Is Money Growth Still a Useful Indicator of Inflation?

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IS MONEY GROWTH STILL
A USEFUL INDICATOR OF INFLATION?

by

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B.S. July 1993, Gazi University

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IS MONEY GROWTH STILL A USEFUL INDICATOR OF INFLATION?

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This thesis examines the linkages among the monetary aggregates, inflation, and the economy through vector autoregression techniques. Multivariate Granger-causality tests, variance decompositions and impulse response functions are utilized to examine causal relationships among key economic variables. In 1987, the Federal open Market Committee (FOMC) decided not to establish a specific target range for M1 growth. Since then, the broader M2 measure of money has been the preeminent variable used in implementing monetary policy; however, the results indicate that M1 can be used in predicting inflation and M2 can be used in predicting real GDP. This suggests that the FED should have two intermediate targets and indicators instead of one.
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I owe a special thanks to Prof. Raymond Strangways for his close attention and his support of my research. I appreciate his discussions and helpful comments that kept me on a straight path. His valuable familiarity with monetary theory reflected as quality in my work. Using a VAR model in my thesis, by the recommendation of Prof. Raymond Strangways, has broaden my knowledge and improved research experiment.
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I. INTRODUCTION

The velocity of M1 declined in the 1980s after an upward trend over the previous twenty years. This apparent break in the process generating velocity was an important consideration in the Federal Reserve’s deemphasis of M1 as an intermediate target in 1982. If money is to have a role in the Federal Reserve’s policy process, two fundamental questions must be answered. First, as a target and indicator of inflation, is money growth still as useful as in the past? Second; insofar as money remains a useful indicator of inflation, which measure of money should receive the most attention? The Depository Institution Deregulation and Monetary Control Act of 1980 (DIDMCA) prescribed regulatory changes and permitted financial innovations. Each change potentially affected the relationship between money growth and economic activity. Recently, some economists have begun to advocate that monetary aggregates receive less emphasis in the policy process because they are less reliably related to the ultimate goals of policy now than in the past.

While this thesis examines the relationships among money growth, inflation, and real GDP, a different approach, the vector autoregressive technique is used to examine quarterly data for the period 1960 to 1995. The VAR methodology avoids imposing any bias inherent in structural models and incorporates sufficient lags to reflect the full dynamic effects of monetary influences over time. Multivariate Granger-causality tests, variance decompositions and impulse response functions are utilized to examine propositions regarding causal relationships among key economic variables.

The journal model is taken from *The American Economic Review*. 
The organization of the thesis is as follows. Section I presents the introduction. Section II presents an overview regarding the financial deregulation in the early 1980s. Section III presents methodology, which contains the definition and details of a VAR model, contains previous VAR research and identifies several problem areas in interpreting the results. Section IV explains my model that consists of the discussion and four six-variable VAR models are established to examine the tests. Section V, VI and VII contains identifications and interpretations of tests, which are the Granger-causality test, variance decomposition and impulse response analysis, respectively. Section VIII concludes the results of the research.
II. THE INSTITUTIONAL SETTING

The Depository Institution's Deregulation and Monetary Control Act of 1980 was signed into law March 31, 1980. It has been described by some as the most significant piece of legislation since the 1930's. The act includes a number of major provisions, which have had considerable impact on the structure and performance of financial institutions.

The act provides for the phasing out of interest rate ceilings on time and savings deposits, a feature of banking regulation since the Depression in the 1930's. With the elimination of rate ceilings, the higher ceilings that had been authorized for saving and loan associations than for commercial banks disappeared. The act acknowledges that interest rate ceilings had become outdated and, in an inflationary environment, had caused substantial shifts of funds from depository institutions to money market instruments.

Another part of the act authorizes all depository financial institutions to offer negotiable order of withdrawal (NOW) accounts, commonly referred to as interest-bearing checking accounts. These had previously been authorized only in the New England States, New York, and New Jersey. Commercial banks had been authorized to make automatic transfers from savings to checking accounts, but this had not been used widely (Cacy, 1981). Thus, the act authorized thrift institutions across the nation to participate directly in the payments mechanism by providing third party payment services. Under the Monetary Control Act, all depository institutions' transactions accounts, non-personal time and saving deposits, and certain Eurocurrency transactions were made subject to Federal Reserve System
reserve requirements.¹ Thus, reserve requirements coverage under the act is extended to nonmember banks, saving institutions, and credit unions. After a phase-in period, depository institutions are subject to a 3 percent reserve requirement on the first $28.9 million of net transactions accounts and a 12 percent reserve requirement on transactions accounts in excess of the base amount. The Board of Governors is authorized to vary reserve requirements on transactions accounts in excess of the $28.9 million base in a range of 8 to 14 percent, with an additional supplemental requirement of 4 percent possible under special conditions.

Reserve requirements on nontransactions liabilities were also modified. Reserve requirements against personal time and savings deposits were eliminated under the act. They were maintained on nonpersonal time deposits, however. Initially set at 3 percent, they can be varied in a range from 0 to 9 percent. The Board also has the authority to determine the maturity of nonpersonal time deposits that are subject to reserve requirements. Finally, the Board can set reserve requirements for certain Eurocurrency liabilities. These requirements were initially set at 3 percent, the same ratio as that for nonpersonal time and savings deposits (Cacy, 1985).

¹The Garn-St Germain Depository Institutions Act of 1982 modifies the 1980 Monetary Control Act by providing that $2 million of reservable liabilities of each depository institution be subject to a zero percent reserve requirement. The exemption amount is adjusted each year for the next calendar year by 80 percent of the percentage increase in total reservable liabilities of all depository institutions measured on an annual basis as of June 30.
The Monetary Control Act also requires changes in discount policy. Before 1980, borrowing from the Federal reserve was generally limited to member banks. The act broadened discount window access to all depository institutions subject to reserve requirements. Under current discount window regulations, borrowing is divided into two categories: adjustment credit and extended credit. Adjustment credit is designed to provide institutions a short-term cushion of funds to balance unexpected outflows from reserve accounts. In contrast, extended credit provides a longer term source of funds to institutions having strong seasonal patterns in loan demand or sustained liquidity pressures.

In addition to legislative developments affecting the role of the policy instruments, the Federal Reserve has initiated a number of regulatory changes in recent years aimed at improving the monetary control process. Three of the most significant developments are the adoption of a contemporaneous reserve accounting system, the use of reserve requirements on managed liabilities as a discretionary policy instrument, and the use of a discount rate surcharge mechanism.

From September 1968 to January 1984, financial institutions operated under a system of lagged reserve requirements (LRR). Required reserves in a given week were calculated on the basis of deposit levels two weeks earlier. This system was designed to make it easier and less costly for institutions to meet required reserves and to simplify the conduct of daily open market operations by removing the uncertainty associated with forecasting contemporaneous deposit levels.

Under new contemporaneous reserve requirements (CRR) effective in February 1984, depository institutions that report weekly to the Federal Reserve
have to maintain required reserves behind transactions deposits on an essentially contemporaneous basis. That is, these institutions compute their required reserves behind transactions deposits on the basis of average daily deposits over a two-week period that begins on a Tuesday and ends on a Monday. Reserves must then be maintained over a two-week period beginning on Thursday, two days after the start of the computation period, and ending on Wednesday, two days after the end of the computation period.

Contemporaneous reserve accounting is designed to improve monetary control by speeding up the adjustment process for reserves held behind transactions deposits. Unlike the two-week lag for LRR, under CRR, from the time that an institution knows its required reserves at the end of the computation period, it has only two days to adjust fully to its required reserves. The basic idea is that when faced with this shorter adjustment period, institutions will attempt to acquire reserves to support growth of transactions deposits on a more timely basis or, alternatively, will attempt to liquidate assets to reduce their required reserves.

Historically, discretionary changes in reserve requirements have been used much less frequently than either open market operations or discount rate policy. At least three reasons have been advanced to explain the relatively infrequent use of reserve requirement changes. First, a given change in reserve requirements can be a rather blunt policy instrument. That is, an across-the-board increase in reserve requirements affects all institutions whether or not they are contributing to a problem of excessive money and credit growth. Second, frequent changes in reserve requirements make it difficult for banks to plan their asset and liability management
decisions.\(^2\) Third, before passage of the Monetary Control Act the voluntary nature of Federal Reserve membership may have limited the use of reserve requirements as a policy instrument. The Federal Reserve has focused its discretionary changes in reserve requirements not on demand deposits or other transactions accounts, but rather than on certain managed liabilities such as large denomination CD’s and Eurodollar borrowings. This regulatory development has increased the flexibility of reserve requirements as a discretionary policy instrument by allowing the Federal Reserve to target reserve requirement changes to larger institutions that make extensive use of managed liabilities to fund credit expansion.

The focused use of reserve requirements is a response by the Federal Reserve to the rapid development and creative use of managed liabilities by banks during the 1960s and 1970s. From the banks' standpoint, an attractive feature of managed liabilities is that they are generally subject to lower reserve requirements than demand deposits. Thus, if the banking system can bring about a shift in the composition of its liabilities from demand deposits to managed liabilities, it can effectively lower reserve requirements and thus extend more credit with the same supply of reserves. Reserve requirements on managed liabilities affect the behavior of banks by changing the cost of these liabilities relative to other sources of funding loan expansion. By raising reserve requirements on a specific type of liability, its use can be discouraged relative to other funding sources. At various times the Federal

\(^2\) The Federal Reserve attempted to reduce this problem in 1972 by adopting a system of graduated reserve requirements based on size of deposits. This system replaced a structure in which reserve requirements depended on geographic location. Under a graduated system, reserve requirements changes can be directed at particular deposit size categories and thus at different size institutions.
Reserve has used this instrument in three distinct ways: to control the overall level of managed liabilities, to change the composition of managed liabilities, and to change the average maturity of managed liabilities.

In October 1979, the Federal Reserve tried to reduce growth in the overall level of managed liabilities by imposing an 8 percent reserve requirement on the amount by which an institution's total managed liabilities exceed a base period amount. This action was designed to slow the expansion in bank credit financed through managed liabilities by increasing the cost of the additional use of these liabilities. Subsequently, in April 1980, this marginal reserve requirement was raised to 10 percent as part of the Credit Control Program before being reduced to 5 percent in June 1980 and 0 percent in July 1980 as credit growth slowed. Discretionary changes in reserve requirements also have been used to affect the composition of managed liabilities. For example, in September 1969 the Federal Reserve imposed a 10 percent marginal reserve requirement on Eurodollar borrowings by U.S. banks (Higgins, 1983). The reason for this action was that banks were apparently avoiding domestic credit restraint by developing overseas sources of funds. Finally, reserve requirements changes have been used in an effort to change the maturity of particular types of managed liabilities. For example, in September 1974 and again in October 1975, the Federal Reserve established differential reserve requirements on large denomination time deposits with different maturities. Lower reserve requirements were set on time deposits with longer maturities.  

---

3 Marginal reserve requirement applies to increases in deposit category above a base period amount. Changes in the marginal rate affect the cost of additions to the base period amount but do not force an institution to alter the base period amount.
maturities. The purpose of this action was to encourage banks to lengthen the maturity of their time deposits by lowering the relative cost of longer term sources of funds.

As in the case of reserve requirements, it has traditionally been difficult to target discount policy to specific size institutions. To make discount policy more flexible, in March 1980 the Federal Reserve introduced a discount rate surcharge applying to large banks that made frequent use of the discount window. The purpose of the surcharge was to prevent large banks with access to the money markets from borrowing excessively while at the same time providing smaller banks with continued access to the discount window. As initially structured, the discount rate surcharge applied to banks with deposits over $500 million that borrowed for two consecutive weeks or for more than four weeks in a calendar quarter. The initial surcharge rate was 3 percent. Thus, large banks subject to the surcharge would pay the basic discount rate plus a 3 percent surcharge. The surcharge was removed in May 1980 but was reintroduced in November 1980, and it remained in effect until November 1981. During this latter period, the surcharge rate changed from 2 to 4 percent (Hoehn, 1983).

On February 19, 1980, Paul A. Volcker presented Congress with the targets for the monetary aggregates in 1980. These targets were couched in terms of newly defined monetary aggregates: M1A, M1B, M2 and M3. The new M1A measure is very similar to the old M1 but differs in excluding demand deposits owned by foreign commercial banks and official situations. M1B differs from the old M1 by excluding these deposits, and by including other checkable deposits at both commercial banks
and thrift institutions. New M2 is closer in concept to the old M3, which included savings and time deposit liabilities at all depository institutions (other than negotiable certificates of deposit at large commercial banks), than it is to the old M2, which excluded the public’s holdings of savings and time deposits at thrift institutions. The major difference between the new M2 and the old M3 measures are that the new M2 includes money market mutual fund shares and overnight repurchase agreements (RP’s) and Eurodollars, and that it excludes all large-denomination time deposits. By including all large-denomination time deposits at all depository institutions, the new M3 is closer in concept to the old M5 measure than the old M4.

The organizing principle underlying the redefined monetary aggregates is that of combining similar kinds of monetary assets at each level of aggregation. This principle has the largest impact on the new M1B, M2 and M3 measures. Two M1 measures were adopted primarily because of uncertainties that would arise during a transition period, should legislation be enacted that permits NOW accounts to be offered nationwide. NOW accounts have properties of both a transactions-type account and a saving-type account: Thus, NOW accounts would tend to attract funds both from household demand deposits and from savings accounts and other liquid assets. This suggests that during a conversion period associated with nationwide NOW accounts, growth in M1B could significantly overstate underlying growth in the public’s transactions balances. M1A, by contrast, would tend to understate such growth as households converted demand deposit balances into NOW accounts.
III. METHODOLOGY

Vector autoregressions have brought with them their own terminology. Granger-causality, variance decompositions, innovation accounting, and impulse response functions fill the places in this methodology that parameter estimates, identifying restrictions, and hypothesis testing do in traditional economic modeling.

The VAR methodology begins with the concept of a covariance-stationary time series, one that has a mean and an autocorrelation that are constant at all lags through time. Covariance stationarity is not an innocuous assumption, but it can be approximated for macroeconomic time series by defining variables as first differences. By Wold’s theorem any time series process, \( x_t \) can be decomposed into two components. The first, \( \eta_t \) is linearly deterministic, that is, exactly predictable given a linear combination of its own past values. The second is a moving average, possibly of infinite length, of white noise errors, \( \epsilon_t \). White noise errors, like covariance stationary series, have constant autocovariances, but in addition have all covariances identically zero. That is, there are no systematic components that would enable the white noise process to be predicted from its own past.

\[
(1) \quad x_t = \eta_t + A(L)\epsilon_t, \quad E(\epsilon_t) = 0 \quad E(\epsilon_t, \epsilon_{t-k}) = \begin{bmatrix} \Omega & k=0 \\ 0 & k \neq 0 \end{bmatrix}
\]

where \( A(L) \) is a polynomial in the lag operator.
When the polynomial $A(L)$ is invertible, an autoregressive representation of equation (1) exists and can be written as

$$A(L)^{-1}x_t = A(L)^{-1} \eta_t + \epsilon_t$$

By moving the lagged $x$'s to the right-hand side of the equation and combining them with the $\eta$'s, which, by definition, are linear functions of lagged $x$'s, the system of equations is as follows:

$$x_t = B(L)x_t + \epsilon_t = \sum_{j=1}^{N} B_j L_j x_t + \epsilon_t$$

In general, $N$, the lag length of the autoregressive representation in equation (3), will be infinite, but in practice it is generally truncated to some number that is both small enough to be computationally feasible and large enough to ensure that the equation residuals are approximately white noise. In this case, equation (3) is the basic form of a vector autoregression in which regressor $x_{it}$, an element of the vector $x_t$, is a linear function of its own lagged values, the lagged values of all other regressors in the system, and a white noise error term. If there are $M$ time-series variables in the model, then the coefficient matrix $B_j$ is of dimension $M$ by $NM$. As a consequence, every variable in the model is treated as being endogenous, and each has two components which are its best linear prediction given information available one period previously, and its linearly unpredictable innovation. The error term $\epsilon_t$ represents that part of the dependent variable not predictable from knowledge of lagged values of the regressors.
Equation (3) takes the form of the multivariate regression model, and the presence of identical sets of regressors for each of the \( M \) equations ensures that the coefficients may be estimated consistently by ordinary least squares. If it is further assumed that the innovations \( \varepsilon_t \) are not only white noise but are also normally distributed, then the estimates of the \( B_j \) coefficients are asymptotically efficient.

In other words, a vector autoregression is simply a system of dynamic linear equations in which each variable is written as a function of a serially uncorrelated error and an equal number of lags of all variables in the system. Efficient estimation of the VAR model is obtained with OLS estimates. Current values are not used because of the possibility of simultaneity. Within this paradigm the only current exogenous variables are unobserved "shocks" to the economy. The residuals from the VAR regressions are taken to be linear combinations of these shocks, and with enough restrictions on the linear combinations, the shocks can be identified from the covariance matrix of the residuals. That is, they can be used to characterize the response to unexpected shocks in policy and other variables.

Sims (1980a) offered an influential critique of what were then standard large-scale macroeconometric models. He argued that large-scale models made 'incredible' identifying restrictions by arbitrarily excluding lags of other endogenous variables which would be important in a dynamic programming framework. Also, he expressed a belief that virtually all variables could be endogenous in a dynamic general equilibrium economy with forward-looking agents. Sims proposed the unrestricted vector autoregressive model as an alternative dynamic specification. All variables in the VAR are endogenous and the dynamic specification is relatively
unrestricted. Sims argued that the primary advantage of this atheoretical VAR approach was that it did not specify restrictions from a particular structural model, yet under relatively weak conditions the VAR provided a reduced form model within which tests of economically meaningful hypotheses can be executed.

Views on the robustness of VAR evidence have been stimulated in no small part by the work Christopher Sims (1980a). Sims estimated a VAR with four variables (interest rates, money, the price level, and output) in order to get evidence on the dynamic relationships among these variables, especially the relationship between money and output. One of Sims’ conclusions was the strikingly nonmonetarist result that unpredicted variations associated with the money stock account for only 4 percent of the unpredicted variations in output (Sims, 1980b). Yet these results may not be entirely reliable because they are derived from a VAR model in which highly nonstationary time-series data are employed, contrary to the assumptions of the vector autoregressive techniques. Nelson and Plosser (1982) suggested that neither output nor most other economic time series data display stationary about a deterministic trend.

King (1984) presented one approach to correcting the problem of nonstationary time series by adding linear and quadratic trends to the estimated system. Money innovations were found to explain 18 percent of the forecast errors of output at the forty-eight-month horizon in the money-output-price model using monthly data. This explanatory power rose to 31 percent when interest rates were included as well. However, inclusion of the linear and quadratic trends in the model does not remove the problem of nonstationarity in the time-series data. The Nelson
and Plosser evidence suggests that simple detrending may be inappropriate. Further support for this conclusion lies in the results derived from King's models using quarterly data. The proportion of output variance explained by monetary innovations increased to 39 percent in the three-variable system and 60 percent in the four-variable system at the sixteen-quarter horizon. The incompatibility of these very high proportions with those derived using annual data suggests that the results may be sensitive to the form in which the data are used.
In 1987, the Federal Open Market Committee (FOMC), citing uncertainties about its underlying relationship to the behavior of the economy and its sensitivity to a variety of economic and financial circumstances, decided not to establish a specific target range for M1 growth. Since then, the broader M2 measure of money has been the preeminent variable used in implementing monetary policy. The problem here is whether or not M2 has enough predictive and effective power over inflation and real GDP. My focus in this thesis is to determine which monetary aggregate (M1 or M2) provides a more useful intermediate policy target to reach the ultimate goals.

The data are expressed as levels of quarterly data. The full sample period is from 1960Q1 to 1995Q4. The subperiods are 1960Q1-1979Q3 and 1979Q4-1995Q4. This choice of sample periods is appropriate because of the well-known October 1979 change in Federal Reserve operating procedures and the money definition problems pursuant to the Monetary Control Act of 1980. These events produced important structural shifts in the measured money-output, money-price relationships.

The variables used in each of the six equation unrestricted VAR model are real GDP (y), the money supply given by M1 and M2 (m), the consumer price deflator (p), the energy price index (e), the velocity of money supply (v), and the average yield on three-month Treasury bills (r).

The problem of nonstationarity in economic time-series data is addressed in this work by using the log first-difference form of all variables. The stationarity of
these regression variables in the form \( GX_t = \ln X_t - \ln X_{t-1} \) was verified by examining autocorrelation coefficients for each series. In every case, the autocorrelation coefficients were small and declined rapidly with time, indicating that no time trend or further detrending of the series was necessary.

The general form of the VAR model is given by the following unrestricted reduced-form system:

\[
Z_t = \alpha + \beta(L)Z_t + v_t
\]

where \( Z_t \) is an 6x1 column vector of the six variables, \( \alpha \) is a 6x1 vector of constants and \( \beta(L) \) is a 6x6 matrix of lagged polynomial coefficients. The lag operators can be expressed simply as

\[
\beta_{ij}(L)Z_t = \beta_{i1}Z_{t-1} + \beta_{i2}Z_{t-2} + \ldots + \beta_{ik}Z_{t-k}
\]

The AIC procedure is a very general method for determining either lag orders or choosing among alternative classes of models. Therefore, in my models Akaike's AIC criterion is used to determine the lag length of the Sims-type VARs. The lag length chosen is the one that minimizes

\[
AIC(k) = \ln \text{det} \Sigma_k + 2d^2/T
\]

\[
k = 1, \ldots, m
\]

where \( d \) is the number of variables in the system, \( m \) is maximum lag length considered, \( \text{det} \Sigma_k \) = determinant of \( \Sigma_k \) which is diagonal matrix of the estimated residual variance for each equation in the system, \( T \) = the number of observation.
The following six-variable VAR model is based on the monetary aggregate of M1 and the full sample period, 1960Q1 through 1995Q4.

\[
\begin{align*}
 m_t &= \alpha_1 + \sum_{k=1}^{8} \beta_{11}m_{t-k} + \sum_{k=1}^{8} \beta_{12}r_{t-k} + \sum_{k=1}^{8} \beta_{13}e_{t-k} + \sum_{k=1}^{8} \beta_{14}p_{t-k} + \sum_{k=1}^{8} \beta_{15}v_{t-k} + \sum_{k=1}^{8} \beta_{16}u_{t-k} + \epsilon_{mt} \\
 r_t &= \alpha_2 + \sum_{k=1}^{8} \beta_{21}m_{t-k} + \sum_{k=1}^{8} \beta_{22}r_{t-k} + \sum_{k=1}^{8} \beta_{23}e_{t-k} + \sum_{k=1}^{8} \beta_{24}p_{t-k} + \sum_{k=1}^{8} \beta_{25}v_{t-k} + \sum_{k=1}^{8} \beta_{26}u_{t-k} + \epsilon_{rt} \\
 e_t &= \alpha_3 + \sum_{k=1}^{8} \beta_{31}m_{t-k} + \sum_{k=1}^{8} \beta_{32}r_{t-k} + \sum_{k=1}^{8} \beta_{33}e_{t-k} + \sum_{k=1}^{8} \beta_{34}p_{t-k} + \sum_{k=1}^{8} \beta_{35}v_{t-k} + \sum_{k=1}^{8} \beta_{36}u_{t-k} + \epsilon_{et} \\
 (7) \ p_t &= \alpha_4 + \sum_{k=1}^{8} \beta_{41}m_{t-k} + \sum_{k=1}^{8} \beta_{42}r_{t-k} + \sum_{k=1}^{8} \beta_{43}e_{t-k} + \sum_{k=1}^{8} \beta_{44}p_{t-k} + \sum_{k=1}^{8} \beta_{45}v_{t-k} + \sum_{k=1}^{8} \beta_{46}u_{t-k} + \epsilon_{pt} \\
 v_t &= \alpha_5 + \sum_{k=1}^{8} \beta_{51}m_{t-k} + \sum_{k=1}^{8} \beta_{52}r_{t-k} + \sum_{k=1}^{8} \beta_{53}e_{t-k} + \sum_{k=1}^{8} \beta_{54}p_{t-k} + \sum_{k=1}^{8} \beta_{55}v_{t-k} + \sum_{k=1}^{8} \beta_{56}u_{t-k} + \epsilon_{vt} \\
 y_t &= \alpha_6 + \sum_{k=1}^{8} \beta_{61}m_{t-k} + \sum_{k=1}^{8} \beta_{62}r_{t-k} + \sum_{k=1}^{8} \beta_{63}e_{t-k} + \sum_{k=1}^{8} \beta_{64}p_{t-k} + \sum_{k=1}^{8} \beta_{65}v_{t-k} + \sum_{k=1}^{8} \beta_{66}u_{t-k} + \epsilon_{yt}
\end{align*}
\]

The conventional orthogonalization procedure requires imposing particular ordering of the variables. This choice is arbitrary and, when there is contemporaneous correlation among the innovations, it can make a significant difference in the variance decomposition. This problem has been noted by Sims.
and widely criticized as a deficiency of VAR methods.

The assumption about causal ordering of contemporaneous errors in a VAR system amounts to a decision about admitting current variables into the estimating equation. To see this, return to the general VAR model in equation (3) and decompose each error term, $\varepsilon_{it}$. There is no reverse causality. We can order the variables so that a given order affects only errors that are lower in the list; that is, $\varepsilon_{ji}$ affects $\varepsilon_{it}$ only if $j < i$. This ordering is called a triangularization of the system. In matrix notation we can write a set of M regression equations

$$\varepsilon_t = C\varepsilon_t + \mu_t$$

where $C$ is a lower triangular MxM matrix with zeros on the diagonal, and whose $i,j$-th element is the regression coefficient of $\varepsilon_i$ on $\varepsilon_j$ for $j < i$. Since the $\varepsilon_t$ vector is orthogonal to all of the regressors in equation (3), the $B$ and $C$ coefficients could also be obtained by fitting the set of regressions,

$$x_t = \sum_{j=1}^{N} B_j x_{t-j} + C\varepsilon_t + \mu_t$$

where each equation except the first includes the residuals from each previous regression in the list of regressors.

I assume a causal chain running from energy prices to money supply then to interest rates then to prices then to velocity of monetary aggregate and then to output. This assumption implies that the reduced-form vectors are related to the underlying shocks according to this model:
Here e's denote reduced-form errors: The u's are underlying shocks to supply and demand, and the $\alpha$, $\beta$, $\gamma$, $\zeta$, $\theta$ coefficients link the underlying shocks to the reduced-form errors.

In matrix notation, the model can be written as

\begin{equation}
(11) \quad e_t = Au_t
\end{equation}

where

\begin{equation}
(12) \quad \begin{bmatrix}
e_{et} \\
e_{mt} \\
e_{rt} \\
e_{pt} \\
e_{vt} \\
e_{yt}
\end{bmatrix} =
\begin{bmatrix}
u_{et} \\
u_{mt} \\
u_{rt} \\
u_{pt} \\
u_{vt} \\
u_{yt}
\end{bmatrix}
\end{equation}

\begin{equation}
(13) \quad A = \begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 \\
\alpha_r & 1 & 0 & 0 & 0 & 0 \\
\alpha_e & \beta_e & 1 & 0 & 0 & 0 \\
\alpha_p & \beta_p & \gamma_p & 1 & 0 & 0 \\
\alpha_v & \beta_v & \gamma_v & \zeta_v & 1 & 0 \\
\alpha_y & \beta_y & \gamma_y & \zeta_y & \theta_y & 1
\end{bmatrix}
\end{equation}
The triangular pattern of the matrix $A$, with ones on the diagonal and zeros above, reflects the causal pattern assumed. Effects flow only downward, from variables earlier in the causal chain to those later.

To find exogenous variables in the VAR model, we can use variance decomposition analysis. The variance decomposition for my six variable VAR models with monetary aggregates of $M_1$, $M_2$, and for all three time period are reported in the following tables. Table 2 reports variance decomposition for each variable in the model attributable to shocks in each of the other variables. Dependent variables are shown in the first column. The remaining columns show the percentage of the forecast error variance attributed to shocks in each of the variables in the model (including lagged values of the dependent variable itself). Each row sums to 100% since all the forecast error in a variable must be explained by the variables in the model. If a variable is exogenous, other variables in the model are not useful in predicting it. A large proportion of that variable's error will be explained by its own innovations. How large is 'large'? According to Ramos (1996), in a six variable model such as mine, 50% is quite high. If another variable is useful in explaining a left column variable, that useful variable will explain some percentage of the prediction error. In practice, it is difficult to distinguish between a variable that has no predictive value and one that has little predictive value. Some conclusions, however, can be derived by comparing the magnitudes.

To illustrate the procedure for determining exogenous variables, Table 2 shows the variance decomposition for the VAR model with $M_1$ for the full sample period.
TABLE 2 - VARIANCE DECOMPOSITIONS OF THE VAR MODEL WITH M1 FOR THE FULL SAMPLE PERIOD

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lag</th>
<th>M1</th>
<th>r</th>
<th>e</th>
<th>p</th>
<th>v</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>1</td>
<td>99.97</td>
<td>0</td>
<td>0.02</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>50.52</td>
<td>30.01</td>
<td>4.96</td>
<td>5.23</td>
<td>4.96</td>
<td>4.29</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>43.90</td>
<td>28.99</td>
<td>6.59</td>
<td>8.89</td>
<td>5.58</td>
<td>6.03</td>
</tr>
<tr>
<td>r</td>
<td>1</td>
<td>0.24</td>
<td>99.74</td>
<td>0.01</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>10.99</td>
<td>61.11</td>
<td>6.57</td>
<td>3.42</td>
<td>11.80</td>
<td>6.09</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>11.37</td>
<td>57.25</td>
<td>8.06</td>
<td>3.53</td>
<td>13.09</td>
<td>6.67</td>
</tr>
<tr>
<td>e</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>6.42</td>
<td>9.72</td>
<td>65.73</td>
<td>6.80</td>
<td>7.37</td>
<td>3.94</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>6.99</td>
<td>9.48</td>
<td>57.16</td>
<td>8.68</td>
<td>11.23</td>
<td>6.43</td>
</tr>
<tr>
<td>p</td>
<td>1</td>
<td>1.70</td>
<td>4.69</td>
<td>0.04</td>
<td>93.55</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>27.30</td>
<td>11.83</td>
<td>8.41</td>
<td>39.93</td>
<td>10.50</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>24.68</td>
<td>8.68</td>
<td>5.70</td>
<td>33.06</td>
<td>23.96</td>
<td>3.89</td>
</tr>
<tr>
<td>v</td>
<td>1</td>
<td>40.78</td>
<td>3.93</td>
<td>0.05</td>
<td>5.42</td>
<td>49.79</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>22.70</td>
<td>22.17</td>
<td>6.27</td>
<td>8.08</td>
<td>33.31</td>
<td>7.44</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>22.53</td>
<td>22.26</td>
<td>7.78</td>
<td>8.12</td>
<td>31.40</td>
<td>7.87</td>
</tr>
<tr>
<td>y</td>
<td>1</td>
<td>0</td>
<td>4.77</td>
<td>0</td>
<td>0.09</td>
<td>90.96</td>
<td>4.15</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>11.06</td>
<td>16.17</td>
<td>4.14</td>
<td>1.81</td>
<td>62.65</td>
<td>4.14</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>11.85</td>
<td>15.92</td>
<td>5.62</td>
<td>2.33</td>
<td>58.69</td>
<td>5.56</td>
</tr>
</tbody>
</table>

At a forecast horizon of 16 months, only 43.90% of the forecast error variance in M1 is explained by its own innovations. This indicates that M1 is not exogenous, and other variables like r and p can be useful in forecasting M1. On the other hand, the exogenous behavior of e is reflected in the 57.16% error explained by its own innovations. The results show that energy prices and interest rates are exogenous variables in this VAR model. Table 3 shows the exogenous variables in the VAR models.
### TABLE 3 - VARIABLES SHOWING EXOGENOUS BEHAVIOR IN MY VAR MODELS

<table>
<thead>
<tr>
<th>VAR model and Period</th>
<th>Exogenous Variables</th>
<th>Error Variance explained by its own innovations</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAR with M1 1960-1979Q3</td>
<td>M1, r, e, v</td>
<td>65.26%, 52.29%, 50.84%, 54.20%</td>
</tr>
<tr>
<td>VAR with M1 1979Q4-1995</td>
<td>r, e, p</td>
<td>56.27%, 60.07%, 51.98%</td>
</tr>
<tr>
<td>VAR with M2 1960-1995</td>
<td>e</td>
<td>59.32%</td>
</tr>
<tr>
<td>VAR with M2 1960-1979Q3</td>
<td>e</td>
<td>52.17%</td>
</tr>
<tr>
<td>VAR with M2 1979Q4-1995</td>
<td>M2, e, p</td>
<td>57.77%, 51.14%, 52.60%</td>
</tr>
</tbody>
</table>
V. GRANGER CAUSALITY TESTS

The Granger technique relies on temporal predictability as an indication of causality between the variables. Granger states that a variable X is said to cause another variable Y, with respect to the given information set that includes X and Y, if current Y can be predicted better by using past values of X than by not doing so, given that all other past information in the information set is used. The use of temporal information enables one to say something about the direction of causation. It is also said to remove the spurious correlation as the tests include the lagged variables.

In general, the result of the hypothesis tests can result in four possible outcomes which are as follows:

1- Accept both null hypotheses, meaning that causality runs neither from X to Y nor from Y to X, though the variables appear to be correlated.

2- Accept the null hypothesis that X does not cause Y but reject the null hypothesis that Y does not cause X, meaning that unidirectional causality runs from Y to X.

3- Reject the hypothesis that X does not cause Y but accept the hypothesis Y does not cause X, meaning the causality runs unidirectionally from X to Y.

4- Reject both null hypotheses, meaning that there exists a feedback causal relation between X and Y.

In this chapter, "cause" will be used in the sense of the null hypothesis that X does not cause Y is rejected, and "does not cause" will be used in the sense of the null hypothesis that X does not cause Y is accepted.
The general form of the Granger (1980) causality test is as follows:

\begin{align}
\Delta Y_t &= \sum_{j=0}^{n} a_j \Delta X_{t-j} + \sum_{j=1}^{n} b_j \Delta Y_{t-j} + \epsilon_t \\
\Delta X_t &= \sum_{j=0}^{n} a'_j \Delta Y_{t-j} + \sum_{j=1}^{n} b'_j \Delta X_{t-j} + \epsilon'_t
\end{align}

If $a_0 = a'_0 = 0$, then these models are simple casual models. If $a_0$ and $a'_0$ are not zero, the variables are stationary with instantaneous causality. Granger (1980) has shown that if $\Delta X_t$ and $\Delta Y_t$ are stationary, $X_t$ is said to cause $Y_t$ in equation (14), or $Y_t$ is said to cause $X_t$ in equation (15), provided that some values of $b_j$ or $b'_j$ are not zero.

Sims (1980a) states that it should be feasible to estimate large-scale macro models as unrestricted reduced forms, treating all variables as endogenous. For example, assume that the maximum lag length is one period and the two variables are the money stock $m$ and income $y$. Then the reduced form would be estimated as

\begin{align}
m_t &= \pi_{11} m_{t-1} + \pi_{12} y_{t-1} + u_{mt} \\
y_t &= \pi_{21} m_{t-1} + \pi_{22} y_{t-1} + u_{yt}
\end{align}

where $E(u_{mt}^2) = \sigma_{mm}$, $E(u_{yt}^2) = \sigma_{yy}$, $E(u_{mt} u_{yt}) = \sigma_{my}$.

The series $y_t$ fails to Granger-cause $m_t$ according to the Granger test if, in a regression of $m_t$ on lagged $m$ and lagged $y$, the latter takes on a zero coefficient. In terms of the reduced form of the VAR model presented above, the regression of interest is just equation (16) and the term that must equal zero is the coefficient $\pi_{12}$. Similarly, $y_t$ fails to Granger-cause $m_t$ according to the Sims test if, in
a regression of $y$ on lagged $y$ and future $m$, the latter takes on a zero coefficient. It is known that the Granger and Sims tests are implications of the same null hypothesis. If $y$ fails to Granger-cause $m$, it is said that $m$ is exogenous with respect to $y$. If in addition $m$ does Granger-cause $y$, $m$ is said to be causally prior to $y$ (Sims, 1972). If we look from another view, we can connect the Granger-causality test with variance decomposition. Variance decompositions give the proportion of the $h$-periods-ahead forecast error variance of a variable that can be attributed to another variable. The pattern of the variance decomposition also indicates the nature of Granger causality among variables in the system. If a variable is exogenous in the Granger sense, i.e. if other variables in the model are not useful in predicting it, a large proportion of that variable's error variance should be explained by its own innovations.

To understand the Granger and Sims tests, suppose that the Federal Reserve determines the money stock $m$ that depends on past as well as present, but assume that The Federal Reserve pays no attention whatever to $y$ in setting the money stock. Now, if in this environment one regresses the money stock on its own past values and past $y$, the latter will take on a zero coefficient (the Granger test). Similarly, because the Federal Reserve pays no attention to $y$ in setting $m$, there is no causal link either way between $y$ and future values of $m$. Hence the prediction of $y$ implied by past $y$ will not be changed if future $m$ is included among the predictors (Sims test). In addition, whenever there is a very large measurement error in one variable, but not in the other, the other variable will tend to appear exogenous in an equation with the error-ridden variable on the left.
<table>
<thead>
<tr>
<th>TABLE 4 - GRANGER CAUSALITY TESTS, VAR MODEL with M1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F Statistics</strong> (H₀: X does not Granger cause Y)</td>
</tr>
<tr>
<td>1960Q1-1995:Q4 with M1, Lag=8</td>
</tr>
<tr>
<td>X→Y, m, p, y, r, v, e</td>
</tr>
<tr>
<td>m  - 2.07876* 0.64407 3.25524* 1.34738 0.2750</td>
</tr>
<tr>
<td>p  1.6125”  -  1.4932** 0.74129 0.90076 2.3864*</td>
</tr>
<tr>
<td>y  1.6326** 1.51262 - 1.47173 0.58694 1.564**</td>
</tr>
<tr>
<td>r  5.3289* 1.81462* 1.90355* - 4.3421* 1.3997</td>
</tr>
<tr>
<td>v  2.7485* 0.87363 1.93391* 0.74323 - 0.5696</td>
</tr>
<tr>
<td>e  1.637** 2.58797* 1.52480** 0.82556 1.39505 -</td>
</tr>
<tr>
<td>1960Q1-1979Q3 with M1, Lag=4</td>
</tr>
<tr>
<td>X→Y, m, p, y, r, v, e</td>
</tr>
<tr>
<td>m  - 1.6482** 1.58717 3.11217 1.54971 4.7246*</td>
</tr>
<tr>
<td>p  1.08345 - 2.68717* 1.00460 0.44479 2.41*</td>
</tr>
<tr>
<td>y  2.8796* 1.14149 - 4.74852* 1.48991 2.8329*</td>
</tr>
<tr>
<td>r  1.7602** 4.38840* 2.45756* - 1.5611 1.9278</td>
</tr>
<tr>
<td>v  4.4805* 1.12435 3.84831* 0.4905 - 1.830**</td>
</tr>
<tr>
<td>e  2.2909* 4.51326* 3.75331* 1.41364 2.3848* -</td>
</tr>
<tr>
<td>1979Q4-1995Q4 with M1, Lag=4</td>
</tr>
<tr>
<td>X→Y, m, p, y, r, v, e</td>
</tr>
<tr>
<td>m  - 0.41229 1.49852 1.7859** 1.41788 1.1825</td>
</tr>
<tr>
<td>p  3.4535*  - 1.97538** 3.53851* 1.61021 3.9823*</td>
</tr>
<tr>
<td>y  2.79034 1.57326 - 0.21382 2.3962* 2.5606*</td>
</tr>
<tr>
<td>r  15.516* 1.61427 2.42853* - 10.349* 1.788**</td>
</tr>
<tr>
<td>v  2.6519* 1.32171 1.79175** 1.7841** - 1.0263</td>
</tr>
<tr>
<td>e  1.48398 1.07637 1.88732** 0.18358 0.96292 -</td>
</tr>
</tbody>
</table>

Note: Table 4 shows F values. ** and * denote that a test statistic is significant at the 5 percent, 1 percent levels of significance, respectively.
Monetary aggregates came to play an increasingly important role during the 1970s, primarily because Congress expressed the legal mandate for the Fed more specifically in terms of monetary growth. In 1975, Congress passed a resolution requiring the Fed to report its objectives for monetary growth. This requirement was embodied in law with the 1978 Humphrey-Hawkins Act, which also mandated semiannual reports to Congress that have become the focus of Congressional oversight of the Federal Reserve. Increased emphasis on controlling monetary growth no doubt also reflected a desire to halt the runaway inflation that characterized the 1970s.

The causality relationship among variables in the period 1960Q1 through 1979Q3 suggests that (at the 5 percent level of significance) M1 growth causes inflation, but inflation does not cause money growth. This indicates that there is unidirectional causality running from M1 to inflation; in other words, M1 growth has a strong effect on inflation. In the period 1979Q4 through 1995Q4, M1 growth does not cause inflation, but inflation causes M1 growth. It means that M1 growth is not causing inflation in this time period.

Figure 1 shows that the relationship between M1 and inflation was fairly close in the 1970s. Inflation and M1 growth rose and fell together in the first half of the decade and a reacceleration in M1 growth in the last half of the 1970s was again accompanied by an upward movement in inflation. During the 1980s, however, the relationship between M1 and inflation began to break down.
As suggested by figure 1, the growth rate of M1 was erratic in this decade but M1 grew more rapidly in the 1980s than it did in the last half of the 1970s. Unlike the late 1970s, though, the rapid M1 growth of the 1980s was not accompanied by high inflation. Inflation declined in the 1980s and has remained at a relatively low level since that time. It is evident that the strong linkage between M1 and inflation of the 1970s has faded in the 1980s.

On the other hand (at the 1 percent level of significance), M1 growth does not cause real GDP growth, but real GDP growth causes M1 growth. In this case, there is also a unidirectional causality relationship running from real GDP growth to M1 growth. The outcome for real GDP growth is the same for the period after 1979Q4.
Figure 2 shows a fairly close relationship between M1 and real GDP except for the period of 1973 through 1975. M1 has grown faster relative to real GDP in the 1980s than in the 1970s. Even though M1 has grown faster in the 1980s, real GDP growth seems to be stable over this period. This supports the Granger-causality test results indicating that the linkage between M1 and real GDP has faded in the 1980s.

The source of these breakdowns lies in a dramatic shift in the behavior of M1 velocity, which is an important factor affecting relationships among M1, the economy and inflation.

The Granger-causality test suggests that there is a unidirectional relationship between M1 and M1 velocity running from M1 velocity to M1 at the 1 percent level.
of significance in the 1970s and in the 1980s. F-statistic of Granger causality test in the 1970s is 4.4805 and in the 1980s is 2.6519. This indicates that the relationship between the M1 velocity and M1 was more powerful in the 1970s than in the 1980s. Figure 3 illustrates that the growth rate of velocity of M1 seems to be stable in the 1970s, but it has been erratic and declined in the 1980s. This decline in M1 velocity is the reason that the rapid M1 growth of the 1980s has not been accompanied by rapid inflation and that M1 growth has been unusually rapid relative to the growth of the economy.

The interesting side of M1's behavior in the 1980s is the sensitivity of M1 to interest rates. The Granger-causality test results suggest that M1 growth (interest rates) causes interest rates (M1 growth), meaning that there exists a feedback causal relation between M1 growth and interest rates. The F statistic of interest
rates-cause-M1 is 1.7602 at the 5 percent significance level in the 1970s and is 15.516 at the 1 percent significance level in the 1980s. In the 1980s, M1 has likely become more sensitive to interest rates. The reason is the deregulation of deposit ceiling rates in the early 1980s. Two developments have accounted for most of the transformation of M1 to date. One was the authorization of nationwide NOW accounts in 1981, and the other was the introduction of ceiling-free Super NOW accounts in 1983. Both new accounts have grown rapidly. As a result, the proportion of M1 in interest-earning checking accounts has climbed. The increasing importance of NOW's and Super NOW's may have affected the interest sensitivity for M1 (Higgins, 1992). The interest sensitivity of demand for a monetary aggregate is an average of the interest sensitivities of demand for various assets in that aggregate. The interest sensitivities of these assets depend on how their own rates respond to changes in market interest rates. If an asset's own rate does not move closely with market interest rates, a change in market rates will affect the opportunity cost of holding the asset, which can be measured by the difference between market rates and the asset's own rate. This change in opportunity cost affects demand for the asset. The size of the effect depends on how much the opportunity cost of holding the asset changes when market interest rates change, as well as how responsive demand for the asset is to changes in its opportunity cost. Thus, if the opportunity cost of NOW's and Super NOW's respond proportionally more or less to changes in market interest rates than does the opportunity cost of currency and demand deposits, and the sensitivities of these to changes in opportunity cost are comparable. The rapid growth of NOW's and Super NOW's has likely changed the
interest sensitivity of demand for M1. Demand for NOW accounts should be more sensitive to market interest rates than is demand for currency and demand deposits. Whereas currency and demand deposits do not earn explicit interest, most NOW accounts earn the ceiling rate. Therefore, a change in market rates has a greater proportional impact on the opportunity cost of holding NOW’s than on the opportunity most of holding demand deposits and currency. Because the opportunity costs of NOW’s and Super NOW’s are relatively sensitive to changes in market interest rates, the importance of these accounts may have increased the sensitivity of M1 to changes in market rates.

<table>
<thead>
<tr>
<th>TABLE 5 - GRANGER CAUSALITY TESTS, VAR MODEL with M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>F Statistics( $H_0$: X does not Granger cause Y)</td>
</tr>
</tbody>
</table>

1960Q1-1995:Q4 with M2, Lag=9

<table>
<thead>
<tr>
<th>X➔ Y</th>
<th>m</th>
<th>p</th>
<th>y</th>
<th>r</th>
<th>v</th>
<th>e</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>-</td>
<td>1.01746</td>
<td>2.66121*</td>
<td>1.21978</td>
<td>1.6824**</td>
<td>0.8437</td>
</tr>
<tr>
<td>p</td>
<td>1.01253</td>
<td>-</td>
<td>1.60005**</td>
<td>0.9079</td>
<td>0.82047</td>
<td>2.1226*</td>
</tr>
<tr>
<td>y</td>
<td>1.17009</td>
<td>1.6858**</td>
<td>-</td>
<td>1.5199**</td>
<td>1.19450</td>
<td>1.564**</td>
</tr>
<tr>
<td>r</td>
<td>1.4482</td>
<td>1.83869*</td>
<td>1.84611*</td>
<td>-</td>
<td>1.00512</td>
<td>1.583**</td>
</tr>
<tr>
<td>v</td>
<td>1.1032</td>
<td>0.72419</td>
<td>3.03486*</td>
<td>1.27932</td>
<td>-</td>
<td>1.4596</td>
</tr>
<tr>
<td>e</td>
<td>1.5426**</td>
<td>2.27506*</td>
<td>1.56546**</td>
<td>0.92242</td>
<td>1.5031**</td>
<td>-</td>
</tr>
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Continued
1960Q1-1979Q3 with M2, Lag=4

<table>
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<tr>
<th>$X \rightarrow Y$</th>
<th>m</th>
<th>p</th>
<th>y</th>
<th>r</th>
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</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>-</td>
<td>1.57824</td>
<td>2.11924*</td>
<td>2.43235*</td>
<td>2.5236*</td>
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<tr>
<td>p</td>
<td>1.4123</td>
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<td>2.68717*</td>
<td>1.00460</td>
<td>0.251</td>
<td>2.41*</td>
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<tr>
<td>y</td>
<td>1.31209</td>
<td>1.14149</td>
<td>-</td>
<td>4.74852*</td>
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<tr>
<td>r</td>
<td>2.16798*</td>
<td>4.38840*</td>
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<tr>
<td>v</td>
<td>0.3612</td>
<td>0.87363</td>
<td>6.18067*</td>
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<td>-</td>
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<td>e</td>
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<td>1.38997</td>
<td>3.75331*</td>
<td>1.41364</td>
<td>3.2426*</td>
<td>-</td>
</tr>
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1979Q4-1995Q4 with M2, Lag=4

<table>
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<tbody>
<tr>
<td>m</td>
<td>-</td>
<td>0.96833</td>
<td>0.77851</td>
<td>0.50226</td>
<td>0.87334</td>
<td>3.2875*</td>
</tr>
<tr>
<td>p</td>
<td>1.5730</td>
<td>-</td>
<td>1.97538**</td>
<td>3.53851*</td>
<td>2.2574*</td>
<td>3.982*</td>
</tr>
<tr>
<td>y</td>
<td>0.84593</td>
<td>1.57326</td>
<td>-</td>
<td>0.21382</td>
<td>0.50143</td>
<td>2.5606*</td>
</tr>
<tr>
<td>r</td>
<td>1.63045</td>
<td>1.61427</td>
<td>2.42853*</td>
<td>-</td>
<td>1.9478**</td>
<td>1.788**</td>
</tr>
<tr>
<td>v</td>
<td>0.91205</td>
<td>2.23626*</td>
<td>1.36930</td>
<td>0.68928</td>
<td>-</td>
<td>3.3454*</td>
</tr>
<tr>
<td>e</td>
<td>1.43181</td>
<td>1.07637</td>
<td>1.88732**</td>
<td>0.18358</td>
<td>0.86294</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: Table 5 shows F values. * and ** denote that a test statistic is significant at the 5 percent, 1 percent levels of significance, respectively.

The Granger-causality test suggests for the period of 1960Q1 through 1979Q3 that at the 1 and 5 percent levels of significance, M2 growth does not cause inflation and also inflation does not cause M2 growth. This means that the causality runs neither from M2 growth to inflation nor inflation to M2 growth. In other words, M2 does not have predictive power over inflation with the F-test 1.57824. I obtained the same result for the period 1979Q4 through 1995Q4 with the F-test 0.96833. F-
test results suggest that in the 1970s inflation was more sensitivity to M2 than that in the 1980s.

Figure 4 illustrates that the relationship between M2 and inflation was close in the early 1970s, but after 1977 and so on, M2 has grown faster relative to inflation, and this relationship began to breakdown. In the 1980s, the relationship between the growth rate of M2 and inflation was low. That means low sensitivity of inflation to M2. Consequently, this supports the Granger-causality results.

Granger-causality tests indicate that M2 growth causes real GDP growth, but real GDP growth does not cause M2 growth. This means that there is unidirectional causality running from M2 growth to real GDP growth. In other words, M2 growth has a strong effect on real GDP growth. This result is not accepted for the period after 1979Q4. Figure 5 illustrates that there was a close relationship between M2...
growth and real GDP growth in the 1970s, but this relationship seems to be broken in the period of 1980 through 1984. Behind this breakdown relationship was the behavior of M2 velocity. M2 velocity is an important factor affecting the relationship between M2 and the economy.

The Granger-causality test suggests that M2 growth causes M2 velocity growth at the 1 percent significance level in the 1970s. That is, M2 velocity is predictable by M2 growth in this period. In the 1980s, M2 growth does not cause M2 velocity growth. That means that the behavior of velocity of M2 cannot be predicted easily in this time period.

M2 velocity performed well for the 1970s as a whole, but there were some divergences in M2 velocity during this period. However, The major reason for the divergences of M2 velocity in the 1970s is that many of the financial innovations
FIGURE 6. GROWTH RATES of M2 and M2 VELOCITY

responsible for reduced demand for M1 balances had little or no effect on the
demand for M2 balances. M2 includes many of the close substitutes for transactions
balances developed as well as transactions balances themselves. As a result,
changes in the public's portfolio of assets have primarily affected the composition
rather than the level of M2 balances. For example, introduction of MMMF's and
increased use of corporate RP's, both of which have contributed to the rapid growth
of M1 velocity, have had a negligible impact on M2 velocity because MMMF's and
corporate RP's are included in M2.

In the 1970s, deposits subject to interest rate ceiling accounted for a very
large portion of M2 assets. Therefore, an increase in market interest rates would
sharply depress M2 growth. However, a large and increasing fraction of M2 assets
yields a market of return. In 1981, assets with a market yield-including MMMF's,
RP's, overnight Eurodollar deposits, and money market certificates-accounted for
34.5 percent of the funds in M2, compared with less than 1 percent in 1970 (Motley, 1988). Therefore, high market interest rates would be expected to have a relatively small impact on the overall demand for M2, although probably substantially affecting the composition of M2. It is not surprising that M2 velocity has increased less rapidly than expected in response to the high market interest rates prevailing in the 1980's. That result can be derived from Granger-causality test. Regulatory changes have continued to affect the behavior of M2 velocity in unpredictable ways. The Monetary Control Act (MCA) mandated the phaseout of interest rate ceiling on all time and savings deposits. As this phaseout proceeds, an increasing number of the components of M2 would have a market-determined yield, and the resulting change in the characteristics of M2 assets would cause continued uncertainty regarding the velocity of M2.

The Granger-causality test suggests that M2 growth (interest rates) causes changes in interest rates (M2 growth) at the 1 percent significance level in the 1970s. After 1979Q4, the null hypotheses are easily accepted. These results suggest that in the 1980s, M2 lost the sensitivity to interest rate changes.

Since M1 assets are also included in M2, introduction of NOW's and Super NOW's has affected M2. More important, though, have been the changes in the nontransactions portion of M2. The nontransactions portion of M2 includes one of the most significant financial innovations in recent years, money market mutual funds (MMMF's). Although introduced in 1974, MMMF’s did not grow rapidly until much later. MMMF’s offered investors market-related rates, high liquidity, and lower minimum balance requirements. Perhaps more than anything else, the inability of
banks and thrifts to compete with MMMF’s spurred the deposit rate deregulation of the early 1980s (Roth, 1985). The Depository Institutions Deregulation and Monetary Control Act of 1980 (DIDMCA) and the Garn-St Germain bill of 1982 provided the means for banks and thrifts to compete with MMMF’s. The DIDMCA called for the complete deregulation of rates paid by banks and thrifts within six years. The Garn-St Germain bill accelerated this deregulation by authorizing banks and thrifts to begin offering money market deposit accounts (MMDA’s) in December 1982. MMDA’s were enthusiastically received because they are liquid, pay a ceiling-free rate, and offer transactions capabilities. Within four months, funds in MMDA’s surpassed those in MMMF’s. Meanwhile, under DIDMCA, ceiling rates on small time deposits were being removed (Rosenblum and Cox, 1989).

Because of deregulation, the proportion of the nontransactions part of M2 paying a market rate is much higher than it was only in the early 1980s. Despite the phase out of ceiling rates and the introduction of unregulated accounts, not all the assets in the nontransactions portion of M2 pay a rate that mirrors market rates. Whereas the yields on money market certificates (MMC’s) and other deregulated time deposits closely track market interest rates, the yields on nontransactions accounts without a specific maturity vary less than market rates. Nevertheless, yields on most nontransactions accounts are closer to market rates than are yields on transactions accounts.

Deposit rate deregulation has likely reduced the interest sensitivity of demand for the nontransactions component of M2. Since as much can be earned on accounts that pay a market rate as on market instruments themselves, there is no
opportunity cost of holding these accounts. Therefore, changes in market interest rates should not affect demand for the ceiling-free accounts in the nontransactions portion of M2. Only a few deposits still subject to regulatory ceiling interest rates are sensitive to changes in market interest rates. As a result, M2 will likely become even less sensitive to market interest rates, another lasting effect of deposit rate deregulation. While demand for the M1 portion of M2 has likely become more interest sensitive, demand for the nontransactions portion has likely become less interest sensitive. Since the nontransactions component is much larger than the M1 component, the probable overall effect is a reduction in the interest sensitivity of M2.

The interesting result for all models in both time periods is that interest rates have strong predictive power over real GDP. Interest rates cause real GDP growth at the 1 percent level of significance.

At the 1 percent level of significance, only M1 causes inflation. M2 does not cause inflation. On the other hand, M2 causes real GDP growth. M1 does not cause real GDP growth for the full time period.

The Granger causality results indicate that monetary policy was quite useful in preventing inflation in the 1970s. However, I cannot say this was the result for the 1980s according to the Granger causality tests.
VI. VARIANCE DECOMPOSITION

Variance decomposition refers to the percentage of the k-period-ahead squared prediction error of a variable produced by an innovation in another variable and is derived from the moving average representation of the model. It is useful in measuring the exogeneity of a variable and also in measuring the contribution of other variables in determining an endogenous variable.

Consider the autoregressive representation

\[ x_t = b(L)x_{t-1} + e_t \]

(18)

where \( x_t \) is a stationary stochastic vector process, L is the lag operator, and \( e_t \) is the vector of innovations to \( x \) at time \( t \). Although VAR estimation is based on this autoregressive representation, most interpretations of VAR are based on the vector moving average representation

\[ x_t = n_t + a(L)e_t \]

\[ E(e_t) = 0 \]

\[ E(e_t e_{t-k}) = W, \quad |k| = 0 \]

\[ 0, \quad |k| \neq 0 \]

(19)

where \( n_t \) is perfectly predictable and the matrix of coefficients of \( a(L) \) at lag zero is the identity matrix. The Wold decomposition theorem shows that the vector or errors \( e_t \) is the forecast error of the autoregression given information available at \( t-1 \) if the roots of \( a(z) \) lie outside the unit circle.
To get from the moving average representation to impulse response functions and variance decompositions requires a normalization. The cumulative response of an element of $x_t$ to an unpredicted innovation in some component of $e_t$ must be orthogonal. Since the sample covariance matrix $W$ is unlikely to be nearly diagonal, the covariance of the residuals must be arbitrarily divided in some way so that the errors themselves are orthogonal. The usual convention is to adopt some particular ordering and allocate any correlation between the residuals of any two elements to the variable that comes first in the ordering.

The variance decomposition is simply a function of the moving average representation. The variance decomposition of the $k$-step-ahead forecast is the proportion of the total forecast variance of one component of $x_{t+k}$ due to shocks to the moving average representation of another variable (Runkle, 1987).

<table>
<thead>
<tr>
<th>Model with M1</th>
<th>Period</th>
<th>e</th>
<th>M1, M2</th>
<th>r</th>
<th>p</th>
<th>v</th>
<th>y</th>
</tr>
</thead>
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<td>1960 -1979Q3</td>
<td>16</td>
<td>15.38</td>
<td>43.09</td>
<td>4.76</td>
<td>23.52</td>
<td>8.62</td>
<td>4.60</td>
</tr>
<tr>
<td>Model with M1</td>
<td>16</td>
<td>20.02</td>
<td>18.46</td>
<td>4.93</td>
<td>51.98</td>
<td>3.43</td>
<td>1.15</td>
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<tr>
<td>1979Q4 -1995</td>
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<td>9.94</td>
<td>1.82</td>
<td>27.22</td>
<td>41.58</td>
<td>11.06</td>
<td>8.34</td>
</tr>
<tr>
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<td>3.79</td>
<td>13.83</td>
<td>52.60</td>
<td>1.06</td>
<td>3.54</td>
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<tr>
<td>1960 -1979Q3</td>
<td>16</td>
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<td>43.09</td>
<td>4.76</td>
<td>23.52</td>
<td>8.62</td>
<td>4.60</td>
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<tr>
<td>Model with M2</td>
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<td>18.46</td>
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<td>27.22</td>
<td>41.58</td>
<td>11.06</td>
<td>8.34</td>
</tr>
</tbody>
</table>

Sims (1980a) says that if a parameterization derived from economic theory fails to be identified, we can always transform the parameter space so that all points in the original parameter space which imply equivalent behavior are mapped into the same point in the new parameter space. This is called normalization.
The variance decomposition results for the VAR model with M1 in two periods reported in Table 6 reflect the percentage of the h-step ahead prediction errors in GDP price deflator (p) attributed to innovations in each of the endogenous variables. The results for GDP price deflator suggest that 23.528 percent of inflation can be explained by its own innovations in the 1970s, but in the 1980s, 51.926 percent of inflation is explained by its own innovations. This may illustrate that Inflation is dependent mostly on the expectation of inflation in the 1980s. The results for GDP price deflator indicate that 43.097 percent of the sixteen-step-ahead prediction errors in GDP price deflator can be attributed to M1 innovations in the 1970s while 18.460 percent is explained by innovations in M1 in the 1980s. This suggests that M1 had more predictive power over inflation in the 1970s. In addition, 8.629 percent of inflation was explained by innovations in M1 velocity in the 1970s while 3.435 percent of that was explained by innovations in M1 velocity in the 1980s. These results illustrate the breakdown between M1 and inflation in the 1980s. Inflation seemed to be more sensitive to interest rates, which better explains the variance in inflation in the 1980s. Why did M1 lose the predictive power in the 1980s? For the rapid M1 growth that began in fall 1984 to be compatible with continued moderate inflation required a number of conditions. First, the decline in interest rates that has accompanied this rapid M1 growth must have derived from market forces rather than from the actions of the activist monetary policy. A second requirement for the high M1 growth to be compatible with continued moderate inflation is that this decline in the equilibrium market rate must have increased M1 demand significantly. The M1 increase then would only be accommodating an increased demand. Therefore, this
second requirement would be met only if financial deregulation has increased the interest sensitivity of M1. In sum, one can argue that a fall in interest rates has interacted with the public's heightened interest sensitivity to its M1 balances caused by financial deregulation to produce a significant increase in M1 demand. This increased demand implies that recent high M1 growth rates will not be inflationary.

Why has the interest sensitivity of M1 increased? An argument that the strength in M1 demand decline in the differential between the rates banks pay on their nonmonetary liabilities - specifically time deposits- and the rates they pay on their interest-bearing checkable deposits - chiefly negotiable order of withdrawal (NOW) accounts. Since 1981, the weighted average interest rate on NOW's calculated for banks nationwide has essentially remained unchanged at somewhat more than 5 percent, while the rate banks offer on certificates of deposits (CDS) has declined dramatically. In August 1981, rates on three-month CDs were at 18 percent, and in June 1986 they were 6.7 percent. Correspondingly, the differential between the rate on bank CDs and the rate on NOWs has declined from more than 12 percent to about 1 percent (Keeton, 1986). It is plausible that funds previously kept in the nonmonetary liabilities of banks, such as CDs, have been transferred to NOW accounts. Such shifting of funds increases M1 but does not provide the public with an incentive to increase its expenditures. Therefore, M1 velocity growth should fall. High M1 growth has been due to the public's substituting bank monetary liabilities to replace bank nonmonetary liabilities. Since the beginning of sustained interest rate decline, the public has practically stopped increasing its holdings of small and large time deposits and passbook savings accounts. At the same time,
the public has significantly increased its holdings of interest-bearing checkable deposits, chiefly NOWs and super NOWs.

The variance decomposition results for the VAR model with M2 in two periods reported in Table 7 reflect the percentage of the h-step ahead prediction errors in GDP price deflator (p) attributed to innovations in each of the endogenous variables. The results for GDP price deflator suggest that 41.589 percent of inflation can be explained by its own innovations in the 1970s, but in the 1980s, 52.603 percent of inflation was explained by its own innovations. The results for GDP price deflator indicate that 1.828 percent of the sixteen-step-ahead prediction error in GDP price deflator can be attributed to M2 innovations in the 1970s while 3.794 percent was explained by innovations in M2 in the 1980s. This suggests that M1 had more predictive power over inflation in the 1980s. In addition, 11.067 percent of inflation was explained by innovations in M2 velocity in the 1970s while 1.063 percent of that was explained by innovations in M2 velocity in the 1980s. Inflation seems to be more sensitive to interest rates, which better explains the variance in inflation in the 1970s about 27.221 percent, but in 1980s, inflation seemed to be less sensitive toward interest rates. These results suggest that the variance of inflation can be explained by the innovations in interest rates more than the innovations in M2. Energy price shocks affected inflation in the 1970s and 1980s. The variance decomposition of GDP price deflator illustrates that in the 1970s, energy price shocks had short run effects on inflation, but these shocks had long run effects on inflation in the 1980s.
The variance decomposition results for the VAR model with M1 and M2 in two periods reported in Table 7 reflect the percentage of the h-step ahead prediction errors in real GDP (y) attributed to innovations in each of the endogenous variables. In this case, the estimated contribution of M1 shocks to forecast error variance for real GDP dropped from 16.24 percent based on pre-1980 data to 11.98 percent base on post-1980 data and also for M2, and the results seems to be stable in both data sets. These suggest that M1 has more power to explain the variance in real GDP than M2 has. Moreover, the innovations in interest rates have more predictive power to explain the variance in real GDP in the 1980s because of financial deregulation.

The results for real GDP in the VAR model with M1 suggest that 6.91 percent of real GDP can be explained by its own innovations in the 1970s, but in the 1980s, 10.03 percent of real GDP is explained by its own innovations, and also with the VAR model with M2 these results were 8.81 and 8.39 in the 1970s and 1980s,
respectively. In addition, 50.84 percent of real GDP was explained by innovations in M1 velocity in the 1970s while 46.60 percent of that was explained by innovations in M1 velocity in the 1980s. These results for M2 were 49.04 percent and 50.54 percent in the 1970s and 1980s, respectively. The variance in real GDP seems to be more sensitive to velocities of monetary aggregates.

<table>
<thead>
<tr>
<th>Model</th>
<th>Period</th>
<th>e</th>
<th>M1, M2</th>
<th>r</th>
<th>p</th>
<th>v</th>
<th>y</th>
</tr>
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<td>8.68</td>
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<td>3.89</td>
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<tr>
<td>Model with M2</td>
<td>16</td>
<td>14.47</td>
<td>16.66</td>
<td>5.40</td>
<td>43.40</td>
<td>5.45</td>
<td>14.58</td>
</tr>
</tbody>
</table>

The various intermediate measures may have the potential to serve as intermediate targets of monetary policy. "Targets" are objectives the Federal Reserve seeks to achieve over some time period with some degree of precision and under some particular set of circumstances. Clearly the main requirement for a good intermediate indicator of the state of the economy is that it be reliable (predictable) related to ultimate goals.
In 1987, The Federal Reserve changed the intermediate indicator from M1 to M2 to reach the ultimate goals such as inflation and real GDP. The problem is here whether or not M2 has enough predictive and effective power over inflation and real GDP. The results from table 8 show that 24.68 percent (16.66 percent) of the sixteen-step-ahead prediction error in GDP Price Deflator can be explained by the innovations in M1 (M2), respectively. Moreover, the results from table 9 suggest that estimated contributions of M1 and M2 shocks to forecast error variance for real GDP are 11.86 and 17.91, respectively.

These results suggest that M1 can be used to prevent inflation and M2 can be used to influence real GDP. Interest rates M1 and M1 velocity have strong predictive power over inflation. As we know, the FED can easily control these variables except M1 velocity and change them in the short run. The total predictive power over inflation of these variables is 57.32 percent. This suggests that M1 can be used for preventing inflation.

M2 seems to be reliable intermediate indicator for real GDP. Consequently, it seems that the FED should have two intermediate targets and indicators to use to reach ultimate goals instead of one.
VII. IMPULSE RESPONSE ANALYSIS

Impulse response shows how one variable responds over time to a single surprise increase in itself or in another variable. This can suggest evolutionary influences for each variable.

Given a set of K time series variables $y_t = [y_{1t}, ..., y_{Kt}]'$. VAR models of the form are as follows.

$$y_t = \sum_{i=1}^{n} A_i y_{t-i} + u_t$$

This model is called a VAR process of order of n. Here $u_t = [u_{1t}, ..., u_{Kt}]'$ is a zero mean independent white noise process with nonsingular, time invariant covariance matrix $\Sigma_u$ and $A_i$ are $(K \times K)$ coefficient matrices. The VAR model can be inverted and written in moving average form.

$$y_t = \sum_{i=0}^{\infty} \theta_i u_{t-i}$$

or we can write the moving average form as follows.

$$y_t = \theta_0 u_t + \theta_1 u_{t-1} + \theta_2 u_{t-2} + ...$$

From the moving average representation equation (19) of a VAR model, each variable can be written as a function of the innovations, so that the response of the $i$th element of $y_{t+k}$ to the innovation in the $j$th variable at date $t$ is just the $i, j$ element of the matrix $\theta$. A tabulation of these responses for $k=0,1,2,3,...$ is called
an impulse response function. Because the covariances among the innovations are zero by definition, the variance of each variable will be the weighted sum of the variances of each variable, with the weights being determined by the elements of \( \theta_k \). Innovation accounting is the exercise of determining which innovations contribute to the forecast errors of each variable.

Figure 7 shows the dynamic response of the percentage change in the GDP price deflator to forecast errors in M1 and M2 in the 1970s. Inflation increases for at least two quarters following shocks to M1. A surprise shock increases inflation in the short run about two quarters. In the eighth quarter the shock is at the maximum level, and the effect dies out slowly in the sixteen quarters. In the 1970s, Figure 7 illustrates that M1 had an important effect on inflation. M1, therefore, can be used as a policy target to prevent inflation compared with M2.
In response to an M2 shock, inflation significantly stays below its preshock level for about four quarters. The effects of the M2 shock on inflation become insignificant at the fourth and eighth quarters. The maximum impact of a one-standard deviation shock in inflation occurs at the fourth quarter. The surprise M2 shocks on inflation show erratic behavior in this time period because M2 has positive effects on inflation and also negative effects on inflation.

FIGURE 8. EFFECT OF ONE S.D. M1 AND M2 INNOVATIONS IN GDP PRICE DEFLATOR IN THE 1980s

Figure 8 illustrates that the dynamic response of prices to a positive one-step-ahead forecast error in M1 was positive in the 1980s but weaker than the response in the 1970s. The effect also died out slowly in the 1980s. The magnitude
of the M1 shock was less about 0.0006 in the 1980s, but it was about 0.0020 stronger in the 1970s. These results suggest that M1 has lost the predictive and effective power over inflation in the 1980s because of financial deregulation.

Figure 8 also illustrates that an unexpected increase in M2 produces a longer decrease over 11 quarters. Moreover, M2 has a negative permanent impact on inflation in the 1980s. Even though the response of GDP price deflator to a positive shock on M2 in the 1970s was mostly positive, it was negative and had no positive effect on inflation in the 1980s. However, M1 had permanent positive effect in the 1970s and 1980s.

The response of the GDP price deflator to an unexpected shock in M1 is completely positive using the full sample. In the short run, M1 has a strong positive effect on inflation while M2 has a strong negative effect on inflation. M1 is losing the positive effect on inflation over ten quarters while M2 is also losing the negative effect on inflation at about ten quarters. After ten quarters, M2 has a positive effect on it and its positive effect seems to be continuous, but M1's positive effect seems to decline. Figure 9 shows that M2 has the power to increase inflation in the long run; however, M1 has only a short run effect on inflation. The FED can intervene in money growth and interest rates in the short run, and these interventions can provide a stable inflation. That is, inflation can be moderated by controlling M1 in the short run. This suggests that M1 can be used as a policy target and indicator for moderating inflation because M1 does not have a long run effect on inflation.
The other problem is how real GDP responses to shocks in M1 and M2 are. I will review these relationships only using the full sample.

An unexpected positive shock in M1 has a short run positive effect on real GDP at about three quarters, but the magnitude of it is small, about 0.0005. That is, M1 has weak power to influence real GDP. After three quarters, the response of real GDP becomes negative. In the short run, M1 has a generally negative effect on real GDP, while M2 has a strong positive effect on real GDP. The maximum response of real GDP to M2 occurs in the fourth quarter. It then declines till the twelfth quarter. After twelve quarters, M2 seems to be insufficient.
Figure 10 shows that M2 has a power to increase real GDP in the short run; however, M1 seems to have no effect on real GDP. This suggests that M2 can be used as a policy target and indicator for growing real GDP.
VIII. CONCLUSION

The monetary aggregate $M_1$ grew at an extremely rapid rate by historical standards in the 1980s. Much of this rapid growth has been due to a shift from time deposits into $M_1$, caused by a fall in money market interest rates relative to rates that banks pay on interest-bearing checkable deposits. In addition, the fall in market rates apparently has prompted banks to require their corporate customers to keep greater compensating balances, thus adding to the shift into $M_1$. One can plausibly argue that the fall in interest rates which induced these behavior changes by asset holders and banks has reflected an autonomous fall in the economy’s equilibrium interest rate, rather than the actions of an activist monetary policy. A fall in interest rates has interacted with the public’s heightened interest sensitivity to its $M_1$ balances caused by financial deregulation to produce a significant increase in $M_1$ demand. This increased demand implies that high $M_1$ growth will not be inflationary.

Because of financial deregulation, the proportion of the nontransactions part of $M_2$ paying a market rate is much higher than it was only the early 1980s. Despite the phase out of ceiling rates and the introduction of unregulated accounts, not all the assets in the nontransactions portion of $M_2$ pay a rate that mirrors market rates. Whereas the yields on money market certificates and other deregulated time deposits closely track market interest rates, the yields on nontransactions accounts without a specific maturity vary less than market rates. Nevertheless, yields on most nontransactions accounts are closer to market rates than are yields on transactions accounts.
Deposit rate deregulation has likely reduced the interest sensitivity of demand for the nontransactions component of M2. Since as much can be earned on accounts that pay a market rate as on market instruments themselves, there is no opportunity cost of holding these accounts. Therefore, changes in market interest rates should not affect demand for the ceiling-free accounts in the nontransactions portion of M2. Only a few deposits still subject to regulatory ceiling interest rates are sensitive to changes in market interest rates. As a result, M2 will likely become ever less sensitive to market interest rates, another lasting effect of deposit rate deregulation. While demand for the M1 portion of M2 has likely become more interest sensitive, demand for the nontransactions portion has likely become less interest sensitive. Since the nontransactions component is much larger than the M1 component, the probable overall effect is a reduction in the interest sensitivity of M2.

The variance decomposition and impulse response functions suggest that M1 can be used to prevent inflation and M2 can be used to affect real GDP. Interest rates, M1, and M1 velocity have more predictive power over inflation. As we know, the FED can easily control these variables and change them in the short run. The total predictive power over inflation of these variables is 57.32 percent. This suggests that M1 can be used for preventing inflation.

M2 seems to be a reliable intermediate target and indicator for real GDP. Consequently, I suggest that the FED has two intermediate targets and indicators instead of one to use to reach ultimate goals of low inflation and stable growth.
REFERENCES

----- "Recent M1 Growth and Its Implications." Federal Reserve Bank of Kansas City Economic Review, Dec 1985, pp. 18-23.


SUPPLEMENTAL SOURCES CONSULTED


Darby, R. Michael; Poole, William; Lindsley, E. David; Friedman, Milton and Bazdarich, J. Michael. "Recent Behavior of the Velocity of Money." Contemporary policy Issues, Jan 1987, 5 (0), pp.1-33.


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