

Historical

Evaluating the Effectiveness
of Monetary Reforms

Arthur J. Rolnick

December 1974

Working Paper #34

Rsch. File #282.1

EVALUATING THE EFFECTIVENESS OF MONETARY REFORMS

by

Arthur J. Rolnick
Federal Reserve Bank of Minneapolis

December 1974

This paper is based on my University of Minnesota Ph.D. dissertation. The research underlying my thesis and the paper was generously financed by the Federal Reserve Bank of Minneapolis. I am indebted to James Henderson, John Kareken, and especially Neil Wallace for their many helpful comments. (None of them, of course, can be held responsible for any errors.)

I. Introduction

The Federal Reserve System (FRS) was established in 1914 to meet the "needs of trade," and to avert future financial breakdowns in the American banking system by providing a "lender of last resort." Over the years, the FRS has turned increasingly toward the broader goals of macroeconomic stabilization as outlined in the Employment Act of 1946. Yet, even though the focus of the central bank has altered, the machinery of monetary control has hardly changed. This study attempts to evaluate this machinery and various new designs.

While proposals for reform abound, few have been supported by relevant evidence.^{1/} Often reforms are evaluated within a deterministic framework where the only measure of effectiveness is some type of bang-per-buck criterion: What is the change in the impact of the interest rate on income? But in a deterministic setting, the potency of the policy instrument is largely irrelevant. Given some target value of the goal variable, an optimal setting for the instrument can generally be found.

This study evaluates reforms in a stochastic setting--stochastic because parameters must be estimated from finite data sets and because unexplained residuals exist. In such a setting, the effectiveness of a reform can be judged by the way it changes the probabilistic relation between instruments and targets.^{2/}

It is assumed here that the policy maker seeks to minimize the expected value of a quadratic loss function in a single variable, income, in a single period, using a single instrument, the FRS's portfolio.^{3/} It follows that the relevant opportunity locus is all attainable combinations (by way of different settings of the policy instrument) of

means and variances of income. Corresponding to each reform is a different structure, and hence a different set of reduced-form equations, and therefore a different locus. A reform is judged effective if the new locus is such that at every mean outcome the variance is reduced; the greater is the reduction in variance, the more valuable the reform.^{4/}

A number of distinguished economists, including Milton Friedman [4] and James Tobin [13], have addressed themselves to the problem of reforming the monetary institution. Friedman's plan includes closing the discount window, repealing present ceilings on the payment of interest on deposits, requiring the FRS to pay interest to member banks on their deposit liabilities, and establishing 100 percent reserve requirements. (He admits as an alternative to 100 percent requirements, revising present requirements to make them uniform for all banks and all types of deposits.) Tobin has made a similar proposal favoring interest payments on bank deposits and requiring the FRS to pay interest on required reserves.^{5/} Other proposals include reducing uncertainty about float, tying the discount rate to a market rate, making all banks members of the FRS, and increasing reserve requirements. Of the various reforms the central bank could initiate, those just enumerated seem to be the most popular and, presumably, the most likely to succeed.

We evaluate reforms using an estimated model of the economy. There is, however, a serious limitation to this approach. When using the model to simulate the effects of an institutional change, we assume the underlying behavioral relationships remain fixed, i.e., the simulation and evaluation of each reform is conditional on existing behavioral patterns. For this reason not all of the aforementioned reforms are considered. To impose 100 percent reserve requirements or to pay interest

on demand deposits, for example, would significantly alter the structure and behavioral relationships underlying the existing financial markets; these changes would be difficult if not impossible to forecast. Hence, we evaluated only those reforms which seem to come closest to maintaining the ceteris paribus assumption.^{6/} They are:

- 1) Reducing uncertainty about float
- 2) Increasing reserve requirements
- 3) Equalizing reserve requirements
 - a) among classes of banks
 - b) between time and demand deposits
- 4) Tying the discount rate to a market rate
- 5) Imposing reserve requirements on nonmember banks

The next section contains a description of the econometric model used to evaluate these reforms. The model attempts to describe the current monetary system by way of a structure detailed enough to allow incorporation of a variety of structural alternatives. In section III there is a discussion of the technique used to derive loci followed by a description of the loci generated for different reforms. The last section contains a discussion of some of the limitations of the model and of the approach used to evaluate reforms, along with some suggestions for further research.

II. An Econometric Model of the Economy

As in most research utilizing mathematical models, the type of model constructed depends on the questions being asked. Since the policy maker's loss function here is defined in terms of a single variable income, the model must explain this variable. More explicitly, since the loss function is defined over one period and since we assume monetary policy affects income only with a lag, the model must explain the linkage between current policy and next period's income. Now a model consisting of a single reduced-form equation of income on a subset of relevant predetermined variables would suffice if we were only interested in predicting income. Yet, a reduced-form model does not allow us to impose overidentifying restrictions. On efficiency grounds, therefore, a structural model would be preferred. Moreover, we are not simply interested in predicting income, but in predicting the impact of various monetary reforms on our ability to control income; for many of these reforms we need the structure in order to model the appropriate institutional changes. Consequently, we construct a model containing a set of structural equations representing a rather detailed and disaggregated financial sector. In order to limit the scope of this study, however, the aggregate demand sector is represented by a single reduced-form equation linking financial markets to future income.

The financial sector essentially models the portfolio behavior of three types of market participants: (1) commercial banks, which are disaggregated by size, by FRS membership, and by city and country classification, (2) the nonbank public, and (3) the FRS. Asset demand functions of both

banks and the nonbank public are motivated by utility maximization subject to wealth constraints, while the behavior of the FRS represents monetary policy. Equilibrium in the financial sector then is an equilibrium of stocks and balance sheets, a situation in which the public and commercial banks are content with their portfolio of assets and the demand to hold each asset is just equal to the stock supply.

A complete description of the U.S. financial sector would include a large number of markets for financial assets. In order to make this study manageable, we assume portfolio behavior is recursive in the following sense. The month is taken to be the observation period and within this period, income, wealth, prices, and the nonbank public's allocation decision between liquid and other assets are assumed to be exogenous. The financial sector, then, focuses only on explaining market behavior for liquid assets, the presumption being that these markets capture the impact of monetary policy.^{7/} Furthermore, we focus on the demand side of most markets by assuming certain rates are set; these include bank rates on time deposits, demand deposits, and loans.

The rest of this section is devoted to a detailed description of the equations contained in the model.

The Financial Sector

The financial sector is composed of four blocks of equations: (1) the nonbank public's asset demand equations and their wealth constraint, (2) commercial banks' (subdivided into four bank classes: city, large country, small country, and nonmember) asset demand equations and their balance sheet constraints, (3) the FRS's balance sheet and float, and (4) a group of equations explaining the distribution of

deposits between bank classes. The complete sector has 27 equations, containing 27 unknowns and 23 exogenous variables.

The first two blocks contain asset demand equations which were motivated by the portfolio theory developed in Parkin, Gray, and Barrett [7]. The exact form of the equations depends on the type of financial investor (e.g., small or large bank, city or country bank, bank or nonbank public) whose behavior is being explained, a specific assumption about how expectations are formed, and the addition of a liquidity proxy.

The demand for an asset is a function of expected interest yields. It is assumed here that all expectations are formed by a weighted average of current and past data. Let x be the variable in question; the value of x expected is defined as

$$\hat{x} = \sum_{t=0}^n \lambda_t x_{-t}.$$

Since the portfolio theory developed by Parkin, Gray, and Barrett takes no account of liquidity needs along the lines of inventory models of money demand, it is postulated here that expected income is a proxy for liquidity demand in the public sector and that expected total loans is a proxy for liquidity demand in the banking sector.

A listing of the model's variables and a description of the model's equations are given below.

Note: Superscripts refer to bank class: city (1), large country (2), small country (3), and nonmember (4).

ENDOGENOUS VARIABLES

1. C : Currency held by nonbank public
- 2.-3. CD^j : Certificates of deposit issued by bank class j ($j=1,2$)

- 4. CD_p : Certificates of deposit held by nonbank public
- 5. D : Demand deposits outstanding at commercial banks
- 6. D_p : Demand deposits held by nonbank public
- 7.-10. D^j : Demand deposits issued by bank class j ($j=1,4$)
- 11. ED^1 : Eurodollars issued by city banks
- 12. FL : Float
- 13.-16. ϕ^j : Funds available to portfolio managers at bank class j ($j=1,4$)
- 17. r_{CD} : Interest rate paid on certificates of deposit
- 18. r_S : Interest rate paid on short-term government securities
- 19.-22. R_f^j : Free reserves held by bank class j ($j=1,4$)
- 23. T : Time deposits, excluding certificates of deposit, held by nonbank public
- 24.-27. T^j : Time deposits, excluding certificates of deposit, issued by bank class j ($j=1,4$)

EXOGENOUS VARIABLES

- 1. D_f : Foreign deposits held at Federal Reserve banks
- 2. D_G : Government deposits held at commercial banks
- 3. L : Total loan claims of commercial banks
- 4.-7. L^j : Loan claims held by bank class j ($j=1,4$)
- 8.-11. ϕ_A^j : Other assets of bank class j ($j=1,4$)
- 12.-15. ϕ_L^j : Other liabilities of bank class j ($j=1,4$)
- 16. OS : Other sources of Federal Reserve assets
- 17. OU : Other uses of Federal Reserve liabilities
- 18. P : Federal Reserve's portfolio - the stock of short-term government securities held by the FRS
- 19. r_d : Discount rate

- 20. r_{ED} : Rate paid on eurodollars
- 21. r_T : Rate paid on time deposits
- 22. W : Liquid wealth
- 23. Y : Income

Nonbank Public

$$1.1 \quad W = C + D_p + T + CD + S_p$$

$$1.2-1.6 \quad \frac{A^i}{W} = a^i + \sum_{t=0}^n b_t^i (r_S)_{-t} + \sum_{t=0}^n c_t^i (r_T)_{-t} + \sum_{t=0}^n d_t^i (r_{CD})_{-t} \\ + \sum_{t=0}^n e_t^i \left(\frac{Y}{W}\right)_{-t} + \epsilon^i$$

where $A^i = C, D_p, T, CD, S_p$ and ϵ^i are random disturbances.

The nonbank public block contains six equations. The first defines liquid wealth as the sum of currency (C), demand deposits (D_p), time deposits (T), time certificates of deposits issued in denominations of \$100,000 or more (CD), and short-term government securities (under one year maturity) held by the nonbank public (S_p). Equations 1.2-1.6 go on to explain how funds are allocated among these five assets; the demand for each asset is a function of current and lagged values of the short-term securities rate (r_S), the time deposit rate (r_T), the certificate of deposit rate (r_{CD}) and the income-wealth ratio ($\frac{Y}{W}$). Notice that the budget constraint, $\sum_{i=1}^5 \frac{A^i}{W} = 1$, implies $\sum_{i=1}^5 a^i = 1$ and $\sum_{i=1}^5 b_t^i = 0$, $\sum_{i=1}^5 c_t^i = 0$,

$$\sum_{i=1}^5 d_t^i = 0, \quad \sum_{i=1}^5 e_t^i = 0, \quad \text{for } t = 0, n.$$

Using 1.1 to eliminate S_p , we are left with four independent equations in this block containing six endogenous variables (C, D_p , T, CD, r_S , r_{CD}) and three exogenous variables (W, Y, r_T).

Commercial Banks

Commercial banks are disaggregated by size, by Federal Reserve membership, and by city and country classification. This breakdown produces four sets of equations: (1) city member banks, (2) large country member banks, (3) small country member banks, and (4) nonmember banks.^{8/}

The maintained hypotheses are that bank behavior is a function of size and may also be related to Federal Reserve membership and to city and country classification. Whether or not these hypotheses are accepted, disaggregation of banks by membership status and city and country classification is necessary in order to study certain reforms.

The bank's balance sheet constraint is normally written as,

$$\text{Total Reserves} + S + L + \phi_A = \text{Borrowed Reserves} + CD + ED + D + T + \phi_L$$

i.e., total assets must equal total liabilities. For our purposes, it is useful to rewrite this constraint in the following way.

$$2.1 \quad R_f^j + S^j - (1-v^j)CD^j - (1-z)ED^j = \phi^j$$

where $\phi^j \equiv (1-k^j)D^j + (1-v^j)T^j + \phi_L^j - \phi_A^j - L^j$ and where the superscript j runs over the four classes of banks; v^j , k^j , and z are reserve requirements. Equation 2.1 restates the balance sheet constraint so that the right-hand side of the constraint contains the sum of the balance sheet items that we are assuming banks take as given. The portfolio decision is how this sum is to be distributed among the items appearing on the left-hand side of 2.1. (In the rest of this paper we treat liabilities as negative assets and refer to all items on the balance sheet as assets.)

The allocation process is described by the following equations.

$$\begin{aligned}
 2.2-2.6 \quad \frac{A^{ij}}{\phi^j} &= f^{ij} + \sum_{t=0}^n g_t^{ij} r_{S-t} + \sum_{t=0}^n h_t^{ij} r_{CD-t} \\
 &+ \sum_{t=0}^n p_t^{ij} r_{ED-t} + \sum_{t=0}^n q_t^{ij} r_{d-t} \\
 &+ \sum_{t=0}^n s_t^{ij} \left(\frac{L}{\phi^j}\right)_{-t} + \delta^{ij}
 \end{aligned}$$

where $A^{ij} = R_f^j, S^j, (1-v^j)CD^j, (1-z), ED^j$ and the δ s are random disturbances; the superscript j , except for CDs and EDs, runs over the four bank classes. (Only city banks participate in both the CD and ED markets. Large country banks issue CDs, but have negligible liabilities outstanding to foreign branches while small country and nonmember participation in these markets is insignificant. Thus, $ED^2 \equiv ED^3 \equiv ED^4 \equiv CD^3 \equiv CD^4 \equiv 0$). The demand for each asset is a function of current and past values of r_S, r_{CD}, r_{ED}, r_d and the L to ϕ ratio. Although the disturbances for a given bank class are not independent, we assume they are independent across bank classes and independent of disturbances in the nonbank public sector.

Analogous to the nonbank public's asset demand equations, the balance sheet constraint 2.1 imposes constraints across the asset demand equations. For each subsector j , $\sum_{i=1}^4 f^i = 1$, and $\sum_{i=1}^4 g_t^i = 0$,

$$\sum_{i=1}^4 h_t^i = 0, \quad \sum_{i=1}^4 p_t^i = 0, \quad \sum_{i=1}^4 q_t^i = 0, \quad \text{and} \quad \sum_{i=1}^4 s_t^i = 0 \quad \text{for } t = 0, n.$$

By using 2.1 to eliminate the S^j equation, we can see that the model now contains 11 additional independent equations: for city banks, 3 independent demand equations (R_f^1, CD^1, ED^1) plus an identity (ϕ^1);

for large country banks, 2 independent equations (R_f^2 , CD^2) plus an identity (\emptyset^2); for small country banks, an asset demand equation (R_f^3) plus an identity (\emptyset^3); and for nonmember banks, an asset demand equation (R_f^4) plus an identity (\emptyset^4). There are 19 additional endogenous variables and 14 new exogenous variables. Free reserves, time and demand deposits and the available funds variable for each bank class plus eurodollar borrowings for reserve city banks and certificates of deposits for reserve city and large country banks are the additional endogenous variables. Other liabilities, other assets, and loans for each bank class plus the discount and eurodollar rates are the new exogenous variables.

The FRS's Balance Sheet and Float

The FRS balance sheet can be expressed in our notation as follows,

3.1 $P + FL + OS =$

$$\sum_{j=1}^4 k^j D^j + \sum_{j=1}^4 v^j T^j + \sum_{j=1}^2 CD^j + zED^1 + \sum_{j=1}^4 R_f^j + C + D_f + OU$$

Roughly speaking, the balance sheet imposes the market clearing condition that reserves supplied must equal reserves demanded. Reserves are demanded for use as required reserves and free reserves by all bank classes, as currency by the nonbank public, and for use in some minor categories that we lump into a predetermined residual labeled other uses. Reserves supplied come from the FRS portfolio of short-term government securities float and a predetermined residual labeled other sources.^{9/}

Float (FL) is simply assumed to be a function of total deposits outstanding at commercial banks (D) plus an independent disturbance (ϵ_{FL}).

$$3.2 \quad FL = m_0 + m_1 D + \eta_{FL}$$

The above equations add to the model 2 independent equations, 2 new endogenous variables (D, FL) and four new exogenous variables (P, OS, OU, D_f).

Distribution of Deposits

Market interaction among the nonbank public, commercial banks, and FRS determines the quantity of time and demand deposits outstanding. Demand deposits outstanding at commercial banks (net of interbank deposits) is found by adding to the public total (D_p), government deposits (D_G), and float (FL), and subtracting foreign balances at Federal Reserve Banks (D_f). The time deposit total (net of interbank deposits) is simply the public's total. We postulate that on average each bank class receives a fixed percentage of the total of each of these two aggregate liabilities. The equations are as follows:

$$4.1 \quad D = D_p + D_G + FL - D_f$$

$$4.2 \quad D = \sum_{j=1}^4 D^j$$

$$4.3-4.6 \quad D^j = \alpha^j D + \mu_D^j \quad j = 1, 4$$

$$4.7 \quad T = \sum_{j=1}^4 T^j$$

$$4.8-4.11 \quad T^j = \beta^j T + \mu_T^j \quad j = 1, 4$$

Equation 4.1 defines total deposits and 4.2 constrains the sum of deposits at all bank classes to the total. The α^j 's in 4.3-4.6 are the fractions of total deposits distributed to the various banking classes. Similarly,

4.7 constrains the sum of time deposits at all bank classes to the total and the β^j 's are the distribution fractions. The terms μ_D^j and μ_T^j are random disturbances which are assumed to be independent of all other random disturbances in the model.

The distribution block adds nine independent equations and one more exogenous variable D_G giving the model 26 independent equations in 27 unknowns. It is completed by identifying CDs held by the public with those issued on net by the banks, $\sum_{j=1}^2 CD^j = CD_P$.

The Aggregate Demand Sector

Aggregate demand is represented by the single reduced-form equation of the form

$$5.1 \quad Y = Y(X_{-1}^*, r_{S-1}^*, \pi^*, t_c, t_Y, G, K, \eta_Y),$$

where Y is nominal income, X is real income, r_S is the short-term government security rate, π is the expected rate of inflation, t_Y is the income tax rate, t_c is the corporate tax rate, G is real government expenditures, K is the capital stock and η_Y is an independent random disturbance. The superscript $*$ means that lagged values of the variable enter the equation. Note that nominal income is assumed to be a function of only lagged interest rates, not the current.

Equation 5.1 is a reduced-form equation of the macro system,

$$5.2 \quad X = f(K, L) \quad f_K > 0, f_L > 0$$

$$5.3 \quad \frac{w}{p} = f_L(K, L) \quad f_{LL} < 0, f_{LK} > 0$$

$$5.4 \quad w = G(L/LF, \pi) \quad G_L > 0, G_{LF} < 0, G_\pi > 0$$

$$5.5 \quad LF = H(w/p) \quad H_w > 0, H_p < 0$$

$$5.6 \quad X = C + I + G$$

$$5.7 \quad I = I(r_{S-1}^* - \pi_{-1}^*, t_c) \quad I_{r_{S-1}} < 0, I_{\pi} > 0, I_{t_c} < 0$$

$$5.8 \quad C = C(X_{-1}^*, t_Y, K) \quad C_{X-1} > 0, C_{t_Y} < 0, C_K > 0$$

where L is total employment, w is the wage rate, p is the price level, LF is the total labor force, I is real investment, and C is real consumption expenditure. There are seven equations containing seven unknowns (X , w , p , LF , L , I , C) and seven predetermined variables (X_{-1}^* , K , π^* , t_Y , t_c , r_{S-1}^* , G). Equation 5.2 is the aggregate production function relating the inputs capital (K) and labor (L) to real output (X). Equation 5.3 is the first-order profit maximizing condition which states that the real wage must equal the marginal product of labor. Equation 5.4 is the wage-setting equation--the money wage is a function of relative employment (L/LF) and price expectations--while equation 5.5 is the labor supply function. Notice that there is nothing here that guarantees full employment (i.e., $LF=L$). Although the wage rate is not rigid, it will generally not be flexible enough to create full employment. The last three equations are the usual Keynesian aggregate demand equations. Total demand is the sum of consumption, investment, and government expenditures; investment is a function of the expected real interest rate and the corporate tax rate; consumption is a function of expected income, the income tax rate, and wealth measured by the capital stock.

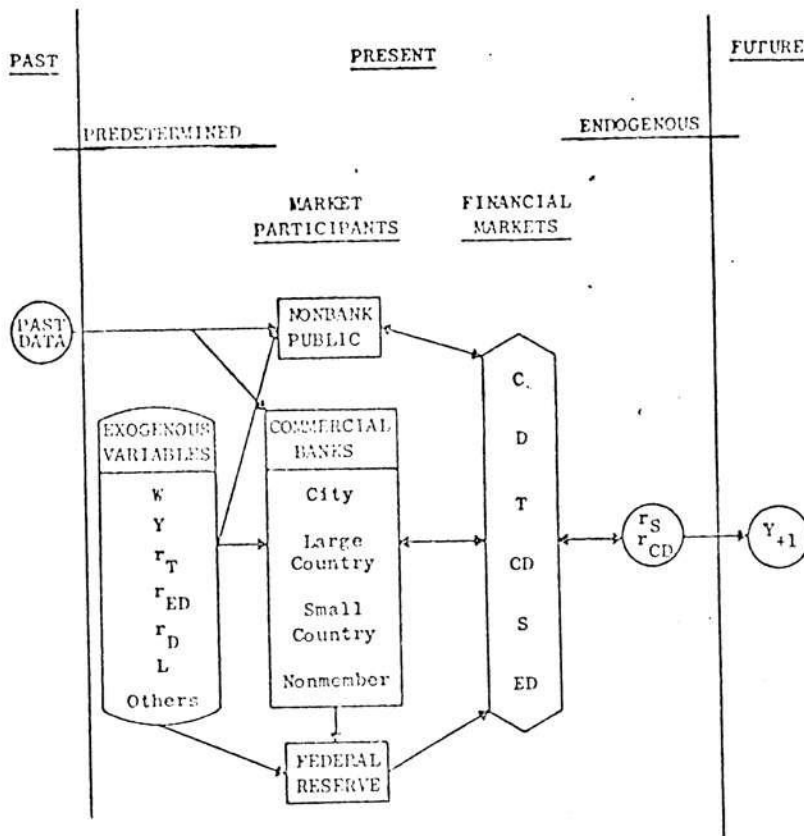
In order to find the signs of the derivatives in equation 5.1, the macro system is in effect linearized around initial equilibrium values of the variables by total differentiating equations 5.2 through

5.8. The linear system is then solved yielding the signs of the reduced-form derivatives. The results are summarized in the table below.

Ceteris Paribus Changes	X	P	Y
X_{-1}, G	+	+	+
r_{S-1}	-	-	-
π_{-1}, π	+	+	+
t_c, t_Y	-	-	-
K	+	?	?

The signs are the expected ones. The only unsigned derivatives are those for capital stock. A rise in K increases both aggregate demand and aggregate supply; consequently, real output increases, but the price effect and hence the nominal income effect is uncertain.

The aggregate demand equation completes the model adding one more equation and one more unknown (Y_{+1}). A schematic summary of the model is presented below.



Estimation

The model was estimated by applying, where appropriate, three-stage least squares. Equations were also estimated for most exogenous variables. An appendix describing the estimation procedure, the resulting point estimates, and the data sources is available upon request.

III. Simulation Results

At the beginning of this paper, it was argued that monetary reforms should be evaluated within a stochastic model. Consequently, it was necessary to construct an empirical model of the economy containing a detailed financial sector. In the previous section such a model was presented; the final task, therefore, is at hand. Using the estimated model, which includes both the point estimates of parameters and the variance-covariance matrices, opportunity loci--mean-variance curves--are constructed for each monetary reform and for the current regime. It is the difference between these curves which measures the effectiveness of a reform.

Generating a Locus

One could try to solve the model for the reduced form of the goal variable Y_{+1} with the hope of analytically deriving opportunity loci. Even if this resulted in a linear relationship between Y_{+1} and the instrument P , the random terms, both coefficients and residuals, enter the reduced form nonlinearly; it follows that the distribution of Y_{+1} is extremely difficult, if not impossible, to derive. What is done here, instead, is to approximate the distribution by way of Monte Carlo experiments. Sample observations from the distribution are generated in the following way: Repeated drawings (150) of coefficients are made consistent with the estimation period mean and variance-covariance estimates; similarly, repeated drawings (150) of the residuals are made consistent with the estimation period variance-covariance estimates.^{10/} For a fixed value of P , at a fixed point in time (December 1970), the

model is solved for each random drawing of coefficients and residuals;^{11/} this generates sample observations (150) on each endogenous variable and, in particular, on Y_{+1} .

Once sample observations are generated, estimating the locus is straightforward. As described above, for a given setting of P, 150 sample observations from the distribution of Y_{+1} are generated from 150 sets of stochastic terms. A sample mean and variance is then computed yielding one point on the locus. By varying P and repeating the procedure, the locus is approximated to the desired degree.

The random terms, both coefficients and residuals are generated by block. (There are eight independent blocks in total: (1) the public sector's asset demand equations, (2) city banks' portfolio equations, (3) large country banks' portfolio equations, (4) small country banks' portfolio equations, (5) nonmember banks' portfolio equations, (6) distribution equations, (7) the float equation, and (8) the aggregate demand equation.) Letting $\hat{\alpha}_k$ stand for the column vector of random coefficients of the kth block, sample values of $\hat{\alpha}_k$, the estimation period vector of point estimates, are generated by the matrix equation

$$\hat{\alpha}_k = \hat{\alpha}_k + R_k' v$$

where v is a column vector of independent, mean zero, variance one, random variables generated by a random number generator,^{12/} and R_k' is a matrix such that $R_k' R_k$ equals the estimation period estimated variance-covariance matrix of the point estimates. It follows, then, that $\hat{\alpha}_k$ generated by the equation above has mean $\hat{\alpha}_k$ and a variance-covariance matrix $R_k' R_k$, the estimated variance-covariance matrix of the point estimates.

Similarly, letting \hat{u}_k stand for the column vector of random residuals of the kth block, sample values are generated by the matrix equation

$$\hat{u}_k = R_k v$$

where R_k here is a matrix such that $R_k R_k'$ equals the estimation period estimated residual variance-covariance matrix and v is a random variable with the same properties as above. It follows, then, that \hat{u}_k has zero mean and a variance-covariance matrix $R_k R_k'$, the estimated residual variance-covariance matrix.

The Output

The Monte Carlo procedure for approximating a locus is repeated for each monetary regime. Since a reform imposes a new structure on the system, it imposes a new locus; each locus then is estimated by the stochastic simulations described above. The results are presented in the graphs at the end of this paper.

For each reform, a diagram is presented. Plotted in the top half is the locus for the current regime (C-C) and for the reformed regime (R-R) where future income, Y_{+1} ,^{13/} is the goal variable. Along side the graph, corresponding to the plotted points, are F-statistics; these are used to test the significance between variances. At the 90 percent level of confidence, with 120 degrees of freedom in both the numerator and denominator, the critical score is 1.26; at the 75 percent level of confidence, the critical score is 1.13. The bottom half of each diagram has the same format as the top except that the means and variances are those for demand deposits. Since much of the recent

literature on monetary policy is concerned with the control of monetary aggregates, it seems of some interest to study the distribution of demand deposits.

By assumption, a reform is effective in the $E(Y_{+1}) - V(Y_{+1})$ plane if the R-R curve lies to the left of the C-C curve. Notice that even though a reform may be effective by the above definition, the R-R curve could lie to the right of the C-C curve in the $E(D) - V(D)$ plane.

A discussion of the simulation results for each reform follows.

Reform 1: Reducing the Variance of Float

Since unexpected changes in float can alter the amount of reserves available to the banking system, it has been proposed that the central bank improve its control over this variable. To yield the maximum benefits, complete control was assumed when simulating this reform. The reform was implemented by replacing equation 3.2 with an identity setting float at its actual value.

Although the reform is effective, i.e., the reform locus lies to the left of the current in the $E(Y_{+1}) - V(Y_{+1})$ plane, the F-statistics are small and insignificant. The reform is considerably more effective in the $E(D) - V(D)$ plane. Not only does the reform locus lie to the left of the current, but the F-statistics are significant at the 90 percent level of confidence.

Reform 2: Increasing Reserve Requirements

Increasing reserve requirements will give commercial banks less leverage in offsetting monetary policy. This seems to be the

rationale of the proponents for higher requirements. In a stochastic framework, however, there exists an optimum level of reserve requirements and it may or may not be higher than current requirements. Since solving for this optimum level is a difficult task, a number of different reserve requirements were tried; the first objective was to find the direction in which requirements should change, the second to find a range containing the optimum level.

In the first simulation, reserve requirements (on both time and demand deposits) were decreased by 50 percent, and the results support the proponents of higher requirements. The opportunity locus shifted rightward decreasing the effectiveness of monetary policy in both planes; moreover, the F-statistics were either significant or close to being significant at the 90 percent level of confidence. (The results were similar, though less significant, for smaller negative changes.) Increases in requirements, of 20 percent and 50 percent, were then tried. The 20 percent increase was effective in both planes, moving the locus to the left, but not very significantly. However, when a 50 percent increase was tried, the locus in the $E(Y_{+1}) - V(Y_{+1})$ plane shifted to the right (it shifted to the left in the $E(D) - V(D)$ plane). While the F-statistics were not significant, there was a clear change in direction. These results suggest that the optimal requirements are somewhere between 20 and 50 percent higher than current levels.

It should be noted that here is a case where using a monetary aggregate as a proxy for the goal variable would lead to an incorrect

evaluation of a reform. Even though the 50 percent increase decreased the effectiveness of monetary policy, it increased the central bank's ability to control demand deposits.

Reform 3a: Equalizing Reserve Requirements
Between Time and Demand Deposits

There are two possibly offsetting effects brought on by this reform. First, if reserve requirements are equalized, public shifts between deposit types would not affect excess reserves and the central bank could better control money markets. At the same time, equalizing reserve requirements means that either the higher requirement is lowered, the lower requirement is raised, or both. This second effect concerns the degree to which the change in requirements is toward or away from the optimum. Since it was impossible to control for this effect, the results are more difficult to interpret. In order to minimize the secondary effect, reserve requirements were equalized by taking a weighted average of current requirements, where the weights were the ratio of deposits (demand and time) to total deposits. Nevertheless, the locus shifted to the right--in the wrong direction--in both planes. The total impact of this reform seems to be dominated by the movements in reserve requirements away from the optimum (the decrease in the demand deposit requirement more than offsetting the increase in the time deposit requirement). The point is that there is an optimum level for each requirement and in general these optimum requirements are not equal. If both requirements start out at nonoptimal levels and if the optimal levels are different, equalizing reserve requirements cannot be optimal;

moreover, as seems to be the case in the above simulation, it may reduce the effectiveness of monetary policy.

Reform 3b: Equalizing Reserve Requirements
Between Classes of Banks

While equalizing reserve requirements between deposit types seems to reduce policy effectiveness, this should not be true when we are equalizing requirements between bank classes. The reason is this: although it may be advantageous to have different requirements on deposit types (offsetting the different impact current income has on the demand for different assets), there is no gain to be had from unequal requirements between bank classes.

The reform was implemented by setting the reserve requirement on demand deposits for city and country banks to a weighted average of the current requirements, where the weights were the ratios of bank class deposit to total deposits. Since the time deposit reserve requirement was already the same across bank classes, the reform was necessary for demand deposits only.

Once again the problem of interpretation arises. There is some optimal level of reserve requirements on demand deposits; movements toward or away from the optimum are secondary effects of this reform. The influence of these secondary effects was neutralized to some degree by taking as the single requirement a weighted average of the current requirements. The result was a leftward shift of the loci in both planes, although the F-statistics were relatively small.

Reform 4: Tying the Discount Rate to the Security Rate

Proponents of this reform have argued that commercial banks can offset restrictive monetary policy by borrowing funds at the discount

window. Tying the discount rate to the security rate would reduce the incentive to borrow and thus make monetary policy more effective. On the other hand, fixing the discount rate and allowing for discrepancies between this rate and market rates encourages bank behavior which offsets unexpected shifts in portfolio demands. Thus, a priori, the total impact of this reform is uncertain and can only be determined empirically.

The reform was implemented by adding an equation which equated the discount rate to the security rate. The results are rather clear-- the reform is perverse; the locus in both planes shifts to the right and the F-statistics are all significant at the 90 percent level. The current regime's automatic stabilizer is more effective than a regime where the interest rate incentive for bank borrowing is eliminated.

Reform 5: Placing Reserve Requirements on Nonmember Banks

In effect, this last reform is a version of two previous reforms: Reform 2--increasing reserve requirements--and Reform 3b--equalizing requirements between bank classes. Nonmember bank reserve requirements are determined by the states in which they reside; the effective requirements are generally much lower than member banks. The reform is simulated by setting requirements equal to those of country banks. This is equivalent to asking whether requirements should be both higher and equalized between bank types. Once again there may be offsetting effects; increasing requirements of nonmember banks to those of country banks may raise the average requirement above its optimum. Hence, the gain from equalization can be neutralized by the suboptimal level of requirements. Turning to the results, this seems to be the case. The locus in the $E(Y_{+1}) - V(Y_{+1})$ plane has shifted to the right although the

F-statistics are not very significant. As in Reform 2, using demand deposits as a proxy for the goal variable would have led to the wrong evaluation; the locus in the $E(D) - V(D)$ shifts to the left and the F-statistics are significant.

IV. Concluding Remarks

An attempt was made in this paper to evaluate the effectiveness of a number of monetary reforms within a stochastic framework. To this end, an econometric model of the economy was constructed and then simulated under different monetary structures. The analysis was static in the sense that the objective function was defined over a single period. In general the reforms were of only minor significance and some were even perverse. Increasing reserve requirements is an effective reform, but the increase should be something less than 50 percent. Reducing float and equalizing requirements between bank classes will also increase policy effectiveness but only marginally. More significantly, tying the discount rate to a market rate should not be implemented, and extending reserve requirements to nonmember banks should be part of a total reform to find the optimum level of requirements, but should not be pursued for the sake of equalization alone.

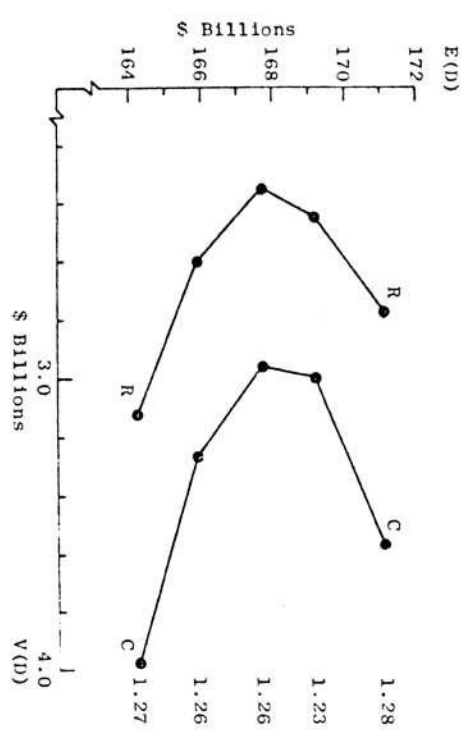
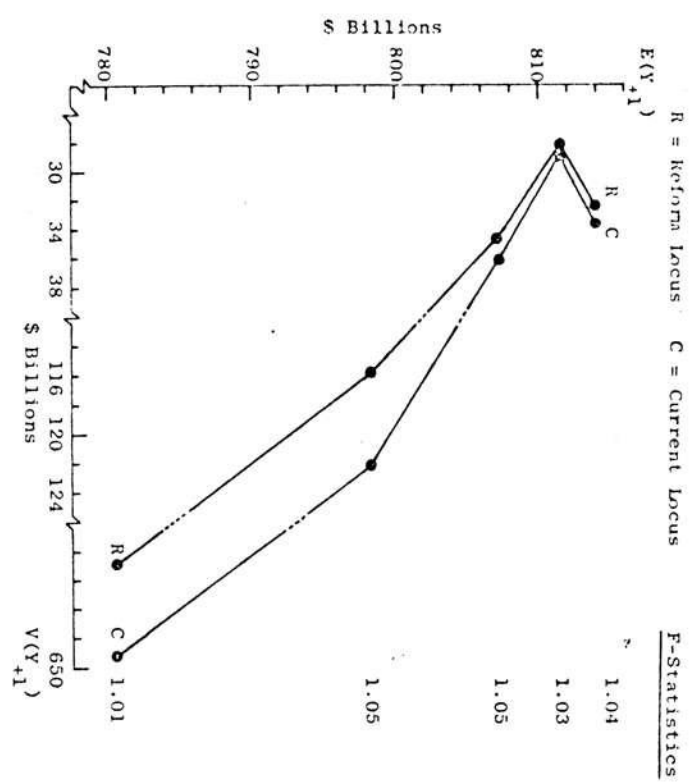
How seriously should a policy maker accept these conclusions? Since the model and the objective function are deficient in a number of respects, as discussed in further detail below, they are at best suggestive. Nevertheless, generating these results demonstrates the feasibility of the approach and the richness of the information it produces.

The analysis could be improved in various ways: (i) The data period only encompasses the sixties and early seventies. The estimates could now be updated and tested for structural change. (ii) The simulation results would have been more credible if the experiments had been repeated at other dates. (iii) A defect in the financial sector was the absence

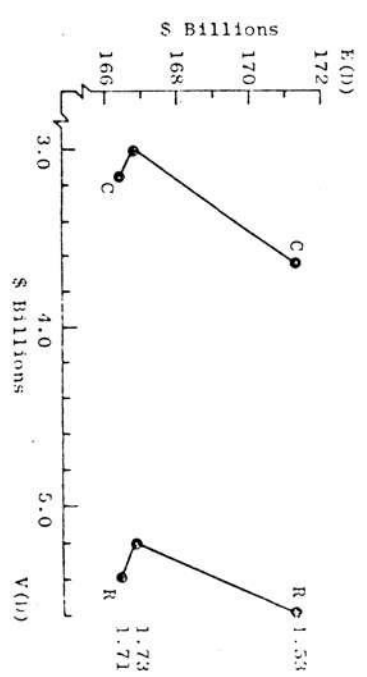
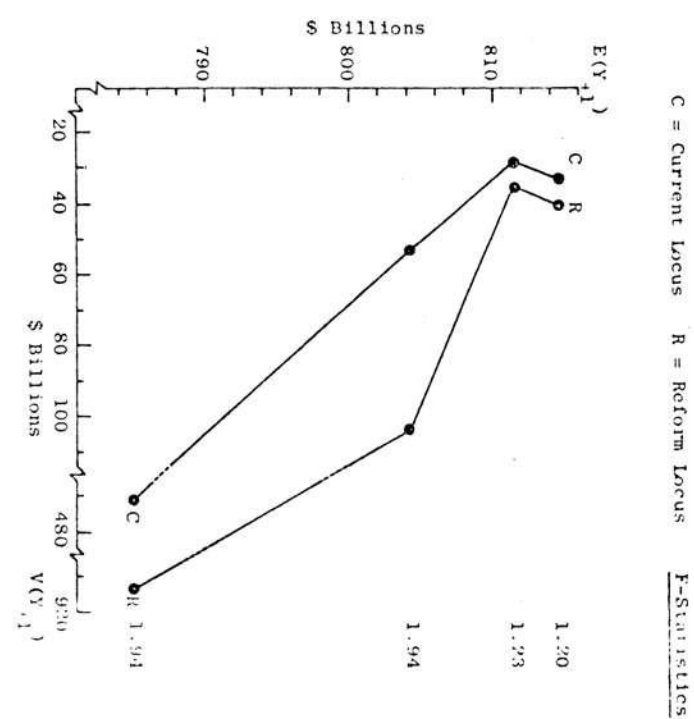
of the federal funds market, a market which is looked at quite closely by the FRS. (The market was subsumed in the aggregated variables ϕ_A and ϕ_L .) If data become available, federal funds supply and demand equations could be estimated for each bank class. (iv) The loss function was a one-period, simple quadratic function of nominal income. If the aggregate demand sector had been a set of structural equations, the loss function could have been made more general by including more targets. (v) Even with the current model, a significant improvement could be made by using a dynamic loss function. The procedure would be to find optimal rules for different monetary regimes; the effectiveness of a reform, then, could be measured by the difference between the minimum loss under the current regime and the minimum loss under the reformed regime. The difficulty with this approach is that the problem of finding the optimal rule in a model containing stochastic coefficients, due to estimation error, has not been solved.

One final note of caution. Even if these suggested improvements were made, this approach still contains a potentially serious limitation. As mentioned earlier in this paper, when simulating the effects of a reform, the models underlying behavioral relationships are assumed to be fixed. We chose reforms which we hoped would come closest to maintaining this assumption. It should be obvious, however, that each reform considered above must, to some degree, alter the true underlying structure.^{14/} Since over the data period most of these reforms have been tried in one form or another, the hope is that the model captures these effects.

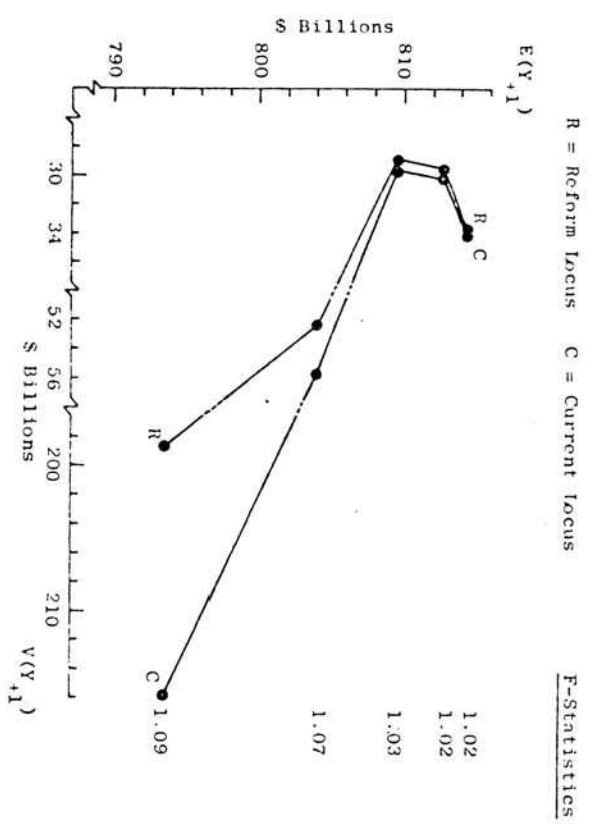
Reform 1: REDUCING THE VARIANCE OF FLOAT



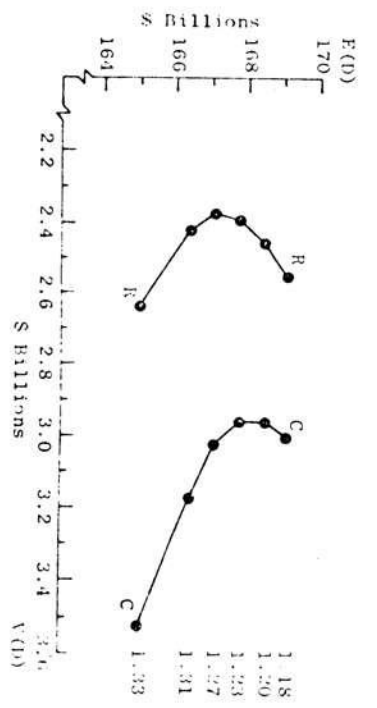
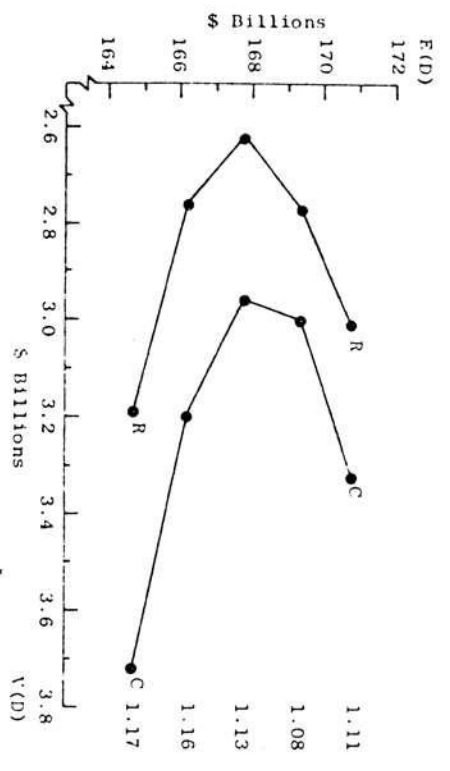
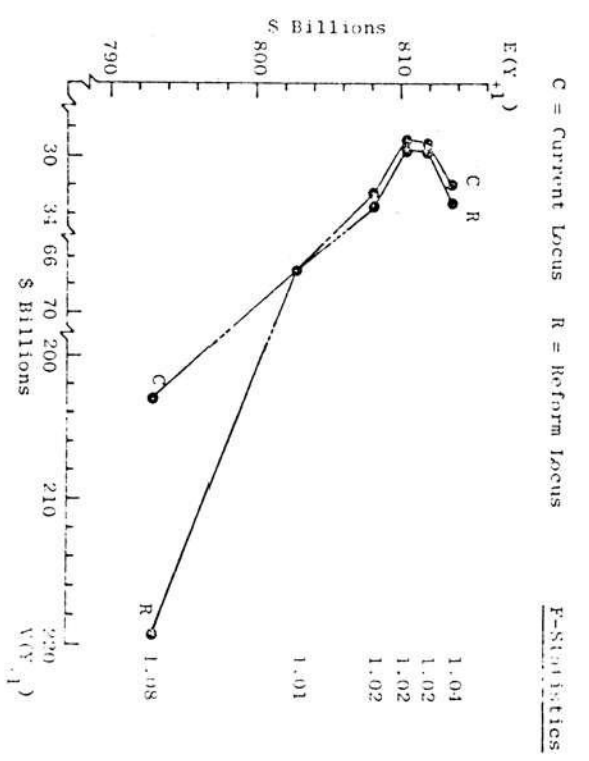
Reform 2: DECREASING RESERVE REQUIREMENTS (1.0)



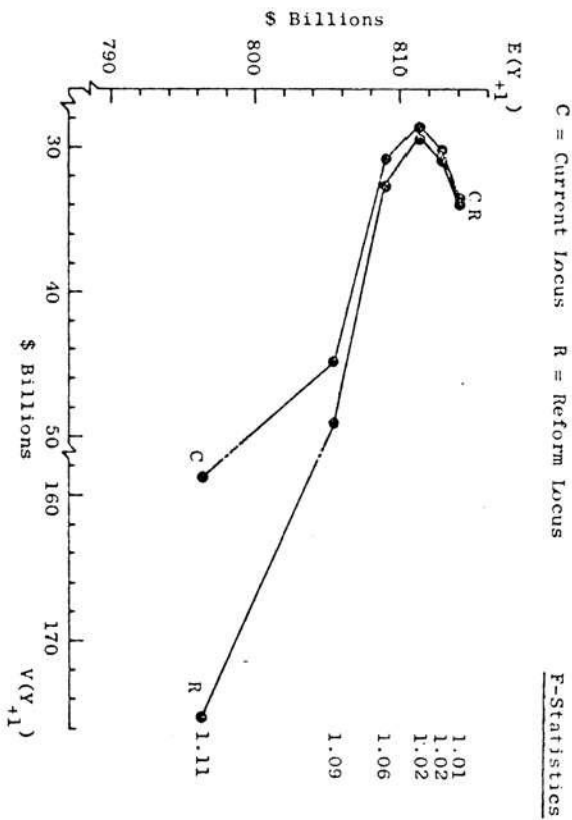
Reform 2: INCREASING RESERVE REQUIREMENTS (.20)



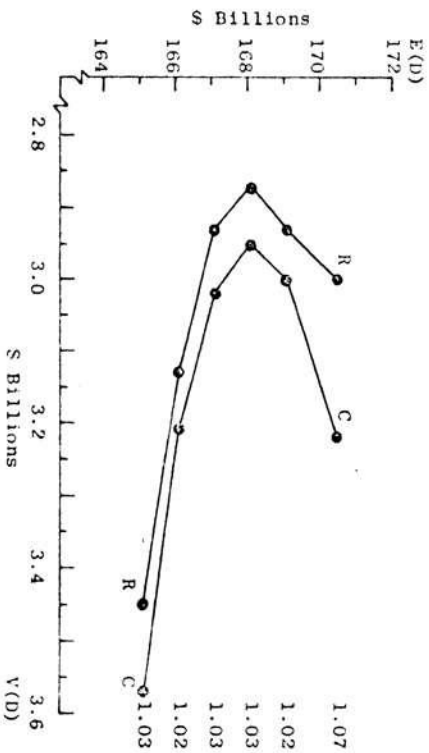
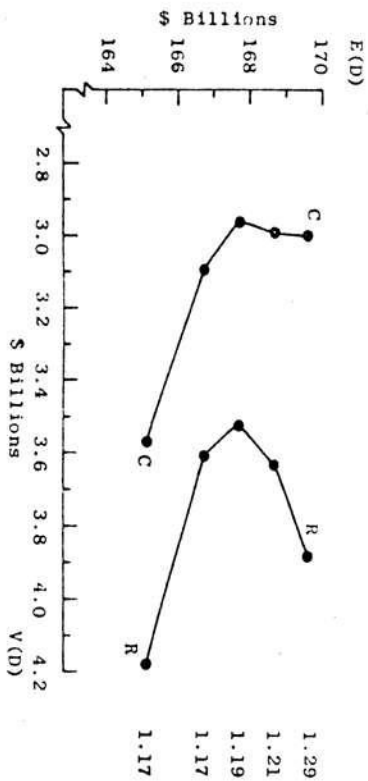
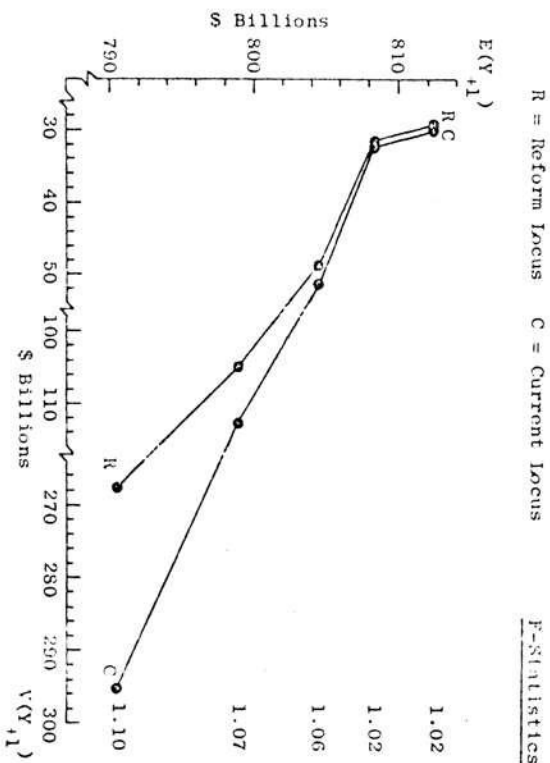
Reform 2: INCREASING RESERVE REQUIREMENTS (.50)



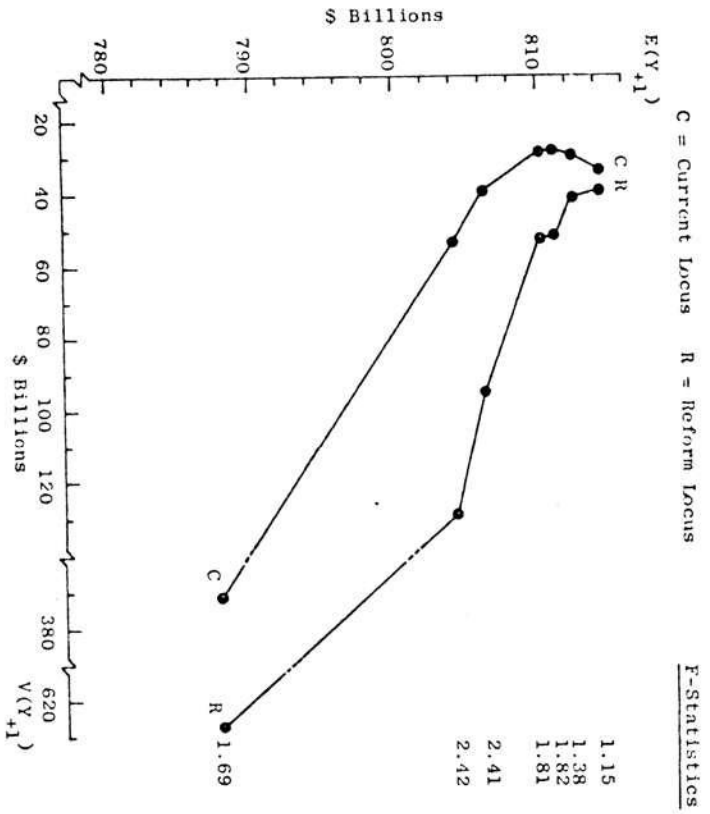
Reform 3a: EQUALIZING RESERVE REQUIREMENTS
BETWEEN TIME AND DEMAND DEPOSITS



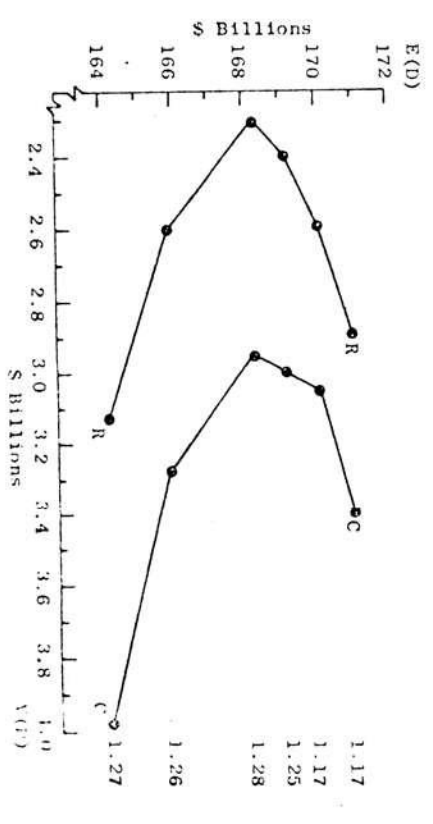
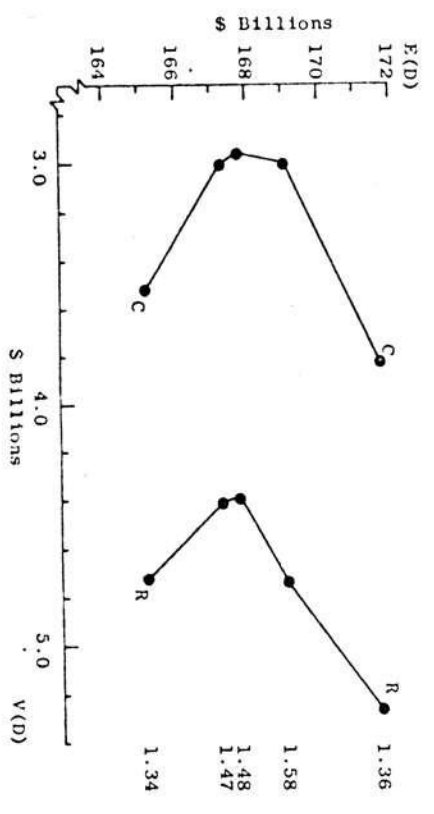
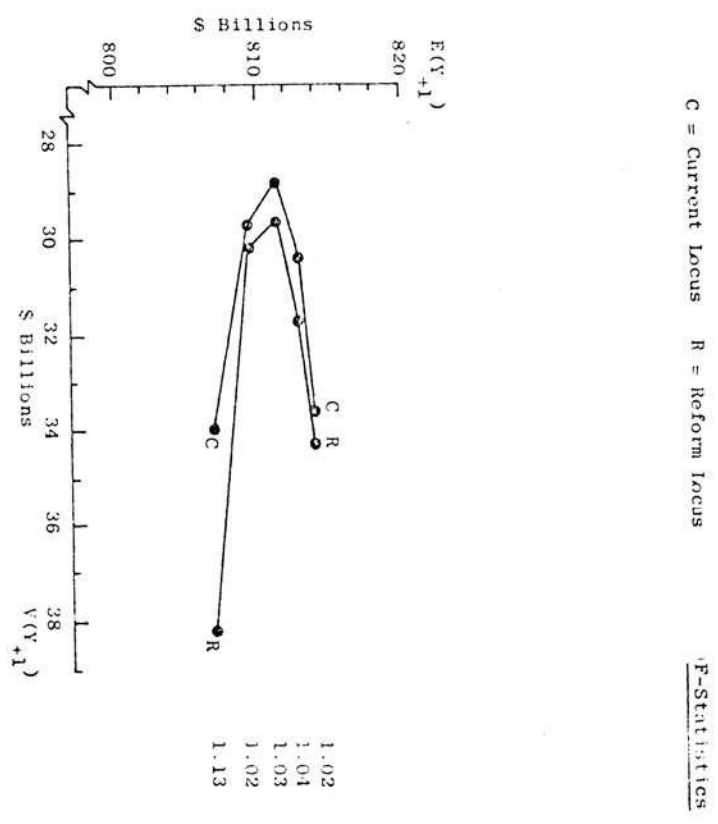
Reform 3b: EQUALIZING RESERVE REQUIREMENTS
BETWEEN BANK CLASSES



Reform 4: TRYING THE DISCOUNT RATE TO THE SECURITY RATE



Reform 5: PLACING RESERVE REQUIREMENTS ON NONMEMBER BANKS



Footnotes

1/ For attempts to evaluate specific reforms see Smith [10], Poole and Lieberman [8], Benston [1], Dewald [3], and Tobin and Brainard [14].

2/ This was first suggested by Brainard [2].

3/ See Theil [12, pp. 2-5] for some comments on the reasons for using a quadratic loss function.

4/ If loci intersect, the effectiveness of a reform will depend on the desired target level of income.

5/ It is interesting to note that although Friedman and Tobin differ significantly as to their opinions of how monetary policy should be implemented (Friedman feels that the state of our knowledge is too tenuous and uncertain with the result that discretionary policy is destabilizing; Tobin, on the other hand, advocates a more participatory and active policy), their proposed reforms suggest that both are in favor of a tighter link between the FRS's instruments and its targets.

6/ See Lucas [6] for a more general discussion of this problem.

7/ Liquid wealth held by the nonbank public is defined to be currency, demand deposits, certificates of deposits, time deposits, and short-term government securities.

8/ The FRS classifies commercial banks as large if they currently have over \$100 million in deposits. Since 99 percent of city banks fall in this classification, and since nonmember bank data by size were not available, no attempt was made to disaggregate these banks.

9/ The predetermined "residual" category other uses includes Treasury cash holdings and Treasury deposits at Federal Reserve banks. The predetermined "residual" category other sources includes, the gold stock, Treasury currency outstanding and U.S. government securities with maturities greater than one year.

10/ Coefficients and residuals were treated as random in the equations explaining exogenous variables as well as in the equations of the model.

11/ The Gauss-Seidel method was used in solving the model. For a description of the method and the computer program utilized see Shapiro [11].

12/ The elements of v are drawn from a truncated normal distribution. Let x be a zero-one normal random variable. Values of x are drawn but only those for which $|x| < 2$ are accepted. The accepted x 's have mean zero and variance $(.88)^2$, so that $v = (1.137) x$

has mean zero and variance one, the desired distribution. The v 's are chosen from a truncated distribution, because most parameters and disturbances do not, a priori, have infinite range.

The above description applies to all parameters except first-order serial correlation coefficients. For their distribution, see Rolnick [9, Appendix 2].

13/ Personal disposable income is used here as the target income variable.

14/ An example of how a reform might change the structure is the case of equating reserve requirements among bank classes. Presumably, this would alter relative costs and returns and change the relative size of classes of banks. Consequently, the distribution equations would not be invariant to such a reform.

Bibliography

- [1] Benston, George J., "An Analysis of Alternative Reserve Requirement Plans," Journal of Finance, December 1969, Vol. 25, pp. 849-70.
- [2] Brainard, William, "Uncertainty and the Effectiveness of Policy," American Economic Review, May 1967, Vol. 57, No. 2, pp. 411-25.
- [3] Dewald, William G., "Reserve Requirements for Commercial Banks and Savings Institutions in the United States," Unpublished manuscript, Ohio State University, February 1971.
- [4] Friedman, Milton, A Program for Monetary Stability, Fordham University Press, New York City, 1959.
- [5] Goldberger, Arthur S., Econometric Theory, John Wiley and Sons, Inc., New York, 1964.
- [6] Lucas, Robert E., "Econometric Policy Evaluation: A Critique," unpublished manuscript, Carnegie-Mellon University, April 1973.
- [7] Parkin, J. M., M. R. Gray, and R. J. Barrett, "The Portfolio Behavior of Commercial Banks" in The Econometric Study of the United Kingdom, K. Hilton and D. Heathfield, eds., Augustus M. Kelley, New York, 1970.
- [8] Poole, William, and C. Lieberman, "Improving Monetary Control" in the Brookings Papers on Economic Activity, A. Okun and G. Perry, eds., The Brookings Institution, Washington, D. C., No. 2, 1972.
- [9] Rolnick, Arthur J., "Evaluating the Effectiveness of Monetary Reforms in Reducing the Uncertainty About the Impact of Monetary Policy," Unpublished Ph.D. thesis, University of Minnesota, 1973.
- [10] Smith, Warren L., "Time Deposits, Free Reserves, and Monetary Policy" in Issues in Banking and Monetary Analysis, G. Pontecovo, R. Shay, and A. Hart, eds., Holt, Rinehart, and Winston, Inc., New York, 1967.
- [11] Shapiro, Harold, "The Sim Model Solution Program by Morris Norman Via Bob Rashe as Interpreted from the Fortran by Harold Shapiro," Unpublished manuscript, University of Michigan, 1971.
- [12] Theil, Henri, Optimal Decision Rules for Government and Industry, North-Holland, Amsterdam, 1964.
- [13] Tobin, James, "Towards Improving the Efficiency of the Monetary Mechanism," Review of Economics and Statistics, August 1960, Vol. 42, pp. 276-9.
- [14] _____ and William Brainard, "Financial Intermediaries and the Effectiveness of Monetary Control," American Economic Review, May 1963, Vol. 53, No. 2, pp. 383-400.