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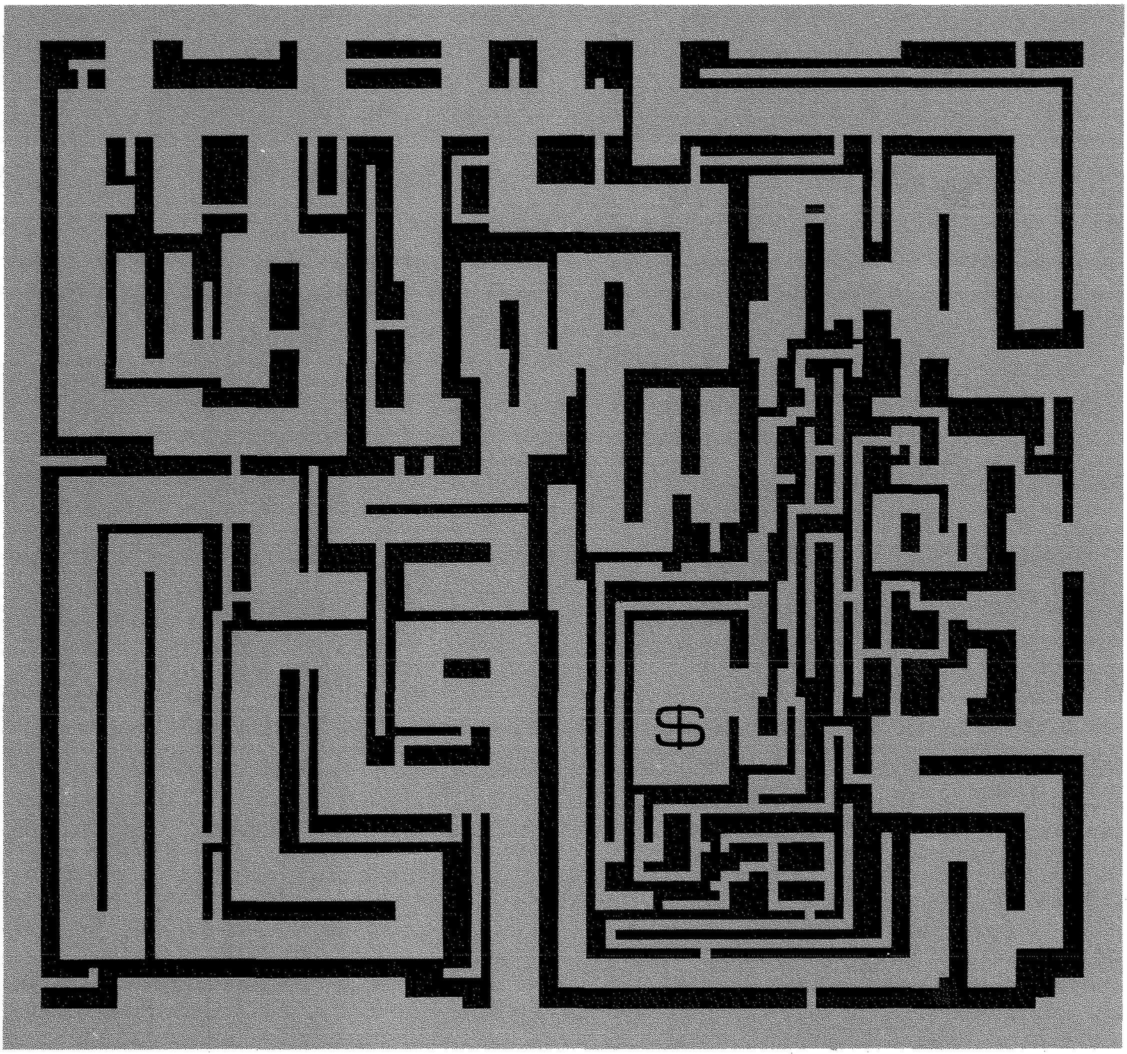

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ALTERNATE STRATEGIES TOWARD INFLATION

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Optimal Control and Money Targets: Should the Fed Look At "Everything"?

Kenneth C. Froewiss and John P. Judd*

Target rates of growth for the monetary aggregates have played an increasingly prominent role in discussions of Federal Reserve policy over the last decade. The Federal Open Market Committee (FOMC) first incorporated the notion of monetary targets into its policy directives in 1970. More recently, the establishment of such targets has been mandated by Congress, first in Joint Resolution 133 in 1975 and then in the Full Employment and Balanced Growth Act of 1978 (the so-called "Humphrey-Hawkins Act").

While virtually all economists agree that the behavior of the money supply has an important effect on economic activity, many question the wisdom of singling out this one variable from among all of those on which the Fed might focus its attention. Indeed, to confer primacy on money goes against a long Fed tradition of "looking at everything" in attempting to gauge the direction of the economy and the correspondingly appropriate monetary policy. Fed spokesmen have, in fact, maintained that they do not interpret the announced monetary targets in any rigid, mechanistic way.[1] Rather, they view these targets as broad guides to policy which may be revised as necessary in the light of new economic information.

The intuitive argument that the Fed should "look at everything" in setting policy instead of slavishly aiming at preannounced monetary targets has found support in the theory of "optimal control".[2] Described in more detail below, the optimal-control literature essentially criticizes the use of targets as being wasteful of information, which, if properly employed, would permit policymakers to be more successful in the pursuit of their economic goals. While we do not dispute the theoretical basis of this optimal-control position, we intend to assess its empirical significance within the context in which it is likely to be used. Specifically, we ask this question: Do those financial-market variables which are frequently cited as being important for the determination of monetary policy convey reliable information about aggregate spending in the economy beyond that contained in the movements of the money supply?

In Section I, we set out the basic principles of optimal-control theory, and then review how these ideas have been used to criticize a policy of monetary targeting. Also, we examine the use of information in the context of "real-world" policymaking. In Section II, we translate these theoretical considerations into econometric tests of the information about aggregate demand contained in a large number of financial-market variables—bank credit and its components, interest rates, and flow of funds—*over and above* monetary policy aggregates targeted by the Federal Reserve. From these tests, we conclude that once policymakers look at a monetary aggregate, they can gain little additional information about nominal GNP by also looking at other financial-market variables. These conclusions, as well as some limitations of the study, are summarized in Section III.

I. Optimal Control and Monetary Policy

Although the theory of optimal control has its origin in the engineering literature, its fundamental ideas can be easily explained in terms of the problems confronted by economic policymakers. The most inexorable problem is uncertainty. In theory, we can think of the economy as being accurately described by a large number of so-called structural equations. This "true model" of the economy includes equations specifying all of the relationships which make up the structure

*The authors are, respectively, Associate Economist, Morgan Guaranty Trust Company of New York, and Senior Economist, Federal Reserve Bank of San Francisco. Patrick Weber, Ladan Amir-Aslani, and Thomas Klitgaard provided research assistance for this study.

of the economy—such as consumption behavior, the demand for money, and so on. Even if policymakers were confident that they knew the "true" model of the economy, in the sense of knowing which variables belong in each equation, the equations of that model would still contain random components which cannot be empirically estimated with complete precision. In fact, policymakers' problems are compounded by a lack of certainty about the underlying structure of the economy.

Another problem is the general inability of available policy tools to affect directly the variables of ultimate concern, such as employment, inflation, and real-output growth. In the language of optimal control, the policy tools are known as "instruments" and the variables such as employment are known as "goal variables." The policymaker, then, chooses settings for the instruments believed consistent with the desired values of the goal variables, while recognizing that the link between the two is uncertain.

The situation is further complicated by the fact that the resulting actual values of the goal variables may not be immediately observable. There may be lags in the transmission of policy. For example, a change in the rate of growth of the money supply may not be fully reflected by a change in the rate of inflation for a period of up to two years.[3] Moreover, there may be further lags in the gathering of data. Figures for GNP are not available until after the end of the quarter to which they refer, and the initial figures are routinely revised, often by substantial amounts. As a result of these lags, the economy could veer off course for some time without policymakers being aware of the situation. Indeed, this possibility is not purely hypothetical. In 1974, a large revision in the inventory-valuation adjustment sharply changed perceptions regarding the overaccumulation of inventories and, hence, the likely severity of the ensuing recession. It is conceivable that, had policymakers access to better information in 1974, their decisions would have been different.

Of course, policymakers need not wait for the release of GNP data to learn about the economy, because monthly figures on personal income, industrial production, retail sales, etc., provide clues as to how the economy is evolving. Based on the observation of these "information variables," they can draw inferences about the unobserved goal variables, and reset instruments if that appears warranted. "Optimal control" makes an important contribution by showing policymakers how to make the most effective use of the feedback from information variables when deciding whether to change the setting of the instruments. The process is "optimal" in the sense of minimizing some measure of the deviation of the actual paths of the goal variables from their desired paths.[4]

The formal mathematics of optimal control theory is complex and will not be presented here. But the underlying logic is simple: In order to achieve optimal settings of the policy instruments, it is necessary to utilize all available information on the unobserved goal variables.[5] Thus, the adherents of an optimal-control approach argue that a policy of monetary targeting inherently wastes information. We now turn to an appraisal of that criticism.

Monetary Policy Targets

As mentioned at the outset, the Federal Reserve has repeatedly stressed in official statements that it does not formulate short-run monetary policy mechanistically, according simply to the criterion of whether the money supply is growing on target. Thus, although we present here a highly stylized representation of monetary targeting, we do not intend this to be used as a description and assessment of how the Fed currently conducts its affairs. Instead, we intend it simply as an expositional device to help highlight some of the key issues in the debate over the virtues of formal money targets.[6]

Consider the situation faced by monetary policymakers at the time targets are initially established. They wish to see the goal variables of unemployment, inflation, and real income growth follow certain desired paths over the planning period for which targets are to be set. For simplicity, these three distinct goal variables can be grouped under the single rubric of "income."[7] On the basis of historical empirical relationships, policymakers then choose growth targets for the monetary aggregates which they believe will be consistent with achievement of the desired path for income.

However, the money supply is not a variable over which the Federal Reserve has direct control, i.e., it is not an "instrument." The Fed can control directly the availability of reserves to the banking system or alternatively it can influence even this variable indirectly by setting a value for the Federal funds rate and providing whatever quantity of reserves is necessary to maintain that rate.[8] Under present Federal Reserve regulations, member banks must hold certain percentages of their various deposit categories in the form of reserves. This means that deposit growth is ultimately constrained by the rate at which reserves are allowed by the Fed to expand. On October 6th, the Fed announced a change in its operating procedures which would involve directly setting the volume of bank reserves (rather than the previous method of using the Federal-funds rate) to attempt to achieve its monetary-aggregates targets. Thus the Fed is now using reserves as its instrument, whereas up to October 6th the instrument was the Federal-funds rate—see the article by Judd and Scadding in this issue. But it would not be appropriate to call money the instrument under either regime.

In the terminology of optimal control, money is an information variable. Observations on the money supply are available on a more timely basis than are observations on income. More importantly, changes in the rate of growth of the money supply tend to lead changes in overall economic activity. If the rate of money growth is observed to be deviating from its target, we may assume that income is (or will be) deviating from its desired path, since the money target was expressly chosen to be consistent with the latter. In this situation, strict adherence to a policy of monetary targets would require that the supply of bank reserves be altered to bring money growth back on target.

This simple description of the workings of a money-targeting policy begs a host of real-world issues. For example, what is the proper time period over which to compare actual and targeted money growth? One week? One month? Furthermore, what should the policy response be when one measure of the money supply is exceeding its target while another is below target? And should *forecasts* of money growth be given any weight, or only *actual* money growth?

While all of these questions are important for the implementation of a targeting procedure, they can be safely ignored for purposes of this study. Here, the concern is with two more fundamental issues. First, can a policy which relies solely on the information contained in money to infer the behavior of income ever be optimal? And second, would a policy which consisted of mechanically moving reserves to bring money back on target whenever it went off track represent an optimal use of the information in money itself? According to the adherents of the optimal-control approach, the answer to both of these questions is, "No."

The logic of the response is intuitively appealing in the case of the first question. Data on a whole host of economic variables other than money are available on a more timely basis than are national-income statistics. For example, the Federal Reserve publishes weekly numbers on bank loans at the same time that it releases its money-supply figures. A large body of economic literature suggests that these numbers should provide important clues to the strength of economic activity.[9] Similarly, interest rates on a wide range of securities can be monitored on a continual basis (as the Open-Market Desk of the Federal Reserve Bank of New York indeed does). To the extent that interest rates are an important link in the transmission of monetary policy, they presumably provide another valuable source of information about income. *A priori,* it is hard to understand why policymakers should choose to ignore such information.

The reasoning behind the optimal-control position on the second issue raised above—whether automatically bringing money back on track, once it has strayed, represents the best use of the information conveyed by the money supply—is less obvious though easily explainable. We look to money for information on income because of the assumption that there is a stable relationship between the two through the money-demand function. If money demand is subject to random disturbances, however, deviations of money from target may merely reflect these random influences, and need not indicate that income is off its desired path. If, for example, the Federal Reserve were to offset a random downward shift in money demand that was unrelated to income, the result would be an excess of money supply over demand, which if it persisted would lead to inflation. If, on the other hand, the drop in money were caused by a random decrease in real economic activity, an increase in the money supply by the Federal Reserve to raise aggregate demand would be appropriate. Furthermore, if other variables than income enter the money-demand equation, policymakers must consider the response of money to these variables when formulating the optimal policy reaction to a deviation of money from target. Since money demand apparently is both subject to stochastic disturbances and responsive to changes in interest rates, it follows that mechanically moving money back to target will not, in theory, be the optimal policy. This is true even if money is used as the sole source of information about income.[10]

The empirical analysis in the remainder of this article focuses only on the first of these two separate issues—that monetary targets waste information. Further, we restrict our attention to financial-market variables as possible supplements to the information on income contained in money. We do not assume that "real" variables convey no information on income. Rather, we limit his study to financial variables because of their prominence in the literature on the transmission of monetary policy to economic activity. An investigation of potential real-sector information variables could be the subject of another long paper. Furthermore, our choice of variables is meant to reflect the natural inclination of monetary policymakers to look to the financial markets for a reading on the economy.

Finally, restricting the analysis to financial variables does not undermine the practical relevance of this study. In early 1979, for example, money growth as measured by both M_1 and M_2 was sluggish, while bank lending was growing rapidly. Policymakers were forced to decide whether the money-supply figures accurately reflected the imminence of a period of slack in real economic activity, despite the surge in bank loans.[11] In fact, the empirical estimation in the next section is based on the kind of analysis which policymakers at least implicitly perform when confronted with such divergent trends.

Information Variables: Policy Context

We noted previously that one of the problems faced by policymakers is their lack of knowledge of the "true model" of the economy. If they knew the equations of that model (or even the variables involved), they would presumably be able to extract information about income out of currently available data. But their uncertainty about the true model leaves them little choice but to rely on a few variables which in their experience have been *correlated* with GNP in the past, and which are available on a timely basis. Because of differences in individual judgment and experience, differences also occur in policymakers' choices of variables to watch. Not surprisingly, then, policy briefings tend to involve the presentation of the latest figures from a wide range of economic time series, from which each policymaker can choose the two or three variables which he or she believes convey the most information about economic activity.

In effect, each policymaker replaces the (unknown) full structural model with a single-equation model, in which income is explained by several variables on which he has focused his attention. These variables generally include monetary-policy and fiscal-policy measures, but are not limited to them. Since many financial-market measures are "endogenous" (i.e., determined in the full model), the single equation is properly called a "semi-reduced form," to distinguish it from a "reduced form" in which only "exogenous" or policy variables are used to "explain" movements in income. Also, these equations do not necessarily represent the optimal way for policymakers to use indirect information about aggregate demand. Instead, they are designed to represent a reasonable approximation to the way policymakers use such information in practice.

In this sense, and only in this sense, we use such equations to establish a strong presumption for the existence of (or lack of) "information" about aggregate demand in the variables tested. Given the use of this concept of "information," the problem reduces to searching for *correlations* between potential information variables and nominal GNP. Where such correlations are found to be statistically significant, we conclude that available information is sufficiently reliable to be potentially usable by policymakers.

Any search for information variables would logically begin with measures of monetary and fiscal policy. Examples would include the policy variables for which the Federal Reserve currently reports targets to Congress (M_1, M_2, M_3, and bank credit). The Fed presumably believes that these aggregates contain significant information about GNP, and besides, it is required under the Humphrey-Hawkins Act of 1978 to specify growth ranges for them in conducting monetary policy. Our basic equations express growth in nominal GNP as functions of growth in several monetary-policy variables (M_1, M_2, and bank credit)—and in addition, as a function of a fiscal-policy variable (high-employment federal expenditures).[12] These basic equations are the familiar St. Louis equations, which have been widely discussed in the economics literature,[13] generally as measures of the relative importance of monetary and fiscal policy. However, we employ these equations in a completely different way. We add various information variables to these equations and ask the question: Do these financial-market variables contain any *additional information* about aggregate demand not already contained in variables measuring monetary and fiscal policy?

The financial-market variables examined include (1) bank credit and its major components, (2) interest rates of various maturities, and (3) aggregate activity in the credit markets. In selecting variables for testing, we tried to be theoretically agnostic: to "run the gamut" of financial variables which are commonly used in economic-policy briefings, and which might logically flow from either Keynesian or Monetarist theories.

Contemporaneous values of these variables were entered in the equations, even though policymakers lack access to some current information because of lags in the data. Thus our equations test for information in the variables themselves, and do not determine whether policymakers actually have access to such information. This is no problem for interest rates, where there are no effective data lags. Also it is only a minor problem for monetary and banking data, where the lags are only a week—but where revisions are occasionally substantial. In the case of flow-of-funds data, however, the lags exceed one quarter, so that any potential information involves the use of either forecasts or lagged data. Since our basic tests may overstate the amount of accessible information in the flow-of-funds variables, we include additional (forecasting) regressions to determine whether our basic results with these particular variables would be affected.

II. Testing for Financial Market Information

The preceding discussion conceptually defined the empirical tests conducted for the information content of financial-market variables. We next describe the particular form of these tests, which are based on econometric estimates of semi-reduced form equations. As mentioned earlier, the equations are designed to determine whether or not the financial-market information variables add significantly to the precision with which monetary—and fiscal—policy variables by themselves explain aggregate demand. Specifically, we use F-tests to determine if standard errors from aggregate-demand equations including only the policy variables are significantly higher than standard errors from equations which also include financial-market variables. The estimating equations are described in (1) below.

The policy variables include those that would normally be found in standard St. Louis equations[14]—high-employment government expenditures as the fiscal-policy variable,[15] and M_1, M_2, and bank credit alternatively as the monetary-policy variable. Bank credit, although having less operational significance for monetary policy at present than the monetary aggregates, has received strong support as an alternate policy measure, especially during the extended debate on this subject in the early 1970's.[16] In agnostic fashion, we have simply performed our tests with all three monetary-policy aggregates.

$$Y_t = a + \sum_{i=0}^{4} b_i M_{t-i} + \sum_{i=0}^{4} c_i F_{t-i} + \sum_{i=0}^{4} d_i I_{t-i} \qquad (1)$$

where all variables are entered approximately as percentage changes[17] and are defined as follows.

See Appendix 1 for data sources and glossary.

Y = nominal gross national product.

M = monetary-policy aggregates.

- M_1 = currency plus commercial-bank demand deposits adjusted
- M_2 = M_1 + commercial-bank saving and time deposits except large negotiable certificates of deposit
- total bank credit (BC)

F = fiscal-policy variable = high-employment Federal expenditures.

I = financial-market "information" variables.

- commercial-bank variables
  - total bank credit (BC)
  - loans to nonfinancial business (BL)
  - ratio of total loans to total bank credit (P)
- interest rates
  - Federal funds rate (RFF)
  - 4-6 month prime commercial-paper rate (RCP)
  - Moody's Aaa corporate-bond rate (RCB)
- flow-of-funds variables
  - total outstanding credit extended to all nonfinancial sectors (TCE)
  - total outstanding credit extended to the household sector (TCE/HH)
  - total outstanding credit extended to the nonfinancial business sector (TCE/NFB)
  - liquid assets, nonfinancial business sector (LA/NFB)

Sample period:

1961:1-1977:4 (quarterly observations).

Distributed lags:

fourth-degree Almon distributions over times t through t-4 where coeffients at times t+1 and t-5 are tied to zero.

Serial correlation:

first degree Cochrane-Orcutt adjustment, where serial correlation was indicated.

Instrumental variables:

contemporaneous values of nonpolicy-information variables replaced by fitted values from instrumental-variables regressions (see Appendix 2 for a description of the instruments used).

In choosing particular series within each of the financial-market categories, we tried to include variables which are systematically involved in the process by which Federal Reserve open-market operations influence the economy. Our purpose was not to advance particular hypotheses, but rather to test as many credible variables as possible. It should be noted that bank credit enters the equations in two roles. This variable appears as a monetary-policy aggregate in conjunction with financial-market information variables, and, alternatively, as a financial-market information variable in conjunction with M_1 and M_2.

The end-point for the sample period was chosen as 1977.4 because later data were influenced by changes in the monetary aggregates, brought about by recent changes in banking regulations.[18] Indeed, an even earlier end-point could have been chosen, because some evidence showed that the demand for money (especially M_1) actually began shifting in 1974.3.[19] But preliminary estimates indicated that the inclusion of 1975-77 in the sample period *uniformly* raised the standard errors of the equations estimated (with and without information variables) and thus did not change any of our conclusions. Meanwhile, the beginning point of the sample period was chosen as 1961.1, because that marked the beginning of some well-documented changes in bank behavior (i.e., the development of liability management).[20]

As mentioned earlier, the equations are semi-reduced forms, in that they include exogenous policy variables which belong in the reduced form of nominal GNP[21] and, in addition, endogenous financial variables. In order to avoid the statistical problems associated with estimating equations with endogenous explanatory variables, we used an instrumental variables approach with respect to the contemporaneous values of the financial-market information variables. Actually, the results from ordinary least-squares (OLS) regressions are presented in the text, since these results are very similiar to those obtained with instrumental variables, and thus do not affect the article's conclusions. The instrumental-variables results are shown in Appendix 3, and the instruments are described in Appendix 2.

Empirical Results

The top row of numbers in Table 1 represent the standard errors from three "St. Louis" equations with nominal GNP regressed on high-employment government expenditures and a monetary-policy variable (alternatively, M_1, M_2, and bank credit), and no financial-market information variables. The standard errors from regressions which include information variables were compared with those from the St. Louis equations, by means of 5-percent and 1-percent F-tests, to see if the information variables could reduce the standard errors in the respective St. Louis equations by a statistically significant amount.

Table 1
Standard Errors of Regressions
1961.1-1977.4
(Ordinary Least Squares Regressions)

Information Variables	Policy Variables M_1,F	M_2,F	BC,F
None	2.95	2.89	3.16
M_1	N/A	2.92	2.99*
M_2	2.92	N/A	2.91**
BC	2.99	2.90	N/A
BL	3.00	2.90	3.16
P	2.95	2.93	3.09
P,RCP	2.94	2.89	3.03
RCP	2.89	2.82	2.97*
RFF	2.88	2.80	2.97*
RCB	2.94	2.96	3.20
RCB,RCP	2.91	2.84	3.00
TCE	2.93	2.88	2.98*
TCE/HH	2.50**	2.53**	2.58**
TCE/NFB	2.86	2.87	3.09
LA/NFB	2.81*	2.84	2.90**

*Indicates standard errors which are significantly lower (at 5 percent) than those of corresponding regressions with no information variables.
**Indicates standard errors which are significantly lower (at 1 percent) than those of corresponding regressions with no information variables.
N/A = not applicable

None of the three bank-credit information variables—aggregate bank credit, bank loans to nonfinancial borrowers, and the ratio of total bank loans to bank credit—passed either test. None of the three contained information in addition to M_1, and M_2, while the latter two credit variables did not significantly reduce the standard errors from the St. Louis equation with bank credit as the monetary policy variable.[22]

Similarly, the various long- and short-term interest rates tested were not found to contain additional information in the M_1, and M_2 equations. But in the bank-credit equation, both the funds rate and the commercial-paper rate significantly reduced the standard errors. Thus tests of eight bank-credit and interest-rate variables (and combinations thereof) against three measures of monetary policy (23 regressions in all) produced only two cases in which additional information was found. Both of these cases involved short-term interest rates as information variables, and bank credit as the measure of monetary policy.

In contrast, the tests of the flow-of-funds variables (last four rows of Table 1) produced a number of cases in which information existed over and above that in the policy variables. Total outstanding credit extended to households was significant for M_1, M_2, and BC. Liquid assets of nonfinancial business significantly reduced the standard errors in the M_1 and BC equations,

Table 2
Standard Errors of Regressions
1961.1-1977.4
(Instrumental Variables Regressions)

Information Variables	Policy Variables M_1,F	M_2,F	BC,F
None	2.95	2.89	3.16
TCE	2.95	2.89	3.02*
TCE/HH	2.68**	2.65**	2.97**
TCE/NFB	2.93	2.89	3.18
LA/NFB	3.01	3.04	3.11

* Indicates standard errors which are significantly lower (at 5 percent) than those of corresponding regressions with no information variables.
** Indicates standard errors which are significantly lower (at 1 percent) than those of corresponding regressions with no information variables.

while outstanding credit extended to all nonfinancial sectors passed the F-test in the BC equation.[23] Thus additional information was detected in six out of the twelve equations estimated with flow-of-funds variables.

Because of the time lag in the availability of flow-of-funds data, the results probably overstate the *usable* information in those variables. To try to extract the necessary information, policymakers would presumably attempt to forecast contemporaneous values of flow-of-funds variables. The instrumental variables regressions provide a convenient approximation to this forecasting situation. In these regressions, the contemporaneous values of financial-market information variables are replaced by in-sample estimates from first-stage equations. Since in-sample estimates are generally more accurate than out-of-sample forecasts, the instrumental-variables regressions perhaps overstate the amount of usable information in flow-of-funds variables. Nevertheless, they should do a better job than the ordinary least-squares regressions summarized in Table 1.

These more realistic results (see Table 2) fail to detect additional information in liquid assets of nonfinancial business in the M_1 and BC regressions, as did the OLS tests. The significance of outstanding credit extended to households (with M_1, M_2, and BC), and the same measure for all nonfinancial sectors (with BC) hold up in the instrumental-variables runs. As for the M_1 and M_2 equations, it is difficult to say why credit extended to the household sector would contain additional information, while the same measure for all nonfinancial sectors and the nonfinancial business sector do not.

The results in Table 1 can also be used to assess the Federal Reserve's practice of targeting more than one monetary-policy aggregate. Is the explanatory power of a single aggregate improved when a second aggregate is also considered? Our results indicate that BC can be improved upon by also looking at M_1 or M_2, but that the reverse is not true.

M_1 and M_2 thus outperform BC as a measure of monetary policy, as can be seen from the fact that the St. Louis equations yield somewhat lower standard errors with M_1 and M_2 (2.95 and 2.89 respectively) than with BC (3.16). In addition, only one of the thirteen information variables tested improved upon the M_1 and M_2 equation, while there were seven such variables for BC.

Further evidence is presented in Table 3, which shows the long-run elasticities of nominal GNP with respect to the monetary-policy variable indicated at the top of each column, when the information variable(s) indicated for each row is (are) also in the regression. M_2 maintains its highly significant coefficient when M_1 and BC are separately added to the equation. M_1 retains its significant coefficient when BC is included in the equation, but becomes insignificant in the presence of M_2. Finally, the significance of BC is eliminated by both monetary aggregates. When the entire list of information variables is considered, the long-run coefficients on M_1 and M_2 are significant in all but a few cases, while this is true for BC in only six of thirteen cases.

Table 3
Long-Run Elasticities of Y with Respect to M
1961.1-1977.4
(Ordinary Least Squares Regressions)

Information Variables	Policy Variables M_1,F	M_2,F	BC,F
None	.74**	.84**	.32*
M_1	N/A	.73*	-.03
M_2	.08	N/A	-.13
BC	.79**	.91**	N/A
BL	.80**	.90**	1.91
P	.68**	.74**	.35*
P,RCP	.70**	.72**	.43*
RCP	.75**	.74**	.47**
RFF	.74**	.74**	.45**
RCB	.73**	.88**	.24
RCB,RCP	.73**	.90**	.58**
TCE	.36	.56	.08
TCE/HH	.51*	.48*	.21
TCE/NFB	1.10**	.88**	.69**
LA/NFB	.39	.58*	.11

* Indicates long-run elasticities which are significantly different from zero at the 5-percent level.
** Indicates long-run elasticities which are significantly different from zero at the 1-percent level.
N/A = not applicable

The empirical results can be summarized as follows:

1. After testing a large number of potential information variables measuring various aspects of bank credit, interest rates and flow of funds, we found only one variable (total credit extended to households) which contained information about aggregate demand *in addition* to M_1 and M_2 (when separately paired with a fiscal-policy variable).

2. When bank credit was used as the measure of monetary policy, we found that two interest rates (on commercial paper and federal funds) and two flow-of-funds variables (total credit extended to nonfinancial sectors and to the household sector) contained additional information.

3. M_2 uniformly outperformed M_1 which, in turn, outperformed bank credit as a measure of monetary policy. We found that BC contained no information over and above that in either M_1 or M_2, while both of the latter variables contained information in addition to BC.

This study thus has accumulated a great deal of negative evidence on the information content of credit-market variables. But in doing so, it has produced one very strong positive result: once money (especially M_2) is included in an aggregate-demand equation, there is little to be gained by also looking at credit-market variables, or for that matter, at other monetary-policy variables.

III. Conclusions

Optimal-control theory implies that monetary policy is unlikely to be optimal if available information about goal variables is not used. While this conclusion is theoretically unassailable, it cannot be considered relevant in practice without determining which variables, if any, contain information in addition to the policy variables on which policymakers naturally rely. This article addresses that important policy question for a representative set of financial-market variables. The statistical tests indicate, in particular, that once policymakers take account of growth in money (especially M_2), they can gain little additional information about aggregate demand from such variables as bank credit (and its components), interest rates, and flow-of-funds variables.

The study has several limitations. First, we have not tested potential information variables from the real sector of the economy. Second, our study uses quarterly data, whereas monetary policy is conducted on a month-by-month basis, so that we may be missing some information from credit-market variables about very short-run changes in aggregate demand. Third, we have not investigated the possibility that only the unexpected portion of movements in financial-market variables contain information about GNP. Finally, as noted earlier, we have not addressed the question of how the Federal Reserve should respond to deviations in money from target—which is an important question if money is used as the sole source of information about aggregate demand. Despite these caveats, we believe that the present research has put the burden of proof on those who argue that the Federal Reserve should not target money because this involves "throwing away" significant financial-market information. Furthermore, these results re-confirm the robustness of the association between money and aggregate demand.

APPENDIX 1

Variable Names and Sources of Data

BC	=	Total loans and investments of all commercial banks (FR Board)
BL	=	Loans to nonfinancial business of all commercial banks (Flow of Funds Accounts)
C	=	Constant term
F	=	High-employment federal expenditures (FRB St. Louis)
LA/NFB	=	Liquid assets of the nonfinancial business sector (Flow of Funds Accounts)
M_1	=	Currency plus demand deposits adjusted (FR Board)
M_2	=	M_1 + time and savings deposits at commercial banks other than large negotiable certificates of deposit (FR Board)
P	=	Total bank loans of all commercial banks/BC (FR Board)
RCB	=	Moody's Aaa bond rate (Moody's Investors Service)
RCP	=	4-6 month prime commercial paper rate (FR Board)
RFF	=	Federal funds rate (FR Board)
TCE	=	Total credit extended to nonfinancial sectors (Flow of Funds Accounts)
TCE/HH	=	Total credit extended to the household sector (Flow of Funds Accounts)
TCE/NFB	=	Total credit extended to the nonfinancial business sector (Flow of Funds Accounts)
Y	=	Nominal gross national product

APPENDIX 2

Instrumental Variables Specifications

The following equations were used to generate the instrumental variables used in the instrumental variables regressions. See Appendix 3 for those regression results.

$$I_t = a + \sum_{i=1}^{2} b_i' I_{t-i} + \sum_{i=1}^{2} c_i' M_{t-i} + \sum_{i=1}^{2} d_i' RFFN_{t-i} + \sum_{i=1}^{2} e_i' F_{t-i} + f' pop_{t-1}$$

where all variables are measured in changes in natural logarithms, and

I	=	financial market information variables as defined in the text.
M_1	=	currency plus demand deposits adjusted.
RFFN	=	federal-funds rate, unless I = federal-funds rate, in which case RFFN = 90-day prime commercial-paper rate.
F	=	high-employment federal expenditures.
pop	=	total U.S. population.

APPENDIX 3
Results from Instrumental Variables Regressions

Table 1A
Standard Errors of Regressions

1961.1-1977.4
(Instrumental Variables Regressions)

Information Variables	Policy Variables M_1,F	M_2,F	BC,F
None	2.95	2.89	3.16
M_1	N/A	2.92	2.99*
M_2	2.92	N/A	2.91**
BC	3.00	2.91	N/A
BL	3.21	3.15	3.17
P	2.95	2.94	3.09
P,RCP	2.95	2.92	3.06
RCP	2.90	2.83	2.99*
RFF	2.88	2.80	2.98*
RCB	2.95	2.97	3.21
RCB,RCP	2.91	2.85	3.01
TCE	2.95	2.89	3.02*
TCE/HH	2.68**	2.65**	2.75**
TCE/NFB	2.93	2.89	3.18
LA/NFB	3.01	3.04	3.11

* Indicates standard errors which are significantly lower (at 5-percent level) than those of corresponding regressions with no information variables.
** Indicates standard errors which are significantly lower (at 1-percent) than those of corresponding regressions with no information variables.
N/A = not applicable

Table 2A
Long-Run Elasticities of Y with Respect to M

1961.1-1977.4
(Instrumental Variables Regressions)

Information Variables	Policy Variables M_1,F	M_2,F	BC,F
None	.74**	.84**	.32*
M_1	N/A	.73*	–.08
M_2	.08	N/A	–.11
BC	.83**	.89**	N/A
BL	1.00**	1.17**	1.90
P	.65**	.72**	.36
P,RCP	.73**	.79**	.48*
RCP	.78**	.76**	.51**
RFF	.76**	.76**	.49**
RCB	.73**	.88**	.25
RCB,RCP	.75**	.90**	.60**
TCE	.30	.51	.08
TCE/HH	.48	.37	.21
TCE/NFB	1.29**	.93**	.49
LA/NFB	.26	.42	.02

* Indicates long-run elasticities which are significantly different from zero at the 5-percent level
** Indicates long-run elasticities which are significantly different from zero at the 1-percent level.
N/A = not applicable

FOOTNOTES

1. This position was first made clear by Arthur Burns in his "Testimony before the Joint Economic Committee", July 23, 1970, and has since been reiterated on a number of occasions.

2. See in particular Benjamin M. Friedman, "The Inefficiency of Short-Run Monetary Targets for Monetary Policy", **Brookings Papers on Economic Activity** (1977:2), pp. 293-335.

3. Milton Friedman and Anna Jacobson Schwartz, **A Monetary History of the United States, 1867-1960** (Princeton, 1963).

4. In particular, the variance of the difference between the actual and desired values of the goal variable(s) over time is generally used.

5. While this condition is necessary for optimal control, it is clearly not sufficient. As discussed in the next subsection, optimal-control adherents also criticize monetary-policy targets for causing inappropriate responses to the information contained in money about GNP.

6. On the question of the usefulness of this simplified description, see B. Friedman (1977), pp. 294-295.

7. The assumption that there is only one goal variable avoids the problem of whether in fact there are sufficient instruments available to achieve several independent goals.

8. The Fed can, of course, affect the volume of reserves through changes in the discount rate, and can alter the effective level of reserves through changes in reserve requirements. These complications are not important for the analysis here, however.

9. See, for example, the discussion in Tim Campbell, "Monetary Policy and Bank Portfolio Composition," **Journal of Money, Credit, and Banking,** 2 (May 1978), pp. 239-251.

10. For a fuller development of this issue, see B. Friedman, (1977), pp. 311-314.

11. See William Poole, "The Monetary Deceleration: what Does It Mean and Why Is It Happening?", **Brook-**

ings Papers on Economic Activity, 1 (1979), pp. 231-240, for a discussion and analysis of the monetary deceleration.

12. A long debate exists in the economics literature over the statistically and conceptually superior measure of fiscal policy. If any consensus has developed, it favors the high-employment federal expenditures measure. See "Technical Notes for Estimates of the High-Employment Budget" Federal Reserve Bank of St. Louis, unpublished paper, March 1968, for a description of this variable. Also see footnote 13 for papers using this variable.

13. See Leonall Anderson and Jerry Jordan, "Monetary and Fiscal Actions: A Test of Their Relative Importance in Economic Stabilization," Federal Reserve Bank of St. Louis **Review** (November 1968), pp. 11-24, Benjamin M. Friedman, "Even the St. Louis Model Now Believes in Fiscal Policy," **Journal of Money, Credit, and Banking** (May 1977), pp. 365-67; and Keith M. Carlson, "Does the St. Louis Equation Now Believe in Fiscal Policy?," Federal Reserve Bank of St. Louis **Review** (February 1978), pp. 13-19.

14. See footnote 13.

15. See footnote 12.

16. See the series of papers by Michael Hamburger, Frederick Schadrack, and Fred Levin under the heading, "The Choice of Intermediate Targets," in **Monetary Aggregates and Monetary Policy,** the Federal Reserve Bank of New York, 1974. A summary discussion of those results may be found in Benjamin Friedman, "Empirical Issues in Monetary Policy," **Journal of Monetary Economics** (1977:3), pp. 87-101.

17. Specifically, the equations are estimated in changes in logarithms, which is similar to using data expressed as percentage changes. Percentage changes have been found to have superior statistical properties than dollar changes in standard St. Louis equations estimated over 1953-1976. See Carlson (1978).

18. See Thomas D. Simpson, "A Proposal for Redefining the Monetary Aggregates," **Federal Reserve Bulletin** (January 1979), pp. 13-42.

19. See Richard D. Porter, Thomas D. Simpson and Eileen Mauskopf, "Financial Innovation and Monetary Aggregates," **Brookings Papers on Economic Activity** (I:1979), pp. 213-229. A paper disputing that a shift occurred is Michael Hamburger, "Behavior of the Money Stock: Is There A Puzzle?" **Journal of Monetary Economics** (April 1978), pp. 151-192.

20. See Jack Beebe, "A Perspective on Liability Management and Bank Risk," Federal Reserve Bank of San Francisco, **Economic Review** (Winter 1977) pp. 12-25.

21. Several researchers have shown that money is exogenous with respect to nominal GNP. A recent example is Y.P. Mehra, "Is Money Exogenous in Money-Demand Equations," **Journal of Political Economy** (1978:2), pp. 211-228.

22. Cambell (1978) obtained significant results with the composition of bank credit in an equation similar to our "P,RCP" equation shown in Table 1. However, he used the 1953-72 sample period, and the raw government surplus for a fiscal variable. The reverse-causation bias in this variable in aggregate-demand equations was the major reason for the development of the high-employment government expenditures variable in Anderson-Jordan (1968).

23. The insignificance of this variable in the M_1 and M_2 equations is consistent with the results in Richard G. Davis, "Broad Credit Measures as Targets for Monetary Policy," **Quarterly Review** (Federal Reserve Bank of New York), pp. 13-22.