An Econometric Examination of Central Bank Behavior

Kyung Moo Kim*

There is an ongoing debate over the appropriate target of open market operations; whether interest rates[1] or monetary aggregates[2] should be chosen has been the subject of considerable discussion. The proponents of the monetary aggregate target may view the causal sequence that the "dynamic" open market operations directly affect the money stock, which is a primary determinant of changes in total spending and thus economic activities. On the other hand, the proponents of the interest rate target, although they readily admit that money matters, may view that the accommodating behavior of the central bank results in an expansion in the money supply by increasing the supply of reserves through the "defensive" open market operations.

Although the causal claims of both views have some validity in explaining central bank behavior, it is indeed an empirical question whether monetary aggregates or interest rates should be chosen as the operating target to achieve monetary policy objectives. The central bank may be undertaking a mixture of monetary aggregate and interest rate target.[3] In some periods, more weight may be placed on the interest rate target for the stabilization of the financial market; while in other periods, emphasis may be placed on monetary growth to achieve the long-run money supply objectives. Thus, the purpose of this paper is empirically to measure the

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1 A broad range of interest rates includes the Federal funds rate, the short and intermediate rates, and rates in the long-term capital market. However, the choice of any particular one is not a crutial issue here.

2 Among the monetary aggregates, there are various measures such as the monetary base, total reserves, nonborrowed reserves, excess reserves and free reserves. The choice of any particular one is again not a critical issue.

3 Lombra and Torto (1975), pp. 6-7.

degree of adjustment within which the central bank responds to changes in the demand for bank reserves.

In Section I, the model to be tested will be derived, and followed by the discussion of estimation procedures in Section II. In Section III, a series of tests is conducted to evaluate the structural stability of the estimated coefficients and, therefore, the model. Section IV presents the regression results accompanied by an interpretation of each equation, and summary and conclusions are drawn in Section V.

I. Econometric Model

The model consists of two parts: the first part is focused on the behavioral variations of commercial banks in response to changes in the public's demand for money and commercial loans; the second is concerned with central bank policy actions in response to changes in the demand for bank reserves. The connection of these two parts will provide a measurement of the degree of adjustment within which the central bank responds to changes in the demand for bank reserves. To meet this end, examination of changes in commercial bank behavior will be based on the behavioral equation, whereas investigation of central bank behavior will be based on stock adjustment equations derived from identities.

I.1. Behavioral Equation:

The behavioral equation represents the reduced form of the three structural equations: commercial bank demand functions for nondeposit sources of funds(NDF), for investment on government securities(CBI), and for free reserves(FR).

The demand functions for the nondeposit sources of funds (NDF) and investment on government securities(CBI) can be written in a linear form as follows;[4]

$$(1.1.1) \quad \widehat{NDF} = a_0 - a_1 RFF + a_2 RCL - a_3 \overline{DD} - a_4 \overline{TD} + a_5 \overline{CBL} + u_1$$

$$(1.1.2) \quad \widehat{CBI} = b_0 - b_1 RFF + b_2 RCL + b_3 \overline{DD} + b_4 \overline{TD} - b_5 \overline{CBL} + u_2$$

4 For the derivation of equations (1.1.1) and (1.1.2), see Kim (1979), ch. 3.

where $\widehat{NDF}$ and $\widehat{CBI}$ are the profit-maximizing levels of NDF and CBI, respectively; RFF is the Federal funds rate; RCL is commercial loan rate measured by the prime rate; $\overline{DD}$, $\overline{TD}$, and $\overline{CBL}$ are the expected levels of demand deposits(DD), time deposits(TD), and commercial bank loans(CBL), respectively; and u_1 and u_2 are random disturbances. In specifying the demand functions for NDF and CBI, various short-term money market interest rates cannot be introduced because of multicollinearity problems. An alternative method is to assume that the short-term money market interest rates are a function of the Federal funds rate[5]. The Federal funds rate and commercial loan rate are thus included in equations (1.1.1) and (1.1.2).

In addition, from the definitional identities and the balance sheet identity, commercial bank demand for free reserves can be expressed as;[6]

$$(1.1.3)\ \widehat{FR} = (1-q_D)\overline{DD} + (1 - q_T)\overline{TD} + \widehat{NDF} - \overline{CBL} - \widehat{CBI}$$

where $\widehat{FR}$ is the profit-maximizing optimal level of bank's demand for free reserves, and q_D and q_T are legal required reserve ratios against demand deposits and time deposits, respectively.

Then, the reduced form of the three structural equations (1.1.1) through (1.1.3) can be written as;

$$(1.1.4)\ \widehat{FR} = c_0 - c_1 RFF - c_2 RCL + c_3\overline{DD} + c_4\overline{TD} + c_5\overline{CBL} + u$$

where $c_0 = (a_0 - b_0)$, $c_1 = (a_1 - b_1)$, $c_2 = (b_2 - a_2)$, $c_3 = (1 - q_D - b_3)$, $c_4 = (1 - q_T - b_4)$, $c_5 = (a_5 + b_5)$, $u = (u_1 - u_2)$.

The reduced form (1.1.4) represents commercial bank reserve adjustment behavior. However, this reduced form shall not be estimated because it contains two main difficulties. The first difficulty is that $\widehat{FR}$ is not directly observable. This problem can be solved by substituting the actually observed level of free reserves as an approximation of $\widehat{FR}$. The second difficulty is that the variables $\overline{DD}$, $\overline{TD}$, and $\overline{CBL}$ pose a more serious multicollinearity problem in estimating the equation (1.1.4). Instead, the conceptually deriv-

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5 Evidence shows that a major portion of the variance in short-term rates can be explained by current and lagged movements in the Federal funds rate. See Lombra and Torto (1975), p. 9, no. 29.

6 For given expected levels of deposits and loan demand, the profit-maximizing level of free reserves is determined by profit-maximizing levels of NDF and CBI.

ed equation for free reserves representing the reduced form (1.1.4) shall be used,[7] i.e.,

(1.1.5) $FR = d_0 - d_1 RFF - d_2 RCL + d_3 FE + u$

where FE is a variable measuring forecasting error committed by commercial banks in estimating DD, TD, and CBL. The quantity of FE is generated by the relationship;

$$FE = (\overline{DD} - DD) + (\overline{TD} - TD) - (\overline{CBL} - CBL).$$

That is, the quantity of forecasting error equals the discrepancy between the expected and actual levels of total deposits less commercial bank loans.[8]

With respect to the coefficient of FE in equation (1.1.5), some additional clarification is necessary. If the coefficient of FE is significantly different from zero, free reserves can be viewed as an important balance sheet item in bank reserve adjustment; whereas if it is not significantly different from zero, the bank's attitude toward managing free reserves becomes less significant and free reserves have tended to become residual balances in bank's portfolio adjustment. The details on this point will be discussed in connection with an interpretation of the regression results of the behavioral equation presented below.

I.2. Stock Adjustment Equations:

In order to examine central bank behavior, the following two stock adjustment equations derived from definitional identity for nonborrowed reserves(NBR) and for the monetary base(MB) will be utilized;

(1.2.1) $\Delta NBR = n_B \Delta RR + n_E [\widehat{FR} - FR_{-1}]$

(1.2.2) $\Delta MB = n_R \Delta NBR + n_C \Delta CC$

where RR is required reserves; CC is currency held by the public; $\widehat{FR}$ is the profit-maximizing level of free reserves; n_B and n_E are commercial bank adjustment coefficients for required reserves and free reserves; and n_R and n_C are central bank adjustment coeffi-

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7 For the details on procedures constructing the conceptually obtained reduced form of free reserves, see Cooper (1974), pp. 27-30.

8 The quantity of forecasting error can be computed as a weighted average of errors in estimating demand deposits, time deposits, and commercial loan demand. Also, the distributional effects among banks can be considered in computing a weighted average. But, for the sake of computational simplicity, distributional effects are ignored in generating a variable.

cients for nonborrowed reserves and currency, respectively. Then, substitution of equation (1.2.1) into equation (1.2.2) leads to the expression of the quasi-reduced form of changes in the monetary base as;[9]

(1.2.3) $\Delta MB = n_Z \Delta RR + n_C \Delta CC + n_F[FR - FR_{-1}]$

where $n_Z = (n_B n_R)$ and $n_F = (n_E n_R)$. Thus, equations (1.2.1) and (1.2.3) can be estimated to obtain central bank adjustment coefficients n_R and n_C.

The central bank adjustment coefficient for bank demand for nonborrowed reserves (n_R) can be computed as;

$$\widehat{n_R} = \frac{\widehat{n_Z}}{\widehat{n_B}}$$

where $\widehat{n_Z}$ is an estimate of a composite coefficient $n_Z(= n_B n_R)$ in equation (1.2.3) and $\widehat{n_B}$ is an estimate of n_B in equation (1.2.1).

The instrument variable estimate of an adjustment coefficient ($\widehat{n_R}$) is a consistent estimator of n_R.[10] If a value of $\widehat{n_R}$ is close to one, it indicates that the central bank has attempted to moderate variations in interest rates by accommodating changes in demand for bank reserves, whereas should it be closer to zero, the central bank has attempted to control the growth of the money supply by placing more weight on control of the monetary base in the face of changes in demand for bank reserves. A value of $\widehat{n_C}$ is expected to be closer to one, based on *a priori* assumption that the central bank supplies whatever quantity of currency that is necessary to meet the public's demand. A value of $\widehat{n_B}$ is also expected to be closer to one because, given legal reserve ratios, the quantity of required reserves is determined by the volume of total deposits.

II. Estimation Procedures

Estimation of the central bank reaction function requires the selection of data that conforms as much as possible to the central

9 The reduced form for changes in the monetary base can be obtained by substituting equations (1.1.4) and (1.2.1) into equation (1.2.2.). However, since coefficients of the reduced form obtained in such a way are composite of structural parameters and various adjustment coefficients, the computation of n_R will be very complicated. Thus, as an alternative way, the quasi-reduced form will be estimated.

10 Goldberger (1964), pp. 284-286.

bank policy reaction. The period to be examined extends from January 1965 to August 1976. The selection of time period examined is based on the development of the financial markets—particularly the Federal funds market since 1965 which has had significant effects both on bank portfolio adjustment behavior and the central bank open market policy changes.[11] The monthly time series is selected because it closely parallels the decision-making time horizon of the Federal Reserve Open Market Committee,[12] and hence provides an adequate examination period within which the projected purpose can be tested.

In estimating procedures, the expected level of demand deposits and time deposits are generated separately by the equation under an adaptive-expectation hypothesis,[13] i.e.,

$$\overline{DD} = \sum_{i=1}^{4} w_i DD_{-i}$$

$$\overline{TD} = \sum_{i=1}^{4} v_i TD_{-i}$$

where w_i and v_i are weights which show the decay in the lag distribution. On the other hand, an attempt is made at estimating the following equation for the public's demand function for commercial loans (CBL);

11 The sample period from January 1965 to August 1976 was selected because of the follwing reason. The 1963 ruling on the Federal funds eliminated restrictions on the amounts that had kept small banks from placing relatively large sums of funds in the Federal funds market, while the 1964 ruling legalized member bank purchase of correspondent balances of nonmember banks as the Federal funds. Moreover, since 1965, as commercial banks borrowed Federal funds more frequently and in larger amounts for the purpose of liability management as well as reserve management, the Federal funds rate was raised to and above the discount rate, and has remained above the discount rate for much of the period. For the details on institutional changes in the Federal funds market, see Lucas, Jones, and Thurston (1977), pp. 33-48.

12 In practice, monthly data are used for projections to guide open market operations. See Holmes (1969), pp. 75-76. Moreover, the fact that the Federal Reserve Open Market Committee meets formally every four weeks substantiates that the System's time horizon approximates a month.

13 The results of least squares estimates are:

$$\overline{DD} = \underset{(170.34)}{1.0029DD_{-1}} + \underset{(0.019)}{0.00016DD_{-2}} - \underset{(0.157)}{0.00131DD_{-3}} + \underset{(0.372)}{0.0021DD_{-4}}$$

$$\overline{TD} = \underset{(72.34)}{1.0306TD_{-1}} - \underset{(0.513)}{0.0105TD_{-2}} - \underset{(0.0151)}{0.0003TD_{-3}} - \underset{(0.778)}{0.0112TD_{-4}}$$

The numbers in parentheses are absolute values of t-statistics.

$$\overline{CBL} = CBL\ [RFF,\ W,\ INV_L,\ CF_L]$$

where W is average money wage rate, INV is the book value of inventories, CF is cash flow measured by business total sales as a proxy measure of operating capital, and L represents the distributed lag operator.[14]

In this procedures, commercial loans are viewed as short-term borrowings from banks to meet disbursement of expenditures of firms. Thus, a variable measuring business fixed capital investment is intentionally excluded from the equation. The money wage rate is directly related to commercial loan demand through changes in total costs, and the availability of cash flow lessens the need for outside funding. Inventories are related to business spending which, in turn, changes the demand for loans. Moreover, the short-term use of bank loans is assumed to be dependent upon the Federal funds rate. Since the Federal funds rate is a barometer of money market conditions and is assumed to be systematically related to other short-term money market interest rates, the Federal funds rate helps to determine whether firms borrow from banks or issue short-term securities to finance the needs for funds.[15]

Finally, in order to avoid serial correlation problems, the following procedures are employed to obtain a consistent estimate. Assume that all series have significant first-order autocorrelation. Further assume that a model under consideration is written as;

$$(2.1)\ Y_t = e_0 + e_1 X_t + u_t$$

$$\varepsilon_t = u_t - \lambda u_{t-1}$$

where residuals $\varepsilon_t = u_t - \lambda u_{t-1}$ are serially independent. Then, multiplying equation (2.1) throughout by $(1 - \lambda L)$ leads to:

$$(2.2)\ (1 - \lambda L)Y_t = e_0(1 - \lambda L) + e_1(1 - \lambda L)X_t + (1 - \lambda L)u_t$$

$$\text{or } Y_t = e_0^* + \lambda Y_{t-1} + e_1(X_t - \lambda X_{t-1}) + \varepsilon_t$$

where $e_0^* = e_0(1 - \lambda)$, $\varepsilon_t = u_t - \lambda u_{t-1}$, and L is the lag operator such that $LX_t = X_{t-1}$ and $L^2 X_t = X_{t-2}$, etc. Then, since the residuals are serially independent, equation (2.2) can be estimated

14 The result is a third-degree polynomial distribution estimate without end-point restrictions:

$$\overline{CBL} = 69700.9 + 1055.74RFF + 7997.88W + 0.4258INV_L - 1.1685CF_L$$
$$\quad\quad (4.197)\quad\quad (5.415)\quad\quad (2.602)\quad\quad (5.097)\quad\quad (5.045)$$

The numbers in parentheses are also absolute values of t-statistics.

15 Short-term borrowing from banks is viewed as an alternative to issuing long-term bonds to finance the need for funds. See Harris (1976), p. 2.

by ordinary least squares. The coefficient of Y_{t-1} will give an estimate of λ.

Applying this procedure to equations (1.2.1) and (1.2.3), an estimate of the coefficient of the lagged dependent variable in each equation, denoted by λ_N for NBR and λ_M for MB, can be obtained.[16] Utilizing an estimated value of FR obtained from the fitted equation of (1.1.5) as an approximation of $\widehat{FR}$, the filtered first-order difference of each variable can be generated as;

$$\Delta NBR^* = NBR - \lambda_N NBR_{-1}$$
$$\Delta RR^* = RR - \lambda_N RR_{-1}$$
$$\Delta\widehat{FR}^* = \widehat{FR} - \lambda_N FR_{-1}$$

and

$$\Delta MB^{**} = MB - \lambda_M MB_{-1}$$
$$\Delta RR^{**} = RR - \lambda_M RR_{-1}$$
$$\Delta CC^{**} = CC - \lambda_M CC_{-1}$$
$$\Delta\widehat{FR}^{**} = \widehat{FR} - \lambda_M FR_{-1}$$

Accordingly, equations to be estimated can be rewritten as;

(1.2.1a) $\Delta NBR^* = n_B \Delta RR^* + n_E \Delta\widehat{FR}^*$
(1.2.3a) $\Delta MB^{**} = n_Z RR^{**} + n_C \Delta CC^{**} + n_F \Delta\widehat{FR}^{**}$

III. A Test for Structural Stability

A test for structural stability is conducted to assess whether a structural shift has taken place or not. In 1970, two important events causing a significant changes in the financial market occurred. First, an amendment to Regulation D allows nonbank financial institutions to enter the Federal funds market. Previously, Regulation D specified that borrowings from commercial banks only had been exempted from reserve requirements. An amendment to the regulation extended the exemption to the borrowing from other nonbank financial institutions, including savings and loan associations, mutual savings banks, and agencies of state and local government, as well as agencies and branches of foreign banks.[17] This regulatory change was particularly important to the

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16 Estimated coefficients for the lagged dependent variables are; $\lambda_N = 0.9986$ and $\lambda_M = 0.9947$ for the pre-1970 period.
$\lambda_N = 1.003$ and $\lambda_M = 0.9957$ for the post-1970 period.
$\lambda_N = \lambda_M = 1.002$ for the entired period examined.
A direct ordinary least squares estimate often overestimates λ, suggesting long adjustment lags. However, this estimate of λ is consistent. See Maddala (1977), pp. 359-364.

17 Lucas *et al.* (1977), p. 41.

large banks entering the Federal funds market for the purpose of liability management practices, and thus the pattern of commercial bank practices in financial markets might be changed. Second, and more importantly, the Federal Reserve took an important step forward in the implementation of monetary policy in 1970. DeRosa and Stern write:

> ...The Federal Reserve has attempted to control the growth of the money stock in the post-1970 period, whereas there is no evidence that such control was pursued in the earlier period.[18]

Their empirical study substantiates that the Federal Reserve has attempted to control growth of the money supply by placing increased emphasis on control of the monetary aggregates since 1970. The System's policy change will alter the structural parameters as well as the central bank adjustment coefficient (n_R). An attempt has thus been made to assess whether the Federal Reserve open market policy has been changed from the period January 1965 through June 1970 [hereafter the pre-1970 period] to the period of July 1970 through August 1976 [hereafter the post 1970 period]. By comparing the two periods, it is possible to assess whether the central bank reaction function can be used to explain behavioral variations of the central bank.

To meet this end, the "Chow Test" method is utilized to test whether the two time series are independent.[19] Suppose that there are n_1 observations during the first period and n_2 observations during the second period. Assume further that a model under consideration can be written in a matrix form as:

$$Y_i = X_i B_i + U_i \, (i = 1, 2)$$

where Y_i is an (n_i x 1) vector of n_i observations on the dependent variable during the ith period; X_i is an (n_i x k) vector of n_i observations on the k independent variables during the ith period; B_i is a (k x 1) vector of parameters; and U_i is an (n_i x 1) vector of distrubances. Then, we may take the null hypothesis, H_0, that a structural change in the parameters has not taken place between the first and the second period, i.e., $H_0: B_1 = B_2$. The alternative hypothesis, H_A, is that such a change has taken place, i.e., $H_A: B_1 \neq B_2$.

18 DeRosa and Stern (1977), p. 217.

19 For a discussion of the construction of the "Chow F-Statistics," see Chow (1960), pp. 591-605; and Fisher (1970), pp. 206-207.

To test the null hypothesis, fit the least squares regression

$$Y_1 = X_1 B_1 + U_1$$

to the first n_1 observations and compute the residual sum of squares $[RSS_1]$. Similarly, fit the same equation to the second n_2 observations and compute the residual sum of squares $[RSS_2]$. As a next step, pool $n_1 + n_2$ sample observations, estimate that regression, and compute the residual sum of squares $[RSS]$. Then, construct a quantity $Q = \{RSS - [RSS_1 + RSS_2]\}$ which represents unexplained variations due to the separation of the sample into two periods. Then, the appropriate test statistic is:

$$F = \frac{Q/k}{[RSS_1 + RSS_2]/[n_1 + n_2 - 2k]}$$

which is distributed as F with $(k; n_1 + n_2 - 2k)$ degrees of freedom.

The equations in Appendix are fitted using 66 observations for the pre-1970 period, 74 observations for the post—1970 period, and 140 observations for the entire period from January 1965 to August 1976. Results of the "Chow Test" are reported in Table 3.1.

Table 3.1
THE CHOW TEST RESULTS FOR STRUCTURAL CHANGE

Dependent Variables	F-Statistics	Level of Significance	Degree of Freedom
FR	3.0584	0.025	(4; 127)
NBR	3.4148	0.025	(3; 129)
MB	6.5457	0.001	(4; 127)

The maintained null hypothesis is thus rejected at the 5 percent level of significance. That is, the structural change has taken place between the two periods. Hence, an econometric examination is conducted for the pre-1970 period and for the post—1970 period separately. The regression results of separate estimation are presented in the next section.

IV. Regression Results

The most striking features of the regression results reported in this section are the apparent instability of the model over the time period examined from January 1965 to August 1976. The apparent instability of the behavioral equation suggests a change in commercial bank behavior, whereas the instability of stock adjustment equations implies a change in the central bank open market policy actions.[20] The instability of the model is recognized as a consequence of more than one event occurring during the period; the discussion will be divided into two parts for analytical simplicity. The first part is concerned with the behavioral equation. The emphasis will be on the effects of regulatory changes in commercial bank reserve adjustment behavior. The second is concerned with stock adjustment equations, placing an emphasis on the central bank's response to changes in commercial bank behavior.

IV.I Behavioral Equation

The ordinary least squares results for the behavioral equation are presented in Table 4.1. The results of the "Chow Test" show the apparent instability of coefficients of the commercial bank demand function for free reserves. The computed F-statistic for the stability test, i.e., $F(4;127) = 3.0584$ as reported in Table 3.1, rejects the null hypothesis that behavior of commercial banks has not been significantly affected by changes in institutional arrangements in the financial markets. The standard error of estimate has significantly increased from the magnitude of 4.35E5 in the pre-1970 period to 48.72E5 in the post-1970 period. This supports the test result that regulatory changes in the financial markets have significant effects on reducing the stability of the banks' demand function for free reserves.

Examination of the regression results reveals that commercial banks' attitude toward managing free reserves has been changed. In the pre-1970 period, the coefficient of forecasting error (FE) was

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[20] The instability of the behavioral equation is the consequence of changes in institutional arrangements, whereas a change in the structural parameters of stock adjustment equations is the result of changes in the central bank open market policy. See Lucas (1976), pp. 39-42.

Table 4.1

REGRESSION RESULTS, THE BEHAVIORAL EQUATION

	Free Reserves	
	Pre-1970 Period	Post-1970 Period
Constant term	977.46 $(5.201)^a$	1511.52 $(4.679)^a$
RFF	−167.32 $(3.636)^a$	−237.83 $(2.319)^a$
RCL	−72.15 (1.277)	−77.23 (0.707)
FE	0.81 $(3.089)^a$	−0.007 (0.797)
R^2 [b]	0.95	0.91
S.E.E. [b]	$4.35E5^c$	$48.72E5^c$
D-W [b]	2.10	1.94

[a]The absolute value of T-statistic is presented in parenthesis below the regression coefficient. The regression coefficient is significant at the 1 percent level in the two-tailed test.

[b]R^2 is the coefficient of determination; S.E.E. is the standard error of estimate; and D-W is the Durbin-Watson statistic.

[c]E5 is used as a short-hand notation to denote that the decimal place is shifted five places to the right.

significantly different from zero at the 1 percent level in the two-tailed test and had an expected positive sign. This means that commercial banks had intended to adjust the profit-maximizing optimal level of free reserves as their expectations on total deposits and commercial bank loan changed. By doing so, they could avoid possible penalities from required reserve deficits and transactions costs in the face of uncertainty about large deposit withdrawals and increased loan demand.

In striking contrast, the coefficient of FE in the post-1970 period is not significantly different from zero and has the opposite

sign. That is, the previously observed relationship between forecasting error and free reserves no longer existed.[21] This is largely the consequence of the following two regulatory changes in the financial markets. The 1970 regulatory change in the Federal funds market specifies that the acquisition of additional funds from the Federal funds market is subject to neither reserve requirement nor the Q ceiling. Commercial banks are thus able to obtain immediately available funds from the Federal funds market, particularly from nonbank financial institutions, at a relatively low transactions cost without loss of borrowed funds into required reserves. Second, it must be recognized in part as the consequence of the lagged reserve accounting conventions (LRA) adopted in the September 1968 amendments to Regulation D. Under the LRA convention in which current deposits determine the required reserve position two weeks later, an unexpected increase in deposits demand will primarily not be associated with an immediate need to meet reserve requirements.[22] Under such institutional arrangements, commercial banks do not need to adjust their free reserve positions immediately in the face of uncertainty about unexpected changes in deposits demand and commercial loan demand. In other words, commercial banks' attitude toward managing free reserves has been changed and free reserves have tended to become residual balances in the reserve adjustment process.

With respect to the coefficient of the Federal funds rate, the coefficient is significant and has the expected negative sign in both the pre-1970 period and the post-1970 period. The magnitude of the coefficient in terms of an absolute value has significantly increased from 167.32 in the pre-1970 period to 237.83 in the post-1970 period. The range of fluctuations in the Federal funds rate is also increased.[23] This implies that commercial banks became more sensitive to changes in the financial market conditions in borrowing funds in slowly adjusting their free reserve positions.

IV.2. Stock Adjustment Equations

The ordinary least squares results for two stock adjustment equations are reported in Table 4.2. The result of stability test for

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21 The same argument can be found in DeRosa and Stern (1977), p. 219.

22 Feige and McGee (1977), pp. 538-540.

23 This can be induced from the fact that, while the magnitude of coefficient increases, the absolute value of t-statistic is decreased because of larger standard deviations.

the bank demand function for nonborrowed reserves indicates that changes in commercial bank behavior have significant effects on reducing the stability of demand for bank reserves.[24] The standard error of estimate has significantly increased from 2.22E5 in the pre-1970 period to 31.57E5 in the post-1970 period. This provides evidence that changes in the commercial banks' attitude toward managing free reserves are the main cause of the instability of demand for nonborrowed reserves. Examination of columns 1 and 2 in Table 4.2 shows that the commercial bank adjustment coeffi-

Table 4.2

REGRESSION RESULTS, STOCK ADJUSTMENT EQUATIONS

	$\triangle$NBR		$\triangle$MB	
	Pre-1970	Post-1970	Pre-1970	Post-1970
Constant term[a]	0.939 (0.105)	22.967 (0.764)	113.144 (1.197)	366.280 $(3.459)^b$
$\triangle$RR	0.974 $(22.316)^b$	0.884 $(13.060)^b$	0.599 $(5.544)^b$	0.162 $(1.925)^c$
$\triangle$FR	0.532 $(10.534)^b$	0.227 $(6.568)^b$	0.212 $(1.516)^d$	−0.027 (0.435)
$\triangle$CC			0.917 $(4.778)^b$	0.941 $(6.678)^b$
R^2	0.90	0.75	0.46	0.45
S.E.E.	2.22E5	31.57E5	13.17E5	79.92E5
D-W	1.88	1.60	2.00	2.56

[a]Since the stock adjustment equation is of the first-order difference form, constant term represents the linear trend in each equation.

[b]Regression coefficient is significant at the 1 percent level.

[c]Regression coefficient is significant at the 5 percent level in the two-tailed test.

[d]Regression coefficient is significant at the 10 percent level in the one-tailed test.

24 The computed F-statistic, i.e., $F = 3.4148$, is significant at the 1 percent level as reported in Table 3.1.

cient for required reserves (n_B) is siginificantly different from zero at the 1 percent level in the two-tailed test. However, the coefficient n_B is not significantly different from one in the pre-1970 period, whereas it is significantly different from one at the 10 percent evel in the two-tailed test in the post-1970 period.[25] The adjustment coefficient for free reserves (n_E) is also significant at the 1 percent level in the two-tailed test. The magnitude of coefficient n_E is increased from the pre-1970 period to the post-1970 period. This is recognized as the consequence of the 1968 amendment to Regulation D on the lagged reserve accounting (LRA) convention and the 1970 amendment to the provision of Regulation D against borrowing Federal funds from nonbank financial institutions. This implies that commercial banks are slow in adjusting their free reserve positions because of the availability of funds at relatively low transactions costs and of the additional two weeks necessary in adjusting reserve positions to meet reserve requirements.

Examination of columns 3 and 4 in Table 4.2 for the central bank reaction function supports the result of stability test[26] which leads to rejection of the null hypothesis that the central bank has attempted to control the growth of the money stock over the entire period of January 1965 through August 1976. Examination of the regression results indicates that the central bank open market policy has been changed from the interest rate target in the pre-1970 period to the monetary aggregate target in the post-1970 period.

The results of empirical test for the central bank reaction function reveal three important features. First, a statistically insignificant trend variable in the pre-1970 period becomes significantly different from zero in the post-1970 period. This implies that the central bank follows, at least partly, the projected pace of the monetary growth rate in order to be consistent with its long-run policy goal. Second, the coefficient of free reserves in the pre-1970 period was positive and significant at the 10 percent level in the one-tailed test. But for the post-1970 period, the coefficient becomes negative and not significantly different from zero. A negative sign would be evidence that the central bank was attemp-

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25 Computed t-statistics are:
        $t = -0.5874$ for the pre-1970 period
        $t = -1.7192$ for the post-1970 period.
26 The computed F-statistic, i.e., $F = 6.5457$, is significant at the 1 percent level.

ting to restrain fluctuations in credit demand by increasing sales of securities in the open market.[27] The fact that the coefficient was not significantly different from zero would be evidence that the previously observed relationship between free reserves and the monetary base no longer existed.[28] This result is consistent with evidence presented by DeRosa and Stern for the period of June 1970 to June 1973.[29] Third, the magnitudes of instrument variable estimates of the central bank adjustment coefficient (n_R) to changes in demand for nonborrowed reserves are significantly different between the pre-1970 period and the post-1970 period. Those estimates are:

For the pre-1970 period: $\hat{n}_R = 0.615$

For the post-1970 period: $\hat{n}_R = 0.183$

This implies that the central bank placed more emphasis on control of interest rates by accommodating changes in the demand for bank reserves in the pre-1970 period, but is placing more weight on control of money-supply growth in recent years.

The coefficient of changes in currency demanded by the public has the expected value of close to one in both periods, which indicates that the central bank has accommodated whatever the quantity of currency demanded by the public. Moreover, the standard error of estimate has significantly increased from 13.1735 in the pre-1970 period to 73.92E5 in the post-1970 period. The poor performance of the central bank reaction function indicates that the monetary base becomes an intermediate target variable in recent years.

V. Summary and Conclusions

In a dynamic and stochastic world, the underlying relationship between monetary aggregates, interest rates, and the level of economic activity are so complex that no single choice criterion can be drawn as a guide to determine the open market policy. On a theoretical level, either monetary aggregates or interest rates can be chosen as the operating target. On a practical level, however,

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27 Feige and McGee (1977), p. 547.

28 DeRosa and Stern (1977), p. 219.

29 The study of DeRosa and Stern takes the "price-adjustment" form of reaction function in which the Federal funds rate is a dependent variable. See DeRosa and Stern (1977), pp. 219-229.

the choice of the appropriate operating target is an empirical question. The central bank may be undertaking a mixture of policies depending upon economic circumstances. In some periods, more weight may be placed on the interest rate target for the purpose of short-run stabilization of the financial markets; while in other periods, emphasis may be placed on monetary growth to achieve the long-run money supply objectives.

Estimation of a short-run dynamic reaction function has provided evidence that the central bank has emphasized control of interest rates in the pre-1970 period, whereas it has emphasized control of the growth of the money stock in the post-1970 period. That is, the central bank adjustment coefficient which measures the degree of the central bank's response to changes in demand for bank reserves is equal to 0.615 in the pre-1970 period and 0.183 in the post-1970 period. The magnitudes of coefficients are significantly different between the two periods. This empirical evidence reveals an important implication for econometric model-builders. It calls for careful attention to the assumption that the monetary base is exogenous in the statistical sense and affects the money supply. Treatment of the monetary base as an exogenous variable results in a mis-specification of the model, which causes bias in econometric model-building. Thus, model-builders must explicitly include both dynamic and defensive open market operations within the framework of the analysis.

Appendix
Equations to be Tested and Data Sources

I. Equations to be tested

1. Behavioral Equation:

$$FR = d_0 - d_1 RFF - d_2 RCL + d_3 FE + U$$
$$\text{where } FE = (\overline{DD} - DD) + (\overline{TD} - TD) - (\overline{CBL} - CBL)$$

2. Stock Adjustment Equations:

$$\Delta NBR = n_B \, \Delta RR + n_E(\widehat{FR} - FR_{-1})$$
$$\Delta MB = n_B n_R \Delta RR + n_C \Delta CC + n_E n_R (\widehat{FR} - FR_{-1})$$

3. Notation:

    MB   = Monetary Base
    NBR = Nonborrowed Reserves
    RR   = Required Reserves
    FR   = Free Reserves
    CC   = Currency held by the Public
    RFF   = Federal Funds Rate
    RCL = Commercial Bank Loan Rate
    FE   = Measurement of Forecasting Error Committed
             by Commercial Banks
    DD   = Demand Deposits in Commercial Banks
    TD   = Time Deposits in Commercial Banks
    CBL = Commercial Loan Outstanding

II. Data Sources

Data are seasonally adjusted and obtained from the National Bureau of Economic Research (NBER) Time-Series Data Bank.

Variable measuring quantity, except money wage rate, are in millions of dollars, and average money wage rate is measured in dollars. The Federal funds rate and commercial loan rate are measured in percentage per annum.

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Notes and Announcements

CENTER FOR ASIAN ECONOMIC RESEARCH at Rutgers University held an international conference on the U.S.-Asia Economic Relations on April 16-18, 1981 in New Brunswick, New Jersey, U.S.A.

THE INTERNATIONAL STUDIES ASSOCIATION has announced that the *International Studies Quarterly*, its official journal, has acquired a new editorial team beginning in 1980. These new editors include Raymond D. Duvall (Political Science), P. Terrence Hopmann (Political Science), Brian L. Job (Political Science), and Robert T. Kudrle (an economist in the Hubert H. Humphrey Institute of Public Affairs), all at the University of Minnesota. The editorial offices for the journal are situated in the Harold Scott Quigley Center of International Studies and the Hubert H. Humphrey Institute of Public Affairs in Minneapolis.

The new editors are seeking to make the *International Studies Quarterly* broadly representative of the world of international studies scholarship. In addition to seeking manuscripts that report on focused empirical research on international relations, they are also looking for manuscripts presenting original and well-structured theoretical arguments about a wide variety of issues in international studies. They hope to represent a wide range of disciplinary orientations to international studies, including fields such as economics, history, political science, sociology, law, psychology, and anthropology, as well as interdisciplinary work. Manuscripts that treat important issues from a truly comparative perspective are also encouraged. Finally, the editors seek to represent a broad range of research done by scholars outside of North America. As editors of a journal with a worldwide audience, they desire to make the *International Studies Quarterly*, in part, a vehicle for sharing alternative scholarly viewpoints and traditions which have flourished within many parts of the world.

Manuscripts, accompanied by a 300-world abstract, should be submitted in triplicate, following the style found in a recent issue of the journal to:

> Editors, *International Studies Quarterly*
> Harold Scott Quigley Center of International Studies
> Hubert Humphrey Institute of Public Affairs
> University of Minnesota
> 1246 Social Sciences Bldg.
> 267 19th Avenue, South
> Minneapolis, MN 55455 U.S.A.

THE UNITED NATIONS ENVIRONMENTAL PROGRAM (UNEP) at a conference in Athens, Greece, May 1980, pulled off a scientific and diplomatic coup; it got all the nations in the Mediterranean Basin but one (Albania) to agree on methods to control pollution in that body of water. The Mediterranean is a closed sea, its only significant outlet being the Strait of Gibraltar. Nearly 90 percent of the sewage that pours into it is untreated. In Naples the sewer system is so old and uncharted that many sewer pipes cannot be found. Sixty percent of Athens is not even connected to a central sewerage system. Along the French and Italian Rivieras, thousands of new chemical plants and factories dump their wastes, untreated, into the rivers or directly into the sea. In this area, typhoid, Dysentery, and viral hepatitis outbreaks are commonplace. Along France's famed Cote d' Azur black pollution flags and, at times, police lines keep bathers out of the water. The biggest polluters are France, Italy, and Spain, and they are expected, under the terms of the conference, to bear the biggest part of the $10 billion cleanup program. The proposed treaty includes a blacklist of banned substances, and all existing factories and sewage systems will be required to install antipollution devices, while new installations will have to conform to treaty specifications.