = +

RANGE 213.400 TO 279.000

PRED.	ACTUAL	ERROR	PERCENT	TIME
214.369	213.400	0.969	0.454	1
218.063	215.900	2.163	1.002	2
222.668	216.200	6.468	2.992	3
220.334	219.800	0.534	0.243	4
224.445	223.100	1.345	0.603	5
224.188	225.200	-1.012	-0.449	6
229.195	227.100	2.095	0.923	7
232.494	231.300	1.194	0.516	8
233.828	233.800	0.020	0.012	9
238.436	236.200	2.236	0.947	10
238.661	237.600	1.061	0.446	11
239.212	240.700	-1.488	-0.618	12
243.827	243.800	0.027	0.011	13
247.046	248.500	-1.454	-0.585	14
253.716	256.200	-2.484	-0.969	15
255.608	260.500	-4.892	-1.878	16
263.349	264.500	-1.151	-0.435	17
266.381	265.900	0.481	0.181	18
267.503	268.500	-0.997	-0.371	19
272.615	276.600	-3.986	-1.441	20
277.170	279.000	-1.830	-0.656	21
276.828	278.800	-1.972	-0.707	22
275.381	276.600	-1.219	-0.441	23
277.015	278.500	-1.485	-0.533	24



SUM OF THE SQUARES = 126.305771
NUMBER OF OBSERVATIONS = 24
ROOT MEAN SQUARE DEVIATION = 2.294066

APPENDIX

Glossary of Terms and Sources of Data

Endogenous Variables*

C	Currency in circulation outside of banks, SA. Table 2, Federal Reserve Statistical Release, Division of Research and Statistics, January 1974.**
CD_{CB}	Outstanding Certificates of Deposit issued by commercial banks, SA. Table 2, Release.
CL_{CB}^{NSA}	Total Commercial and Industrial Loans at all commercial banks, NSA. November 1973 Federal Reserve Bulletin, pp. A96-A98, updated from current Bulletin, p. A17.
CL_{CB}^{SA}	Total Commercial and Industrial Loans at all commercial banks, SA. November 1973 Bulletin, pp. A96-A98, updated from current Bulletin, p. A17.
D_{CB}	Total Commercial Bank Deposits, SA. Calculated according to the identity: $M_2 - C + DD_{CB}^{G} + CD_{CB}$.
D_{MB}	Total Member Bank Deposits subject to reserve requirements, NSA. Series MF3476, S. F. Financial Database, updated from Table 7, Release.
DD_{CB}^{P}	Private Commercial Bank Demand Deposits, SA. Table 2, Release.
DD_{CB}^{T}	Total Commercial Bank Demand Deposits, SA. Calculated according to the identity: $DD_{CB}^{T} = DD_{CB}^{P} + DD_{CB}^{G}$.
DD_{MB}^{P}	Private Member Bank Demand Deposits subject to reserve requirements gross of net interbank deposits, NSA. Series MF3478, S. F. Financial Database, updated from Table 7, Release.
DD_{MB}^{PNB}	Private Member Bank Demand Deposits subject to reserve requirements exclusive of net interbank deposits, NSA. Calculated according to the identity: $DD_{MB}^{PNB} = DD_{MB}^{P} - DD_{MB}^{IB}$.

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*SA denotes seasonally adjusted data; NSA, seasonally unadjusted data.

**This release will be referred to as Release in subsequent citations.

DD^T_{MB} — Total Member Bank Demand Deposits subject to reserve requirements gross of net interbank, NSA. Calculated according to the identity:

$$DD^T_{MB} = DD^P_{MB} + DD^G_{MB}.$$

ER — Member Bank Excess Reserves, NSA. Calculated according to the identity:

$$ER = RT - RR.$$

FR — Member Bank Free Reserves, NSA. Calculated according to the identity:

$$FR = RU - RR.$$

M_1 — Narrowly defined Money Stock (currency plus demand deposits), SA. Table 1, Release.

M_2 — Broadly defined Money Stock (M_1 plus time deposits other than large CD's), SA. Table 1, Release.

RB — Member Bank Borrowed Reserves, NSA. Calculated according to the identity:

$$RB = RT - RU.$$

RCD — Yield on three month CD's. Part IV, Table 1, An Analytical Record of Yields and Yield Spreads, Salomon Brothers.

RCL — Rate on Commercial Loans. Interpolated by the method described by Friedman [6] from quarterly RCL data, using the prime rate as a related series. Quarterly RCL data are from the SSRC-MIT-PENN Econometric Model database. The prime rate is taken from the Bulletin, p. A28.

RCP — Rate on 4- to 6-months prime commercial paper (averages of the most representative daily offering rate quoted by dealers). Series MF1400, S. F. Financial Database, updated from Bulletin, p. A29.

RFF — Federal Funds Rate. Series MF1403, S. F. Financial Database, updated from Bulletin, p. A29.

RR — Member Bank Required Reserves, NSA. Table 7, Release.

RT — Total Member Bank Reserves, NSA. Table 7, Release.

RTB — Market Yield on 3-month Treasury Bills. Series MF1405, S. F. Financial Database, updated from Bulletin, p. A29.

TD^{XCD}_{CB} — Commercial Bank Time and Savings Deposits exclusive of CD's, SA. Table 2, Release.

TTD_{CB} — Commercial Bank Time and Savings Deposits gross of CD's, SA. Calculated according to the identity:

$$TTD_{CB} = TD^{XCD}_{CB} + CD_{CB}.$$

TTD_{MB} — Member Bank Time and Savings Deposits, NSA. Series MF3477, S. F. Financial Database, updated from Table 7, Release.

QTBB — Quantity of Treasury Bills held by Commercial Banks, NSA. Bulletin, p. A39.

QTBP — Quantity of Treasury Bills held by Private Investors, NSA. Bulletin, p. A39.

Exogenous Variables

DD^{G}_{CB} — U. S. Government Demand Deposits at Commercial Banks, NSA. Table 3, Release.

DD^{G}_{MB} — U. S. Government Demand Deposits at Member Banks, NSA. Series MF3479, S. F. Financial Database, updated from Table 7, Release.

DD^{IB}_{MB} — Net Interbank Demand Deposits, NSA. Table 7, Release.

ΔH — Change in business inventories, SA. Calculated from monthly, end of period data, Economic Indicators.

K_D — Reserve Requirement Ratio on Demand Deposits. Calculated according to the identity:

$$KD = (RR - KT^{*}TD)/DD.$$

K_T — Reserve Requirement Ratio on Time and Savings Deposits. Interpolated from quarterly figures in the SSRC-MIT-PENN Econometric Model database.

PI — Total Personal Income, SA. Series MN101, S. F. National Accounts Database. Updated from Bulletin, p. A69.

RCB — Yield on Aaa Corporate Bonds. Series MF1425, S. F. Financial Database. Updated from Bulletin, p. A30.

RDIS — Discount Rate, weighted average computed from the New York City rate. Bulletin, p. A8.

RTD — Rate on Time and Savings Deposits. Linearly interpolated from quarterly figures in the SSRC-MIT-PENN Econometric Model database.

RU — Non-Borrowed Reserves. Table 7, Release.

S_1-S_{12} — Seasonal. 0-1 dummy variables.

T — Time, January 1962 = 1.

QT — CD runoff dummy variable. QT = 0 when RCD < ZCD. During CD runoff periods, QT is a time variable that is initialized at 1 at the start of each runoff period.

QTBT	Quantity of Treasury Bills held by commercial banks and private investors. Constructed according to the identity: $$QTBT = QTBP + QTBB.$$
ZCD	<u>CD ceiling</u> (Reg. Q), <u>Bulletin</u>, p. A10.

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